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STATE OF CALIFORNIA

REGIONAL WATER QUALITY CONTROL BOARD

COMPLIANCE WITH REMAND OF A PORTION OF NPDES PERMIT RE COOLING WATER INTAKE OF NEW UNITS 1&2
WASTE DISCHARGE REQUIREMENTS ORDER NO. 00-041
NPDES PERMIT NO. CA0006254

TESTIMONY OF DUKE ENERGY MOSS LANDING LLC

Analysis of Cooling Alternatives: Moss Landing Power Plant

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I. Introduction and Summary

Pursuant to the Board's Notice of Public Hearing ("Notice") dated March 7, 2003, Duke Energy Moss Landing LLC ("Duke" or "Duke Energy") hereby submits its direct testimony and supporting legal and policy arguments ("testimony") in this matter. As required by the Notice, this testimony provides additional information to the Board, supplementing and confirming that already in this record, to enable a "thorough and comprehensive analysis of Best Technology Available applicable to Moss Landing Power Plant."[1] As also required by the Notice, this testimony addresses issues pertaining "only to entrainment impacts of the Units 1&2 cooling water intake."[2]

This testimony is organized as follows. We begin by setting the context for the testimony. This consists of reviewing the legal context of this proceeding and the applicable law governing the Board's decision. Also to provide context, we briefly review the timeframe assumed for this analysis.

With that background, we turn to the technical review of cooling impacts and alternatives. The technical review begins with examining the entrainment impacts from once-through cooling at the MLPP. Since the alleged benefits of alternative cooling systems consist of removing or reducing these impacts, it is critical that the Board keep these impacts in mind. In Section IV, Duke reviews the evidence and shows that the entrainment impacts from modernized once-through cooling at the MLPP are not significant and therefore there is little, if any, benefit from alternative systems. As demonstrated in Section IV, an extensive analysis of entrainment impacts, an additional analysis using the U.S. EPA's trophic transfer method for valuing those impacts and fifty years of historic experience at this site all confirm that reducing or eliminating entrainment impacts at the MLPP would not produce any substantial environmental benefit.

The testimony then turns to the benefits of the habitat enhancement mitigation ordered by the Board in its prior decision. That evidence shows that this approach is producing dramatic benefits that more than fully offset any impacts from entrainment, even using the most conservative assumptions. Indeed, the benefits of this approach have been proven to be greater than the Board assumed in its earlier decision.

Then the testimony reviews all of the available alternatives to once through cooling that have the potential to reduce or eliminate entrainment. This includes a review of closed cycle cooling options. This testimony considers the technical and legal feasibility of each of these options, their costs, and their non-water quality impacts in certain key areas such as air quality, land use, noise and visual impacts. This analysis, which is summarized in Table 1, concludes that all of the alternatives to once through cooling for the MLPP are not feasible.

This testimony also demonstrates that the costs of each alternative are wholly disproportionate to the benefits of the alternative within the meaning of the Clean Water Act. Duke has evaluated

[1] Notice at p. 3.
[2] Notice at p. 4. Consistent with that requirement, all references in this testimony to the Moss Landing Power Plant or MLPP are intended to refer to Units 1&2 unless stated otherwise.

the costs of various alternatives in two ways. In the "April 2000 Case", we present the relative cost of alternatives as of the date of the Board's prior decision (i.e., assuming no modernization or mitigation has already occurred). In the "Real World Today Case", we present the costs of the alternatives as they would in fact be today, given what has occurred since the Board's original decision. While Duke believes it is important to look at both cases, the bottom-line for both analyses is the same. The Board's conclusions in Finding No. 48 were correct in April, 2000, and they are correct today.

Thus, although Duke presents new analysis of these options here pursuant to the hearing order, this evidence merely serves to confirm the expert opinion relied upon by the Board in its prior decision.

Table 1: Summary Results: Analysis of Alternative to Once Through Cooling

Technology	Technically Feasible?	Environmentally Feasible?	Pre Construction April 2000 PV Cost (in millions)	Post Construction "Real World Today" PV Costs (in millions)	Biological Benefit
Base Case: Once Through Cooling	**Yes**	**Yes**	$56.1	N/A	Substantial. HEP Program Offsets Far More Biological Effects Than Once Through Cooling Creates
Seawater Mechanical Draft Cooling System	**Yes**	**NO:** insufficient PM_{10} ERCs; visual impacts, land use impacts	$49.2	$110.7	Negligible
Freshwater Mechanical Draft Cooling System	**NO:** inadequate freshwater supply	**NO:** inadequate freshwater supply, visual impacts; land use impacts	$87.4	$148.7	Negligible
Natural Draft Cooling System	**Yes**	**NO:** insufficient PM_{10} ERCs; visual impacts, land use impacts	$70.1	$131.6	Negligible
Air (Dry) Cooling	**Yes**	**NO:** land use impacts	$75.8	$139.9	Negligible
Hybrid Cooling	**NO:** inadequate freshwater supply	**NO:** inadequate freshwater supply, visual impacts; land use impacts	$75	$140	Negligible
Spray Ponds	**NO:** insufficient land; inadequate freshwater supply	**NO:** insufficient PM_{10} ERCs; visual impacts, land use impacts; safety concerns	Not calculated	Not calculated	Negligible

b. Are there reasons that any of these alternatives may not be feasible?
c. What are the costs of these alternatives to once-through cooling?
d. What are the environmental benefits of each alternative?
e. Is the cost of the alternatives wholly disproportionate to their environmental benefit?[5]

This testimony responds to these questions.

III. The Timeframe of this Analysis

In this unusual proceeding, the Board finds itself asked to revisit a decision that it reached after years of careful study, multiple public hearings, and the input of the best technical experts in the field (including a Technical Working Group of independent scientists that the Board convened solely for that decision).

Duke, in reliance upon the Board's prior approval and in order to assist the state during a true energy crisis, has invested over $525 million in Units 1&2.[6] Units 1&2 are now fully built and providing critically needed power to California. In addition, pursuant to the Board's permit requirements, Duke has provided $7 million to the Elkhorn Slough Foundation for habitat enhancement projects to mitigate entrainment from once-through cooling.[7] The Foundation, in turn, has relied upon these funds to acquire property, to plan and implement programs and to leverage matching contributions.

Implementation of an alternative cooling system now would waste Duke's investment in *at least* the once-through cooling system for Units 1&2. Depending on the cost of the alternative, it might also render the entire modernization uneconomic and waste the entire investment. In addition, construction of an alternative cooling system will require taking the plant off-line for some period of time and will thereby deprive California electric consumers with an important source of reliable, low-cost electricity.

Furthermore, selection of an alternative cooling system now would mean that Duke cannot be required to fund habitat enhancement in Elkhorn Slough, since the justification for these funds is to mitigate entrainment. Plainly, it would be an abuse of discretion for the Board to require Duke to fund mitigation for entrainment while also demanding that entrainment not occur. Thus, implementation of an alternative cooling method (such as closed-cycle cooling) now would mean that the Elkhorn Slough Foundation would be required to return to Duke essentially all of the $7 million in habitat enhancement funds. That, in turn, would raise a host of questions regarding the commitments that the Foundation has made in reliance on such funds.

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[5] Notice at p. 4.
[6] In total, Duke has spent over $800 million on the Moss Landing modernization project (including the retrofit of Units 6&7 and the construction of Units 1&2).
[7] As the Board has already found, these projects will more than mitigate the entrainment impacts of the approved once-through cooling system even using very conservative assumptions.

Thus, because the plant is already built, a decision by the Board now to require an alternative to once-through cooling would have different costs and impacts than would have been the case had the Board made such a decision originally. At the same time, in this unusual remand proceeding, the Board is arguably being asked to "turn back the clock" and reconsider its conclusions in Finding 48 based on additional evidence without regard to these changed circumstances. These circumstances present a potential dilemma: should the alternatives be evaluated in light of the real world costs of implementing them today (with the plant already built and mitigation already funded) or in light of their relative merit as of the date of the Board's prior decision.

Duke has evaluated the costs of various alternatives both ways. In the "April 2000 Case", we present the relative cost of alternatives as of the date of the Board's prior decision (i.e., assuming no modernization or mitigation has already occurred). In the "Real World Today Case", we present the costs of the alternatives, as they would in fact be today, given what has occurred since the Board's original decision. While Duke believes it is important to look at both cases, the bottom-line for both analyses is the same. The Board's conclusions in Finding No. 48 were correct in April, 2000, and they are correct today.

IV. Reducing or eliminating entrainment at the MLPP does not produce a substantial environmental benefit.

As interpreted by EPA over the last 25 years, Section 316(b) excludes from consideration as Best Technology Available ("BTA") any technology whose costs are wholly disproportionate to the benefits (i.e., reductions in impingement and entrainment) that would be gained thereby. Thus, the issues addressed by the Board in Finding No. 48 depend not only on considering the costs, but also upon the benefits, of the various alternative intake technologies in reducing entrainment. That, in turn, depends upon an assessment of the significance of the entrainment impacts resulting from once-through cooling in the first place. In this case, the entrainment impacts from once-through cooling are not considered to be significant. Consequently, the benefits of reducing or eliminating these impacts are slight as well.

The Board has already studied in great depth the entrainment impacts of the MLPP. The Board's analysis was based upon extensive studies that were performed under the direction of the Board Staff and the independent scientists of the Technical Working Group (TWG). The methods and results of these studies are summarized in Appendix A.

These studies concluded that even using unrealistic assumptions that greatly exaggerate entrainment effects, the proportional mortality of entrained larvae is relatively small. Assuming that the plant will operate 100% of the time (which it plainly will not), that none of the entrained larvae survive (despite evidence of up to 80% survival), and that there is no compensatory response[8] within the population (despite evidence that compensatory response is a common phenomenon), the Board staff concluded that the MLPP would have a "proportional mortality"[9]

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[8] Compensatory response is the phenomenon whereby species losses produce a compensating increase in the rates of survival of the remaining members of the population due to, for example, reduced competition for food and habitat.
[9] Proportional mortality is a technical term for a measure of the <u>risk</u> of entrainment for larvae which takes into account many factors (*see* Appendix A). It is <u>not</u> the same as proportional loss and does <u>not</u> represent the proportion of the population lost to entrainment.

of 13%. It should also be noted that this figure assumes the source water body for entrainment is Elkhorn Slough, ***not*** Monterey Bay (see discussion in Appendix A). This assumption greatly overstates the effects of entrainment— more than doubling the proportional mortality figure (5% to 13%). Nonetheless, despite the compounding effect of these multiple unrealistically conservative assumptions, the proportional mortality estimates derived from the TWG directed studies show a relatively small risk that entrainment will have any population effects.

Based on the life strategies of the entrained species, a 13% risk of entrainment is relatively small in the context of population effects. These species produce larvae in vastly greater numbers than their adult populations and depend on the sheer numbers of their larvae, rather than the survivability of the larvae, to sustain adult populations. Thus, with or without entrainment, the chances that the larvae will grow to adults in the population that produced them is exceedingly small. The vast majority of all larvae (including those that might be entrained) will not contribute to the species' adult population due to mortality, export and many other factors. This means that the effects of entrainment on adult populations are greatly attenuated and insignificant, if they exist at all.

Given the small fraction of Elkhorn Slough and harbor larvae that are entrained, there will be no significant population-level impacts on aquatic biological resources from once-through cooling at MLPP Units 1&2. This conclusion is supported by empirical, real world experience with once-through cooling at the MLPP site. Unlike many projects reviewed by the Board, in this case there is a considerable amount of directly relevant, historic data regarding entrainment effects at the MLPP. Monterey Bay and the Elkhorn Slough have been quite extensively studied over several decades. The fact that the MLPP has operated at this site for a half century with greater once-through cooling water usage than the proposed cooling system — without any evidence of an adverse impact on marine resource populations — provides qualitative evidence of the insignificance of the project's potential entrainment effects.

Other factors which reduce the significance of any entrainment effects include the fact that larval entrainment at the MLPP does not impact species with commercial or recreational value. As described in Appendix A, less than 5% of the entrained larvae have commercial or recreational value. Indeed, over 86% of the entrained larvae are various types of gobies. In addition, as indicated above, the MLPP intake is located at a point where the source water volume is very large (Monterey Bay). This also reduces the relative significance of larval entrainment. For all these reasons, and especially the real world experience at the site, there is ample evidence that the impact of entrainment on species populations is *de minimis* . Conversely (and equally importantly), there is no evidence to support a contrary conclusion.

Notwithstanding the *de minimis* nature of the impact in this case, a brief discussion of the various benefit valuation methods currently being considered by EPA is useful to a broader understanding of this issue. In cases where a significant impact from impingement or entrainment has been found to exist, EPA may rely upon any of several economic valuation methods to quantify, in economic terms, the benefits of reducing these impacts (either through closed-cycle cooling or some other technology).[10] The most straightforward of these methods is

[10] Since all of the EPA proposed methods are in a public draft for comment form, the results of the MLPP benefits evaluation are of a strictly heuristic nature and purpose. For the purposes of this benefits analysis only, the closed-

the commercial or recreational value of the entrained species. In this case, as noted above, less than 5% of the entrained larvae have any commercial or recreational value. The economic value of the percentage of these larvae that would survive to adulthood and be available for commercial or recreational harvest is thus extremely small.

The remaining 95 percent of the larval fish entrained by the MLPP (mostly gobies) are designated as "nonuse species". The EPA has proposed several ways to quantify the nonuse benefits of closed-cycle cooling. The first, known as the 50 percent rule, assumes that the nonuse value is at least 50 percent of the commercial and recreational use benefit. However, since there is no commercial or recreational use benefit loss attributable to once-through cooling at MLPP, application of this method would estimate the value of closed-cycle cooling at zero.[11]

EPA is also exploring the use of contingency valuation (CV) techniques to estimate the benefits of closed-cycle cooling. The CV technique is predicated upon the belief that, while certain species may not have commercial or recreational uses, society nevertheless attaches a value to their status or quality, which can be expressed monetarily in terms of stated preferences. As described by EPA, stated preference methods ask participants in a survey to state their willingness to pay (WTP) for particular ecological improvements. The CV technique asks interviewees, for example, to indicate what it would be worth to them, in the form of a tax or fee, to conserve an acre of coastal marsh. Both the survey techniques and results have remained highly controversial since the CV method was first used, and the EPA is presently at work to improve the methodology. However, lacking the results of a CV survey applicable to the Moss Landing area or even to California, the technique cannot be applied to evaluating nonuse benefits of closed-cycle cooling alternatives for Units 1&2 at the MLPP.

The third method being evaluated by EPA is known as the "trophic transfer" method. This method, which is also under considerable discussion among the experts, proposes to convert the entrained number or biomass of "nonuse" species to a "use" species number or biomass by a factor of 20 percent. For example, at MLPP, the number of entrained larval gobies would be converted to biomass of larval gobies. This value would then be converted by a factor of 20 percent into biomass of a use species that preys on gobies (probably California halibut or starry flounder). The direct transfer estimate of benefit assumes that individuals of a "use species" consume all of the goby biomass, and that all of the individuals consuming the goby biomass create a surplus that is harvested. The model also assumes that the harvested surplus does not affect market values used to estimate the value of closed-cycle cooling benefits. Using the EPA trophic transfer method, the *maximum* estimated benefit of reduced entrainment with any of the alternative technologies (arising from a reduction of entrained goby biomass that became harvested halibut) would be approximately $2,900.

To be sure, the values resulting from this or *any* of the above EPA methods are highly debatable. Accordingly, Duke presents this information not to suggest that this is the precisely correct value. However, this example is another measure that illustrates the truly *de minimis* impact of

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cycle cooling alternatives discussed below are assumed to be theoretically feasible for use with MLPP Units 1&2. However, see Appendix D of this testimony for discussion of the actual feasibility of these various options.

[11]Alternatively, one might say that the method cannot be applied where there are no commercial or recreational losses.

entrainment in this case. The fact that application of the only two EPA methods for conducting such evaluations that can be applied in this case results in estimates of either zero impact or $2,900 provides further evidence that entrainment impacts are not significant.

In summary, extensive analysis of potential entrainment impacts, consideration of EPA's methods of valuing the benefits of eliminating entrainment, and fifty years of historic experience at this site all confirm that reducing or eliminating entrainment impacts at the MLPP would not produce any substantial environmental benefit.

V. The entrainment impacts from once-through cooling at the MLPP have been more than adequately mitigated through the HEP ordered by this Board.

In its prior decision in this case, the Board determined that BTA for the MLPP is once-through cooling in conjunction with a habitat enhancement program (HEP). Pursuant to the Board's direction, Duke has provided $7 million to the Elkhorn Slough Foundation to fund its efforts to preserve and enhance this resource.[12] Restoration and preservation of the Elkhorn Slough ecosystem serves as the Board's preferred alternative to provide mitigation for any and all impacts. In fact, this program will offset many times the entrainment effects given the "conservative upon conservative" assumption framework used by the Board.

The sufficiency of these funds to mitigate entrainment effects is well established in this record. Using the 316(b) assessment of entrainment effects expressed as the average of each entrained species of larval fish fractional loss[13] of its source water population (PM), Board staff and the independent scientists estimated the number of acres of Elkhorn Slough habitat required to produce the PM fraction of entrained larvae. The Board's experts in marine habitat restoration and preservation costs converted the number of acres to a dollar value. Duke provided the Board staff with information on the availability and potential acquisition costs for local parcels of land that might be suitable candidates for restoration or preservation purposes.[14] The cost of the

[12] In addition to these funds, Duke has also committed to fund an additional $1 million in monitoring funds beyond that ordered by the Board in a voluntary effort to respond to the concerns of certain local environmental groups. Also, while not related to entrainment, Duke has agreed to provide $425,000 to the Coastal Waters Evaluation Program developed by the Monterey Bay National Marine Sanctuary to fund studies of the thermal effects of once-through cooling at the MLPP.

[13] As already noted, the estimate of entrainment loss assumed 1) 100 percent mortality of all entrained larvae and 2) that the number entrained of larvae is equal to the number that would be entrained if all of the cooling water intake pumps ran continuously (24/7) for an entire year, neither of which would be true for actual plant operations. Some larvae will survive entrainment, up to 80 percent depending on the species, and the cooling water pumps will never be continuously run for a 12 month period.

[14] In practice, the value of restoration required to offset the project's entrainment effects was determined by multiplying the average entrainment effect on larval fish (PM = 0.13) times the number of wetted acres reported for Elkhorn Slough that produced the larvae and converting the resulting number of restoration acres to mitigation dollars using estimates of per acre costs to acquire, restore and preserve Elkhorn Slough habitat. This habitat is both the direct and indirect source of the majority of the project's entrained organisms.

restoration was ultimately determined by the Board in consultation with its Staff, representatives of various state and federal agencies, and the scientists on the Technical Working Group.

The Board determined by this method that the cost of required mitigation for entrained larvae is equivalent to approximately $7 million of acquired, restored and preserved Elkhorn Slough wetlands. This figure stands in stark contrast to the *de minimis* (or lower) values produced by EPA valuation methodologies, another indication of the extreme conservatism of the Board's assumptions in estimating entrainment impacts

This method of using restoration valuation for entrainment effects is both science-based and ecologically sound. Nearly 90 percent of the entrained larvae are species of gobies that live in Elkhorn Slough and the surrounding tidal mudflats and marshes. It is also ecologically sound to equate the number of larvae in the MLPP source water to the acres of adjacent and surrounding adult spawning habitat. Therefore, it logically follows that the fraction of the source water's larval population that is affected by entrainment is equivalent to the fraction of spawning habitat that produced the species source water population of larvae.

In requiring the habitat enhancement program, the Board called for the funding of projects "for permanent preservation and enhancement" of habitat within the Elkhorn Slough watershed to increase the health and biological productivity of the aquatic environment. The adopted mitigation measures encourage cost share and leveraging of the mitigation fund "to obtain additional benefits for the Elkhorn Slough watershed without additional expenditures from the dedicated account." To do this, criteria were developed to directly protect, enhance and restore wetlands and to acquire and manage upland areas that could cause potential damage to aquatic resources from sediments and chemicals in watershed runoff to the slough. An extensive and thorough plan for the Elkhorn Slough environmental enhancement and mitigation program plan has been developed and agreed upon by the interested parties for implementation through the Elkhorn Slough Foundation.[15] As shown in the following section, the Foundation and its partners have made significant progress toward realizing the goal of increasing the health and productivity of the Elkhorn Slough as outlined in the Elkhorn Slough Environmental Enhancement and Mitigation Plan (ESEEMP).[16]

Leverage

The mitigation funds ordered by the Board have already helped the Elkhorn Slough Foundation leverage substantial other slough improvement projects. The Duke funds have helped the Foundation persuade sellers and/or givers of land parcels that the Foundation will have the resources and expertise to permanently improve the ecological health and to monitor ongoing needs of the slough. In turn, such projects will improve the productivity of the slough, thereby increasing the already-ample biological improvement effects of the once-through cooling mitigation funds.

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[15] MOSS LANDING POWER PLANT: ELKHORN SLOUGH ENVIRONMENTAL ENHANCEMENT AND MITIGATION PROGRAM PLAN, Moss Landing Power Plant Environmental Enhancement Program, NPDES Permit No. 00-041, Finding No. 50 from the NPDES permit.

[16] Annual Report on the Elkhorn Slough Environmental Enhancement and Mitigation Plan (ESEEMP).

The appraisal value of the properties so leveraged to date has been approximately $5.8 million; the actual purchase price was approximately $3.5 million. These efforts are already underway to reduce damaging inputs to the slough and to improve and restore key habitats.[17] This progress represents the power of a sound and comprehensive plan and of pooling resources to implement conservation goals. In September 2002, the Foundation acquired a key 356 acre property in the main drainage of the slough. This brings the total acquisitions to nearly 1,000 acres since the Foundation completed the plan. With this addition, the Foundation now owns or manages over 2,500 acres of land in the watershed.

Dr. Silberstein, the Foundation's Director, reports that the following lands have been acquired with funding and gifts leveraged from the mitigation plan:

Table 3: Lands Acquired By the Elkhorn Slough Foundation

Property	Acreage	Appraisal	Purchase Price
Upper 3M	134	$850,000	$400,000
Porter Ranch	256	$1,700,000	Gift
El Chamisal Ranch	200	$1,270,000	$1,150,000
Brothers Ranch	356	$2,000,000	$2,000,000
Totals	946	$5,820,000	$3,550,000

In addition, the Foundation currently holds in escrow the Hambey Ranch and the Sale property and has a purchase agreement for Ranch #2:

Table 4: Additional Lands In Process of Being Acquired by the Elkhorn Slough Foundation

Property	Acreage	Appraisal	Offer
Hambey	540	$3,140,000	$3,140,000
Sale	5.5	$25,000 (est.)	Gift
Ranch #2	32	$390,000	$350,000
Grand Totals	1518	$9,600,000	$7,040,000

[17] Elkhorn Slough Foundation Newsletter, Winter 2003.

Furthermore, the Foundation is engaged in discussions regarding several other key properties that meet the criteria outlined in the Plan. Foundation members are energized by their quick environmental enhancement success and accomplishment with the funds entrusted to them by the Board and the CEC. The Foundation is now preparing a proposal that will apply the acquisition and restoration portion of the Duke MLPP mitigation fund to a land transaction that meets ESEEMP criteria.

Monitoring and Other Activities

In addition to these land acquisitions, Duke's funding is assisting the Foundation in providing background monitoring in support of the mitigation plan. The Foundation is working in close association with the Elkhorn Slough National Estuarine Research Reserve (ESNERR) to implement the Enhancement and Mitigation Plan background monitoring efforts. The Foundation now employs nine people that report to the Reserve on monitoring and education programs in the Reserve and also collaborate on data acquisition and interpretation. A number of key programs are in place to support an evaluation of the Duke MLPP mitigation program.

Another way the Board's current MLPP mitigation program is made most effective are the various other ongoing resource protection and monitoring activities of the Foundation. See Appendix M for a discussion of these programs.

The Foundation has voiced their great appreciation for the opportunity to work with the Regional Board and Commission to protect and improve the long-term health of the Elkhorn estuary. The leverage provided by Duke's mitigation fund has enabled the Foundation to move far faster than they anticipated in acquiring lands that restore and protect the biological productivity of the Elkhorn Slough

In all these ways, the funding provided by Duke pursuant to the Board's direction is assisting the Foundation to protect and enhance the Elkhorn Slough. Moreover, as illustrated above, Duke's funding has enabled the Foundation to leverage land acquisition funding to substantially increase the $7 million provided by Duke. Thus, Duke's contribution is directly enabling benefits to the wetlands that exceed the Board's mitigation fund. These benefits will directly translate into benefits to the entrained species, particularly the most commonly entrained gobies that depend upon the Slough for essential habitat.

As shown above and elsewhere in this testimony, these benefits far exceed those of other approaches or technologies to address entrainment effects, including even those prohibitively costly alternatives. The evidence strongly supports the conclusion that the Board's existing permit approach not only provides benefits without disproportionate costs, but that it provides the greatest overall benefit to the environment of all the alternative intake technologies.

VI. There is no alternative method of cooling that can be justified pursuant to the CWA requirements with or without consideration of the sunk costs.

The CCRWQCB has asked parties to identify the alternatives to once-through cooling that have the potential to reduce entrainment.

To properly perform this assessment, it is necessary to address related questions that provide additional context. For example, when assessing feasibility, it is necessary to circumscribe its meaning within the context of the Clean Water Act legal framework:

- Is the alternative technology proven and available? Does it have demonstrated operability and reliability at a cooling water intake having a similar size and environmental setting to that at the MLPP?
- Is the alternative technology feasible at MLPP site, based on site-specific conditions and considerations of engineering, operations, efficiency and reliability?
- Can the alternative technology be applied at MLPP in a way that is consistent with all applicable laws, ordinances, regulations and standards? Will the alternative technology cause or increase significant adverse environmental impacts relative to once-through cooling?

To perform this analysis, Duke built off of the existing 316(b) report for MLPP, dated April 28, 2000. Duke reviewed each of the technologies identified in the 316(b) report and updated the analysis where appropriate. Specifically, a number of technologies were identified in Table 7-1 of the original 316(b) report as "proven and available for consideration" as it relates to both impingement and entrainment impacts. Since the focus of this remand hearing is on alternatives to once through cooling, the first step was to cull from this list those technologies that either are not alternatives to once-through cooling or would not affect entrainment.

These steps resulted in the list of technologies below as being "demonstrated proven and available" for consideration to reduce entrainment impacts at the MLPP and represent alternatives to once through cooling. Such a screening list does not mean that they are feasible at MLPP specifically.

Based on the above considerations, the following technologies are subject to review in this proceeding:

- Mechanical Draft Cooling System Using Seawater
- Mechanical Draft Cooling System Using Fresh Water
- Natural Draft Cooling System
- Dry Cooling System

- Hybrid Wet/ Dry Cooling System
- Spray Ponds

The results of the analysis of these options is set forth in Appendix D and is summarized below.

Mechanical Draft Cooling: Seawater

With a Mechanical Draft Cooling system, warm water from the steam turbine condensers and other cooling water uses in the plant flows to the mechanical draft cooling towers consisting of air-to-water contact surfaces (known as "tower fill") and electric motor-driven fans. The recirculating water to be cooled falls from the top through the tower where it contacts a high airflow drawn through the tower by the fans. Cooling occurs primarily through partial evaporation of the falling water (similar to the operation of a "swamp" cooler) and contact cooling of the water by the cooler air. Cooled water collects in large basins beneath the towers where water circulation pumps return the water to the condensers and other equipment to repeat the cycle.

Feasibility of Option

Mechanical Draft Cooling using seawater is infeasible due to environmental constraints. There are insufficient particulate offsets for this alternative. In addition, this alternative has visual resource impacts that cannot be mitigated. Finally, this alternative is not consistent with local land use law. This system would also create unquantified impacts from salt deposition through the local area, including in and around the PG&E switchyard.

Summary of Cost Analysis

For Mechanical Draft Cooling using Seawater, Duke has determined that the present value of the capital and ongoing costs for the April 2000 Case is $49.2 million on an after-tax basis. The cost of this alternative is $6.8 million less than once-through cooling However, these cost savings cannot be realized due to the infeasibility of this alternative.

For the Real World Today Case, the present value of the capital and ongoing costs is $110.7 million on an after-tax basis. The incremental cost of this alternative compared to once-through cooling (including mitigation costs) is $54.6 million. These costs are plainly wholly disproportional to the *de minimis* benefits as discussed in Section V, above.

Thus, this alternative cannot be deemed the best technology available for this project.

Mechanical Draft Cooling: Freshwater

This option is the same as the seawater option, except that freshwater is used instead of seawater.

Feasibility of Option

Mechanical Draft Cooling using freshwater is infeasible due to the lack of sufficient available fresh water, visual resource impacts, and inconsistency with local land use laws.

Summary of Cost Analysis

For Mechanical Draft Cooling with Freshwater, Duke has determined that the present value of the capital and ongoing costs for the April 2000 Case is $87.4 million on an after-tax basis. The incremental cost of this alternative compared to once-through cooling (including mitigation costs) is $31.3 million. For the Real World Today Case, the present value of the capital and ongoing costs is $148.7 million on an after-tax basis. The incremental cost of this alternative compared to once-through cooling (including mitigation costs) is $92.7 million. These costs are plainly wholly disproportional to the *de minimis* benefits as discussed in Section V, above.

Thus, this alternative is not environmentally or economically feasible and the costs and benefits are such that it cannot be deemed the best technology available for this project.

Natural Draft Cooling

A natural draft cooling system is similar in principal to the mechanical draft system, but vastly different in appearance. The primary difference is that the mechanical fans are replaced by what is essentially a large chimney. Because natural draft cooling systems are preferred where there are very large cooling water flow rates, a humid climate, a high cost for power use, low construction labor rates, and no severe seismic requirements, these systems are relatively rare in California.

Feasibility of Option

A natural draft cooling system is infeasible for several reasons. There are insufficient particulate offsets for this alternative (using seawater) as well as insufficient available freshwater supply for a freshwater system. Furthermore, this alternative has visual resource impacts that cannot be mitigated and is inconsistent with local land use laws. This system would also create unknown impacts from salt deposition through the local area, including in and around the PG&E switchyard.

Summary of Cost Analysis

For Natural Draft Cooling, Duke has determined that the present value of the capital and ongoing costs for the April 2000 Case is $70.1 million on an after-tax basis. The incremental cost of this alternative compared to once-through cooling (including mitigation costs) is $14.0 million. For the Real World Today Case, the present value of the capital and ongoing costs is $131.6 million on an after-tax basis. The incremental cost of this alternative compared to once-through cooling (including mitigation costs) is $75.5 million. These costs are plainly wholly disproportional to the *de minimis* benefits as discussed in Section V, above.

Thus, this alternative is not feasible for several reasons and the costs and benefits are such that it cannot be deemed the best technology available for this project.

Dry Cooling

An Air Cooled Condenser (ACC) system utilizes ambient air to condense the exhaust from the existing steam turbine generators (STGs), thus replacing the existing surface condensers. In an

ACC system, exhaust steam from the STG is cooled and condensed in a large external heat exchanger using atmospheric air as the cooling medium. Large, electric motor-driven fans move large quantities of air across finned tubes (similar in principle to an automobile radiator) through which the exhaust steam is flowing. Heat transfer from the hot steam to the air cools the steam, which condenses and is returned to the steam cycle. The now warmer air is exhausted to the atmosphere.

Air-cooled condensers for power plants are very large structures and consume significant amounts of power for fan operation. The higher condensing temperature of these ACC systems significantly lowers steam turbine power output and electrical generation compared to electrical efficiency of once-through or recirculating water-cooled condensers.

Feasibility of Option

An ACC system is not feasible due to conflicts with local land use laws requiring coastal dependent uses at the MLPP site and significant efficiency losses.

Summary of Cost Analysis

For Dry (Air) Cooling, Duke has determined that the present value of the capital and ongoing costs for the April 2000 Case is $75.8 million on an after-tax basis. The incremental cost of this alternative compared to once-through cooling (including mitigation costs) is $19.7 million. For the Real World Today Case, the present value of the capital and ongoing costs is $139.9 million on an after-tax basis. The incremental cost of this alternative compared to once-through cooling (including mitigation costs) is $83.9 million. These costs are plainly wholly disproportional to the *de minimis* benefits as discussed in Section V, above.

Thus, Dry Cooling is not feasible due to significant efficiency losses and land use conflicts, and the costs and benefits are such that it cannot be deemed the best technology available for this project.

Hybrid Cooling

A parallel condensing wet/dry system utilizes a parallel condensing cooling system where the steam turbine exhaust is condensed simultaneously in both a standard steam surface condenser (SSC) and in an ACC. Hybrid condensing is most often used when some water is available, but not enough to supply the entire plant. Use of even partial air condensing on warm days will still significantly reduce the plant's thermal efficiency.

Feasibility of Option

Hybrid cooling is infeasible due to environmental constraints. This system has all the challenges of both the freshwater or seawater mechanical draft systems and the dry cooling system (particulates, or freshwater supply, visual mitigation, efficiency losses). Even though hybrid cooling emits less particulates and consumes less water than dry cooling, it does not appear feasible to secure even the reduced amount of particulate offsets or the reduced quantity of freshwater supply necessary.

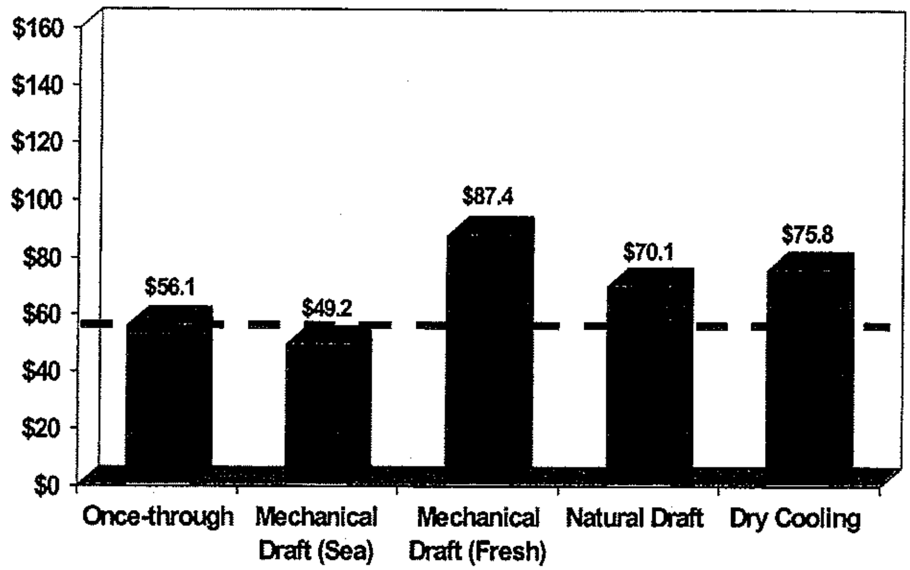
Thus, this alternative is not environmentally feasible and the costs and benefits are such that it cannot be deemed the best technology available for this project.

Conclusion

As set forth in Appendix D and E, all of the alternatives to once-through cooling at the MLPP are either not feasible based on site-specific considerations of engineering, operations, efficiency or reliability, or have costs that are disproportionate to their benefits within the meaning of the Clean Water Act. Thus, the testimony confirms the Board's prior finding on the issues remanded by the Court.

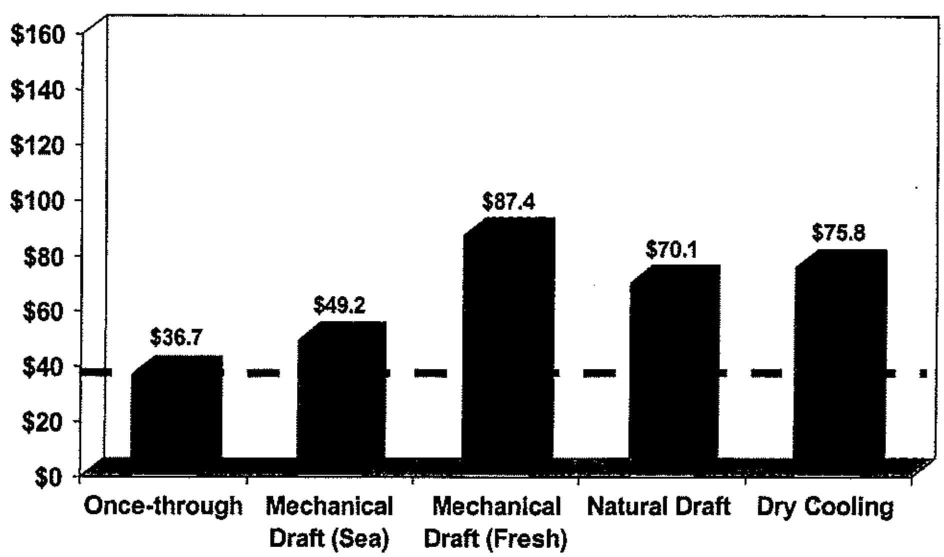
The comparative present value cost summaries of the alternatives are presented in Figure E below.

Figure E-2a: April 2000 Case PV Costs
(in millions)



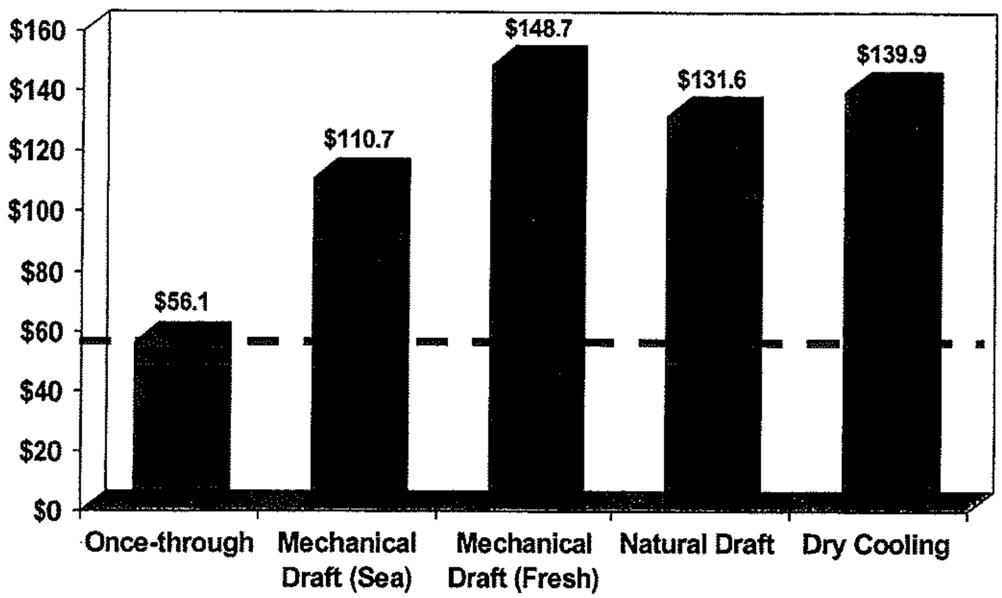
Note: The value above the dashed line is the incremental cost of the alternative compared to once-through cooling

Figure E-2b: April 2000 Case PV Costs
Intake Expenditure Only
(in millions)



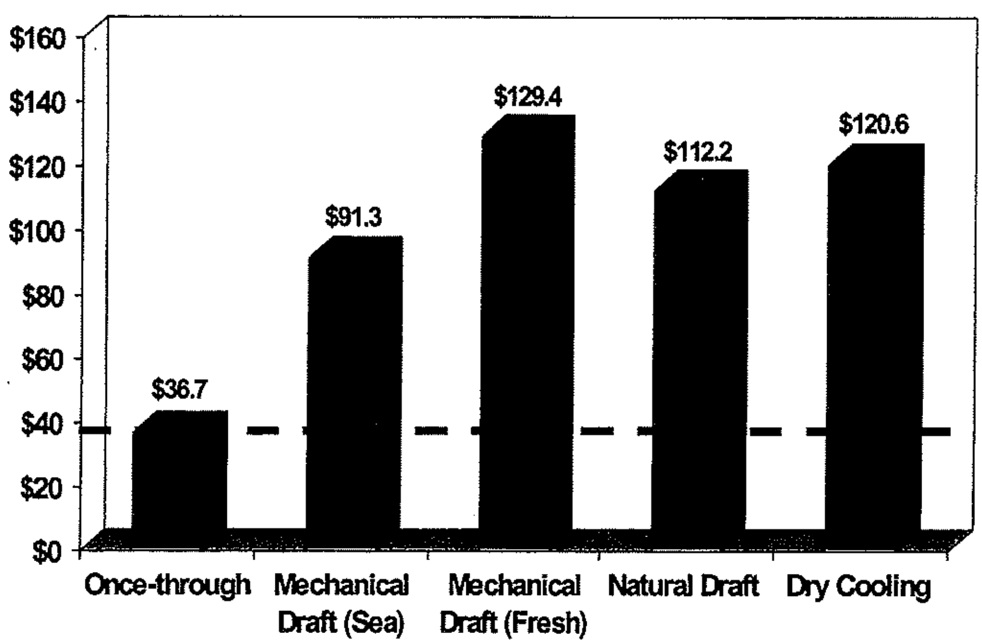
Note: The value above the dashed line is the incremental cost of the alternative compared to once-through cooling

Figure E-3a: Real World Today Case PV Costs (in millions)



Note: The value above the dashed line is the incremental cost of the alternative compared to once-through cooling

Figure E-3b: Real World Today Case PV Costs Intake Expenditure Only (in millions)



Note: The value above the dashed line is the incremental cost of the alternative compared to once-through cooling

Appendix A

Appendix A - Summary of the Original 316(b) Entrainment Analysis

Entrainment and Source Water Studies

The MLPP is situated at the intersection of three distinct marine geographic areas: Elkhorn Slough (tidal lagoon), Moss Landing Harbor, and Monterey Bay. Each of these areas has its own unique aquatic biological habitats. Distinct aquatic habitats present within the boundaries of Moss Landing Harbor and Elkhorn Slough include shallow open water, submerged aquatic vegetation, sand/mud/salt flats, fresh/salt/brackish marshes, rocky subtidal, and intertidal. Distinct habitats present in Monterey Bay include sandy beach, rocky intertidal, and subtidal and open water areas.

At the direction from the Technical Working Group, data from samples collected in front of the intakes for the MLPP 1 and 2 combined-cycle units were used to evaluate entrainment effects. These data were used assuming 100 percent entrainment mortality, with data collected from the source water to assess the potential impact to fishery resources. They also assumed 100% round-the-clock operation of the New Units 1&2. The studies were designed to address the following questions:

> Have changes occurred in MLPP's source water bodies that would lead to alteration of the estimates of abundance or distribution of source water stocks of entrainable larval fishes or cancer crab megalops?
>
> What is the potential impact of the power plant's cooling water system on larval fishes and cancer crabs?

These results also provide site- and species-specific information used to evaluate the potential effectiveness of intake modifications for minimizing the potential effects of entrainment and to evaluate available intake technologies for the new combined-cycle Units 1&2 of the Moss Landing Power Plant.

Sampling Frequency.

Sampling frequency was based on observed seasonality of larval abundance in the area of MLPP (PG&E, 1983) and on the scientific literature (Matarese et al., 1989; Moser, 1996) (Yoklavich et al., 1992) . The entrainment and source sampling efforts (one 24-hr period per week) took place during the periods of peak larval abundances of most of the eight taxa listed in Table 1. Otherwise, biweekly sampling continued during the remainder of the year (July through October).

Table A-1. Common Entrainment Period and Peak Concentrations, in order of Abundance, for the Eight Most Abundantly Entrained Larval Fish Taxa at MLPP during 1978–1980 (PG&E, 1983).

Name	Most Common Entrainment Period	Peak Concentration (number/ m^3)
Northern anchovy (*Engraulis mordax*)	November to April	5.4 (March)
Gobies (Gobiidae)	Year-Round	2.5 (January)
Silversides (Atherinidae)	November to April	2.7 (March)
Smelts (Osmeridae)	January to September	4.2 (February)
Pacific Staghorn sculpin (*Leptocottus armatus*)	September to May	0.5 (February)
White croaker (*Genyonemus lineatus*)	August to April	0.7 (November and December)
Longjaw mudsucker (*Gillichthys mirabilis*)	Year-Round	0.5 (September and October)
Pacific herring (*Clupea pallasi*)	Two spawning periods: December to March and May to Early August	0.5 (January) and 1.3 (June)

Entrainment Samples

Towed net sampling began March 2, 1999 and continued through February 24, 2000. Samples taken from in front of the intakes for the new combined-cycle units and for Units 6&7 were collected by towing a bongo frame with 0.71-m (2.3-ft) diameter openings and equipped with two 335-µm mesh plankton nets and codends. Samples were collected over a continuous 24-hour period; each period was divided into six 4-hour sampling cycles. Two tows were conducted during each cycle. Samples were collected at stations located directly in front of the intake structures for both the new combined-cycle units and for Units 6&7 (Figure 1).

Source Water

Samples were collected at six stations monthly (Table 2) in one of two ways; oblique tows for the ocean and harbor stations and push nets for the Kirby Park and Dairies stations. The locations for the source water stations are shown in Figure 1. The following three stations were chosen to conform to locations previously studied by Nybakken et al. (1977): (1) between the Highway 1 Bridge and the entrance to the Moss Landing Harbor, (2) near the Dairies, and (3) near Kirby Park. The remaining three station locations were chosen based on discussions with the Technical Work Group, including an additional at the harbor's entrance and one ocean station located one mile (1.6 km) to the north of the harbor entrance and another one mile (1.6 km) to the south of the harbor entrance (Figure 1). Two samples of at least 40 m^3 were collected in daylight at each station during one high and one low tide. Source water sampling was scheduled to occur during the same 24-hour period as the entrainment collections. Sampling at the harbor entrance and ocean stations consisted of an oblique tow using the same methodology described above. Sampling at the Dairies and Kirby Park stations (Figure 1) consisted of pushing a 0.71 m (2.3 ft) diameter net of 335   m mesh on the surface in front of a moving boat. All source water samples were processed in the laboratory.

Figure A-1. Moss Landing Power Plant Sampling Locations

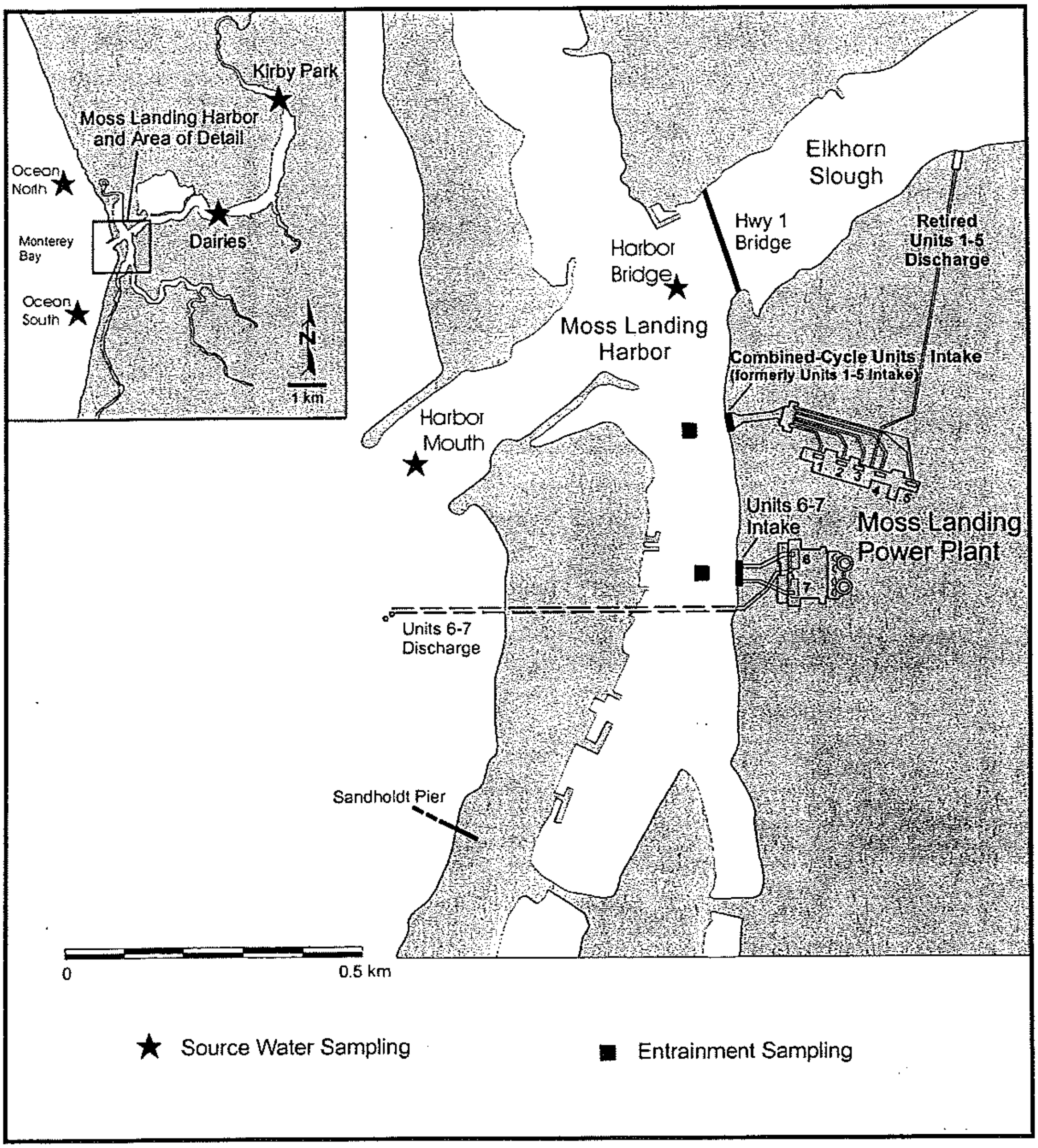
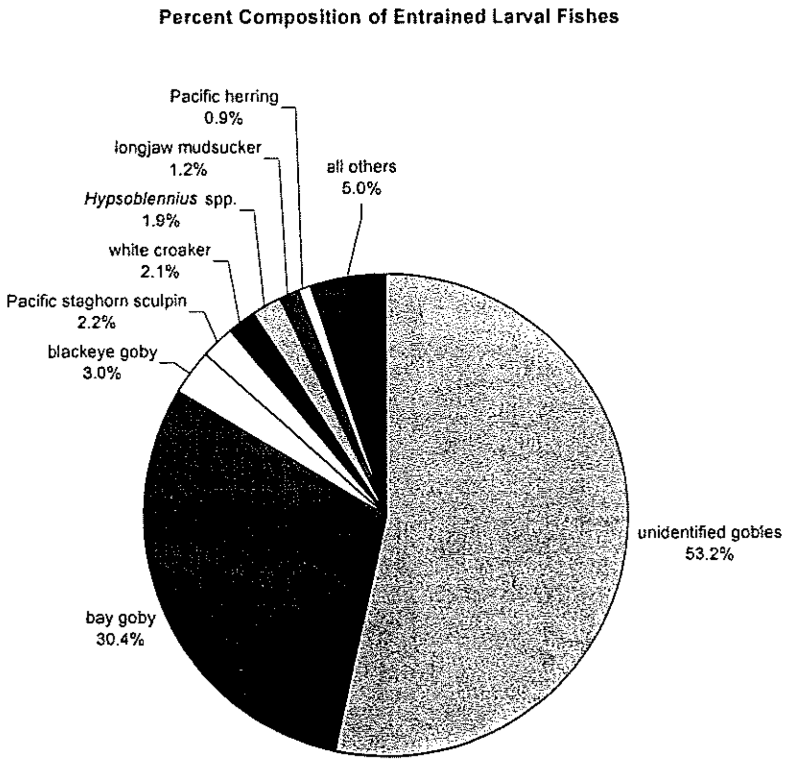


Table A-2. Collection Specifications for Source Water Sampling at MLPP.

Station Name	Description	Location (Lat. / Long.)	Station Depth at MLLW (m / ft)
Ocean North	One mile north of ML harbor mouth, at the 20-meter depth contour.	36° 48.84' N / 121° 48.40' W	20 m / 66 ft
Ocean South	One mile south of ML harbor mouth, at the 20-meter depth contour.	36° 47.44' N / 121° 48.52' W	20 m / 66 ft
Harbor Mouth	Entrance to Moss Landing Harbor from Monterey Bay; between the north and south breakwaters.	36° 48.38' N / 121° 47.40' W	7 m / 23 ft
Harbor Bridge	Moss Landing Harbor channel at Highway 1 bridge.	36° 48.292' N / 121° 47.150' W	7 m / 23 ft
Units 6&7 Intake	Moss Landing Harbor channel at MLPP Units 6&7 intake structure.	36° 48.292' N / 121° 47.130' W	5.5 m / 18 ft
Dairies	Elkhorn Slough main channel about 2.2 km (1.4 miles) inland from the Highway 1 bridge.	36° 48.74' N / 121° 45.70' W	4 m / 13 ft
Kirby Park	Elkhorn Slough main channel about 6.2 km (3.9 miles) inland from the Highway 1 bridge.	36° 50.40' N / 121° 44.75' W	3 m / 10 ft

Figure A-2: a) Percent composition of the most abundant larval fish taxa and b) *Cancer* spp. megalops collected in entrainment surveys at the Moss Landing Power Plant: March 1999 through February 2000



Assessing the effects on Entrained Species

The potential effects of the MLPP's CWIS on entrained species of larval fish and crabs was assessed using three different effects models and the data collected from the entrainment and source water studies described above. An Empirical Transport Model is used to compare the fraction of the number of a species larva entrained to the estimated number of its larvae in the source water. The resulting estimates of proportional entrainment, PE, when integrated over a species' annual cycle of abundance produces an estimate on annual mortality, PM, adjusted for the length of time that the species' larvae are at risk to entrainment based on duration of the larval stage. The model's estimate of entrainment mortality rates does not require knowledge of mortality rates for larval stages, has the statistical properties of a normal random variable, and is reasoned to be relatively insensitive to annual variations in larval abundances.

Table A-3: Fishes Entrainment Assessment Results

	Total Entrainment	*FH*	*AEL*	*ETM*(a)	*ETM*(b)
Unidentified gobies	2.7×10^8	300,006	*	0.026	0.107
Bay goby	1.5×10^8	*	1,045,588	0.039	0.214
Blackeye goby	1.7×10^7	1,825	16,636	0.043	0.075
Longjaw mudsucker	8.0×10^6	497	*	0.052	0.089
Hypsoblennius spp.	1.7×10^7	9,086	10,247	0.111	0.182
Pacific herring	4.4×10^6	235	243	0.129	0.134
White croaker	8.6×10^6	107	*	0.016	0.129
Pacific staghorn sculpin	*	*	*	0.036	0.118

	FH	Total Entrainment	Egg Survival	Yolk-sac Survival	Larvae Survival	Eggs/year
Unidentified gobies	300,006	2.7×10^8	*	*	0.68	1,750
Bay goby	*	1.5×10^8	*	*	*	*
Blackeye goby	1,825	1.7×10^7	*	*	0.74	8,062
Longjaw mudsucker	497	8.0×10^6	*	*	0.45	38,750
Hypsoblennius spp.	9,086	1.7×10^7	*	*	0.55	1,340
Pacific herring	235	4.4×10^6	0.3	*	0.22	67,000
White croaker	107	8.6×10^6	*	*	0.15	105,000
Pacific staghorn sculpin	*	1.0×10^7	*	*	*	*

A second model used is commonly referred to as an Adult Equivalent Loss (AEL) model[18]. Unlike the ETM model, AEL is sensitive to annual variation in larval abundances and requires detailed and often unavailable information on a species' mortality rates for each life stage from egg to reproductive adult. The model's purpose is to provide an estimate of the number of reproductive adults or any older life that would have resulted from some number of entrained eggs or larvae. An AEL can forecast the number of adults only when the information about the mortality of each life stage is available. However, the AEL model is useful for modeling entrainment effects and population-level impacts on well-studied species of fish, for example, striped bass. Recently the EPA in their efforts to determine the benefits of cooling system alternatives without respect to impacts have used the commercial or recreational use value of AEL entrainment losses to evaluate the benefits of reduced entrainment. The same AEL estimates can be extrapolated in a production foregone model to assess the longitudinal effect of

[18] Adult equivalent loss models evolved from impact assessments that compared power plant losses to commercial fisheries harvests and/or estimates of the abundance of adults. In the case of adult fishes impinged by intake screens, the comparison was relatively straightforward. To compare the numbers of impinged sub-adults and juveniles and entrained larval fishes to adults, it was necessary to convert all these losses to adult equivalents. Horst (1975) provided an early example of the equivalent adult model (*EAM*) to convert numbers of entrained early life stages of fishes to their hypothetical adult equivalency. Goodyear (1978) extended the method to include the extrapolation of impinged juvenile losses to equivalent adults.

AEL losses through succeeding generations of a species. However, if the input data on a species' individual life stage mortalities is deficient for an AEL model, then a production foregone extrapolation of the deficiency takes any AEL estimate further away from reality. In the MLPP 316(b) CWIS assessment (Tenera 2000) there were no species in the top ten most abundantly entrained larval where solid information on larval stage mortalities could be obtained that would enable a reliable AEL estimate. Maybe more importantly, none of these most abundantly entrained species have a reported commercial or recreational use value that would enable an evaluation of the benefits of a closed-cycle cooling alternative, for example, at MLPP in an EPA-type benefits analysis.

The Fecundity Hindcast (FH) model, the third model employed in the MLPP 316(b) assessment, estimates the number of adult females whose reproductive output has been eliminated by entrainment of larvae and crab megalops. The FH model is essentially the same as the AEL model except that rather than forecasting from the number of adults from the number of eggs and larvae, the FH hindcasts from some number of entrained larvae to the number of females required to produce them given the fecundity of females. Instead of requiring age-specific survival information from larvae to adult in the AEL model, the FH model requires estimates of larval to egg survivorship and fecundity rates.

Species-specific survivorship information (e.g., age-specific mortality) from egg, larvae, and megalop to adulthood was limited for many of the taxa considered in this MLPP 316(b) assessment. In the final stages of the MLPP assessment, members of the TWG agreed that among the three models, the ETM procedure provided the most consistent and robust estimate of entrainment effects as well as useful direct estimate of potential population level impacts.

The TWG working group also agreed to resolve the problem of expressing the entrainment effect as a single numerical value by simply averaging the PMs for the most abundant species. The MLPP assessment of entrainment effects is based on average of the eight most commonly entrained species of larval fish. The eight most commonly entrained species included species representative of Monterey Bay, Moss Landing Harbor, or Elkhorn Slough habitats. However the average varied from 0.07[19] (or 0.14[20]) for all species, 0.08 (or 0.12) for harbor and slough species, to 0.04 (or 0.12) considering only larval fish species from Elkhorn Slough. The inflated PM values for Monterey Bay species nearly doubled the average PM for Elkhorn Slough species. The MB species PM's were based on an unrealistic condition imposed on the model by the TWG that limited the volume of MB to the volume of Elkhorn Slough. This unrealistic model had the effect of nearly doubling the PM value used to assess MLPP entrainment effects on Elkhorn Slough species and consequently doubling the acres of slough habitat in the restoration settlement. It is easy to see that the average PM value used by the RWQCB overestimates the level of restoration required to mitigate the project's entrainment effects and consequently creates a high degree of conservatism in the restoration alternative.

There will be no significant population-level impacts on aquatic biological resources from the entrainment effects of MLPP Units 1&2, given the small fraction of Elkhorn Slough and harbor larvae entrained. The fact that the Moss Landing Power Plant has operated at this site for a half century with greater once-through cooling than the proposed cooling system without any

[19] ETM values calculated using source water volumes 275, 21, and 2.2 $m^3 \times 10^6$.

[20] ETM values calculated using source water volumes 21, 21, and 2.2 m3 x 10^6.

evidence of an adverse impact on marine resource populations provides qualitative evidence of the insignificance of the project's potential entrainment effects.

Appendix B

Appendix B: Technologies Reviewed in 316(b) Report

Intake Technologies	Demonstrated Proven and Available	Not Demonstrated Proven and Available
Intake Location	Offshore	
	Onshore	
Intake Configuration	Shoreline	
	Recessed	
Behavioral Barrier	Light	Velocity gradient
	Sound	Electrical barrier
	Air bubble curtain	
	Velocity cap (applicable to offshore intake location only)	Chemicals
		Magnetic field
		Chains and cables
Diversion Systems	Louvers	
	Angled Screens	
Physical Barrier		Media filter
	Centerflow screen	Porous dike
	Vertical Traveling screen	Radial Well
	Barrier net	Stationary screen
	Gunderboom	Horizontal traveling screen
		Caisson
		Drum screens
		Cylindrical, wedge-wire screens
Fish Collection, Removal, and Conveyance Systems	Modified traveling water screens	
	Gravity sluiceway	
	Fish pump	
Operational and Flow-reduction Alternatives		
Maintenance and Operational Modifications	Closed-cycle cooling	
	Cooling water pump flow reduction	
	Dredging	
	Seasonal Flow Reduction	
	Alternate biofouling control	

Appendix C

Appendix C: Methodology: Analysis of Entrainment Reducing Options

A. Introduction and Evaluation Criteria

The CCRWQCB has asked parties to identify the alternatives to once-through cooling for Units 1&2 that have the potential to reduce entrainment only. Specifically, the Notice of Hearing directs the parties to address the following five questions:

> Which of these alternatives are effective to reduce entrainment?
>
> Are there reasons that any of these alternatives may not be feasible?
>
> What are the costs of these alternatives to once-through cooling?
>
> What are the environmental benefits of each alternative?
>
> Is the cost of the alternatives wholly disproportionate to their environmental benefit?" [21]

To properly perform this assessment, it is necessary to address related questions that provide additional context. For example, when assessing feasibility, it is necessary to circumscribe its meaning within the context of the Clean Water Act legal framework:

> Is the alternative technology proven and available? Does it have demonstrated operability and reliability for a power plant cooling system having a similar size and environmental setting to that at the MLPP?
>
> Is the alternative technology feasible at MLPP site, based on site-specific conditions and considerations of engineering, operations, efficiency and reliability?
>
> Can the alternative technology be applied at MLPP in a way that is consistent with all applicable laws, ordinances, regulations and standards? Will the alternative technology cause or increase significant adverse environmental impacts relative to once-through cooling?

To perform this analysis Duke Energy built off of the existing 316(b) report for MLPP, dated April 28, 2000. Duke reviewed each of the technologies identified in the 316(b) report and updated the analysis where appropriate. Specifically, a number of technologies were identified in Table 7-1 of the original 316b report as "proven and available for consideration" as it relates to both impingement and entrainment impacts. Since the focus of this remand hearing is on alternatives to once through cooling, the first step was to cull from this list those technologies that related only to cooling systems.

This resulted in the following list of technologies for consideration here at this time as part of this remand hearing as being "demonstrated proven and available" for consideration in the goal

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[21] Notice of Public Hearing, Compliance with Remand of a Portion of the NPDES Permit re: Cooling Water Intake of New Units 1&2, Waste Discharge Requirements, Order No. 00-041 NPDES Permit No. CA0006254 Issued to Duke Energy Moss Landing, LLP. page 4

of reducing entrainment impacts at the MLPP and representing alternatives to once through cooling. This does not mean that they are feasible at MLPP specifically.

Based on the above considerations, Table C-1 lists those technologies that are subject to review in this proceeding.

Table C-1: Entrainment Reducing Technology Summary Table

Intake Technology Area	Technology
Closed Cycle Cooling	Fresh water mechanical draft cooling
	Seawater mechanical draft cooling
	Natural draft cooling (freshwater and seawater)
	Air (dry) cooling
	Hybrid cooling (wet/dry system)
	Spray Ponds

These technologies represent the scope of Duke's further assessment for this proceeding.

For each technology, a summary table has been developed that summarizes the answers to the questions discussed at the beginning of this section. The questions have been blended together in their logical place for convenience. The generic format of the table is shown in Table C-2 below. This table is meant to help summarize the key and major findings, but does not otherwise constitute the entirety of the findings for each technology.

Table C-2: Example -- Summary Table for Each Technology

Question	Answer
Is this alternative potentially effective at reducing entrainment at MLPP? To what extent?	
Is the alternative proven and available (i.e. it has demonstrated operability and reliability for a cooling system having a similar size and environmental setting to that at the MLPP?	
Are there reasons that this alternative may not be feasible? Alternatively, is the alternative feasible at MLPP site, based on site-specific conditions and considerations of engineering, operations, efficiency and reliability?	
What are the costs of this alternative relative to once-through cooling?	

Question	Answer
What are the environmental benefits of this alternative? Can the alternative be applied at MLPP in a way that is consistent with all applicable laws, ordinances, regulations and standards? Will the technology cause or increase significant adverse environmental impacts relative to once-through cooling?	
Is the cost of the alternative wholly disproportionate to the environmental benefit?	

2. Design Approach

For those technologies with the potential to reduce entrainment and represent alternatives to once through cooling, Duke then commissioned a more thorough review of the engineering, environmental and economic implications of the alternative technology than that presented in the original 316(b) report from April, 2000. This analysis takes into account numerous technology and site-specific facility considerations and characteristics, such as:

What are the facility operating needs? (e.g. for reliability, safety, output) What are the typical operating conditions of the facility?

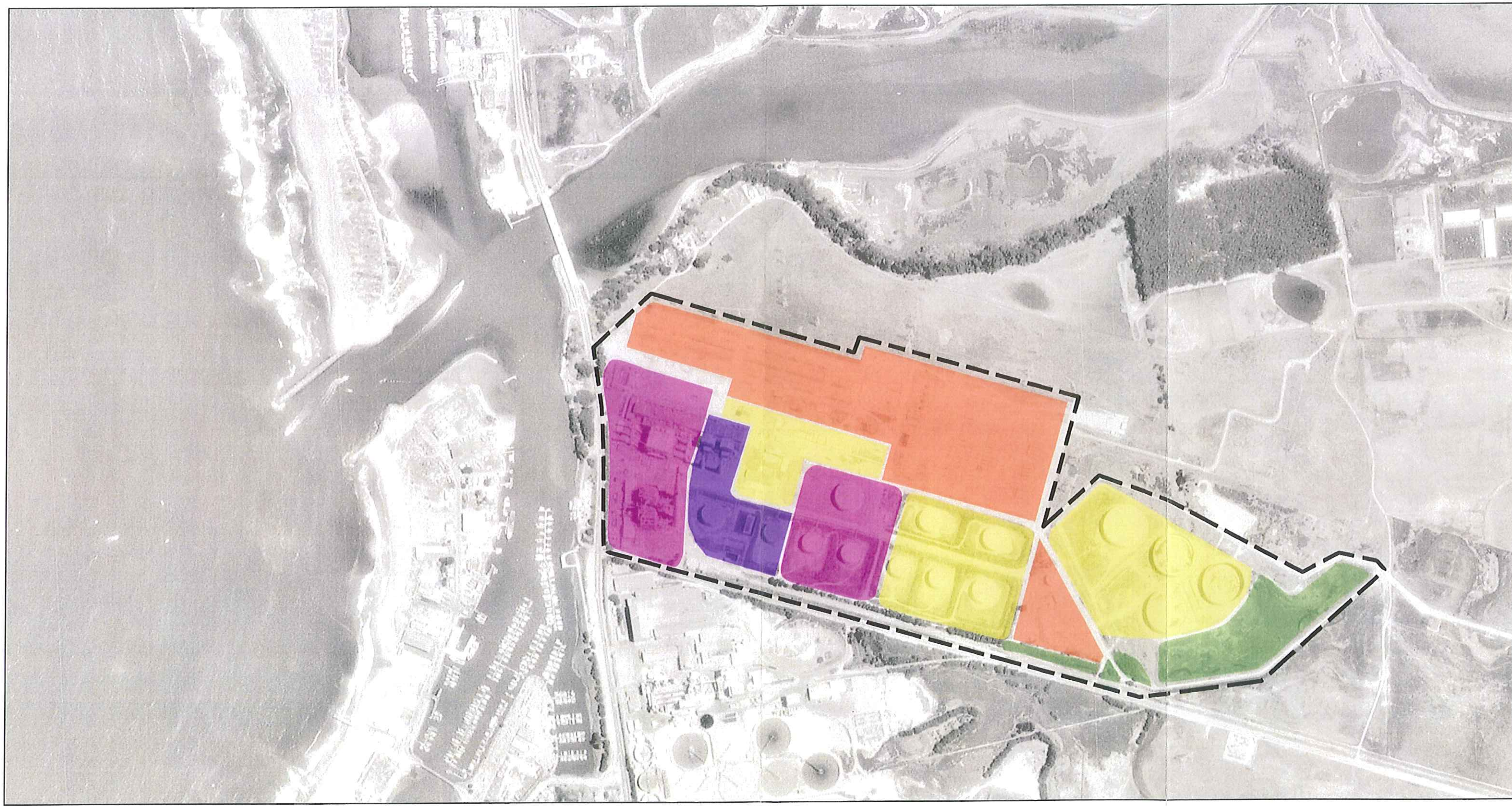
What are the engineering and construction requirements for the system? What parts of the existing system can be reused, and what needs to be abandoned? How much space is required? Where will the equipment be placed?

What obstructions are on site that will require replacement or relocation?

Can the equipment be located, built and operated in a manner that ensures long term safe and reliable operation?

Does the system need water? How much? Is water available?

For each of the closed cycle cooling options a site-specific design was determined that takes into account the facility operating requirements for steam condensing under various operating conditions. Basic equipment sizing requirements were determined based on performance calculations for the hypothetical cooling system. Construction experts with knowledge of the MLPP site evaluated various equipment location options that optimized around performance, constructability and long term maintainability (Figure C-1 shows the MLPP site constraints). When possible, locations for equipment were chosen that minimized the cost of relocating equipment and infrastructure such as overhead transmission lines. With basic sizing and location requirements defined, estimates were developed for equipment and installation costs.



Key:
- Existing Generation
- Miscellaneous Site Facilities
- PG&E Switchyard and Gas Transmission
- ESHA
- Available Land
- MLPP Industrial Site

Site Constraints
Figure C-1
EDAW
APRIL 2003

P:\2003\3s026.01\Indd\Constraints_Diagram.indd

The plant performance data was used to determine the loss in efficiency between the once through cooled system and the alternative. This loss in efficiency is expressed in terms of a heat rate, which is the amount of fuel energy required to produce a unit of electrical energy. With this information it is possible to translate the efficiency loss into a cost impact of operations. This process is discussed in more detail in Appendix E.

With the basic high-level engineering determined, it was then possible to address the environmental constraints. At times this inquiry was reiterative. For example, knowledge was needed about the noise compliance standards and this influenced the engineering design. If the design could not meet noise requirements than further engineering analysis was performed.

The approach to each of the principal environmental areas is discussed. It should be noted here, however, that it was not possible to perform an extensive analysis in all issue areas. Rather, the areas of land use, visual resources, air quality resources, and noise were selected as the most obvious candidates for review, analysis and site optimization considerations. This does not mean that there may not be additional constraints and impacts in other issue areas such as hazardous materials handling, waste management, public health risk exposure, transmission safety, reliability, cultural resources, traffic and transportation, or other areas. It was simply not possible to analyze all issue areas and judgment had to be used to hone in on those areas that would most likely be most problematic.

When environmental constraints presented themselves, we determined if they could in fact be cost-effectively mitigated. If so, these costs are then incorporated into the economic analysis. In some instances, the environmental constraints present themselves as fatal flaws, with no known way to mitigate.

With the design basis, engineering layout and requirements and environmental constraints defined, it was then possible to develop the economic analysis for each option. Questions posed included:

> How much will the system cost both upfront and on an on-going basis?
>
> Is the system less efficient than the once-through system? How much additional fuel will be consumed because of the system? What is the likely cost of this fuel?

The details of the economic evaluation are presented in Appendix E.

To accomplish this evaluation Duke engaged a team of consultants and experts in the areas of expertise shown in Table C-4 to address these questions. Resumes are attached in Appendix N for these experts.

Table C-3: Assessment Areas and Representatives

Area	Duke's Available Expert Witness
Power plant design	Alan MacKenzie, DFD
Power plant design	Christopher Stacklin, DFD
Power plant design	John Ruud, DFD
Power plant construction	Russell Poquette, DFD
Power plant operations	Randy Hickock, Duke Energy
Power plant financial analysis	Randy Hickock, Duke Energy
Air Cooling and Hybrid Cooling System Vendor	Frank Ortega, GEA
Power Plant Noise Analysis & Impacts	Bob Mantey, Industrial Noise
Power Plant Visual Analysis & Impacts	Paul Curfman, EDAW
Land Use Analysis & Impacts	Kirk Marckwald, CEA
Power Plant Air Quality Analysis & Impacts	Gary Rubenstein, Sierra Research
Marine Biology Analysis & Impacts	Dave Mayer, Tenera

3. Environmental Analysis

Introduction

For each of the alternative technologies to once-through cooling that were potentially applicable to MLPP, Duke evaluated the potential environmental impacts of the alternative. As mentioned earlier, due to time constraints, it was necessary to hone in on the most obvious environmental constraints and concerns for the alternatives and identify potential fatal flaws that would render the application of the technology infeasible at MLPP. This, however, does not mean that there are not other environmental issues that may present themselves with these technologies that are not identified in this testimony and may add substantial mitigation costs. Areas that were not analyzed at this time include: terrestrial biology, soils, geology hazards and resources, cultural resources, hazardous materials handling, waste management, socioeconomic, agricultural resources, paleontologic resources, traffic and transportation, transmission system impacts, or worker safety. The areas that received an extensive review and for which fatal flaws present themselves include: land use, water resources, visual resources, and air quality.[22]

Noise

Level one screening of every area

The scope of the noise analysis is a review of only those technologies with a potential to generate adverse noise impacts. Specifically, a review was performed of the closed cycle cooling options. All of the cooling system alternatives would be in lieu of the existing sea water intake, underground, and outfall facilities and would be an addition to the AFC-certified plant design.

[22] The issue of noise compliance represented a potential fatal flaw, but after the analysis presented in this testimony concluded that the alternatives could be deployed and meet the required noise standards.

As such, the options would add noise sources and aggregate plant noise emissions, when compared to the plant design as is currently operating. These potential additional noise impacts were investigated to determine a first-order assessment of the changes due to alternative cooling. The manufacturer provided noise level information which was used to assess the additional plant emissions.[23] This noise information was engineering data only and is not fully qualified, nor contractually guaranteed by the vendor. As such, there is some potential for error in using these values, but they were deemed adequate for this first-order evaluation.

The first-order noise evaluation involved an incremental analysis of these added cooling systems. That is, the projected noise levels from these systems were added to the noise environment of the existing power plant to determine if an incremental change would result. The basis of comparison was the measured environment of the running facility (both original and expanded plants) that was shown to be in full compliance with the CEC Conditions of Certification concerning noise. This noise compliance was demonstrated in August 2002.[24]

The expected layout plans that located the new cooling equipment on the site[25] and fundamental noise propagation principles were used to calculate the incremental contributions from the additional noise sources at the pertinent CEC receptor locations. These incremental contributions were compared to the measured noise levels to assess the impacts from adding cooling systems to the current plant configurations.

Level Two analysis of specific areas

For alternatives in this testimony, the Level One analyses, discussed in more depth in subsequent sections, showed an indiscernible change to the compliant noise environment around the MLPP. The incremental addition of alternative cooling systems did not exceed noise requirements. Since the Level One analysis is considered to be quite conservative and since no problems were found, a Level Two analysis was deemed to be unnecessary.

Methodology

As outlined above, the noise impact analysis methodology relied on an incremental assessment of the added contributions from new cooling system equipment at the MLPP site. As the first step in this process, the currently-envisioned layout plans for each alternative were reviewed with respect to how the potential placements might affect the revised total noise environment at the pertinent receptor locations. The manufacturer-supplied noise levels[26] for their standard-design equipment were projected out from the power plant to the nearest pertinent receptor

[23] The vendor contacted for these analyses was GEA Power Cooling Systems, Inc.

[24] Noise compliance was demonstrated in the report entitled "New Moss Landing Power Plant, Community Noise Verification Survey Report" dated August 2002 by Alliance Acoustical Consultants, Inc.

[25] See Figures D-3, D-7, and D-11 in Appendix D.

[26] Noise levels for large equipment items such as air-cooled condensers or cooling towers are usually specified in terms of both near-field values and far-field values. The near-field specification values are typically valuable for assessing employee exposures in the working areas adjacent to the equipment. The far-field specification values, being at a distance that is beyond close-in reflection, phasing, and reactivity effects, are valuable for assessing impacts to community or off-site receptors. These far-field noise values, typically specified at a standard distance of 400 feet from the source, were used for this community noise impact evaluation.

locations; in this case Receptors 1 and 5 which are northwest and southwest of the power block, respectively. The noise level projection for the Level One analysis involved taking the manufacture-specified overall noise level and applying a conservative propagation calculation to quantify the noise level reduction with increasing distance (away from the source).

This conservative approach used standard spherical spreading loss to calculate the decreasing noise levels. For noise sources that are effectively point sources – as is the case for propagation distances over several hundred feet – the spherical spreading loss amounts to a reduction factor of 6 dB for every doubling of distance. Thus, the noise level at 800 feet from a given source would be projected to be 6 dB less than the noise level from the same source at 400 feet away. This is a conservative analysis because it only accounts for the fundamental energy spreading attenuation, while neglecting other attenuation factors such as air absorption, ground effects, barrier attenuation, etc. that would additionally reduce the noise energy as it traveled away from the source.

These conservatively calculated contributions from the added cooling system sources were then compared to the measured noise levels around the MLPP facility. If the cooling sources were near or below the lowest measured MLPP levels, it was concluded that the incremental equipment would not discernibly add to the compliant noise environment. This conclusion is based on the August 2002 results that the new power plant (Units 1&2) was not audible and, thus, did not significantly contribute to the measured noise levels at any of the CEC assessment locations due to the noise from both the original plant (Units 6&7) as well as the significant traffic noise from both Pacific Coast Highway and Dolan Road.[27]

If this assessment showed an insignificant incremental contribution from prospective cooling system sources (which was the case for all the studied configurations), then additional analyses were not conducted and noise control treatments were not considered.

Air Quality

The assessment of air quality impacts associated with the alternative cooling options was based on a common set of assumptions and methodologies. These included the following:

> A screening analysis was performed to determine whether the cooling tower structures would influence air quality impacts associated with the Moss Landing Boilers (Units 6&7) and the combined cycle plant (Units 1&2). This screening analysis indicated that none of the cooling alternatives would influence air quality impacts from Units 6&7. Consequently, all subsequent analyses looked only at air quality impacts due to the cooling alternatives themselves, and their influence on the combined cycle units.
>
> Direct particulate emissions from the wet cooling alternatives were calculated based on the concentration of dissolved solids expected to be present in the cooling water, the cooling water circulation rate, and the efficiency of the mist eliminator. Wet cooling alternatives result in no direct emissions other than particulate matter emissions. All

[27] See discussion in "New Moss Landing Power Plant, Community Noise Verification Survey Report" dated August 2002 by Alliance Acoustical Consultants, Inc.

particulate matter emissions were assumed to be fine particulate (PM_{10}), consistent with typical analyses for these types of emission sources.

For the wet cooling alternatives that use sea water, the concentration of dissolved solids in the sea water was assumed to be approximately 35,000 parts per million by weight (ppmw). The sea water is assumed to be subject to two cycles of concentration in the cooling tower, resulting in a basin concentration of total dissolved solids (TDS) of 70,000 ppmw.

For the wet cooling alternatives that use fresh water, the concentration of TDS in the incoming fresh water was determined to be 500 ppmw based on recent well water analyses. The fresh water is assumed to be subject to four cycles of concentration in the cooling tower, resulting in a basin TDS concentration of 2,000 ppmw.

All of the wet cooling tower alternatives are assumed to be equipped with mist eliminators designed to achieve current requirements for best available control technology. As a result, all of the wet cooling tower alternatives are assumed to have drift eliminators designed to achieve a drift rate of not more than 0.0005%.

The dry cooling alternatives have no direct air emissions.

The air quality analysis for each cooling alternative includes four elements:

Specification of technical assumptions

Calculation of direct emissions

Analysis of direct air quality impacts

Estimate of indirect air quality impacts

Each of these elements is discussed further below.

Specification of technical assumptions

For each of the cooling alternatives, there is a brief discussion of the key technical assumptions associated with the air quality impact analysis. This includes key dimensions for the structures associated with the cooling alternative; technical assumptions necessary to calculate emission rates for the cooling alternative; and stack parameters, if any, for the cooling alternative.

Calculation of direct emissions

Direct emissions were calculated for each cooling alternative based on the technical assumptions for that alternative. As noted above, the only direct emissions associated with the cooling tower alternatives are PM_{10} emissions associated with the drift of water droplets escaping the wet cooling towers. There are no direct emissions associated with the dry cooling alternatives.

Analysis of direct air quality impacts

There are two aspects of direct air quality impacts that were assessed for each alternative. First, the increase in emissions was evaluated and compared with applicable requirements of the

Monterey Bay Unified Air Pollution Control District (Monterey air district). The only applicable requirement identified that would apply to any of the cooling alternatives is the requirement to provide emission reduction credits (also referred to as emission offsets). The quantity of offsets required is calculated and compared with the current inventory of credits available for sale within the Monterey air district, and an assessment is made of the potential for acquiring sufficient offsets for the cooling alternative. In addition, the cost of obtaining those offsets is estimated based on the most recent market information published by the California Air Resources Board for the Monterey air district. If the quantity of emission offsets required for a cooling alternative exceeds the quantity of offsets available within the Monterey air district, the alternative is found to be infeasible.

The second aspect of direct air quality impacts that was assessed is the effect of the cooling alternative on ambient air quality. These impacts were assessed using air quality dispersion models approved by the Monterey air district and USEPA. The same models, meteorological data, and modeling assumptions used in the preparation of the Application for Certification for the Moss Landing Power Plant project were used in this assessment of cooling alternatives. As noted above, none of the cooling alternatives is expected to result in an increase in air quality impacts associated with operation of Units 6&7; as a result, the dispersion modeling analysis is limited to the combined cycle units (Units 1&2) and the cooling alternatives.

Air quality impacts for each cooling alternative were evaluated using the EPA guideline model ISCST3 (version 02035). Meteorological data were collected at the Moss Landing site in 1997 by PG&E. Details of the models and modeling assumptions are contained in the Application for Certification filed with the California Energy Commission.

The air quality impacts for each cooling alternative are compared with the impacts previously estimated for the combined cycle units using the once-through sea water cooling system, and are compared with applicable regulatory criteria; in addition, these impacts are combined with background concentrations (the same as those used in the AFC analysis) and compared with applicable ambient air quality standards.

Two sets of air quality regulatory criteria were used to evaluate the significance of the air quality impacts of the cooling alternatives. The first are the air quality significance levels established by regulation under the federal Prevention of Significant Deterioration (PSD) program. Impacts from the combined cycle units, in conjunction with the cooling alternative, which result in concentrations in excess of the PSD significance levels will be determined to have the potential to cause significant air quality impacts. However, these impacts can be mitigated through the use of best available control technology and, as long as the impacts do not exceed the applicable PSD increments, no significant air quality impacts will be found.

The second set of criteria is the state and federal ambient air quality standards. If the impacts from the combined cycle units, in conjunction with the cooling alternative, would create a new violation of a state or federal ambient air quality standard, the cooling alternative will be found to have the potential to cause a significant air quality impact. Such an alternative would not be approved by the Monterey air district and/or USEPA and, as a result, will be found to be infeasible.

Estimate of Indirect Air Quality Impacts

In addition to the calculation and modeling of direct air quality impacts from each cooling alternative, indirect air quality impacts will be estimated as well. For each cooling alternative, the indirect impacts are associated with the reduction in plant efficiency (and corresponding reduction in output of the combined cycle units. The combined cycle units are among the cleanest power generation units in the world; thus, a conservative (low) estimate of the increased emissions associated with the loss of capacity from the combined cycle units can be calculated based on the loss in capacity and emission rates of the Moss Landing combined cycle units. It is not possible to predict with any certainty where the lost capacity will be made up; hence, it is similarly difficult to predict the location where the increased emissions associated with making up that lost capacity will occur. However, it is a certainty that the lost capacity will be made up at some location, and that the increase in emissions at that location will be at least as great as the emissions estimated herein.

Visible Water Vapor Plumes

The wet cooling alternatives have the potential to generate visible water vapor plumes under certain operating conditions. In numerous licensing proceedings, the California Energy Commission has evaluated the potential for visible water vapor plumes to create a significant environmental impact. There are no regulatory bases for predicting the frequency of visible water vapor plumes, nor are there any regulatory bases for determining the significance of those impacts. Both the methodology and significance thresholds applied by the California Energy Commission remain the subject of great dispute. Techniques comparable to those used by applicants in CEC licensing proceedings are used in this analysis to evaluate the frequency with which the wet cooling alternatives may result in visible water vapor plumes, and the average and expected worst-case dimensions for those plumes.

Land Use

Each alternative-cooling scenario was evaluated for potential land use impacts by analyzing federal, state, and local laws, ordinances, regulations, and standards (LORS). The LORS reviewed included:

Federal Clean Water Act

California Coastal Act

Monterey County General Plan

Monterey County North County Area Plan

Monterey County Coastal Implementation Plan, Part 1

Monterey County Coastal Implementation Plan, Part 2

Monterey County Coastal Land Use Plan

In summary, installing any of the alternative cooling systems at the MLPP site will conflict with multiple LORS. Appendix G provides the exact text of the policies that conflict with the alternative cooling technologies and reasons why the conflict occurs. Table C-4 below summarizes the Land Use findings.

Table C-4: Summary of LORS Impacts for Alternative Cooling Options at MLPP

Conflict	Mechanical Draft (seawater)	Mechanical Draft (fresh water)	Natural Draft System	Hybrid Cooling System	Dry Cooling System
Non Coastal Dependent Use		Yes			Yes
Height Restrictions	TBD	TBD	Yes	TBD	TBD
Visual Impacts	Yes	Yes	Yes	Yes	
Water Conservation		Yes			
Violation of CWA Best Technology Available Standard	Yes	Yes	Yes	Yes	Yes

All of the alternatives violate the Best Technology Available Standard in the Clean Water Act. This issue is discussed in main testimony, as well as Appendix D and E.

Visual Resources

The visual analysis reviewed the impacts of four alternative cooling options for MLPP. The options evaluated include: Mechanical Draft Cooling Systems (both Sea and Fresh Water), Dry Cooling System using Air Cooled Condensers, and Natural Draft Cooling Tower[28]. The methodology used in each of these evaluations relies on information about the size and placement of each cooling alternative provided by the engineering team. Plume size and frequency is incorporated from the air quality modeling evaluation. Photo realistic visual simulations, which show each cooling option from selected nearby Key Observation Points (KOPs), form the basis of this visual evaluation and are incorporated into Appendix F. Each simulation is evaluated according to several key issues to determine visual significance. The key issues analyzed and discussed under each alternative cooling option include:

1. Equipment size in relation to existing infrastructure
2. Plume size and frequency
3. Representation by photo simulations from KOP
4. What is visible from each KOP and the visual character of the viewshed

[28] The visual simulations for the seawater mechanical draft and the fresh water mechanical draft are identical, and as such only 3 options are in fact simulated.

5. Duration and number of viewers affected
6. Cumulative impacts.

Significance of visual impacts is analyzed based on CEQA guidelines. For all cooling options, the only relevant CEQA significance criterion is an evaluation of "Substantial degradation of the existing visual character or quality of the site and its surroundings." To evaluate the potential for degradation of visual character at Moss Landing, four key issues are addressed in the analysis of the Key Observation Points as described below;

1. Quality of the existing view (High, Moderate or Low)
2. Degree of industrial change imposed on the view (High, Moderate or Low)
3. Number of viewers and their duration of view (High, Moderate or Low for both)
4. Size and frequency of plume visibility (Large and frequent versus small and infrequent)

Selection of Key Observation Points (KOPs)

Three KOPs used in this visual analysis correspond to those used in the Application for Certification (AFC) for Units 1&2. All eleven KOPs in the AFC were selected because of their public accessibility and because they were commonly experienced views. Figure C-2 shows the locations of all original KOPs used in the AFC visual analysis. The determination of visual significance in the AFC was based on the collective evaluation of all eleven KOPs. The subset of KOPs selected for this evaluation, KOPs 6, 8, and 9 are the closest to the project site, represent the views from three different directions, and best show the potential visual implications of the alternatives. Visual analysis was not performed on the remaining KOPs, but there is a high degree of probability that the plumes from several alternatives will be visible and create impacts at these other locations, as well. The photo simulation from Dolan Road, identified as KOP 12, is new to this analysis and is introduced to show the Dry Cooling alternative, which was not visible from the other KOPs. The locations of the selected KOPs are illustrated on Figure C-3. These include:

KOP 6 - NW View from Intersection of Sandholdt Road and Highway 1

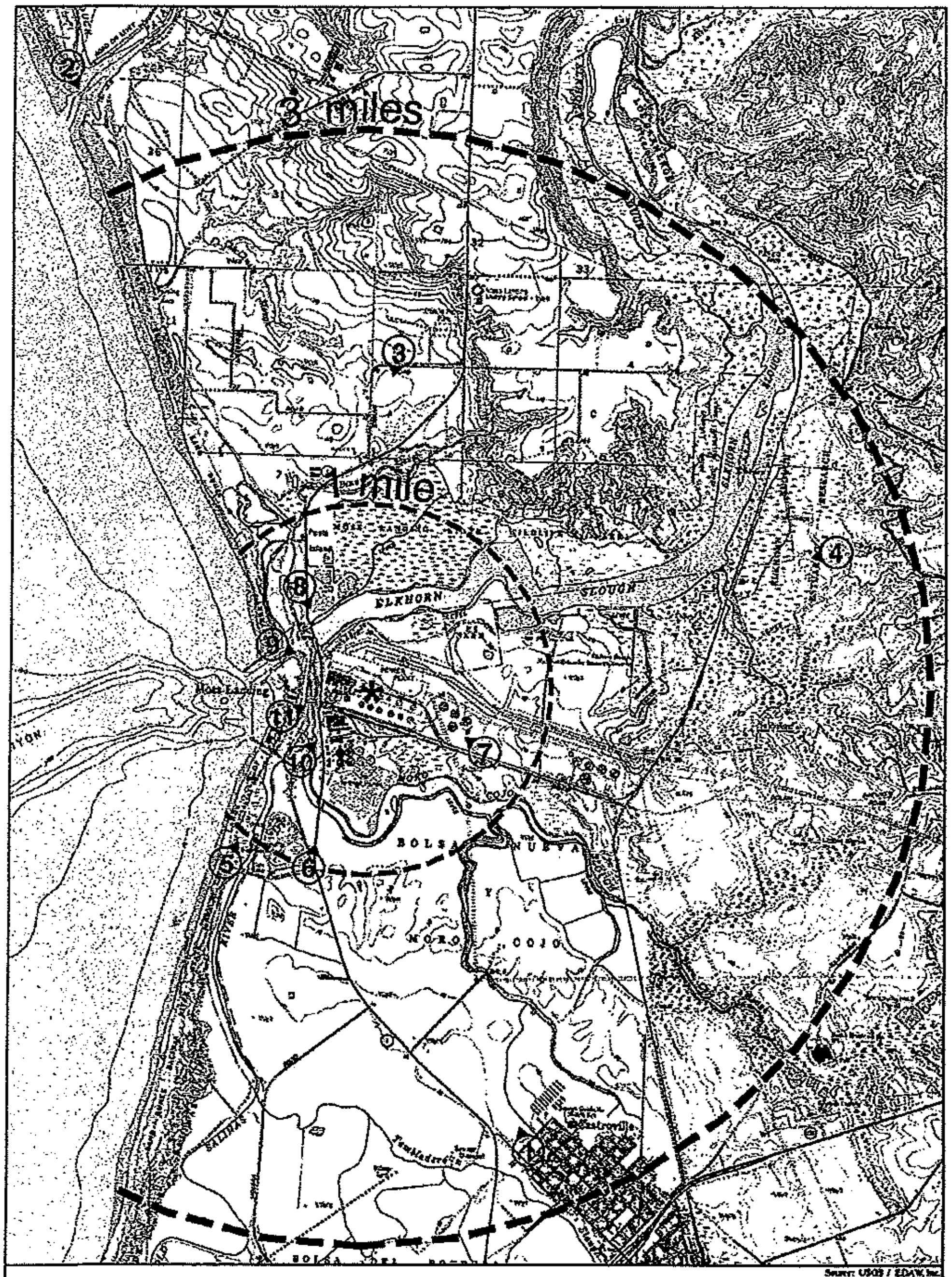
KOP 8 - SSE View from Highway 1 Bridge over Elkhorn Slough

KOP 9 - SE View from Moss Landing State Beach at Elkhorn Slough

KOP 12 - NW View from Dolan Road at MLPP Entrance Gate

The full size (11x17) simulations of each proposed alternative cooling option are located in Appendix F and are in order by KOP for easy comparison of the alternatives from any one view point. The Existing Conditions visual simulations are Figures VIS B, VIS E, VIS H, and VIS K.

Figure C-2: Eleven KOP Locations from the MLPP AFC

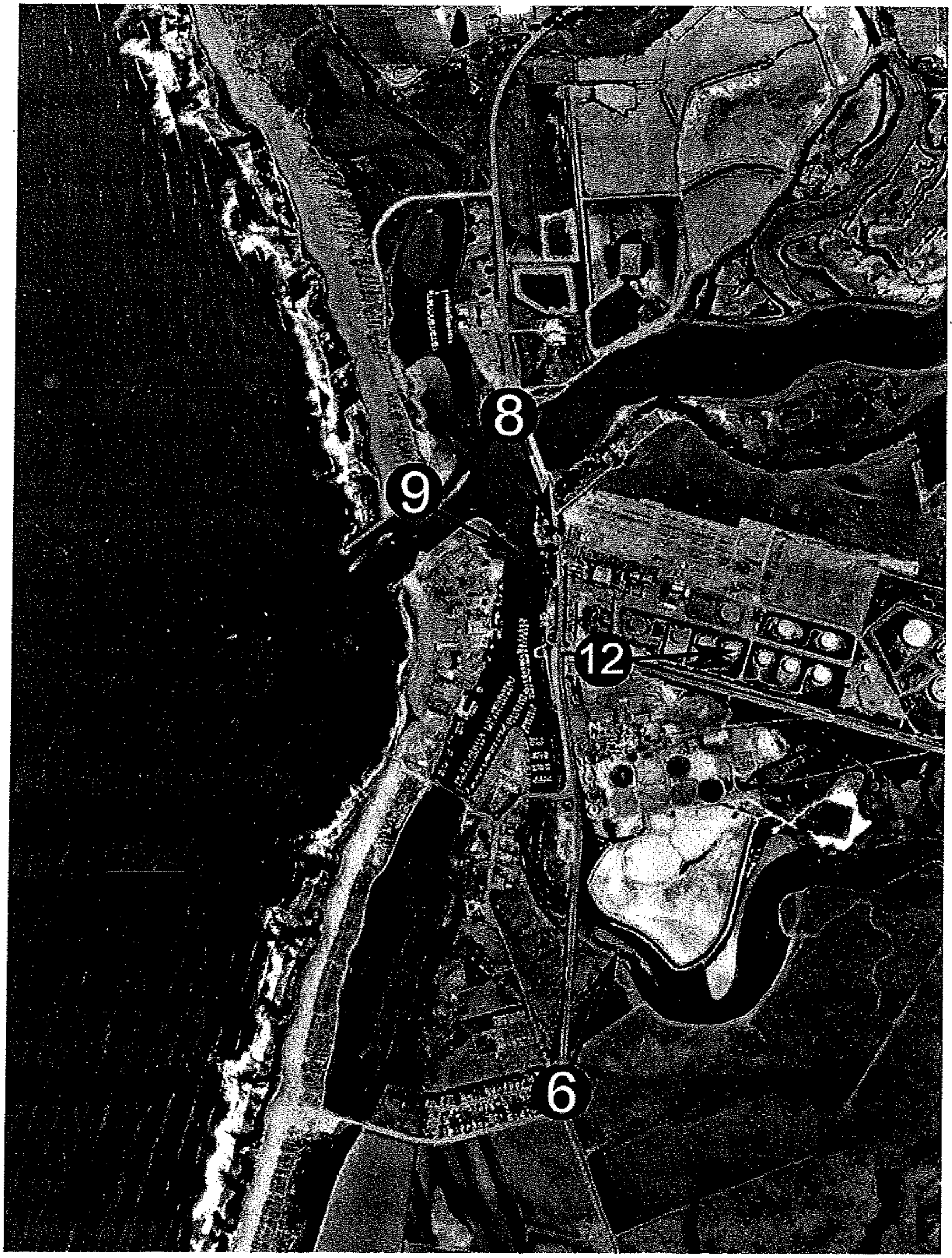


Key Observation Point Locations

Duke Energy

Moss Landing, L.L.C.

Figure C-3: Alternative Cooling KOP Locations



Visual Considerations in Existing Conditions

MLPP is located on Highway 1, a designated California Scenic Highway. As part of Duke Energy's AFC for Units 1&2, eight stacks were removed from the MLPP facility to improve visual conditions along the Scenic Highway Corridor. Currently, only Units 6&7 as well as the administration building are directly adjacent to the Highway, and while they are visually dominant elements in that portion of the viewshed, they also act to screen from the Highway view much of the eastern portion of the site. To the east of these buildings is the new Units 1&2 the switchyard and the transmission lines. The closest place to view this equipment is from Dolan Road, although it is also visible from a moderate distance from Highway one to the south.

The layout of Units 1&2 utilized a visually compact configuration, with one unit mirroring the other, building up to the four stacks in the center. This was the first time such a configuration had been used by Duke and it was developed primarily to reduce visual impacts. Another visual benefit of the introduction of Units 1&2 onto the Project site was the removal of the previously existing fuel-oil tank farm, which consisted of several 40+ foot high by 200 foot wide circular storage tanks that were highly visually detrimental.

The most prominent features currently existing in KOP 6, the view looking Northwest from the intersection of Sandholdt Road and Highway 1, are the two 500 foot high stacks associated with Units 6&7. The four shorter 145 foot stacks of Units 1&2 appear above the horizon, yet are not a major visual element. This view from the south is experienced by approximately 24,500 vehicles per day traveling northbound along Highway 1. The main qualities of this view are the rural coastal environment from scenic Highway 1 approaches the Salinas River crossing. The view is compromised by the dominance of the MLPP Units 6&7 stacks. Overall this view is of moderate quality.

From KOP 8, when looking south on Highway 1 towards the MLPP site the two 500' stacks associated with Units 6&7 are the most visually prominent features. KOP 8 was taken where the Highway crosses the Elkhorn Slough Bridge, approximately 4,000 feet away from MLPP. The dense vegetation on the east of Highway 1 blocks many of the potential views of the eastern portion of the site and serves to screen equipment from Highway 1. Similar to KOP 6, there are approximately 24,500 vehicles per day traveling the route. The main qualities of this view, like KOP 6, are the rural coastal environment as scenic Highway 1 approaches the Elkhorn Slough crossing. This view, is also compromised by the dominance of the MLPP Units 6&7 stacks. Overall this view is of moderate quality.

KOP 9, the view looking southeast from Moss Landing State Beach, shows the Project site from a distance of approximately 3,500 feet. Like most views towards MLPP, the two 500' stacks associated with Units 6&7 are the most prominent visual features in the viewshed. The water and vegetation surrounding the Moss Landing Harbor softens the foreground view. The dense vegetation along the western border of the Project site effectively screens most of the existing infrastructure on the eastern portion of the site. Because of the water, the vegetation and the harbor, this view is of better quality than those from KOPs 6 and 8. However Units 6&7 still dominate the image, therefore the overall visual quality of KOP 9 is of moderate to high quality.

Sizes of the Alternative Cooling Equipment

The dimensions of the three proposed alternative cooling options are presented in Table C-5. Subsequent, Figures D-4, D-8, and 12, located in each respective alternative discussion to follow, show the proposed elevations of each alternative cooling option in relation to the existing infrastructure on the Project site.

Table C-5: Dimensions of Cooling Equipment

Dimensions (per tower)

Cooling Alternatives	No. Req'd	Length (ft)	Width (ft)	Elev of Top (ft a.g.)	Stack Diameter	Stack Outlet Elev (ft a.g.)	No. of Stacks
Dry Cooling System (ACC)	2	230	220	102			(5 bays/ 5 fans ea)
Mechanical Draft Cooling System (Sea & Fresh Water)	2	462	42	46	26	46	11
Natural Draft Cooling System	1	255 dia (base)	150 dia (mid)	450	170 dia (top)	450	1

[a]ACC denotes air cooled condenser (dry cooling)

Source: DFD, April 2003.

Appendix D

Appendix D: Review of Entrainment Reducing Options

Mechanical Draft Cooling System Using Sea Water
Mechanical Draft Cooling System Using Fresh Water
Natural Draft Cooling System
Dry Cooling System
Hybrid Wet/ Dry Cooling System
Spray Ponds

Mechanical Draft Cooling System Using Sea Water

General Description

This closed-cycle cooling water alternative would replace the existing once-through seawater cooling water system with a recirculating cooling water system and mechanical draft cooling towers. The reduced make-up water needs of the system would come from seawater most likely drawn from the existing intake structure for Units 1&2, although the required quantity of seawater is less than 5 percent of the needs for the once-through system. Mechanical draft cooling systems are quite prevalent throughout the world. Systems using seawater are less common that those utilizing freshwater, but they share common engineering design considerations.

Figures D-1 and D-2 present a schematic flow sketch and photographs, respectively, of mechanical draft cooling tower systems. With this system, warm water from the steam turbine condensers and other cooling water uses in the plant would flow to the mechanical draft cooling towers consisting of air-to-water contact surfaces (known as "tower fill") and electric motor-driven fans. The recirculating water to be cooled falls from the top through the tower where it contacts a high airflow drawn through the tower by the fans. Cooling occurs primarily through partial evaporation of the falling water (similar to the operation of a "swamp" cooler) and contact cooling of the water by the cooler air. Cooled water collects in large basins beneath the towers where water circulation pumps return the water to the condensers and other equipment to repeat the cycle.

Recirculating water is lost from the process principally in two ways: through evaporation from the towers and "blowdown" (purge) streams. The blowdown stream is removed to prevent the buildup of dissolved solids in the recirculating water, since solids do not evaporate in the tower. A third minor loss consists of liquid water droplets (drift) entrained with the air and water vapor leaving the top of the cooling tower. The evaporation, blowdown, and drift losses must be replenished by adding replacement ("makeup") water to the system.

Design and Sizing

The cooling tower size and operating parameters are primarily set by the following two plant-specific criteria:

> The desired cooling water temperatures at the inlet and outlet of the steam condenser, which determine the cooling water flow rate and significantly affect the steam turbine generator efficiency.[29]
>
> The relative humidity, and therefore the water vapor holding capacity, of the atmosphere at the plant site on the warmest day that the desired heat rejection

[29] Cooler steam condensing temperatures increase generation efficiency by increasing the energy recoverable in the steam turbine, which results in more power produced for the same fuel use. For a fixed power demand, increased efficiency translates to reduced fuel consumption and less air pollution on a system-wide basis.

capacity is required, typically expressed as wet bulb temperature.[30] The temperature of the cooled water in the tower cannot be less than the wet bulb temperature of the air plus a certain margin.

With these conditions established, the cooling tower size is then determined by the cooling water circulation rate and the air flow through the tower required to remove the heat added by the steam condenser.

Moss Landing Design Considerations

The sea water mechanical draft cooling tower evaluation at Moss Landing for Units 1&2 selected a cooling water flow rate and temperature rise across the condensers to approximately match these values for the existing once-through cooling system. These assumptions allowed the existing steam turbine surface condensers to be reused. The design ambient conditions of air temperature and relative humidity were selected using the one percent exceedance values for the plant vicinity as published by the American Society of Heating, Refrigeration, and Air-conditioning Engineers. The cooled water temperature was specified at 12 °F above the design ambient wet bulb temperature of 63 °F.

Using this basis, the seawater mechanical draft cooling towers for the MLPP combined cycle units would consist of two structures, one for each steam turbine unit, each about 462 feet x 42 feet x 46 feet high. Figure D-3 presents a conceptual plot plan location for the MLPP utilizing seawater mechanical draft cooling towers sized for the existing combined-cycle units. Ocean water makeup for this system would be supplied from the existing Units 1&2 once-through cooling intake structure. Due to the continuous evaporation in the tower, the circulating water and blowdown stream would contain salinity (dissolved solids) approximately twice as great as local seawater. The estimated combined full capacity flow rates for both towers are:

Table D-1: Seawater Mechanical Draft System Flow Rates

Parameter	Flow Rate
Recirculating Water	238,000 gpm
Blowdown (returned to ocean)	3,800 gpm
Makeup (withdrawn from ocean)	7,600 gpm

[30] The wet bulb temperature of the air is measure of the evaporative cooling capacity of air at a given temperature and humidity. It is always less than (or equal to) the actual ("dry bulb") temperature of the air at the same conditions.

Figure D-1: Mechanical Draft Schematic Flow Sketch

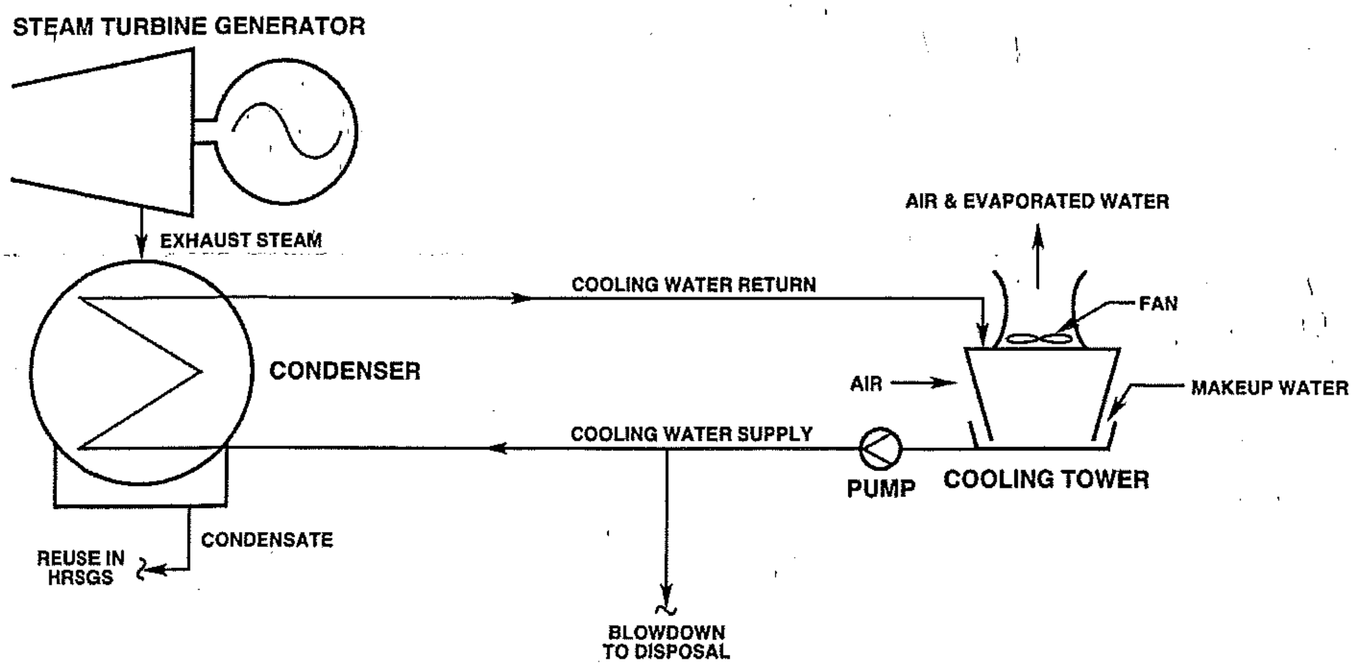
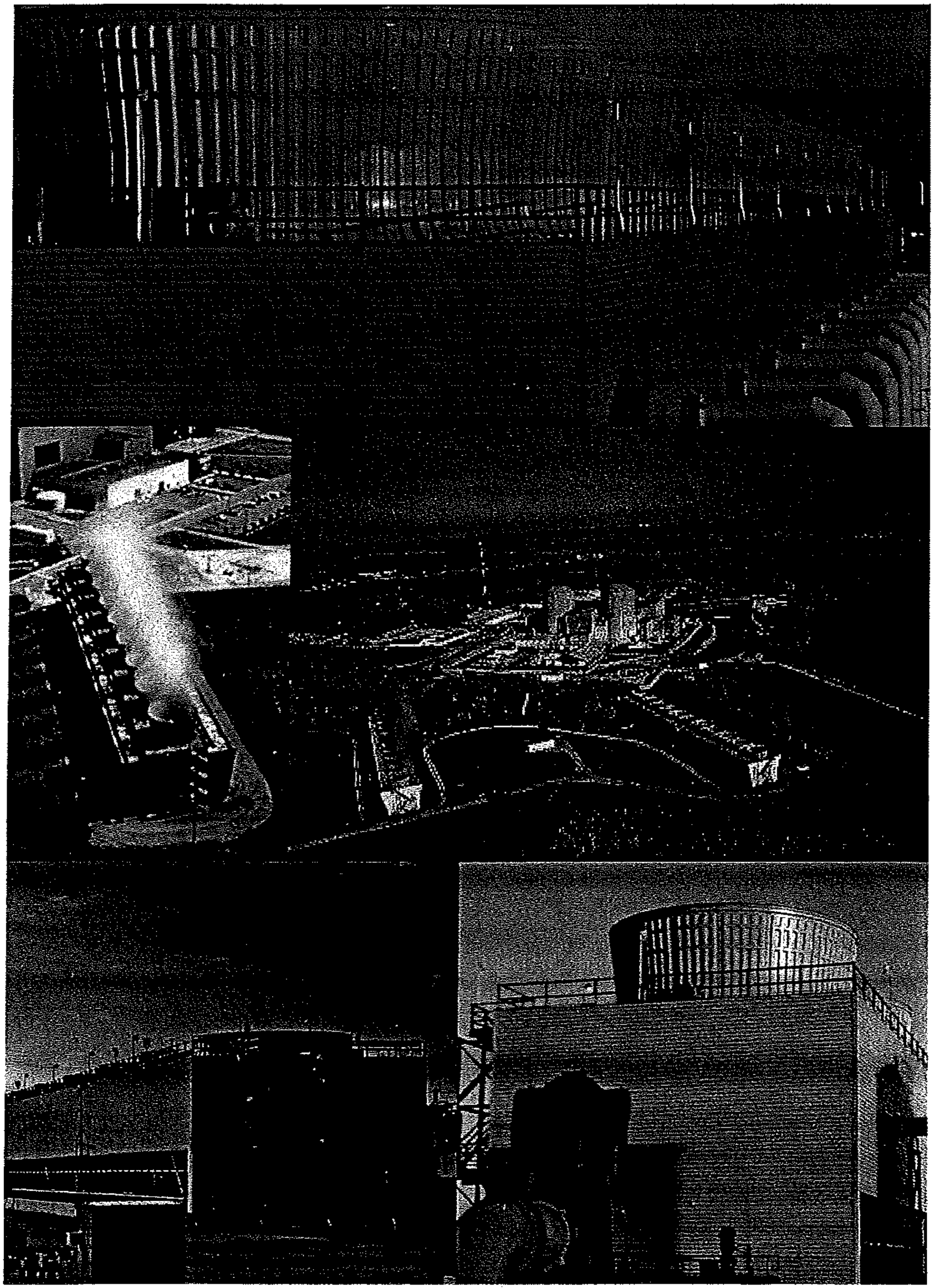


Figure D-2: Mechanical Draft Photograph



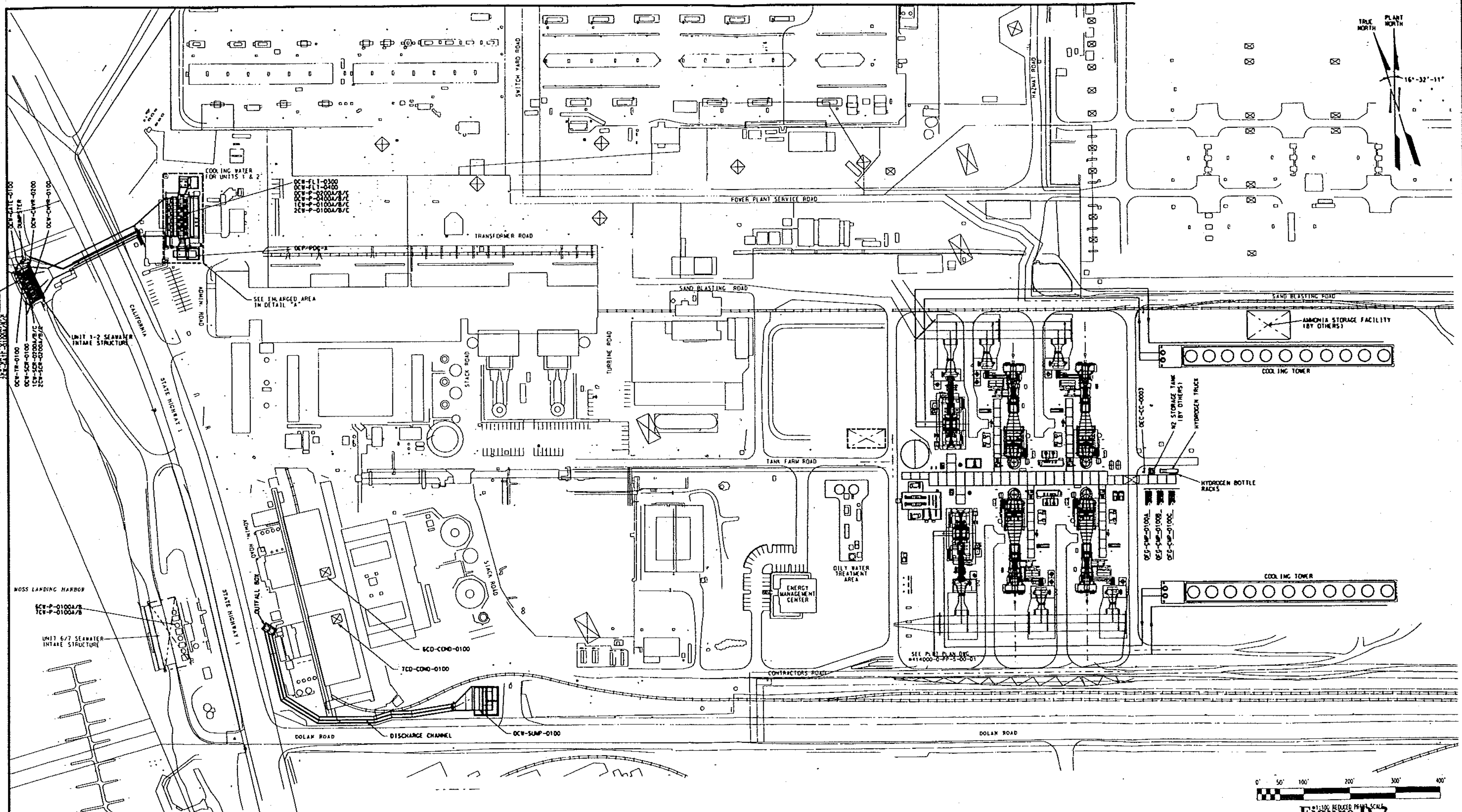


Figure D-3

REV.	DATE	REVISION DESCRIPTION	DRWN / CHK.	LAYO / MECH	CIVIL / ELEC	ENGM / PROJ
1	10/17/00	APPROVED FOR CONSTRUCTION	RK / HS	MB		
2	04/18/01	APPROVED FOR CONSTRUCTION	WA / HB	MB		

DWG NO.	REFERENCE DRAWINGS
414000-0-PP-5-00-01	PLOT PLAN, POWER GENERATION UNITS 1 & 2
414000-0-PP-5-00-03	OVERALL PLOT PLAN, POWER PLANT-EAST

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ENGINEERING MANAGER	A. MACKENZIE	A.M. 10/24/00
PROJECT DIRECTOR	C. MERCHIERS	C.M. 10/24/00

DUKE ENERGY NORTH AMERICA, LLC
MOSS LANDING POWER PLANT PROJECT
MOSS LANDING, CA

OVERALL PLOT PLAN
POWER PLANT - WEST
SEA WATER COOLING TOWER

SCALE	CONTRACT NUMBER	UNIT No	DOC TYPE	DISC	SUBJECT CODE	SEQ No	REV.
1"=100'	414000	0	PP	5	003	2	2

Plot User Plot Date & Time
$$$$date$time$$$$ MANUAL CHANGES MADE - YES ☐ NO☐ DWG. FILE UPDATED - YES ☐ NO☐ MODEL UPDATED - YES ☐ NO☐

DIST. CODE 051 WRK. PKG. A CADD FILE No. PP03.DGN CONTRACT PKG.
SOGNSPECS
DFD_D.DGN 10-2-98

Cooling Tower Location and Supporting Facilities

The most advantageous location for the new cooling towers is the presently unused area to the east of, and immediately adjacent to, existing Units 1&2 (see Figure D-3). This location was chosen to place the cooling towers downwind of the main equipment areas. This downwind location avoids potential damage from concentrated sea water drift droplets from the cooling tower plumes, while still minimizing the length of the large diameter cooling water pipelines between the existing condensers and the new towers.[31] Another significant reason is that this area is vacant and existing equipment does not need to be relocated.

An 84-inch diameter, underground cooling water supply line would be installed between each cooling tower and the existing condenser it serves, routed along the northern and southern boundaries of Units 1&2. Additionally, new 84-inch underground lines will return the heated cooling water from both condensers to the towers, following the same routing as the supply lines. The existing once–through cooling water pumps at the Units 1&2 sea water intake structure will be replaced with much smaller pumps to provide makeup sea water to both towers. A new connection line from the existing once-through cooling water supply line to each cooling tower will convey the makeup flow to the towers. Cooling tower blowdown will be discharged through a new connection from the condenser return line to the existing once-through cooling water discharge line, which eventually combines with the once-through cooling water discharge from Units 6&7. The remainder of the existing once-through cooling water system would be abandoned in place (in accordance with applicable regulations and after being secured for long term safety considerations).

Use of Existing Facilities

Retrofit of mechanical seawater cooling tower for Units 1&2 would mean that the existing once-through cooling system could be partially reused to convey cooling tower makeup and blowdown to and from the new towers as described above (i.e., continued use of the intake structure, intake pipes and discharge pipe). However, this reuse represents only a minor (a few percent) utilization of the installed capacity. (The seawater use requirement for the cooling tower is estimated at 7600 gpm, vs. 250,000 gpm for the once through system, representing about 97 percent reduction in seawater use with a corresponding reduction in entrainment levels.)

The existing surface condensers for each steam turbine would continue to be used. However, the once-through cooling water pumps currently installed at the new cooling water intake structure would be removed from service. The substantial electrical load represented by the large motors serving these pumps would be replaced by the electric fan motors and new circulating pumps in the new the new cooling tower. This change will require significant relocation of internal electric power distribution within the plant.

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[31] The length of piping between the steam turbines and the condensers is an important design consideration that affects overall plant cooling efficiency. However this is less of a factor, relatively speaking, with mechanical draft cooling systems than with dry cooling systems. For dry cooling systems, as will be discussed later, it is impractical to locate the condensers on the east side of the powerblocks due to efficiency and cost considerations. It is also impractical to relocate the steam turbines.

Plant Performance

Mechanical draft cooling towers would significantly diminish the net power output and operating efficiency of the recently installed combined cycle plant. There are several effects of the reduced efficiency of a mechanical draft cooling tower system when compared to the once-through system.

The plant's internal electrical load is greater for the mechanical cooling tower alternative than for the once-through cooling system because the cooling tower circulation pumps plus the cooling tower fans require more power than the existing once-through cooling pumps. The plant performance computations supporting this analysis take these electrical loads into account and these electrical loads are factored into the resulting net electrical capacity value and the heat rate value.

The combination of the higher steam turbine condenser temperatures caused by the recirculating cooling system (the STGs can not recover as much energy as with the once-through system) and the higher plant electrical load compared to the once-through cooling water case would decrease the net power output available from the new combined cycle units by approximately 20 MW (at annual average ambient conditions). Units 1&2 can currently generate about 1048 MW at annual average site conditions, but with a mechanical draft system this capacity is reduced to 1028 MW. This power output loss would be even greater at higher ambient temperatures. This reduction in capacity will have to be made up by other, potentially less efficient and more polluting power sources located elsewhere.

The overall thermal efficiency of the new combined cycle plant would be decreased by about two percent as compared to the existing once-through system. This means that more fuel would be needed to produce the same net amount of electricity. With the recent increase in natural gas prices, this will have an adverse affect on the cost of electrical power to the California consumer.

To understand the cost penalty associated with this option it is important to note that not only is there less electrical generating capacity at any given time, but this capacity also operates at a lower thermal efficiency in terms of utilization of fuel. This is illustrated by the heat rate,[32] measured in terms of the fuel energy consumed in Btu's for each unit of electrical energy produced in kW-hrs. Power generation at this lower capacity (i.e., 1028 MW) occurs at an increased heat rate, meaning the plant would consume more fuel per unit of electricity generated as compared to the present once-though cooled system. The once-through system burns fuel at a heat rate of about 6790 Btu/kW-hr, whereas the mechanical draft system would consume fuel at a heat rate of about 6930 Btu/kW-hr.

For purposes of this analysis, however Duke conservatively considers only a portion of the cost elements discussed here: the additional cost per unit of production to run the facility at the lower capacity. The cost of the reduced plant capacity in not considered in the economic analysis.

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[32] Heat rate is a measure of efficiency, expressed using either the higher heating value (HHV) or a lower heating value (LHV) of the fuel, and measured in terms of fuel Btu's consumed per kW-hr of electricity generated. The difference between HHV and LHV has to do with the water content of the fuel combustion products. Throughout this analysis, Duke expresses the efficiency considerations in terms of HHV.

Environmental Features

The following environmental protection features are incorporated into the conceptual design of the mechanical draft seawater cooling tower:

The maximum practical salinity was chosen for the circulating cooling water stream to minimize seawater withdrawal and discharge of blowdown back to the ocean in order to minimize marine biological effects.

The tower will incorporate modern, high efficiency drift eliminators to minimize the emission of entrained water droplets in the cooling tower exhaust air and thereby reduce PM_{10} emissions which form from the solids dissolved in the water when the droplets evaporate in the atmosphere. The drift eliminators have an efficiency of 0.0005% and are assumed to represent Best Available Control Technology for PM_{10} emissions. No other air quality environmental protection measures are available for this alternative.

At the proposed location, the tower would be effectively shielded by existing structures or landscaping as much as possible and practical to minimize visual impacts from key observation points. Nonetheless, as discussed in the visual resource section, visible plumes result on a near constant round-the-clock basis.

Manufacturer information indicated that each bank would be predicted (on an engineering estimate basis) to produce 65 dBA at 400 feet from the tower. The large cooling water circulation pumps associated with each tower, assuming no noise control or special design, would be expected to produce no more than 62 dBA at 400 feet.[33]

Cost Analysis

Table D-2 shows the capital cost components for sweater mechanical draft system. Costs are shown for both the Cases under consideration –the April 2000 case and the Real World Today Case. These cases are explained in more detail in Appendix E. Capital costs for each were estimated by using preliminary design information, by soliciting input from vendors, and by utilizing engineering judgment that includes experience designing and building similar systems elsewhere. Relevant costs to include are: all equipment, installation and erection costs, site preparation, and interference and relocation costs. If applicable, one-time environmental costs are also included.

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[33] This noise value for circulating water pumps is based on both vendor-supplied information and near-field field measurements of actual installations on numerous similar power generation projects. The information and data were projected outward to calculate an estimated far-field emissions value. This estimate is for standard-equipment and it could be fairly easily reduced by at least 5 to 8 dB with a prudent noise control design and/or implementation of noise control treatments. If more mitigation was needed, additional noise reduction could be applied to these pumps with a localized barrier wall system to shield noise in the directions of pertinent receptors.

Table D-2: Capital Costs for Seawater Mechanical Draft Cooling System ($ millions)

	Seawater Mechanical Draft – April 2000 Case	Seawater Mechanical Draft – Real World Today Case
Site Preparation	3.7	3.7
Cooling System Equipment Package	22.5	22.3
Installation	13.8	13.8
Demolition / Relocations	n/a	6.8
Transmission Line Relocation	n/a	n/a
Mitigation Costs	7.0	7.0
Total Capital Costs	47.0	53.6

Mitigation costs for systems using saltwater include the cost of particulate offsets. This is explained in greater detail in Appendix E.

Environmental Analysis

Noise

The noise evaluation used the conceptual layout for this alternative, coupled with manufacture-supplied noise predictions. At the distances to the nearest pertinent CEC receptor locations, approximately 1,500 to 1,600 feet to Receptor 5 (to the southwest) and approximately 2,300 to 2,500 feet to Receptor 1 (to the northwest), the predicted noise levels (assuming only spherical spreading loss for propagation attenuation) attributed to the Mechanical Draft Cooling System were 55 dBA at Receptor 1 and 58 dBA at Receptor 5. The measured ranges of 10-minute L_{eq} at these locations were 53 to 64 dBA (Location 1) and 71 to 79 dBA (Location 5).[34] Again, it should be noted that at both these locations nearest to the MLPP Units 1&2, contributions from Units 1&2 were not audible or measurable.

Since the incremental contribution from the Mechanical Draft Cooling Water system was near the lower end of the range of measured noise at Location 1 and more than 10 dB below the lowest measured values at Location 5, Duke concluded that this cooling alternative would not produce a discernible difference to the compliant conditions at these two nearest receptor locations. The other CEC assessment locations were not evaluated since they are two to five times more distant and any potential incremental cooling system noise contributions would be even less consequential, compared to the current conditions. It should be noted, however, that noise levels at other locations around the MLPP site that are adjacent to the new cooling systems,

[34] The L_{eq} noise metric is known as the energy average sound level. It is the value of a steady sound which, in the stated time period, has the same A-weighted sound energy as the (original) time-varying sound.

primarily just to the south of the plant along Dolan Road, may increase discernibly. However, to the south of the MLPP is another heavy-industrial land use, a mineral processing facility, that is not considered a sensitive receptor. These facts, coupled with the significant influence of traffic noise sources along Dolan Road, indicate that there would not be significant impacts along the MLPP property boundary that is adjacent to the prospective cooling system.

Since all potential noise impacts from the Sea Water Cooling Tower system are deemed to be insignificant, no noise mitigation is called for and no noise-related additional costs would be involved in the implementation of this cooling alternative.

Air quality

Technical assumptions

The mechanical draft cooling system using sea water is assumed to have the following characteristics:

Table D-3
Cooling Tower Design Parameters
Sea Water Mechanical Draft Cooling System

Parameter	Value
Number of towers	2
Number of cells per tower	11
Overall length, per tower (feet)	462
Overall width, per tower (feet)	42
Elevation at top of tower (feet above grade)	46
Elevation at fan deck (feet above grade)	36
Exhaust stack diameter (feet)	26
Circulating water flow rate (gal/min)	119,000
Circulating water flow rate (lbs/hr)	59,000,000
Drift rate (%)	0.0005%
Drift rate (lbs water/hr)	300
Makeup water TDS level (ppmw)	35,000
Cycles of concentration	2
Basin TDS level (ppmw)	70,000
PM_{10} Emissions	
Grams/second (per cell)	0.24
Pounds/hour (per tower)	21.0
Tons/year (total, all towers)	184
Exhaust gas flow rate (per cell; acfm)	982,000
Exhaust gas temperature (°F)	89°F

Direct emissions

Based on the above assumptions, the sea water mechanical draft cooling system will have direct PM_{10} emissions of approximately 184 tons/year. By way of comparison, the maximum allowable direct PM_{10} emissions from the combined cycle power plant are 151 tons/year (total for all four turbines). Thus, the use of the sea water mechanical draft cooling alternative would more than double the PM_{10} emissions associated with the combined cycle units.

Direct air quality impacts

Table D-4 shows the current permit limits for the combined cycle units, and the increase in emissions (above those limits) associated with the sea water mechanical draft cooling system.

Table D-4
Current Emission Limits and Changes
Sea Water Mechanical Draft Cooling System (tons/year)

	VOC	CO	NOx	SOx	PM_{10}
Current Emission Limits	348	7,191	659	55	508
Increase due to Sea water Mechanical Draft Cooling System	0.0	0.0	0.0	0.0	184
Revised Emission Limits Required	348	7,191	659	55	692
BACT required?	No	No	No	No	Yes
Offsets required?	No	No	No	No	Yes
Note: Emission limits apply to the combined emissions from all power generation equipment at the Moss Landing facility, including Units 6&7 and the combined cycle units. Emissions are limited on a calendar quarter basis, but are shown here in units of tons/year for purposes of simplification.					

As shown in Table D-4, the addition of a sea water mechanical draft cooling system will trigger requirements for best available control technology (BACT) and emission offsets. The use of drift eliminators with an efficiency of 0.0005%, already incorporated into the cooling system design, is expected to satisfy the BACT requirements. Emission offsets in the amount of 184 tons/year of PM_{10} would be required to satisfy Monterey air district requirements.

Table D-5 shows all of the PM_{10} emission reduction credits held within the Monterey air district at this time.[35] Not all of these credits are available for sale; based on Duke's experience in seeking offsets for the combined cycle units in 1999 and 2000, it is Duke's understanding that most of these credits are being held for future use by their current owners. However, even if all of these credits were available for sale, the quantity of PM_{10} credits would not be sufficient to satisfy the regulatory requirements. Only if the Monterey air district approved the use of SOx and NOx credits to offset the PM_{10} impacts from the cooling tower and credits not generally available for sale were to come onto the market would there be sufficient emission reduction credits available for this cooling alternative. Even in such a case, the sea water mechanical draft cooling alternative would consume approximately 20% to 40% of the total quantity of PM_{10} precursor offsets available within the entire Monterey air district.

The California Air Resources Board's Emission Reduction Credits Offsets Transaction Cost Summary Report for 2002 (http://www.arb.ca.gov/erco/erco.htm) indicates an average cost of

[35] Credits for PM_{10} precursors, including SOx and NOx emissions, are shown as well, under the assumption that these could be used, at a 1.0:1 ratio, to satisfy MBUAPCD offset requirements.

$19,690 per ton for PM_{10} credits in 2002 in the Monterey air district. Although this cost was based on a single transaction, the average cost per ton for PM_{10} credits in the Monterey air district in 2001 was comparable, at $18,580 per ton. To estimate the cost of obtaining the necessary emission reduction credits for the sea water mechanical draft cooling alternative, an assumed cost of $19,000 per ton was used. At this price, the cost of obtaining the required PM_{10} emission reduction credits would be between $4.2 million and $7.0 million, depending on the location of the credit source.

Due to the large quantity of offsets required, the question as to whether there are sufficient offsets for sale, and the large fraction of the Monterey air district's offset market that would be impacted, this option is believed to be infeasible.

Table D-5
Current Inventory of PM_{10} Precursor Emission Reduction Credits
Monterey Bay Unified APCD (tons/year)

ERC Holder	NOx	SOx	PM_{10}	Total
U.S. Army	1.5	2.0	0.3	3.8
Texaco USA	56.6	144.6	58.0	259.2
Tri Valley	3.8	0.1	0.3	4.2
Stone Container	1.9	0.0	0.0	1.9
AERA Energy	289.7	208.6	120.9	619.2
National Refractories	53.3	0.3	0.2	53.8
Salz Leathers	0.6	0.0	0.2	0.8
Totals	**407.4**	**355.6**	**179.9**	**942.9**
ERCs Required[1]			**221 – 368**	

Note:

1. The quantity of ERCs required reflect the application of Monterey air district offset ratios of 1.2:1 to 2.0:1, depending on the location of the ERC source.

The air quality impacts of the sea water mechanical draft cooling system were assessed using the same dispersion models as were used in the application for certification for the combined cycle units. The results of the dispersion modeling analysis are shown in Tables D-6, D-7, and D-8, and AQ-A6. These tables present the original and revised modeling results and compare them with the applicable federal PSD significance thresholds, preconstruction monitoring *de minimis* levels, and ambient air quality standards, respectively.

Table D-6
Maximum Modeled Impacts and Federal PSD Significance Thresholds
Moss Landing Power Plant Combined Cycle Units With Sea Water Mechanical Draft Cooling

POLLUTANT	AVERAGING TIME	MAXIMUM MODELED IMPACTS (µg/m³)		FEDERAL PSD SIGNIFICANCE THRESHOLD (µg/m³)	SIGNIFICANT UNDER FEDERAL PSD?	
		Original	Revised		Original	Revised
NO_2	Annual	0.4	0.4	1	No	No
PM_{10}	24-Hour	5.9	8.2	5	Yes	Yes
	Annual	0.2	0.7	1	No	No

Table D-7
Comparison of Modeled Concentrations
with Federal PSD Preconstruction Monitoring Thresholds Moss Landing Power Plant Combined Cycle Units with Sea Water Mechanical Draft Cooling

POLLUTANT	AVERAGING TIME	EXEMPTION CONCENTRATION (µg/m³)	MAXIMUM MODELED CONCENTRATION (µg/m³)	
			Original	Revised
NOx	annual	14	0.4	0.4
SO_2	24 hours	13	0.7	0.7
CO	8 hours	575	296.1	296.1
PM_{10}	24 hours	10	5.9	8.2

Table D-8
Modeled Maximum Project Impacts
Moss Landing Power Plant Combined Cycle Units with Sea Water Mechanical Draft Cooling

POLLUTANT	AVERAGING TIME	MAXIMUM PROJECT IMPACT ($\mu g/m^3$)		BACKGROUND CONCENTRATIONS ($\mu g/m^3$)	TOTAL IMPACT ($\mu g/m^3$)		MOST STRINGENT STANDARD ($\mu g/m^3$)
		Original	Revised		Original	Revised	
NO_2	1-hour	148.2	148.2	113	261	261	470
	Annual	0.4	0.4	21	21.4	21.4	100
SO_2	1-hour	7.1	7.1	156	163	163	650
	24-hour	0.7	0.7	39	40	40	109
	Annual	0	0	0	0	0	80
CO	1-hour	2,228	2,228	6,900	9,128	9,128	23,000
	8-hour	296	296	3,222	3,518	3,518	10,000
PM_{10}	24-hour	5.9	8.2	59	65	67	50
	Annual	0.2	0.7	20.8	21.0	21.5	20

The modeling analysis indicates that 24-hour average and annual PM_{10} concentrations will increase as a result of the sea water mechanical draft cooling tower. However, these increases would not change the conclusions regarding the air quality impacts of the project and would not cause any new violations of state or federal ambient air quality standards.

Indirect air quality impacts

As discussed above, the sea water mechanical draft cooling alternative will reduce the plant's output by 20 MW at average ambient conditions. This will result in the need to generate additional power from other power generation sources. Since the Moss Landing combined cycle units are among the cleanest generating units in the country, it is unlikely that the replacement energy will be provided by a lower emitting source. Consequently, the emissions increase associated with this replacement power are conservatively estimated based on the pounds of emissions per megawatt hour (lbs/MWh) produced by the Moss Landing combined cycle units. This increase in emissions is shown in Table D-9.

Table D-9
Indirect Emission Increases
Sea Water Mechanical Draft Cooling System

	VOC	CO	NOx	SOx	PM_{10}
Maximum Annual Emissions from Moss Landing Combined Cycle Units (tons/year)	89.4	1,326.4	284.5	21.8	151.2
Lbs/MWh emission rate[1]	0.020	0.301	0.065	0.005	0.034
Indirect emission increases[2] (tons/year)	1.7	25.3	5.5	0.4	2.9

Notes:

1. Calculated based on 8,400 hours per year of full load operation at 1048 MW, consistent with the assumptions used for maximum annual emissions.
2. Calculated based on 168,000 MWh of energy lost due to parasitic and/or efficiency losses associated with the sea water mechanical draft cooling system. There is a small difference between this amount of lost energy and that shown in Appendix I. This small difference has no material effect on the calculation.

Visible water vapor plumes

The sea water mechanical draft cooling system will result in the formation of visible plumes under certain meteorological conditions. Using models that have been developed for the purpose of analyzing the frequency and dimensions of visible water vapor plumes in proceedings of the California Energy Commission, the proposed sea water mechanical draft cooling system was analyzed. The results of this analysis are presented in Tables D-10 and D-11.

Table D-10
Visible Plume Frequency
Sea Water Mechanical Draft Cooling System

	Sea Water Mechanical Draft Cooling Tower		
	1997 Moss Landing Meteorological Data		
	All Hours	Daylight Hours	Night Hours
	Frequencies for all plumes		
Number of hours when plume is visible	8347	4117	4230
Hours in period	8760	4380	4380
Percent of hours in period when plume is visible	95%	94%	97%
Percent of all hours when plume is visible	95%	47%	48%

Table D-11
Visible Plume Dimensions
Sea Water Mechanical Draft Cooling System

	Sea Water Mechanical Draft Cooling Tower 1997 Moss Landing Meteorological Data					
	All Hours		Daylight Hours		Night Hours	
	Maximum	Average	Maximum	Average	Maximum	Average
	Dimensions for all plumes					
Plume Height (ft)	1960	185	1960	**163**	963	206
Plume Diameter (ft)	1531	119	1531	**111**	1112	127
Plume Length (ft)	16096	312	8841	**189**	16096	432
	Dimensions for plumes of 90th percentile height					
Plume Height (ft)		303		**209**		
Plume Diameter (ft)		184		**126**		
Plume Length (ft)		510		**161**		

The data indicate that a visible water vapor plume will be present from the sea water mechanical draft cooling system nearly all the hours of the year. The implications of these plumes with respect to visual resources are presented below.

Visual

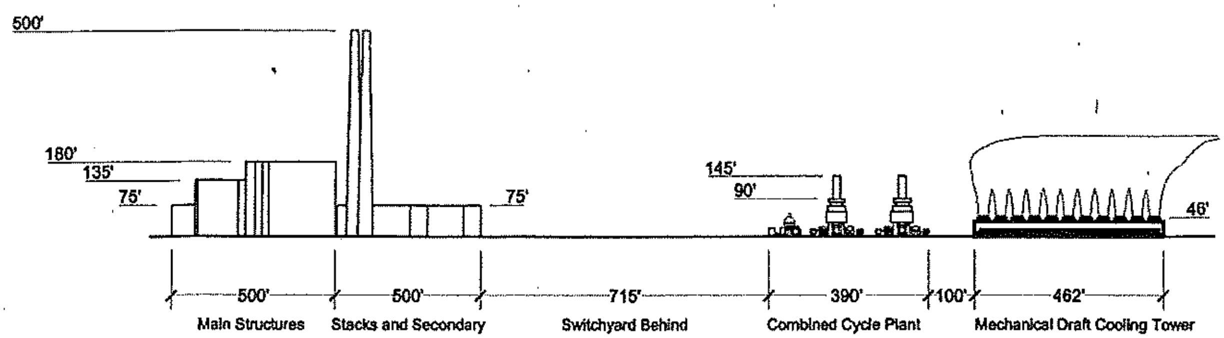
Both the Sea and Fresh Water Mechanical Draft Cooling Systems are addressed as one option in this analysis since they both have similar negative visual impacts. The built features associated with both options are identical, and the visual plume emitted from the stacks only varies by a couple of feet in height, width, and length. The mechanical draft cooling equipment consists of two buildings, each 462 feet long, 46 feet high and 42 feet wide. Each building contains eleven fans. Both are located to the east of Units 1&2, parallel to Dolan Road. (For a site plan see Figure D-3.) The closest unit would be directly visible from Dolan Road at a distance of about 1,000 feet.

The most effective method of protecting the visual environment for this cooling option is the planting of vegetative screening and utilization of appropriate paint colors to make the equipment blend in with the surroundings, consistent with local LORS.

Equipment size in relation to existing infrastructure

Figure D-4 shows an elevation of the Mechanical Draft Cooling System in relation to existing infrastructure on the Project site. The addition of the cooling equipment, seen on the right of the drawing, extends the area occupied by industrial equipment by approximately 20 percent.

Figure D-4:
Elevation looking North of Mechanical Draft Cooling System and Existing Facilities



Existing Facilities with Mechanical Draft Cooling Tower
Elevation - View Looking North

Source: DFD/EDAW, Inc. April 2003

Plume Size and Frequency

The size of the water vapor plume that is expected during average conditions was presented in the air quality analysis in Table D-11 above. For the Mechanical Draft Cooling System alternatives, each of the 22 fans would emit a 163 foot high by 189 foot long water vapor plume. Since the equipment is in two bays of eleven fans each, there would appear to be two plumes, one from each bay. The average size of the two overall plumes would actually be ten times the individual plume diameter plus the length of the eleventh plume. Based on this calculation each of the two average plumes emitted from the Mechanical Draft Cooling Systems would still be 163 feet high but the length would extended to 1,299 feet. The average plume is shown in the simulations in Appendix F. For the 90th percentile plume the length would be 1,421 feet by 209 feet high.

The average frequency that the described plumes would be visible is 94% of daytime hours and 97 percent of nighttime hours and 95 percent overall. For more information about the plume frequency calculations see Table D-10 in the air quality section.

KOP discussion

<u>KOP 6 - NW View from Intersection of Sandholdt Road and Highway 1</u>

KOP 6, with the Mechanical Draft Cooling System is illustrated by VIS Figure C in Appendix F. The distance from KOP 6 to the Project site is 4,900 feet. Looking north, the Mechanical Draft Cooling System infrastructure is just visible on the horizon. These long, rectangular structures are 46 feet tall, 462 feet long, and 42 feet wide. Some of the built structure would be screened by existing tree vegetation along Dolan Road. The alternative cooling structure does not attract visual attention from this perspective, or change the quality or character of the viewshed since it stays generally within the horizon line. It does however expand the industrial character of the landscape farther to the east (to the right in the photo) by about 20 percent. The average water vapor plumes emitted from each of the two sets of 11 stacks are nearly 1,300 feet long, nearly as long as the plumes from Units 6&7, yet they are low in profile. These new plumes appear large in the viewshed, are very noticeable, and therefore have an adverse visual effect. They are not, however, a new element in the viewshed given the existing 500 foot tall stacks and associated occasional plumes.

Number of viewers & duration of view

The expected viewers from this location include residential, recreational and mobile viewers. According to the AFC and 1990 census data, approximately 176 people live within the census block area of 78 acres in which the KOP is located. These people could have a constant duration view of the Project site from this general direction. There are 200 recreational visitors to the Salinas River State Beach, which would have an extended duration view of the Project site (typically a couple of hours). Traveling on Highway 1, approximately 24,500 vehicles per day would have a moderate duration view, lasting approximately one minute, of the Project site due to the orientation of the road.

KOP 8: SSE View from Highway 1 Bridge over Elkhorn Slough

KOP 8, with the Mechanical Draft Cooling System is illustrated by VIS Figure F in Appendix F. Approximately 4,000 feet from the MLPP, this viewshed is dominated by the existing 500 foot high tall stacks and associated infrastructure, directly adjacent to Highway 1. Vegetation on the east side of Highway 1 screens much of the development located to the east (left). Only one stack from Units 1&2, and none of the Mechanical Draft Cooling System infrastructure is visible. However, the two 1,300 foot long average plumes rise 163 feet into the air and are quite noticeable where there are breaks in the existing vegetation. The addition of new large plumes into the viewshed would expand and reinforces the industrial character of landscape in lieu of the natural character of the vegetative screen. This cooling alternative therefore introduces an adverse visual effect from this perspective.

Number of viewers & duration of view

Most of the viewers at this KOP would be mobile travelers, since it is a highway view. According to the AFC, the average daily traffic is 24,500 southbound vehicles, the passengers of which would experience this moderate duration view along Highway 1.

KOP 9: SE View from Moss Landing State Beach at Elkhorn Slough

KOP 9, with the Mechanical Draft Cooling System, is illustrated by VIS Figure I in Appendix F. This photo was taken approximately 3,500 feet to the west of Units 6&7, while the Mechanical Draft Cooling infrastructure is an additional 2,000 feet to the east. The plume from the Mechanical Draft Cooling System is the only visible cooling element from this perspective. The 1,300 foot by 163 foot tall plume emitted from each of the two bays of exhaust fans, would be nearly consistently visible above the vegetative screening and existing infrastructure. However, because existing power plant, especially the two 500 foot high stacks, remains the dominant visual element in the viewshed, the distant plume does not introduce an adverse visual effect from this perspective.

Number of viewers & duration of view

Only an estimated 800 vehicles per day would experience the short duration view of the Project site from KOP 9. The Moss Landing State Park has an average daily visitation of 191 people, who would experience a moderately long duration view of the Project site (depending on how long they stay – typically a couple hours). According to the AFC, there is only one residence in the 144 acre 1990 Census Block, in which the KOP is located, which would have an extended duration view from this general direction.

Summary

Both Mechanical Draft Cooling Options produce plumes that expand the industrial character of the viewsheds and adversely affect the visual quality of the viewshed from the two of the three selected KOPs. The water vapor plume appears most noticeable from KOPs 6 and 8, both of which are along the well traveled Highway 1. However, the water vapor plume associated with the Mechanical Draft Cooling System is not a new or unique visual element into the viewshed, as the two 500 foot stacks currently emit a much more visually dominant plume as a result of their height. However the regularity of the mechanical draft cooling plume, particularly as viewed from Highway 1, would adversely affect the majority of viewing experiences. As such, the implementation of the Mechanical Draft Cooling System would adversely affect the viewshed because the degree of industrial change imposed on most of moderate quality views is high and the number of viewers, especially from Highway 1 is also high. Also there is the near permanent condition of the large plumes above the skyline.

Potential mitigation measures, such as additional screening in the form of landscaping (large trees) could be used along the perimeter of the Project site (especially along Dolan Road) to screen the new 46 foot high Mechanical Draft Cooling System structures. These measures would be in addition to he extensive landscaping requirements already required by the CEC and carried out by Duke. Moreover, mitigation cannot reduce the visual effect of the two water vapor plumes that would rise over 160 feet high by approximately 1,300 feet long that are associated with the Mechanical Draft Cooling System. This plume would represent a new skylined visual element into the viewshed.

Cumulative Impacts

What was recently an industrial site with two massive 500 foot stacks, eight 225 foot stacks, and an extensive fuel-oil tank farm, has now been substantially cleaned up. The eight 225 foot stacks and the tank farm have been removed and replaced with a new smaller, more compact combined cycle facility. The compactness of this new facility, however, would be diminished by the addition of more large, visually obvious, power generation equipment such as the Mechanical Draft Cooling Systems and associated water vapor plume.

The incremental addition of new large equipment on the MLPP site would create a completely urbanized, industrial complex. More development on the Project site would draw further attention to the amount of infrastructure on the site, and change the visual character of the overall viewshed, particularly in relationship to the Elkhorn Slough with the presence of visible plumes, it is likely that there would be a cumulative visual impact under CEQA. Overall, the mechanical draft cooling creates adverse and potentially significant visual impacts because of the near permanent plumes that are nearly 160 feet tall and nearly 1,300 feet in length, and because of the large number of viewers having relatively long duration views from Highway 1.

Land use

Visual LORS Conflicts

As discussed in the air quality and visual analyses, the mechanical draft cooling option would add two units each about 462 feet x 42 feet x 46 feet high the each emit plumes nearly 1,300 feet long. Given the size, height, location, and plume presented by mechanical draft cooling there are several conflicts with existing land use regulations and ordinances.

There are multiple policies in the Costal Act, Certified Land Use Plan, and Coastal Implementation Plan, as well as the North County Area Plan, and County General Plan that call for protecting and improving the visual corridors in Moss Landing. For example, Section 30251 of the Coastal Act states:

> The scenic and visual qualities of coastal areas shall be considered and protected as a resource of public importance. Permitted development shall be sited and designed to protect views to and along the ocean and scenic coastal areas, to minimize the alteration of natural land forms, to be visually compatible with the character of surrounding areas, and, where feasible, to restore and enhance visual quality in visually degraded areas. New development in highly scenic areas such as those designated in the California Coastline Preservation and Recreation Plan prepared by the Department of Parks and Recreation and by local government shall be subordinate to the character of its setting.

Section 20.144.140.B.5.c of the Coastal Implementation Plan states, "Development of new or expanded industrial facilities shall only be permitted where… [t]he development shall meet visual resource, environmentally sensitive habitat, and other development standards of this ordinance." Similarly, the LUP policy 2.2.2 states "views to and along the ocean shoreline from Highway One, Molera Road, Struce Road and public beaches, and to and along the shoreline of Elkhorn Slough from public vantage points shall be protected."

Placing these towers on the MLPP site is not consistent with state and local visual policies due to the cumulative nature of the visual impacts (see the visual analysis and KOPs for more specific information on the detrimental visual impacts). See Appendix G for a full description of the LORS impacts.

Conclusions

The following table summarizes Duke's conclusions about mechanical draft cooling using seawater.

Table D-12: Seawater Mechanical Draft Cooling

Question	Answer
Is this alternative potentially effective at reducing entrainment at MLPP? To what extent?	Yes. Seawater use and therefore entrainment would be reduced approximately 95%.
Is the alternative proven and available (i.e. it has demonstrated operability and reliability at a cooling water intake having a similar size and environmental setting to that at the MLPP).	Yes.
Are there reasons that this alternative may not be feasible? Alternatively, is the alternative feasible at MLPP site, based on site-specific conditions and considerations of engineering, operations, efficiency and reliability?	Yes mostly due to environmental constraints. There are no obvious ways to secure particulate offsets, to mitigate for visual resource impacts, or to overcome land use zoning restrictions. This system would also create unknown impacts from salt deposition through the local area, including in and around the PG&E switchyard.
What are the costs of this alternative relative to once-through cooling?	The PV of the April 2000 system is $49.2 million. The incremental PV of the April 2000 case over-and-above the once-through system is $-6.8 million. The PV of the real world today case is $110.7 million. The incremental PV of the real world today case over-and-above the once-through system is $54.6 million.
What are the environmental benefits of this alternative? Can the alternative be applied at MLPP in a way that is consistent with all applicable laws, ordinances, regulations and standards? Will the technology cause or increase significant adverse environmental impacts relative to once-through cooling?	There are no net environmental benefits to this alternative. The economic value of the entrained species is minor. For example, using EPA's trophic transfer rule, the maximum estimated benefit of reduced entrainment arising from a reduction of entrained goby biomass that became harvested halibut would create a benefit worth approximately $2,900. The Elkhorn Slough enhancement program is preferable to the alternative of avoiding the entrainment. Also, this system would create the following impacts: Particulate emissions, and salt deposition Near constant visual plumes Land use zoning violations
Is the cost of the alternative wholly disproportionate to the environmental benefit?	Yes.

Mechanical Draft Cooling System Using Fresh Water

There are insufficient sources of fresh water to operate a Mechanical Draft Cooling System using fresh water. It would be prohibitively expensive to secure an alternative fresh water supply. This option would also have the same visual and land use impacts as a system using seawater.

General Description

A fresh water mechanical draft cooling tower for Units 1&2 would be essentially the same as the seawater mechanical draft system (see previous description), except that fresh water would be used in the tower instead of seawater. Cooled water from the tower basin would be pumped to the existing surface condenser in each unit to condense the steam exhausted from the STGs. The warmer water would flow back to the top of the cooling tower where it would be cooled through partial evaporation by the large air flow from the tower fans. The flow sketch and photos shown in the seawater mechanical draft cooling are applicable to a fresh water tower as well (see Figures D-1 and D-2).

This alternative would completely eliminate the use of seawater for cooling of the combined cycle units. Makeup fresh water would be used to replace the water lost from the system through evaporation, drift, and the blowdown purge stream. One significant difference between the fresh water and seawater systems is that, because the makeup fresh water is much lower in dissolved solids content than seawater, less blowdown is needed to control dissolved solids accumulation in the circulating water. This reduced blowdown requirement also reduces the necessary makeup water, compared to a seawater system. Additionally, lower solids concentration in the circulating water for the fresh water system results in significantly lower PM_{10} emissions from drift than for the seawater system.

As discussed in detail below, securing an adequate fresh water supply at the Moss Landing site for this type of cooling tower is probably impossible or, at best, costly.

Design and Sizing

The process of designing a fresh water mechanical draft cooling system (at this conceptual level) is almost identical to the seawater mechanical system. The principal design criteria of condenser heat rejection, cooling water circulation rate, cooling water supply temperature to the condenser, and design wet bulb temperature are the same for both types of cooling systems. Minor differences in flow rates, tower size, or internal arrangement sometimes are needed due to the slight difference in physical properties between fresh water and seawater. In addition, fresh water is less corrosive than seawater, resulting in some cost savings in materials selection.

Moss Landing Design Considerations

Using the same design basis as the seawater mechanical draft system, the fresh water mechanical draft cooling towers for the combined cycle units is the same size as the saltwater option: two structures, one for each steam turbine unit, each about 462 feet x 42 feet x 46 feet high. The plot plan showing the location of the seawater cooling towers applies to the fresh water towers, as well (see Figure D-3).

The makeup water requirement for the fresh water towers was estimated using the dissolved solids content of the on-site well water.[36] Using this basis, the dissolved solids concentration of the circulating water and blowdown stream would be approximately four times the dissolved solids concentration of the makeup water. The estimated combined full capacity flow rates for both towers are:

Table D-13: Fresh Water Mechanical Draft System Flow Rates

Parameter	Flow Rate
Recirculating Water[37]	230,000 gpm
Blowdown (discharged to ocean)	1,300 gpm
Makeup (from fresh water source to be determined)	5,200 gpm

Moss Landing Water Supply Issues

The Moss Landing Water Company currently operates two groundwater wells at the power plant location that supply two other private users and the power plant. The maximum combined capacity of these wells is approximately 1,200 gpm, however, about half of this capacity is restricted by Monterey County and can only be used for emergency backup. Since 1998, the wells have supplied about 100 gpm on average, including about 50 gpm to Duke for the power plant uses. The plant consumes groundwater for domestic use by employees, fire protection systems, and periodic maintenance activities.

Units 1&2 (the new combined cycle units) presently use about 90 gpm, on average, for boiler feedwater makeup. This flow is presently provided from treated groundwater but will soon switch to seawater when the new plant seawater evaporation system comes on line in spring 2003. In 2002, the Moss Landing Water Company produced an average of 160 gpm, about 100 gpm of which was consumed by the power plant.

Comparison of the water makeup required for the fresh water cooling tower alternative to the recent production rates from the wells shows that this option would require about 30 times more groundwater than produced last year, and the well capacity would have to be increased by more than four times (based on the normal supply well plus the emergency backup well). Given the current groundwater supply and quality concerns in the area, obtaining these quantities of additional water from the local aquifer is clearly impossible.

[36] If better quality makeup water is used instead, the makeup stream flow rate could be reduced somewhat, perhaps by as much as 20 percent.
[37] The small difference in recirculating water flow rate between the fresh water and seawater mechanical systems is due to the slight difference in physical properties of fresh water compared to seawater.

Significant practical restrictions on groundwater use are in place in this portion of Monterey County (see the Land Use analysis in this section, below). Seawater intrusion due to groundwater extraction is a serious concern. Moss Landing Power Plant has been encouraged over the years to reduce, rather than increase, consumption of groundwater. Significant reductions were achieved by the plant in 1987 when a seawater evaporation system replaced groundwater as the source of boiler feedwater makeup and in 1995 when the original Units 1 – 5 were permanently shut down.

Duke has been unable to identify a suitable source for the quantities of water required for the fresh water cooling alternative other than from a hypothetical desalination plant, an extremely costly source for cooling water. If another fresh water source could be found, it would likely be very costly as well, perhaps as expensive as desalinated water.

Cooling Tower Location and Supporting Facilities

The most advantageous location for the new fresh water cooling towers is the same location proposed for the seawater case, the area to the east of the existing Units 1&2 (see seawater mechanical cooling plot plan, Figure D-3). The same reasons apply for choosing this location: to place the cooling towers downwind of the main equipment areas and thereby avoid potential damage from water drift droplets from the cooling tower plumes, while still minimizing the length of the very large diameter cooling water pipelines between the existing condensers and the new towers. Another significant reason is that this area is vacant and existing equipment does not need to be relocated.

As discussed in the seawater case above, a new 84-inch diameter, underground cooling water supply line would be installed between each cooling tower and the existing condenser it serves, probably routed along the northern and southern boundaries of Units 1&2. Additionally, new 84-inch underground lines will return the heated cooling water from both condensers to the towers, following the same routing as the supply lines. Makeup fresh water would be supplied from a yet to be determined source. A new pipeline from this source would be needed to convey the makeup supply to the towers (for example, from a new desalination plant located across Dolan Road from the power plant). Similar to the seawater case, cooling tower blowdown would be discharged through a new connection from the condenser return line to the existing once-through cooling water discharge line, which eventually combines with the once-through cooling water discharge from Units 6&7.

Use of Existing Facilities

Retrofit of fresh water mechanical cooling tower for Units 1&2 would mean that the existing once-through cooling system would be almost completely abandoned. As described above, a small portion of the existing once-through cooling water return line could be used for the cooling blowdown discharge. However, this reuse represents utilization of only a very small portion of the total existing system. Essentially, the investment in resources and capital recently expended to install the once-through cooling water system would be wasted.

As with the seawater case, the existing surface condensers for each steam turbine would continue to be used. The once-through cooling water pumps currently installed at the new cooling water intake structure would be removed from service. The substantial electrical load represented by the large motors serving these pumps would be replaced by the electric fan motors and new circulating pumps in the new the new cooling tower. This change will require significant relocation of internal electric power distribution within the plant.

Plant Performance

As previously explained in the seawater cooling tower discussion, mechanical draft cooling towers would significantly diminish the net power output and operating efficiency of the recently installed combined cycle plant (see previous seawater discussion for a detailed explanation). Compared to the existing once-through cooling system, the fresh water mechanical option would decrease the maximum plant net output at average site conditions by about 19 MW, to 1029 MW.

The adverse consequences of this significant decrease are the same as described for the seawater case: more costs to the ratepayer for electricity, probably more system-wide emission of air pollutants, and increased costs to Duke.

Environmental Features

Most of the environmental protection features as described for the seawater tower would also be incorporated into the design of the mechanical draft fresh water cooling tower:

The tower will incorporate modern, high efficiency drift eliminators to minimize emission of entrained water droplets in the cooling tower exhaust air and thereby reduce PM_{10} emissions which form from the solids dissolved in the water when the droplets evaporate in the atmosphere. As previously explained, however, the estimated PM_{10} emission rate for fresh water is only a small fraction of that for the seawater towers. The drift eliminators have an efficiency of 0.0005% and are assumed to represent Best Available Control Technology. No other air quality environmental protection measures are available for this alternative.

Fresh water cooling use will also result in significantly less dissolved solids discharged to the ocean as compared to seawater cooling towers.

At the proposed location, the tower would be effectively shielded by existing structures or landscaping as much as possible and practical to minimize visual impacts from key observation points. However, condensate plumes will be frequently visible from all directions.

Manufacturer information indicated that each bank would be predicted (on an engineering estimate basis) to produce 64 dBA at 400 feet from the tower. The large cooling water circulation pumps associated with each tower, assuming no noise control or special design, would be expected to produce no more than 62 dBA at 400 feet.

Cost Analysis

Table D-14 shows the capital cost components for the freshwater mechanical draft cooling system. Costs are shown for both the cases under consideration – the April 2000 case and the Real World Today Case. These cases are explained in more detail in Appendix E. Capital costs for each were estimated by using preliminary design information, by soliciting input from vendors, and by utilizing engineering judgment that includes experience designing and building similar systems elsewhere. Relevant costs to include are: all equipment, installation and erection costs, site preparation, and interference and relocation costs. If applicable, one-time environmental costs are also included.

Table D-14: Capital Costs for Freshwater Mechanical Draft Cooling System ($ millions)

	April 2000 Case	Real World Today Case
Site Preparation	3.9	3.8
Cooling System Equipment Package	19.7	19.2
Installation	13.9	14.0
Demolition / Relocations	n/a	7.0
Transmission Line Relocation	n/a	n/a
Mitigation Costs	n/a	n/a
Total Capital Costs	37.5	44.0

Environmental Analysis

Noise

The noise evaluation used the conceptual layout for this alternative, coupled with manufacture-supplied noise predictions. At the distances to the nearest pertinent CEC receptor locations, approximately 1,500 to 1,600 feet to Receptor 5 (to the southwest) and approximately 2,300 to 2,500 feet to Receptor 1 (to the northwest), the predicted noise levels (assuming only spherical spreading loss for propagation attenuation) attributed to the Mechanical Draft Cooling Tower System were 56 dBA at Receptor 1 and 59 dBA at Receptor 5. The measured ranges of 10-minute L_{eq} at these locations were 53 to 64 dBA (Location 1) and 71 to 79 dBA (Location 5). Again, it should be noted that at both these locations nearest to the MLPP Units 1&2 project, contributions from Units 1&2 were not audible or measurable.

Since the incremental contribution from the Fresh Water Cooling Tower system was near the lower end of the range of measured noise at Location 1 and more than 10 dB below the lowest measured values at Location 5, Duke concluded that this cooling alternative would not produce a discernible difference to the compliant conditions at these two nearest receptor locations. The other CEC assessment locations were not evaluated since they are two to five times more distant and any potential incremental cooling system noise contributions would be even less consequential, compared to the current conditions. It should be noted, however, that noise levels at other locations around the MLPP site that are adjacent to the new cooling systems, primarily just to the south of the plant along Dolan Road, may increase discernibly. However, to the south of the MLPP is another heavy-industrial land use, a mineral processing facility, that is not considered a sensitive receptor. These facts, coupled with the significant influence of traffic noise sources along Dolan Road, indicate that there would not be significant impacts along the MLPP property boundary that is adjacent to the prospective cooling system.

Since all potential noise impacts from the Fresh Water Cooling Tower system are deemed to be insignificant, no noise mitigation is called for and no noise-related additional costs would be involved in the implementation of this cooling alternative.

Air quality

Technical assumptions

The mechanical draft cooling system using fresh water is assumed to have the characteristics shown in Table D-15:

Table D-15
Cooling Tower Design Parameters
Fresh Water Mechanical Draft Cooling System

Parameter	Value
Number of towers	2
Number of cells per tower	11
Overall length, per tower (feet)	462
Overall width, per tower (feet)	42
Elevation at top of tower (feet above grade)	46
Elevation at fan deck (feet above grade)	36
Exhaust stack diameter (feet)	26
Circulating water flow rate (gal/min)	115,000
Circulating water flow rate (lbs/hr)	57,000,000
Drift rate (%)	0.0005%
Drift rate (lbs water/hr)	290
Makeup water TDS level (ppmw)	500
Cycles of concentration	4
Basin TDS level (ppmw)	2,000
PM_{10} Emissions	
Grams/second (per cell)	0.01
Pounds/hour (per tower)	0.6
Tons/year (total, all towers)	5.3
Exhaust gas flow rate (per cell; acfm)	903,000
Exhaust gas temperature (°F)	89°F

Direct emissions

Based on the above assumptions, the fresh water mechanical draft cooling system will have direct PM_{10} emissions of approximately 5 tons/year. By way of comparison, the maximum allowable direct PM_{10} emissions from the combined cycle power plant are 151.2 tons/year (total for all four turbines). Thus, the use of the fresh water mechanical draft cooling alternative would increase the PM_{10} emissions associated with the combined cycle units by approximately 3.5%.

Direct air quality impacts

Table D-16 shows the current permit limits for the combined cycle units, and the increase in emissions (above those limits) associated with the fresh water mechanical draft cooling system.

Table D-16
Current Emission Limits and Changes
Fresh Water Mechanical Draft Cooling System (tons/year)

	VOC	CO	NOx	SOx	PM_{10}
Current Emission Limits	348	7,191	659	55	508
Increase due to Fresh Water Mechanical Draft Cooling System	0.0	0.0	0.0	0.0	5
Revised Emission Limits Required	348	7,191	659	55	513
BACT required?	No	No	No	No	Yes
Offsets required?	No	No	No	No	Yes
Note: Emission limits apply to the combined emissions from all power generation equipment at the Moss Landing facility, including Units 6&7 and the combined cycle units. Emissions are limited on a calendar quarter basis, but are shown here in units of tons/year for purposes of simplification.					

As shown in Table D-16, the addition of a fresh water mechanical draft cooling system will trigger requirements for best available control technology (BACT) and emission offsets. The use of drift eliminators with an efficiency of 0.0005%, already incorporated into the cooling system design, is expected to satisfy the BACT requirements. Emission offsets in the amount of approximately 5 tons/year of PM_{10} would be required to satisfy Monterey air district requirements.

Table D-17 shows all of the PM_{10} emission reduction credits held within the Monterey air district at this time.[38] Not all of these credits are available for sale; based on Duke's experience in seeking offsets for the combined cycle units in 1999 and 2000, it is Duke's understanding that most of these credits are being held for future use by their current owners. However, it appears that sufficient credits would be available to satisfy the regulatory requirements for the fresh water mechanical draft cooling system.

The California Air Resources Board's Emission Reduction Credits Offsets Transaction Cost Summary Report for 2002 (http://www.arb.ca.gov/erco/erco.htm) indicates an average cost of \$19,690 per ton for PM_{10} credits in 2002 in the Monterey air district. Although this cost was based on a single transaction, the average cost per ton for PM_{10} credits in the Monterey air district in 2001 was comparable, at \$18,580 per ton. To estimate the cost of obtaining the necessary emission reduction credits for the sea water mechanical draft cooling alternative, an assumed cost of \$19,000 per ton was used. At this price, the cost of obtaining the required PM_{10} emission reduction credits would be between \$122,000 and \$200,000, depending on the location of the credit source.

[38] Credits for PM_{10} precursors, including SOx and NOx emissions, are shown as well, under the assumption that these could be used, at a 1.0:1 ratio, to satisfy MBUAPCD offset requirements.

Table D-17
Current Inventory of PM_{10} Precursor Emission Reduction Credits
Monterey Bay Unified APCD (tons/year)

ERC Holder	NOx	SOx	PM_{10}	Total
U.S. Army	1.5	2.0	0.3	3.8
Texaco USA	56.6	144.6	58.0	259.2
Tri Valley	3.8	0.1	0.3	4.2
Stone Container	1.9	0.0	0.0	1.9
AERA Energy	289.7	208.6	120.9	619.2
National Refractories	53.3	0.3	0.2	53.8
Salz Leathers	0.6	0.0	0.2	0.8
Totals	**407.4**	**355.6**	**179.9**	**942.9**
ERCs Required[1]			**6 – 11**	

Note:

1. The quantity of ERCs required reflect the application of Monterey air district offset ratios of 1.2:1 to 2.0:1, depending on the location of the ERC source.

The air quality impacts of the fresh water mechanical draft cooling system were assessed using the same dispersion models as were used in the application for certification for the combined cycle units. The results of the dispersion modeling analysis are shown in Tables D-18, D-19, and D-20. These tables present the original and revised modeling results, and compare them with the applicable federal PSD significance thresholds, preconstruction monitoring de minimis levels, and ambient air quality standards, respectively.

Table D-18
Maximum Modeled Impacts and Federal PSD Significance Thresholds Moss Landing Power Plant Combined Cycle Units With Fresh Water Mechanical Draft Cooling

POLLUTANT	AVERAGING TIME	MAXIMUM MODELED IMPACTS ($\mu g/m^3$)		FEDERAL PSD SIGNIFICANCE THRESHOLD ($\mu g/m^3$)	SIGNIFICANT UNDER FEDERAL PSD?	
		Original	Revised		Original	Revised
NO_2	Annual	0.4	0.4	1	No	No
PM_{10}	24-Hour	5.9	5.9	5	Yes	Yes
	Annual	0.2	0.2	1	No	No

TableD-19
Comparison of Modeled Concentrations
with Federal PSD Preconstruction Monitoring Thresholds
Moss Landing Power Plant Combined Cycle Units
with Fresh Water Mechanical Draft Cooling

POLLUTANT	AVERAGING TIME	EXEMPTION CONCENTRATION (μg/m³)	MAXIMUM MODELED CONCENTRATION (μg/m³)	
			Original	Revised
NOx	annual	14	0.4	0.4
SO_2	24 hours	13	0.7	0.7
CO	8 hours	575	296.1	296.1
PM_{10}	24 hours	10	5.9	5.9

Table D-20
Modeled Maximum Project Impacts Moss Landing Power Plant Combined Cycle Units with Fresh Water Mechanical Draft Cooling

POLLUTANT	AVERAGING TIME	MAXIMUM PROJECT IMPACT (μg/m³)		BACKGROUND CONCENTRATIONS (μg/m³)	TOTAL IMPACT (μg/m³)		MOST STRINGENT STANDARD (μg/m³)
		Original	Revised		Original	Revised	
NO_2	1-hour	148.2	148.2	113	261	261	470
	Annual	0.4	0.4	21	21.4	21.4	100
SO_2	1-hour	7.1	7.1	156	163	163	650
	24-hour	0.8	0.8	39	40	40	109
	Annual	0	0	0	0	0	80
CO	1-hour	2,228	2,228	6,900	9,128	9,128	23,000
	8-hour	296	296	3,222	3,518	3,518	10,000
PM_{10}	24-hour	5.9	5.9	59	65	65	50
	Annual	0.2	0.2	20.8	21.0	21.0	20

The modeling analysis indicates that pollutant concentrations will not increase as a result of the fresh water mechanical draft cooling tower.

Indirect air quality impacts

As discussed above, the fresh water mechanical draft cooling alternative will reduce the plant's output by 19 MW. This will result in the need to generate additional power from other power generation sources. Since the Moss Landing combined cycle units are among the cleanest generating units in the country, it is unlikely that the replacement energy will be provided by a lower emitting source. Consequently, the emissions increase associated with this replacement power are conservatively estimated based on the pounds of emissions per megawatt hour (lbs/MWh) produced by the Moss Landing combined cycle units. This increase in emissions is shown in Table D-21.

Table D-21
Indirect Emission Increases
Fresh Water Mechanical Draft Cooling System

	VOC	CO	NOx	SOx	PM_{10}
Maximum Annual Emissions from Moss Landing Combined Cycle Units (tons/year)	89.4	1,326.4	284.5	21.8	151.2
Lbs/MWh emission rate[1]	0.020	0.301	0.065	0.005	0.034
Indirect emission increases[2] (tons/year)	1.6	24.0	5.2	0.4	2.7

Notes:
1. Calculated based on 8400 hours per year of full load operation at 1060 MW, consistent with the assumptions used for maximum annual emissions.
2. Calculated based on 159,600 MWh of energy lost due to parasitic and/or efficiency losses associated with the fresh water mechanical draft cooling system. There is a small difference between this amount of lost energy and that shown in Appendix I. This small difference has no material effect on the calculation.

Visible water vapor plumes

The fresh water mechanical draft cooling system will result in the formation of visible plumes under certain meteorological conditions. Using models that have been developed for the purpose of analyzing the frequency and dimensions of visible water vapor plumes in proceedings of the California Energy Commission, the proposed fresh water mechanical draft cooling system was analyzed. The results of this analysis are presented in Tables D-22 and D-23.

Table D-22
Visible Plume Frequency
Fresh Water Mechanical Draft Cooling System

	Fresh Water Mechanical Draft Cooling Tower 1997 Moss Landing Meteorological Data		
	All Hours	Daylight Hours	Night Hours
	Frequencies for all plumes		
Number of hours when plume is visible	8348	4117	4231
Hours in period	8760	4380	4380
Percent of hours in period when plume is visible	95%	94%	97%
Percent of all hours when plume is visible	95%	47%	48%

Table D-23
Visible Plume Dimensions
Fresh Water Mechanical Draft Cooling System

	Fresh Water Mechanical Draft Cooling Tower					
	1997 Moss Landing Meteorological Data					
	All Hours		Daylight Hours		Night Hours	
	Maximum	Average	Maximum	Average	Maximum	Average
	Dimensions for all plumes					
Plume Height (ft)	1912	180	1912	**158**	938	203
Plume Diameter (ft)	1487	118	1487	**111**	1125	124
Plume Length (ft)	16279	315	8448	**192**	16279	434
	Dimensions for plumes of 90th percentile height					
Plume Height (ft)		297		**205**		
Plume Diameter (ft)		180		**122**		
Plume Length (ft)		538		**165**		

The data indicate that a visible water vapor plume will be present from the fresh water mechanical draft cooling system nearly all the hours of the year. The implications of these plumes with respect to visual resources are presented below.

Visual

See the discussion under saltwater mechanical draft cooling for a full discussion of the visual impacts. A summary of the findings is repeated below.

Summary

Both Mechanical Draft Cooling Options produce plumes that expand the industrial character of the viewsheds and adversely affect the visual quality of the viewshed from the two of the three selected KOPs. The water vapor plume appears most noticeable from KOPs 6 and 8, both of which are along the well traveled Highway 1. The water vapor plume associated with the Mechanical Draft Cooling System is not a new or unique visual element into the Highway 1viewshed, as the two 500 foot stacks currently emit a much more visually dominant plume as a result of their height. However the regularity of the mechanical draft cooling plume, particularly as viewed from Highway 1, would adversely affect the majority of viewing experiences. As such, the implementation of the Mechanical Draft Cooling System would adversely affect the viewshed because the degree of industrial change imposed on most of moderate quality views is high and the number of viewers, especially from Highway 1 is also high. Also, there is the near permanent condition of the large plumes above the skyline.

Potential mitigation measures, such as additional screening in the form of landscaping (large trees) could be used along the perimeter of the Project site (especially along Dolan Road) to screen the new 46 foot high Mechanical Draft Cooling System structures. However, mitigation cannot reduce the visual effect of the two water vapor plumes that would rise over 160 feet high by approximately 1,300 feet long that are associated with the Mechanical Draft Cooling System. This plume would represent a new skylined visual element into the viewshed.

Cumulative Impacts

What was recently an industrial site with two massive 500 foot stacks, four 225 foot stacks, and an extensive fuel-oil tank farm, has now been substantially cleaned up. The four 225 foot stacks and the tank farm have been removed and replaced with a new smaller, compact combined cycle facility. The compactness of this new facility, however, would be diminished by the addition of more large, visually obvious, power generation equipment such as the Mechanical Draft Cooling Systems and associated water vapor plume.

The incremental addition of new large equipment on the MLPP site would create a completely urbanized, industrial complex. More development on the Project site would draw further attention to the amount of infrastructure on the site, and change the visual character of the overall viewshed, particularly in relationship to the Elkhorn Slough with the presence of visible plumes, it is likely that there would be a cumulative visual impact under CEQA. Overall, the mechanical draft cooling creates adverse and potentially significant visual impacts because of the near permanent plumes that are nearly 160 feet tall and nearly 1,300 feet in length, and because of the large number of viewers having relatively long duration views from Highway 1.

Land use

Conflicts with the County of Monterey Definition of Costal Dependent

The MLPP site is zoned for heavy industrial use in the coastal zone (HI (CZ)). However, multiple policies in the County land use planning documents require any new development or expansion of existing development to be a coastal dependent use (LUP Policies 4.3.6.F.1 and 5.5.2.10 and Coastal Implementation Plan policies 20.144.140.B.5.c.1 and 20.144.160.C.1.k). The Coastal Implementation Plan uses the Coastal Act definition for the term "Coastal-Dependent", consistent with Section 30101 of the Coastal Act, as an area for uses that must be "located on or adjacent to the sea in order to function." (page NC-3) Elimination of the once-through seawater cooling system would render the facility non-coastal dependent and create a project that is inconsistent with these policy requirements.

Water conservation conflicts

Freshwater mechanical draft cooling towers would put an enormous stress on the County's already depleted fresh water supply. This technology would require 5,200 gallons per minute or 8,386 acre feet per year. For perspective, the Monterey Peninsula Water Management District that serves the Monterey Peninsula uses 18,000 acre feet per year (personal communication with MWMD, March 2003). Therefore freshwater mechanical draft cooling at MLPP would require 47% of the current volume of freshwater currently used by all of the Monterey Peninsula.

Of the three onsite wells located at MLPP, well #7 no longer provides potable water and is not in use and well #9 provides low quality water and Monterey County has required that this only be used for emergency back-up. The remaining well (#8) provided 70 million gallons (215 acre feet) of water in 2001 for MLPP, PG&E's Switchyard, and Calcagno (for animal husbandry operations associated with Moon Glow Dairy). This amount is far short of the necessary 8,386 acre feet per year required for freshwater mechanical draft cooling option. In addition, Duke has recently been asked by the Monterey County Water Resources Agency to reduce water use and

County Ordinances 3886 and 3663 require limited use of fresh water resources and conservation. Therefore, onsite water is not available.

Duke has also contacted the County and Cal-AM to find other sources of fresh water to purchase. No additional water is available as the entire northern portion of Monterey County is in a state of severe overdraft. A building moratorium has been in place since August 2000 due to this severe water shortage. Monterey County Ordinance 4083 prohibits new industrial development that uses more than 0.4 acre feet of water per year in the North County while the County land use planning documents are updated.

Desalinization is the only remaining option to supply the large amount of fresh water to the freshwater mechanical draft cooling option. According to Plan B Documents submitted to the Public Utilities Commission, a 9 mgd desalinization plant (operating a full capacity 95% of the time to produce a 9,430 acre feet per year) would cost $73.7 million in capital costs with anther $3 million per year in O&M costs (assuming electricity is 3 cents per kwh). Duke needs approximately 83% of this capacity that would have capital costs of at least $61.2 million making this option unavailable due to wholly disproportionate costs.

Given the limiting factors noted above freshwater usage at this level is not feasible. Even if it were, it would conflict with the following LORS:

> North County LUP Policy 4.3.4: All future development within the North County Coastal Zone must be clearly consistent with the protection of the area's significant human and cultural resources, agriculture, natural resources, and water quality.
>
> North County LUP Policy 4.3.5.6: The only industrial facilities appropriate for the area are coastal-dependent industries that do not demand large quantities of fresh water and contribute low levels of air and water pollution. Industries not compatible with the high air quality needed for the protection of agriculture shall be restricted.
>
> North County LUP 4.3.6.F.4: A basic standard for all new or expanded industrial uses is the protection of North County's natural resources. Only those industries determined to be compatible with the limited availability of fresh water and the high air quality required by agriculture shall be allowed. New or expanded industrial facilities shall be sited to avoid impacts to agriculture or environmentally sensitive habitats.
>
> Coastal Implementation Policy 20.144.140.B.5.c: Development of new or expanded industrial facilities shall only be permitted where able to meet the following criteria: ...2. The industry shall not use quantities of water that will exceed or adversely impact the safe, long-term yield of the local aquifer.

The current MLPP does not endanger fresh water resources.

Visual LORS Conflicts

As discussed above and in the saltwater mechanical draft section, this option would add two structures, one for each steam turbine unit, each about 462 feet x 42 feet x 46 feet high that each emit plumes nearly 1,300 feet long. Given the size, height, location, and plume presented by mechanical draft cooling there are several conflicts with existing land use regulations and ordinances.

There are multiple policies in the Costal Act, Certified Land Use Plan, and Coastal Implementation Plan, as well as the North County Area Plan, and County General Plan that call for protecting and improving the visual corridors in Moss Landing. For example, Section 30251 of the Coastal Act states:

> The scenic and visual qualities of coastal areas shall be considered and protected as a resource of public importance. Permitted development shall be sited and designed to protect views to and along the ocean and scenic coastal areas, to minimize the alteration of natural land forms, to be visually compatible with the character of surrounding areas, and, where feasible, to restore and enhance visual quality in visually degraded areas. New development in highly scenic areas such as those designated in the California Coastline Preservation and Recreation Plan prepared by the Department of Parks and Recreation and by local government shall be subordinate to the character of its setting.

Section 20.144.140.B.5.c of the Coastal Implementation Plan states, "Development of new or expanded industrial facilities shall only be permitted where… [t]he development shall meet visual resource, environmentally sensitive habitat, and other development standards of this ordinance." Similarly, the LUP policy 2.2.2 states "views to and along the ocean shoreline from Highway One, Molera Road, Struce Road and public beaches, and to and along the shoreline of Elkhorn Slough from public vantage points shall be protected."

Placing these towers on the MLPP site is not consistent with state and local visual policies due to the cumulative nature of the visual impacts (see the visual analysis and KOPs for more specific information on the detrimental visual impacts). See Appendix G for a full description of the LORS impacts.

Conclusions

The following table summarizes Duke's conclusions about mechanical draft cooling using freshwater

Table D-24: Freshwater Mechanical Draft Cooling

Question	Answer
Is this alternative potentially effective at reducing entrainment at MLPP? To what extent?	Yes. Seawater use and therefore entrainment would be reduced almost completely for Units 1&2.
Is the alternative proven and available (i.e. it has demonstrated operability and reliability at a cooling water intake having a similar size and environmental setting to that at the MLPP).	Yes.
Are there reasons that this alternative may not be feasible? Alternatively, is the alternative feasible at MLPP site, based on site-specific conditions and considerations of engineering, operations, efficiency and reliability?	Yes mostly due to environmental and economic constraints. There are no obvious ways to secure an adequately large freshwater supply, to mitigate for visual resource impacts, or to overcome land use zoning restrictions.
What are the costs of this alternative relative to once-through cooling?	The PV of the April 2000 case is $87.4 million. The incremental PV of the April 2000 case over-and-above the once-through system is $31.3 million. The PV of the real world today case is $148.7 million. The incremental PV of the real world today case over-and-above the once-through system is $92.6 million.
What are the environmental benefits of this alternative? Can the alternative be applied at MLPP in a way that is consistent with all applicable laws, ordinances, regulations and standards? Will the technology cause or increase significant adverse environmental impacts relative to once-through cooling?	There are no net environmental benefits to this alternative. The economic value of the entrained species is minor. For example, using EPA's trophic transfer rule, the maximum estimated benefit of reduced entrainment arising from a reduction of entrained goby biomass that became harvested halibut would create a benefit worth approximately $2,900. The Elkhorn Slough enhancement program is preferable to the alternative of avoiding the entrainment. Also, this system would create the following impacts: Near constant visual plumes Land use zoning violations Very high costs to secure water supply
Is the cost of the alternative wholly disproportionate to the environmental benefit?	Yes.

Natural Draft Cooling System

General Description

This closed-cycle cooling water alternative would replace the existing once-through seawater cooling water system plant with a recirculating cooling water system and natural draft cooling tower. A natural draft cooling tower system is similar in principal to the mechanical draft system, but vastly difference in appearance. The primary difference is that the mechanical fans are replaced by what is essentially a large chimney. Natural draft cooling towers are a relatively common heat rejection system for large cooling loads. Local conditions that favor natural draft towers over mechanical draft towers include very large cooling water flow rates, humid climate, high cost for power use, low construction labor rates, and no severe seismic requirements. Hence, natural draft cooling towers are fairly common in the Eastern U.S., Europe, and Asia, but are relatively rare in California.[39]

Figure D-5 and D-6 presents a schematic flow sketch and photographs for this type of cooling system, respectively. Air is drawn in at the base of the tower due to the less dense, warmer air exiting the top of the tower. This natural air circulation contacts the returned cooling water inside the tower and cools the water, mainly by evaporation. As a result, the cooling water recirculation, blowdown, and makeup rates and quality would be very similar to the mechanical system. Drift losses (and therefore the associated emissions of PM_{10} particulates) for a natural draft cooling tower are expected to be about the same as from a mechanical draft tower, but are quite difficult to measure.

Natural draft cooling towers are typically very high massive structures. Figure D-6 is a photograph that illustrates this massive size.

Design and Sizing

The principal design criteria for sizing a natural draft cooling tower are the same criteria that were used for the mechanical draft tower (see previous discussion for seawater mechanical draft towers), namely the desired temperature rise across the steam condenser and the design (maximum) ambient wet bulb temperature. In addition, the maximum ambient actual (dry bulb) temperature is also an important parameter. The dry bulb temperature is used to determine the density difference between the warmed air exiting the top of tower and the surrounding air. This density difference determines the draft of the tower (chimney effect) and strongly influences the required tower height for a given cooling load.

The performance characteristics of a natural draft tower, as compared to a mechanical draft tower for the same cooling load, require that the cooled water temperature exiting the tower is somewhat warmer for the natural draft tower than for the mechanical draft design. This warmer cooling water temperature results in a higher steam condensing pressure and, therefore, somewhat reduced steam turbine generator output and overall plant thermal efficiency as compared to the mechanical draft system.

[39] Natural draft cooling tower applicability information based on telephone conversation with Marley Cooling Technologies, Inc, representative, April 4, 2003.

Figure D-5: Natural Draft Schematic Flow Sketch

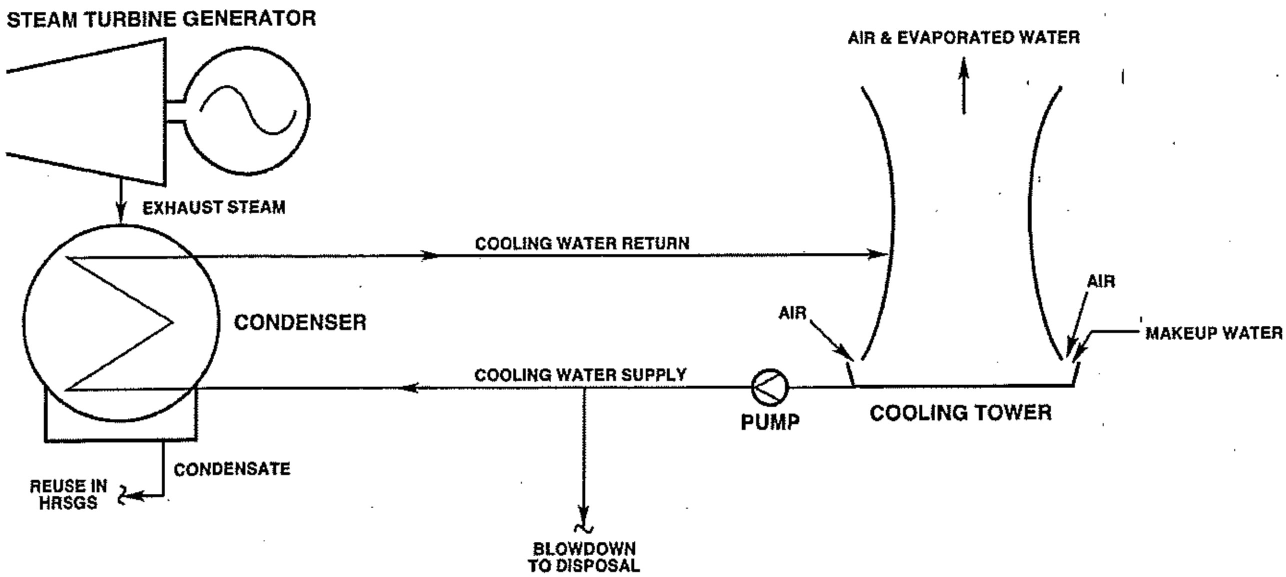
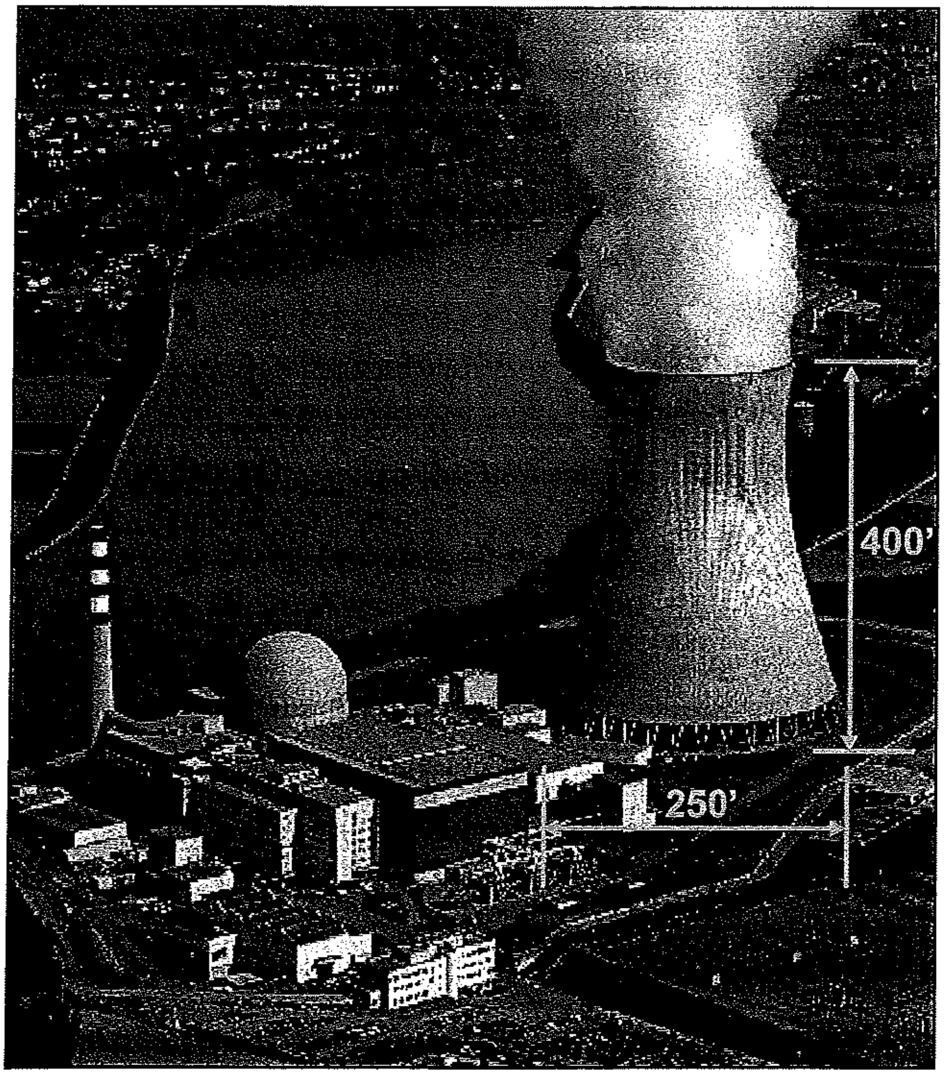


Figure D-6: Natural Draft Photograph



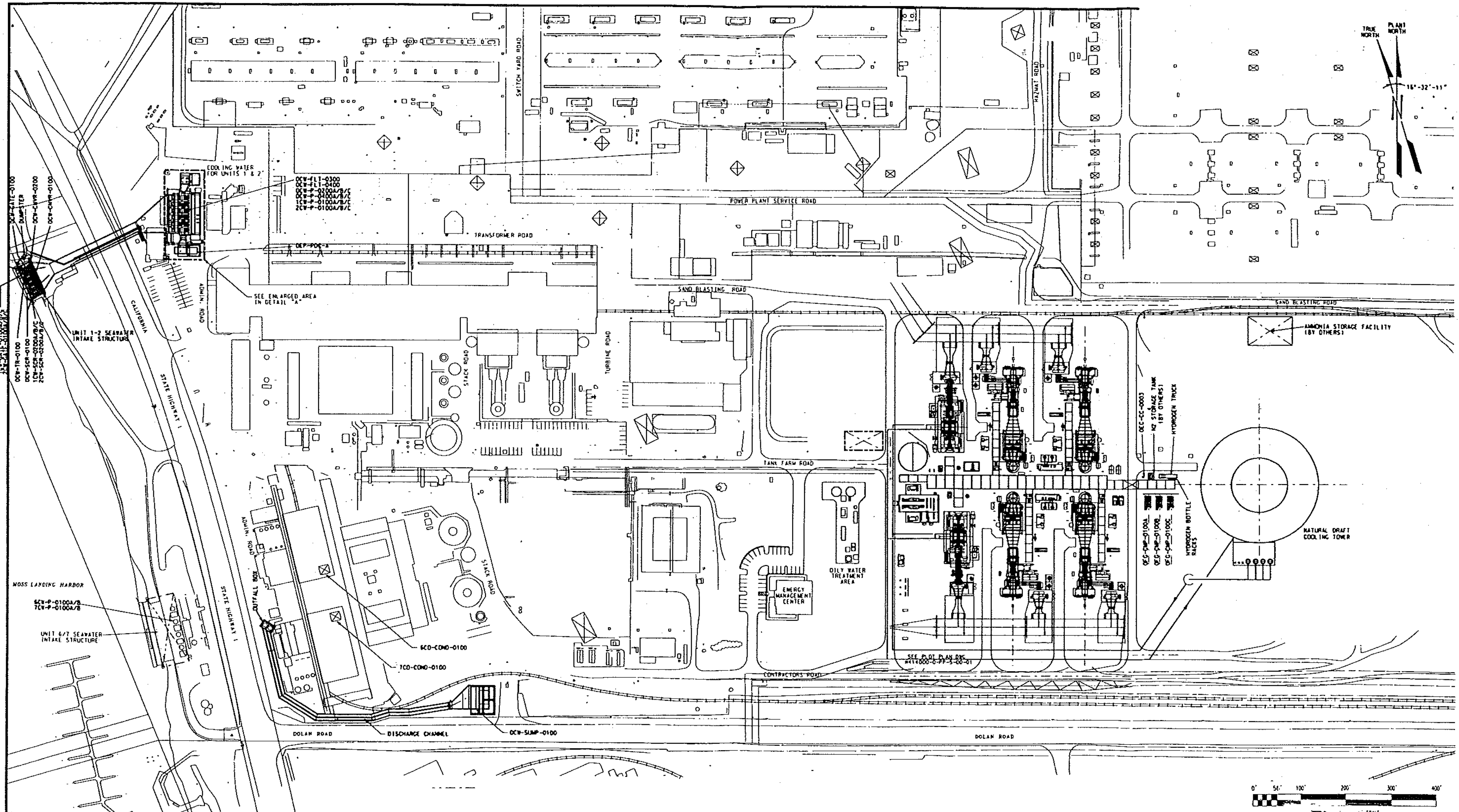


Figure D-7

REV.	DATE	REVISION DESCRIPTION	DRWN / CHK	LAYO / MECH	CIVIL / ELEC	ENGM / PROJ	REV.	DATE	REVISION DESCRIPTION	DRWN / CHK.	LAYO / MECH	CIVIL / ELEC	ENGM / PROJ
1	10/17/00	APPROVED FOR CONSTRUCTION	RK / HS	MB									
2	04/18/01	APPROVED FOR CONSTRUCTION	WA / HB	MB									

Plot User   Plot Date & Time

DWG.NO.	REFERENCE DRAWINGS
414000-0-PP-5-00-01	PLOT PLAN, POWER GENERATION UNITS 1 & 2
414000-0-PP-5-00-03	OVERALL PLOT PLAN, POWER PLANT-EAST

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PROJECT DIRECTOR C. MERCHERS	C.M. 10/24/00

DUKE ENERGY NORTH AMERICA, LLC
MOSS LANDING POWER PLANT PROJECT
MOSS LANDING, CA

OVERALL PLOT PLAN
POWER PLANT - WEST
NATURAL DRAFT COOLING TOWER

SCALE	CONTRACT NUMBER	UNIT No.	DOC TYPE	UNC	SUBJECT CODE	SEQ No.	REV.
1"=100'	414000	0	PP	5	005	2	2

MANUAL CHANGES MADE - YES ☐ NO ☐   DWG. FILE UPDATED - YES ☐ NO ☐   MODEL UPDATED - YES ☐ NO ☐

DIST. CODE 051 WRK. PKG. A CADD FILE No. PP05.DGN

DFD_D.DGN 10-2-98

Moss Landing Design Considerations

The design considerations for a natural draft cooling tower at Moss Landing would include the same performance specifications as the mechanical seawater cooling tower such as matching the once through cooling water flow rate and temperature rise, the design ambient wet bulb temperature, etc. In addition, a maximum ambient dry bulb temperature of 75 °F was selected to determine the tower height needed for adequate air flow through the tower.

A single, natural draft cooling tower to serve both Moss Landing combined-cycle units would be approximately 255 feet in diameter at the base and about 450 feet in height. Figure D-7 presents a conceptual plot plan location for the MLPP utilizing a natural draft cooling tower sized for the new combined-cycle units. As with the seawater mechanical draft tower, ocean water makeup for this system would be supplied from the existing Units 1&2 once-through cooling intake structure.[40] Due to the continuous evaporation for cooling in the tower, the circulating water and blowdown stream would contain salinity (dissolved solids) approximately twice as great as local seawater. The estimated full capacity flow rates for the natural draft tower are:

Table D-25: Seawater Natural Draft System Flow Rates

Parameter	Flow Rate
Recirculating Water	230,000 gpm
Blowdown (returned to ocean)	3,800 gpm
Makeup (withdrawn from ocean)	7,600 gpm

Cooling Tower Location and Supporting Facilities

As with mechanical tower, the most advantageous location for the new natural draft tower is in the presently unused area to the east of existing Units 1&2. This location was primarily chosen to place the cooling tower downwind of the main equipment areas. This location also avoids potential damage from rainout of concentrated sea water drift droplets in the cooling tower plume, while still minimizing the length of the large diameter cooling water pipelines between the existing condensers and the new tower. Another significant reason is that this area is vacant and existing equipment does not need to be relocated.

Common underground cooling water supply and return lines, 120 inches in diameter, would be installed between the existing condensers and the cooling tower, probably routed along the southern boundary of Unit 2. The existing once–through cooling water pumps at the Units 1&2 sea water intake structure would be replaced with much smaller pumps to provide makeup sea water to the tower. A new connection line from the existing once-through cooling water supply

[40] A freshwater natural draft cooling tower was not evaluated based on the findings of the mechanical draft freshwater analysis that concluded 1) there was little or no fresh water available (onsite or from others) and 2) the additional costs of desalinization would also render this alternative infeasible.

line the cooling tower would convey the makeup flow to the tower. Cooling tower blowdown would be discharged through a new connection from the condenser return line to the existing once-through cooling water discharge line, which eventually combines with the once-through cooling water discharge from Units 6&7. The remainder of the existing once-through cooling water system would be abandoned in place (in accordance with applicable regulations and after being secured for long term safety considerations).

Use of Existing Facilities

Like the mechanical draft tower, installation of a new natural draft cooling tower for Units 1&2 would allow the existing once-through cooling system to be partially reused to convey cooling tower makeup and blowdown to and from the new tower as described above. However, this reuse represents only a minor (a few percent) utilization of the originally installed capacity. The portions of the system that are not reused would be essentially abandoned in place.

The large, existing surface condensers for each steam turbine would continue to be used. However, the once-through cooling water pumps currently installed at the new cooling water intake structure would be removed from service. The substantial electrical load represented by the large motors serving these pumps would be replaced by the new circulating pumps in the new cooling tower. This change will require significant relocation of internal electric power distribution within the plant.

Plant Performance

As explained above, a natural draft cooling tower would diminish the net power output and operating efficiency of the steam turbine generator even more than the mechanical towers. The efficiency loss of the higher steam turbine condenser temperatures caused by the warmer cooling water for the natural draft application is partially offset by the reduced plant electrical load (no mechanical air fans are needed for the tower). However, in the site specific case of MLPP, the natural draft cooling tower option results in somewhat reduced plant power generation and efficiency compared to the mechanical tower option and substantially reduced efficiency when compared to the base case (once-through cooling). This reduction in capacity will have to be made up by other, probably less efficient and more polluting power sources located elsewhere. This also means that more fuel would be needed to produce the same net amount of electricity. With the recent increase in natural gas prices, this will have an adverse affect on the cost of electrical power to the California consumer.

Similar to the seawater mechanical draft cooling tower, the efficiency degradation attributable to the natural draft tower, as compared to the existing once-through cooling system, would cause both a decrease in the maximum generation capacity of the plant and an increase in the amount of fuel required for a given amount of electricity generated. Units 1&2 can currently generate about net 1048 MW at annual average site conditions, but with a natural draft system this capacity is degraded by 26 MW to net 1022 MW. This power output loss would be even greater at higher ambient temperatures. The heat rate (fuel consumed per unit of net power produced) would be increased from about 6794 Btu/kW-hr for the existing plant to about 6970 Btu/kW-hr for the natural draft cooling tower option. (See the previous plant performance discussion for the seawater mechanical draft tower for a more detailed description of plant capacity and heat rate.)

For purposes of this analysis, however Duke conservatively assumes that only a portion of the cost element discussed here is used for the economic comparisons: the additional cost per unit of production to run the facility at the lower capacity.

Environmental Features

The conceptual design of the natural draft seawater cooling tower incorporates the same environmental protection features as the mechanical tower case.

The maximum practical salinity was chosen for the circulating cooling water stream to minimize seawater withdrawal and discharge of blowdown to the ocean in order to minimize marine biology effects.

The tower will incorporate modern, high efficiency drift eliminators to minimize the emission of entrained water droplets in the cooling tower exhaust air and thereby reduce PM_{10} emissions which form from the solids dissolved in the water when the droplets evaporate in the atmosphere. The drift eliminators have an efficiency of 0.0005% and are assumed to represent the best available control technology. No other air quality environmental protection measures are available for this alternative.

The natural draft option is a passive system for heat exchanging and therefore the only significant noise sources are the main circulating water pumps (located to the south of the tower). Experience on numerous previous projects with this size water pump indicates that this system would be predicted (on an engineering estimate basis) to produce no more that 62 dBA at 400 feet from the set.

Cost Analysis

Table D-26 shows the capital cost components for natural draft mechanical draft system. Costs are shown for both the cases under consideration –the April 2000 case and the Real World Today Case. These cases are explained in more detail in Appendix E. Capital costs for each were estimated by using preliminary design information, by soliciting input from vendors, and by utilizing engineering judgment that includes experience designing and building similar systems elsewhere. Relevant costs to include are: all equipment, installation and erection costs, site preparation, and interference and relocation costs. If applicable, one-time environmental costs are also included.

Table D-26: Capital Costs for Natural Draft Cooling System ($ millions)

	April 2000 Case	Real World Today Case
Site Preparation	1.7	1.7
Cooling System Equipment Package	31.7	32.6
Installation	7.7	6.8
Demolition / Relocations	n/a	6.6
Transmission Line Relocation	n/a	n/a
Mitigation Costs	7.0	7.0
Total Capital Costs	48.1	54.8

Mitigation costs for systems using saltwater include the cost of particulate offsets. This is explained in greater detail in Appendix E.

Environmental Analysis

Noise

The noise evaluation used the conceptual layout for this alternative, coupled with manufacture-supplied noise predictions. At the distances to the nearest pertinent CEC receptor locations, approximately 1,700 feet to Receptor 5 (to the southwest) and approximately 2,550 feet to Receptor 1 (to the northwest), the predicted noise levels (assuming only spherical spreading loss for propagation attenuation) attributed to the Natural Draft Cooling System were 42 dBA at Receptor 1 and 47 dBA at Receptor 5. The measured ranges of 10-minute L_{eq} at these locations were 53 to 64 dBA (Location 1) and 71 to 79 dBA (Location 5). Again, it should be noted that at both these locations nearest to the MLPP Units 1&2, contributions from Units 1&2 were not audible or measurable.

Since the incremental contribution from the Natural Draft Cooling Water System was more than 10 dB below the lowest measured values at both Locations 1 and 5, Duke concluded that this cooling alternative would not produce a discernible difference to the compliant conditions at these two nearest receptor locations. The other CEC assessment locations were not evaluated since they are two to five times more distant, and any potential incremental cooling system noise contributions would be even less consequential, compared to the current conditions. It should be noted, however, that noise levels at other locations around the MLPP site that are adjacent to the new cooling systems, primarily just to the south of the plant along Dolan Road, may increase discernibly. However, to the south of the MLPP is another heavy-industrial land use, a mineral processing facility, that is not considered a sensitive receptor. These facts, coupled with the significant influence of traffic noise sources along Dolan Road, indicate that there would not be significant impacts along the MLPP property boundary that is adjacent to the prospective cooling system.

Since all potential noise impacts from the Natural Draft Cooling System are deemed to be insignificant, no noise mitigation is called for and no noise-related additional costs would be involved in the implementation of this cooling alternative.

Air quality

Technical assumptions

The natural draft cooling system using sea water is assumed to have the following characteristics:

Table D-27
Cooling Tower Design Parameters
Sea Water Natural Draft Cooling System

Parameter	Value
Number of towers	1
Number of cells per tower	1
Overall length, per tower (feet)	255 (dia;base)
Overall width, per tower (feet)	150 (dia;mid)
Elevation at top of tower (feet above grade)	450
Elevation at fan deck (feet above grade)	N/A
Exhaust stack diameter (feet)	170
Circulating water flow rate (gal/min)	230,000
Circulating water flow rate (lbs/hr)	115,000,000
Drift rate (%)	0.0005%
Drift rate (lbs water/hr)	575
Makeup water TDS level (ppmw)	35,000
Cycles of concentration	2
Basin TDS level (ppmw)	70,000
PM_{10} Emissions	
Grams/second (per cell)	5.3
Pounds/hour (per tower)	42.0
Tons/year (total, all towers)	184
Exhaust gas flow rate (per cell; acfm)	15,222,000
Exhaust gas temperature (°F)	98°F

Direct emissions

Based on the above assumptions, the sea water natural draft cooling system will have direct PM_{10} emissions of approximately 184 tons/year. By way of comparison, the maximum allowable direct PM_{10} emissions from the combined cycle power plant are 151.2 tons/year (total for all four turbines). Thus, the use of the sea water natural draft cooling alternative would more than double the PM_{10} emissions associated with the combined cycle units.

Direct air quality impacts

Table D-28 shows the current permit limits for the combined cycle units, and the increase in emissions (above those limits) associated with the sea water natural draft cooling system.

Table D-28
Current Emission Limits and Changes
Sea Water Natural Draft Cooling System (tons/year)

	VOC	CO	NOx	SOx	PM_{10}
Current Emission Limits	348	7,191	659	55	508
Increase due to Sea Water Natural Draft Cooling System	0.0	0.0	0.0	0.0	184
Revised Emission Limits Required	348	7,191	659	55	692
BACT required?	No	No	No	No	Yes
Offsets required?	No	No	No	No	Yes
Note: Emission limits apply to the combined emissions from all power generation equipment at the Moss Landing facility, including Units 6&7 and the combined cycle units. Emissions are limited on a calendar quarter basis, but are shown here in units of tons/year for purposes of simplification.					

As shown in Table D-28, the addition of a sea water natural draft cooling system will trigger requirements for best available control technology (BACT) and emission offsets. The use of drift eliminators with an efficiency of 0.0005%, already incorporated into the cooling system design, is expected to satisfy the BACT requirements. Emission offsets in the amount of 184 tons/year of PM_{10} would be required to satisfy Monterey air district requirements.

Table D-29 shows all of the PM_{10} emission reduction credits held within the Monterey air district at this time.[41] Not all of these credits are available for sale; based on Duke's experience in seeking offsets for the combined cycle units in 1999 and 2000, it is Duke's understanding that most of these credits are being held for future use by their current owners. However, even if all of these credits were available for sale, the quantity of PM_{10} credits would not be sufficient to satisfy the regulatory requirements. Only if the Monterey air district approved the use of SOx and NOx credits to offset the PM_{10} impacts from the cooling tower and credits not generally available for sale were to come onto the market would there be sufficient emission reduction credits available for this cooling alternative. Even in such a case, the sea water mechanical draft

[41] Credits for PM_{10} precursors, including SOx and NOx emissions, are shown as well, under the assumption that these could be used, at a 1.0:1 ratio, to satisfy Monterey Air District offset requirements.

cooling alternative would consume approximately 20% to 40% of the total quantity of PM_{10} precursors available within the entire Monterey air district.

The California Air Resources Board's Emission Reduction Credits Offsets Transaction Cost Summary Report for 2002 (http://www.arb.ca.gov/erco/erco.htm) indicates an average cost of \$19,690 per ton for PM_{10} credits in 2002 in the Monterey air district. Although this cost was based on a single transaction, the average cost per ton for PM_{10} credits in the Monterey air district in 2001 was comparable, at \$18,580 per ton. To estimate the cost of obtaining the necessary emission reduction credits for the sea water natural draft cooling alternative, an assumed cost of \$19,000 per ton was used. At this price, the cost of obtaining the required PM_{10} emission reduction credits would be between \$4.2 million and \$7.0 million, depending on the location of the credit source.

Due to the large quantity of offsets required, the question as to whether there are sufficient offsets for sale, and the large fraction of the Monterey air district's offset market that would be impacted, this option is believed to be infeasible.

Table D-29
Current Inventory of PM_{10} Precursor Emission Reduction Credits
Monterey Bay Unified APCD (tons/year)

ERC Holder	NOx	SOx	PM_{10}	Total
U.S. Army	1.5	2.0	0.3	3.8
Texaco USA	56.6	144.6	58.0	259.2
Tri Valley	3.8	0.1	0.3	4.2
Stone Container	1.9	0.0	0.0	1.9
AERA Energy	289.7	208.6	120.9	619.2
National Refractories	53.3	0.3	0.2	53.8
Salz Leathers	0.6	0.0	0.2	0.8
Totals	**407.4**	**355.6**	**179.9**	**942.9**
ERCs Required[1]			**221 – 368**	

Note:

1. The quantity of ERCs required reflect the application of Monterey air district offset ratios of 1.2:1 to 2.0:1, depending on the location of the ERC source.

The air quality impacts of the sea water natural draft cooling system were assessed using the same dispersion models as were used in the application for certification for the combined cycle units. The results of the dispersion modeling analysis are shown in Tables D-30, D-31, and D-32. These tables present the original and revised modeling results and compare them with the applicable federal PSD significance thresholds, preconstruction monitoring de minimis levels, and ambient air quality standards, respectively.

Table D-30
Maximum Modeled Impacts and Federal PSD Significance Thresholds Moss Landing Power Plant Combined Cycle Units With Sea Water Natural Draft Cooling

POLLUTANT	AVERAGING TIME	MAXIMUM MODELED IMPACTS (μg/m³)		FEDERAL PSD SIGNIFICANCE THRESHOLD (μg/m³)	SIGNIFICANT UNDER FEDERAL PSD?	
		Original	Revised		Original	Revised
NO_2	Annual	0.4	12.8	1	No	Yes
PM_{10}	24-Hour	5.9	35.3	5	Yes	Yes
	Annual	0.2	6.1	1	No	Yes

Table D-31
Comparison of Modeled Concentrations with Federal PSD Preconstruction Monitoring Thresholds Moss Landing Power Plant Combined Cycle Units with Sea Water Natural Draft Cooling

POLLUTANT	AVERAGING TIME	EXEMPTION CONCENTRATION (μg/m³)	MAXIMUM MODELED CONCENTRATION (μg/m³)	
			Original	Revised
NOx	annual	14	0.4	12.8
SO_2	24 hours	13	0.7	4.2
CO	8 hours	575	296.1	2585
PM_{10}	24 hours	10	5.9	35.3

Table D-32
Modeled Maximum Project Impacts
Moss Landing Power Plant Combined Cycle Units with Sea Water Natural Draft Cooling

POLLUTANT	AVERAGING TIME	MAXIMUM PROJECT IMPACT ($\mu g/m^3$)		BACKGROUND CONCENTRATIONS ($\mu g/m^3$)	TOTAL IMPACT ($\mu g/m^3$)		MOST STRINGENT STANDARD ($\mu g/m^3$)
		Original	Revised		Original	Revised	
NO_2	1-hour	148.2	235.7	113	261	349	470
	Annual	0.4	12.8	21	21.4	34	100
SO_2	1-hour	7.1	16.0	156	163	172	650
	24-hour	0.7	4.2	39	40	43	109
	Annual	0	0.8	0	0	1	80
CO	1-hour	2,228	2,228	6,900	9,128	9,128	23,000
	8-hour	296	2,585	3,222	3,518	5,807	10,000
PM_{10}	24-hour	5.9	35.3	59	65	94	50
	Annual	0.2	6.1	20.8	21.0	26.9	20

The modeling analysis indicates that concentrations of all pollutants will increase by a substantial amount as a result of the sea water natural draft cooling tower. The increase in 24-hour average PM_{10} concentrations is so great that it would violate the Monterey air district's allowable increment of 21.1 $\mu g/m^3$ for that pollutant. As a result, this alternative could not be permitted under Monterey air district rules and, as a result, is infeasible.

Indirect air quality impacts

As discussed above, the sea water natural draft cooling alternative will reduce the plant's output by 26 MW. This will result in the need to generate additional power from other power generation sources. Since the Moss Landing combined cycle units are among the cleanest generating units in the country, it is unlikely that the replacement energy will be provided by a lower emitting source. Consequently, the emissions increase associated with this replacement power are conservatively estimated based on the pounds of emissions per megawatt hour (lbs/MWh) produced by the Moss Landing combined cycle units. This increase in emissions is shown in Table D-33.

Table D-33
Indirect Emission Increases
Sea Water Natural Draft Cooling System

	VOC	CO	NOx	SOx	PM_{10}
Maximum Annual Emissions from Moss Landing Combined Cycle Units (tons/year)	89.4	1,326.4	284.5	21.8	151.2
Lbs/MWh emission rate[1]	0.020	0.301	0.065	0.005	0.034
Indirect emission increases[2] (tons/year)	2.3	34.1	7.4	0.6	3.9

Notes:

1. Calculated based on 8400 hours per year of full load operation at 1060 MW, consistent with the assumptions used for maximum annual emissions.
2. Calculated based on 226,800 MWh of energy lost due to parasitic and/or efficiency losses associated with the sea water natural draft cooling system. There is a small difference between this amount of lost energy and that shown in Appendix I. This small difference has no material effect on the calculation.

Visible water vapor plumes

The sea water natural draft cooling system will result in the formation of visible plumes under certain meteorological conditions. Using models that have been developed for the purpose of analyzing the frequency and dimensions of visible water vapor plumes in proceedings of the California Energy Commission, the proposed sea water natural draft cooling system was analyzed. The results of this analysis are presented in Tables D-34 and D-35.

Table D-34
Visible Plume Frequency
Sea Water Natural Draft Cooling System

	Sea Water Natural Draft Cooling Tower		
	1997 Moss Landing Meteorological Data		
	All Hours	Daylight Hours	Night Hours
	Frequencies for all plumes		
Number of hours when plume is visible	8472	4276	4196
Hours in period	8760	4380	4380
Percent of hours in period when plume is visible	97%	98%	96%
Percent of all hours when plume is visible	97%	49%	48%

	Hours
	Average
	761
F	410
	1705
	t
F	

The data i ater natural draft cooling sy with respect to visual reso

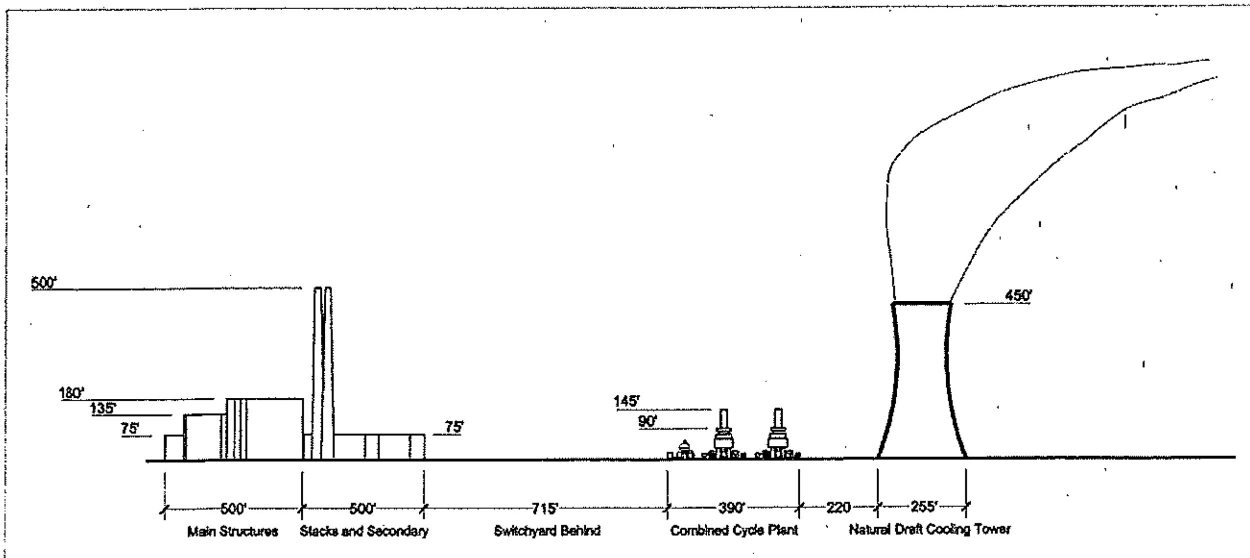
Visual

The natura ject site does little to af 250 foot wide structure v

Equipmen

Figure D-8 tion to the existing in ower would be the furthes acks, to the west, are s le of the proposed c on the Project site. The considerably smaller in

Figure D-8:
Elevations of the Natural Draft Cooling Tower



Existing Facilities with Natural Draft Cooling Tower
Elevation - View Looking North

Source: DFD/EDAW, Inc. April 2003

Plume size and frequency

The size of the water vapor plume that is expected during the average conditions is presented in TableD-35 in the air quality section above. On average, during daylight hours, the plume emitted from the Natural Draft Cooling Tower would rise 870 feet into the air, and would be 693 feet in length. Larger plumes would occur regularly. The frequency that the expected plume would be visible is 98 percent during daylight hours, and 96 percent during nighttime hours. Overall, the plume from the Natural Draft Cooling Tower would be visible for 97 percent of the time.

KOP discussion

Full size photo simulations of the Natural Draft Cooling Tower are provided as Figures VIS D, G and J and are available in the Appendix F. The following discussion focuses what is visible from the KOPs, as well as the duration and number of viewers at each KOP location.

KOP 6: NW View from Intersection of Sandholdt Road and Highway 1 (Figure VIS D)

This photo point is 4,900 feet south of the Project site, along Highway 1. When looking north towards the site, the main visual features include the existing 500' stack (only one of two is visible), as well as the 450' high and approximately 250' wide Natural Draft Cooling Tower to the east. The proposed Natural Draft Cooling Tower attracts considerable visual attention and appears as an icon of the nuclear industry (even though MLPP is not nuclear). The water vapor plumes emitted from both of these features are clearly evident, particularly from the Natural Draft Cooling Tower. The plume portrayed is a statistical average and does not necessarily reflect the meteorological conditions present at the time of the photograph. Even though this site encompasses an existing power generation facility, the amount of visual change created by the Natural Draft Cooling Tower represents a significant change to the existing visual character and quality of this viewshed, and therefore the impact would be significant.

<u>Number of viewers & duration of view</u>

The viewers from this location, documented in the AFC include residential, recreational, and mobile populations. Approximately 176 people live within 78 acres of the Project site that would have a constant duration view from this general direction. On average, the 200 daily recreational visitors to the Salinas River State Beach would have an extended duration view of the Project site (typically a couple of hours). Traveling on Highway 1, approximately 24,500 vehicles per day would have a moderate duration view of the Project site due to the flat topography of the surrounding landscape as well as the orientation of the Highway 1. For all types of viewers, the duration of view of the Natural Draft Cooling Tower would be higher than any existing feature in the viewshed (with the exception of the 500 foot stacks), due to the massive scale and distant visibility of the proposed structure. Mitigation of this visual impact is not feasible.

KOP 8: SSE View from Highway 1 Bridge over Elkhorn Slough **(Figure VIS G)**

This simulation from KOP 8 clearly shows the proposed Natural Draft Cooling Tower from a distance of 4,000 feet north of the Project site along Highway 1. The plume emitted from this massive structure extends out of the normal cone of view from this perspective on Highway 1. Here as with KOP 6, the visual impact of the Natural Draft Cooling Tower would be significant. The Natural Draft Cooling Tower would be a prominent visual element and noticeably degrade the visual quality of the existing viewshed. The addition of this proposed cooling alternative presents a feeling of heavy urbanization and industrialization into the view, as it greatly expands the realized footprint of the power plant.

<u>Number of viewers & duration of view</u>

Most viewers from this KOP would be mobile travelers. On average, approximately 24,500 southbound vehicles experience this moderately short duration view along Highway 1. A similar, but lower angle view is available to recreational users below the bridge on Elkhorn Slough.

KOP 9: SE View from Moss Landing State Beach at Elkhorn Slough **(Figure VIS J)**

The addition of the proposed Natural Draft Cooling Tower adds to visual dominance of the industrial infrastructure from this location and would degrade the visual quality of the beach experience. The Natural Draft Cooling Tower structure, as well as the water vapor plume emitted from the stack, would be a prominent visual element in the landscape, draw significant visual attention to the Project site, and take the visual focus away from the views of the much more natural surroundings. The visual quality of the overall viewshed would be substantially diminished with the addition of the proposed Natural Draft Cooling Tower; therefore, it would have a significant adverse visual impact.

Number of viewers & duration of view

According to the AFC, an estimated 800 vehicles per day would experience the short duration view of the Project site from KOP 9. The Moss Landing State Park has an average daily visitation of 191 people, who would experience a moderately long duration view of the Project site (depending on how long they stay – typically a couple hours). There is one residence, within 144 acres of the Project site, which would have an extended duration view from this general direction.

Summary

Implementation of the Natural Draft Cooling Tower would represent a significant adverse impact to the existing visual environment. This structure is massive in form, and produces, on average, an 870 feet high by 693 feet long water vapor plume that is visible 97 percent of the time. This would represent a dramatic change to the existing visual character of the landscape from almost all views. Due to the scale of this facility, mitigation could not be effective. This new structure would attract visual attention from essentially all areas that can currently see the existing 500 foot tall stacks on the Project site. The intrusion of this structure on the existing views would be far greater than that of any other alternative cooling options.

Cumulative Impacts

What was recently an industrial site with two massive stacks and an extensive oil tank farm, has now has been cleaned up. Old stacks and the tank farm have been removed and have been replaced with a new, more compact combined cycle facility. The compactness of that facility, however, would be diminished by the addition of a larger, visually obvious power generation equipment, such as the Natural Draft Cooling tower.

The incremental addition of new large equipment on the MLPP site, as illustrated in this Natural Draft Cooling Tower example, would create a completely urbanized industrial complex. The addition of a massive tower on the Project site would draw more attention to the amount of development on the site, and change the visual character of the overall viewshed, particularly in relationship to the Elkhorn Slough and the Moss Landing Harbor. Overall, natural draft cooling would have significant, unmitigatable adverse impacts.

Land Use

Visual LORS Conflicts

As discussed above, the natural draft cooling option requires a 150 foot wide and 450 foot high tower that would emit a near constant plume 870 feet high and 693 feet in length. Given the size, height, location, and plume presented by this option there are several conflicts with existing land use LORS.

There are multiple policies in the Costal Act, Certified Land Use Plan, and Coastal Implementation Plan, as well as the North County Area Plan, and County General Plan that call for protecting and improving the visual corridors in Moss Landing. For example, Section 30251 of the Coastal Act states:

> The scenic and visual qualities of coastal areas shall be considered and protected as a resource of public importance. Permitted development shall be sited and designed to protect views to and along the ocean and scenic coastal areas, to minimize the alteration of natural land forms, to be visually compatible with the character of surrounding areas, and, where feasible, to restore and enhance visual quality in visually degraded areas. New development in highly scenic areas such as those designated in the California Coastline Preservation and Recreation Plan prepared by the Department of Parks and Recreation and by local government shall be subordinate to the character of its setting.

Section 20.144.140.B.5.c of the Coastal Implementation Plan states, "Development of new or expanded industrial facilities shall only be permitted where… [t]he development shall meet visual resource, environmentally sensitive habitat, and other development standards of this ordinance." Similarly, the LUP policy 2.2.2 states "views to and along the ocean shoreline from Highway One, Molera Road, Struce Road and public beaches, and to and along the shoreline of Elkhorn Slough from public vantage points shall be protected."

Placing this tower on the MLPP site is not consistent with state and local visual policies due to the cumulative nature of the visual impacts (see the visual analysis and KOPs for more specific information on the detrimental visual impacts).

Height Restrictions

The 450 foot high natural draft cooling tower would not comply with the County of Monterey Title 20: Coastal Implementation Plan Part 1 Section 20.28.070 A or the exception clause listed in 20.62.303 C. This clause requires the cubical contents on the 450-foot high structure to be less that the cubical contents of the same structure if it were 35 feet tall; it is not feasible to build this technology 35 feet high. Accordingly, this option creates a non-conforming use due to the height limit that would only be permitted if the County Board of Supervisors approved change to the current ordinance.

Conclusions

The following table summarizes Duke's conclusions about natural draft cooling.

Table D-36: Natural Draft Cooling System

Question	Answer
Is this alternative potentially effective at reducing entrainment at MLPP? To what extent?	Yes. Seawater use and therefore entrainment would be reduced approximately 95%.
Is the alternative proven and available (i.e. it has demonstrated operability and reliability at a cooling water intake having a similar size and environmental setting to that at the MLPP).	Yes, but in locations with much different characteristics (very large cooling water flow rates, humid climate, and no severe seismic constraints.)
Are there reasons that this alternative may not be feasible? Alternatively, is the alternative feasible at MLPP site, based on site-specific conditions and considerations of engineering, operations, efficiency and reliability?	Yes. There are no obvious ways to secure particulate offsets (or alternative to acquire an adequately large freshwater supply for a freshwater system), to mitigate for visual resource impacts, or to overcome land use zoning restrictions. This system would also create unknown impacts from salt deposition through the local area, including in and around the PG&E switchyard.
What are the costs of this alternative relative to once-through cooling?	The PV of the April 2000 case is $70.1 million. The incremental PV of the April 2000 case over-and-above the once-through system is $14 million. The PV of the real world today case is $131.6 million. The incremental PV of the real world today case over-and-above the once-through system is $75.5 million.
What are the environmental benefits of this alternative? Can the alternative be applied at MLPP in a way that is consistent with all applicable laws, ordinances, regulations and standards? Will the technology cause or increase significant adverse environmental impacts relative to once-through cooling?	There are no net environmental benefits to this alternative. The economic value of the entrained species is minor. For example, using EPA's trophic transfer rule, the maximum estimated benefit of reduced entrainment arising from a reduction of entrained goby biomass that became harvested halibut would create a benefit worth approximately $2,900. The Elkhorn Slough enhancement program is preferable to the alternative of avoiding the entrainment. Also, this system would create the following impacts: Massive new structure in view sheds Near constant visual plumes Particulate emissions Land use zoning and height restriction violations
Is the cost of the alternative wholly disproportionate to the environmental benefit?	Yes.

Dry Cooling System

General Description

This closed-cycle cooling water alternative would replace the once-through seawater cooling system with a direct air-cooled condenser (ACC) system. The ACCs would utilize ambient air to condense the exhaust from the existing steam turbine generators (STGs), thus replacing the existing surface condensers. ACCs are commonly used on combined cycle power plants in arid regions with insufficient water supplies for wet cooling.

In an ACC system, exhaust steam from the steam turbine generator (STG) is cooled and condensed in a large external heat exchanger using atmospheric air as the cooling medium. Figures D-9 presents a schematic flow sketch for this type of cooling system and Figure D-10 shows a photograph of a typical ACC.. Large, electric motor-driven fans move large quantities of air across finned tubes (similar in principle to an automobile radiator) through which the exhaust steam is flowing. Heat transfer from the hot steam to the air cools the steam, which condenses and is returned to the steam cycle. The now warmer air is exhausted to the atmosphere. In this case, no seawater is required for condenser cooling.

Air-cooled condensers for power plants are very large structures and consume significant amounts of power for fan operation. The higher condensing temperature of these ACC systems significantly lowers steam turbine power output and electrical generation compared to electrical efficiency of once-through or recirculating water-cooled condensers.

Design and Sizing

The required air cooled condenser size for a particular application depends on: the maximum steam flow rate exiting the STG, the desired or maximum allowable exhaust pressure for the STG (back pressure), and the maximum ambient air temperature at which the STG maximum back pressure is to be met. The STG back pressure is mainly dependent on the condensing temperature of the steam in the ACC. The higher the condensing temperature, the higher the back pressure on the STG. Higher back pressure translates to less energy extracted by the STG, which decreases the thermal efficiency of the turbine and thereby lowers the amount of electricity generated for a fixed fuel consumption rate.

The condensing steam temperature for a given steam flow rate depends on the ambient air temperature and the amount of surface area available for heat transfer. Obviously, the condensing temperature cannot be less than the air temperature. The smaller the difference between the condensing temperature and the air temperature, the more surface area required and a larger ACC structure. Selecting the ACC size, then, is a tradeoff between ACC cost and the value of lost power generation for the STG within the additional constraint of allowable STG back pressure limitations.

The performance computations for the ACC have been based on the existing MLPP steam turbine.

Figure D-9: Dry Cooling Schematic Flow Sketch

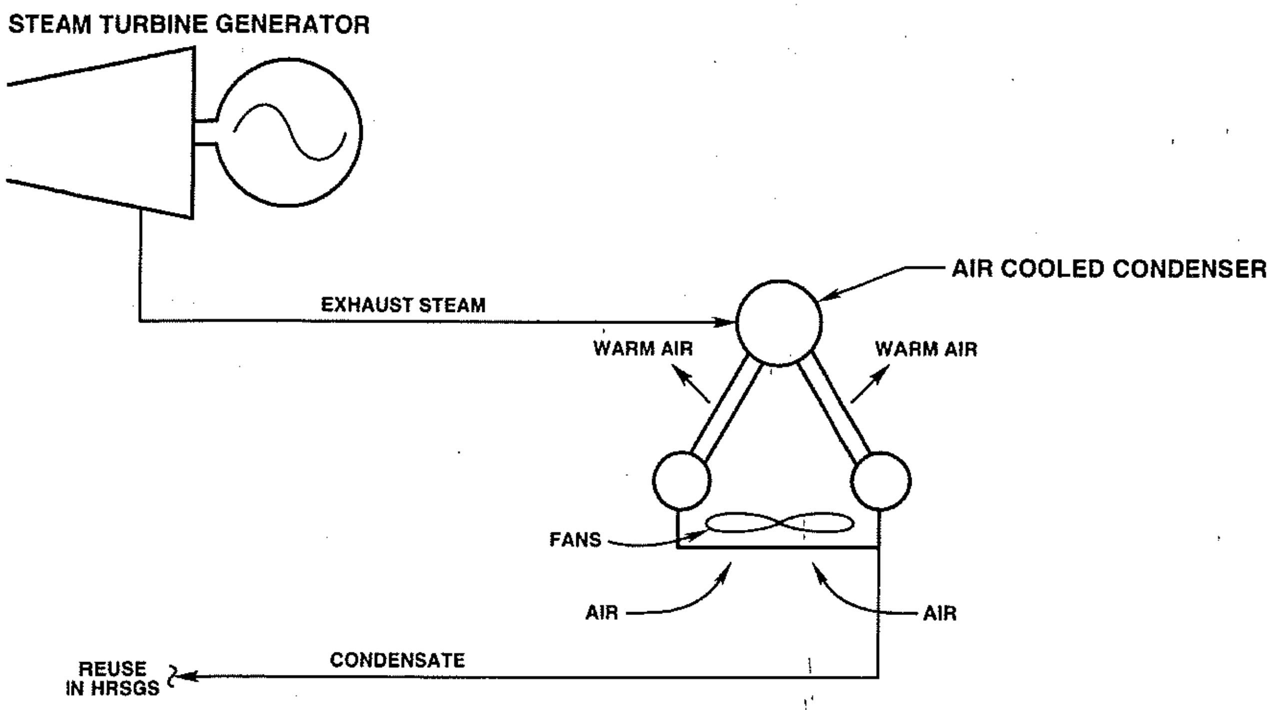
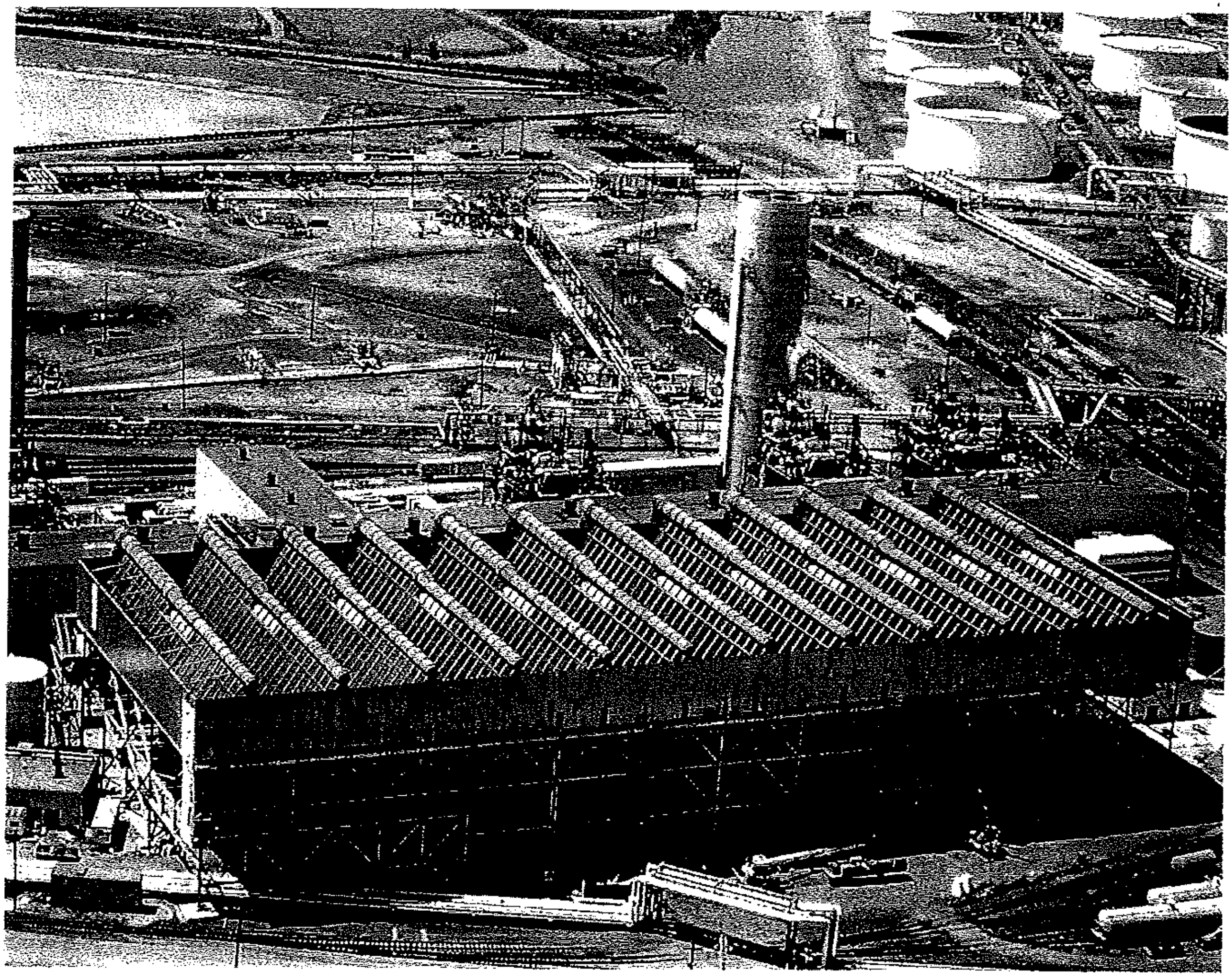


Figure D-10: Dry Cooling System Photograph. (Courtesy of GEA)



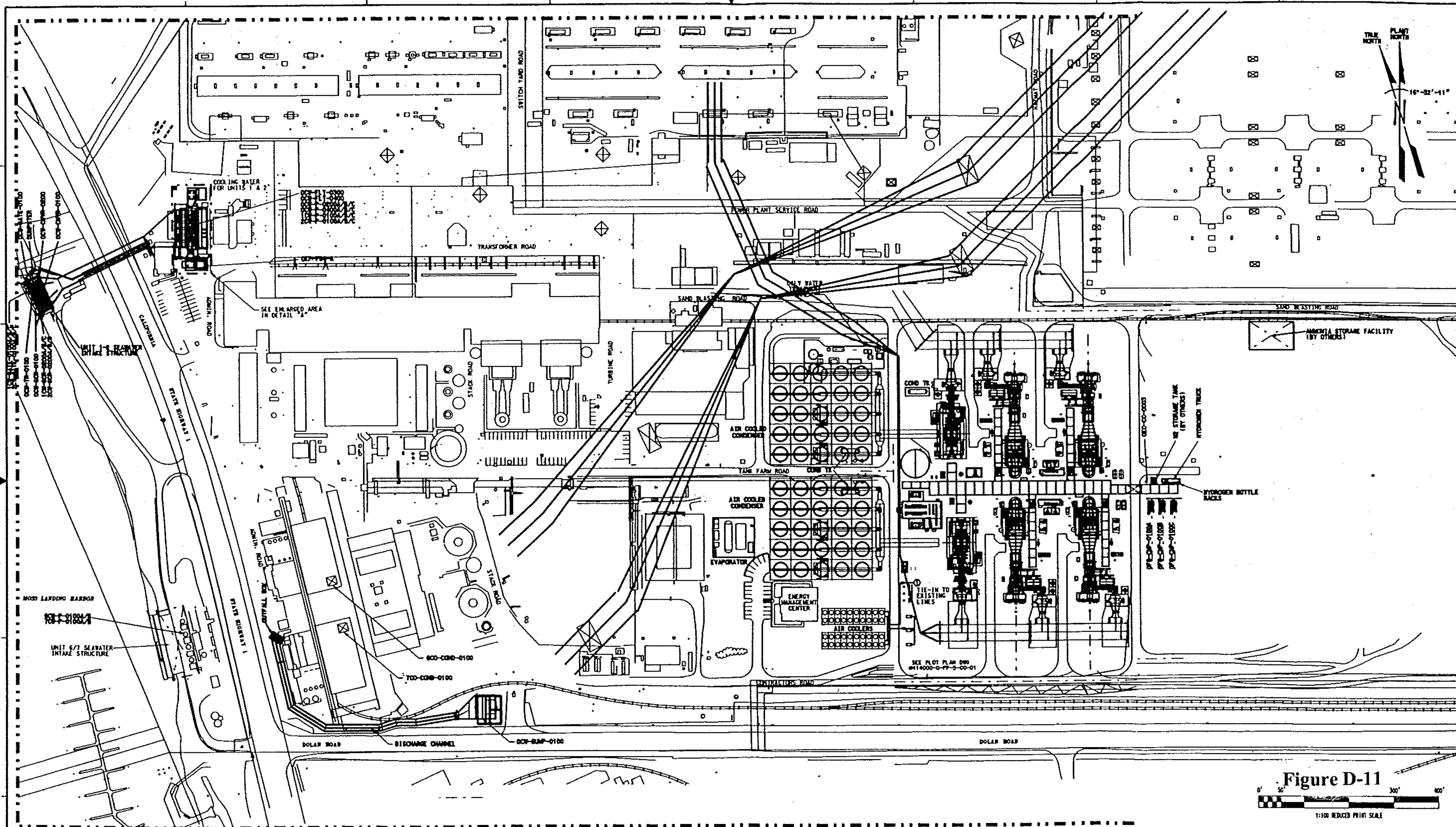


Figure D-11

REV.	DATE	REVISION DESCRIPTION	DRWN CHK.	LAYO MECH	CIVIL ELEC	ENGR PROJ
1	10/17/00	APPROVED FOR CONSTRUCTION	RK HS	MB		
2	04/18/01	APPROVED FOR CONSTRUCTION	WA HB	MB		

DWG. NO.	REFERENCE DRAWINGS
414000-0-PP-5-00-01	PLOT PLAN, POWER GENERATION UNITS 1 & 2
414000-0-PP-5-00-03	OVERALL PLOT PLAN, POWER PLANT-EAST

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DUKE ENERGY NORTH AMERICA, LLC
MOSS LANDING POWER PLANT PROJECT
MOSS LANDING, CA

OVERALL PLOT PLAN
POWER PLANT - WEST
AIR COOLED CONDENSER

SCALE 1"=100' — 414000-0-PP-5-002-2-2

03-APR-2003 14:12 — MANUAL CHANGES MADE - YES ☐ NO☐ — DWG. FILE UPDATED - YES ☐ NO☐ — MODEL UPDATED - YES ☐ NO☐

DIST. CODE 051 WRK. PKG. A CADD FILE No. PP02.DGN

Moss Landing Considerations

An important consideration in retrofitting an ACC for the existing Moss Landing combined cycle units is to meet the constraints of the existing STGs, which are designed for the much lower condensing pressure achievable with the present once-through cooling system. For this reason, a relatively high design ambient temperature of 85 °F was specified for sizing the ACC to avoid an automatic high back pressure shutdown of the STG during warm conditions.

Given these constraints and parameters, the dry cooling system for the MLPP Units 1&2 would consists of two separate ACCs, one for each unit. Each ACC would be about 220 ft wide by 230 ft long by 102 ft high and contain 25 individual air fan modules.

Condenser Location and Supporting Facilities

The ACC is usually located as close possible to the STG due the very large and costly vacuum ductwork needed to connect the ACC to the STG. For a new greenfield plant, this requirement is a primary consideration in the development of the plant arrangement. Given the location of the existing STGs at the Moss Landing plant, the logical location for new ACCs would be immediately to the west of Units 1&2. However, this area has insufficient open space to accommodate the new equipment without substantial relocation of existing facilities.

As an alternate, the vacant area immediately to the east of the existing combined cycle units was evaluated for the new ACCs. The challenges involved with this location are immense. The vacuum duct lines to convey the STG exhaust steam to each ACC would be 16 feet in diameter, much too large for the two required lines to take the most direct route along the existing piperack separating Unit 1 and Unit 2. The only option would be to route the lines around the existing plant, probably one to the north of Unit 1 and the other to the south of Unit 2. These routes would each be about 900 feet in length and would need to be at least partially elevated to allow satisfactory operations and maintenance access to, as well as safety egress from, the existing plants. Elevating these very large lines would significantly add to the installation cost. Longer lines and changes in direction (elbows) would also add to the system frictional losses with the end result of an additional increase in STG back pressure, further degrading the plant thermal efficiency. Also, since these lines operate at elevated temperature, thermal expansion of the metal must be accommodated with expansion joints and/or expansion loops. Since the length of thermal expansion is proportional to the total system length, these long lines would require very elaborate thermal expansion control. For all these reasons, the eastern location for the ACCs was not given further consideration.

Therefore, although extensive relocation of existing facilities would be required as described below, the western location was selected for this evaluation. Figure D-11 shows the proposed location for the new ACCs and the considerable plot space that would be consumed (about the same size area as currently occupied by two of the existing gas turbine generators and a STG). Duke estimates that the new air-cooled condensers for the Moss Landing combined-cycle units, one for each unit, would <u>each</u> occupy more than one acre and extend to a height of about 100 feet to the top of the steam distribution ducting.

In order to make room for the new ACCs, the following equipment and facilities would need to be relocated. Figure D-11 shows the new locations for these existing items:

Two 500 kV transmission lines and one 230 kV transmission line (each of the three systems includes three conductors) which traverse the site at the proposed location would be rerouted away from the new ACCs.

The existing plant oily water separator system would be moved to the north of the ACCs.

The recently completed, new plant seawater evaporation system would have to be moved to the west of the ACCs.

In addition to these relocations, the existing STG surface condensers would need to be substantially demolished and removed to provide clearance for the new 16-foot diameter steam ducts.

The existing plant includes an auxiliary cooling system for miscellaneous equipment cooling requirements such as such as lube oil coolers, rotating equipment bearing cooling, etc. This auxiliary cooling system currently uses heat exchangers to reject this waste heat to a small side stream from the once-through cooling system. Since no cooling water system is available for the ACC alternative, the existing heat exchangers will be replaced with new air coolers, similar to the ACCs, but much smaller. The circulating cooling medium for the auxiliary cooling system will be routed to these new air coolers for heat removal instead of the existing heat exchangers.

Use of Existing Facilities

This alternative would completely replace the existing once-through cooling system including:

The Units 1&2 intake structure, cooling water circulation pumps, and traveling screens

The extensive 84- and 120-inch diameter cooling water supply and return underground piping system

The existing surface condensers

The auxiliary cooling system heat exchangers

Virtually none of these recently installed systems could be reused. As described above, the surface condensers would have to be demolished and removed. The large underground piping system would probably be safely abandoned in place, as allowed by applicable codes and regulations. Other equipment would be abandoned in place, removed and salvaged, or scrapped.

Plant Performance

Air-cooled condensers for power plants are very large structures and consume significant amounts of power for operation of the fans. The combination of the higher steam turbine condenser temperatures and the higher plant electrical load caused by the air cooled condensing system would decrease the net power output available from the combined cycle units significantly more than any other cooling alternative considered in this evaluation. At the annual average site conditions, ACCs would diminish the net power output and operating efficiency of the existing plant by about 20 MW as compared to once-through cooling for the same fuel consumption. This significant shortfall in generation would have to be met by another plant that would likely not be as efficient as the current Moss Landing facility and would require more natural gas than if once-through cooling continues at Moss Landing.

Similar to the seawater mechanical draft cooling tower, the efficiency degradation attributable to the ACCs, as compared to the existing once-through cooling system, would also cause an increase in the amount of fuel required for a given amount of electricity generated. This power output loss would be much greater at higher ambient temperatures. The heat rate (fuel consumed per unit of net power produced) would be increased from about 6790 Btu/kW-hr for the existing plant to about 7080 Btu/kW-hr for the ACC option. (See the previous plant performance discussion for the seawater mechanical draft tower for a more detailed description of plant capacity and heat rate.)

For purposes of this analysis, however Duke conservatively assumes that only a portion of the cost element discussed here is considered for the economic comparisons: the additional cost per unit of production to run the facility at the lower capacity.

Environmental Features

The following environmental protection features are incorporated into the conceptual design of the air-cooled condenser system:

> At the proposed location, the ACC structures would be effectively shielded by existing structures or landscaping as much as practical to minimize visual impacts from key observation points (refer to following visual analysis).
>
> Manufacturer information indicated that each Air-Cooled Condenser bank would be predicted (on an engineering estimate basis) to produce 63 dBA at 400 feet from the bank. There are condensed water recirculation pumps associated with each bank, which are estimated to produce no more than 59 dBA at 400 feet (assuming no special noise control treatments or designs). The auxiliary Air Coolers have fan drive motors of only 25 horsepower (hp). As such, they were considered as inconsequential when compared to the much larger, much noisier 200 hp motors for the main Air-Cooled Condenser banks and the Auxiliary Air Coolers were not included in the evaluation.

There are no atmospheric emissions directly associated with the ACCs.[42] Consequently, there are no air quality environmental protection measures incorporated into the design for this alternative.

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[42] However, there would probably be increased system-wide emissions because the reduced output at Moss Landing would have to be replaced by increased operation at other plants (see following air quality analysis).

Cost Analysis

Table D-37 shows the capital cost components for the dry cooling system. They are shown for both the cases under consideration –the April 2000 case and the Real World Today Case. These cases are explained in more detail in Appendix E. Capital costs for each were estimated by using preliminary design information, by soliciting input from vendors, and by utilizing engineering judgment that includes experience designing and building similar systems elsewhere. Relevant costs to include are: all equipment, installation and erection costs, site preparation, and interference and relocation costs. If applicable, one-time environmental costs are also included.

Table D-37: Capital Costs for Air (Dry) Cooling System ($ millions)

	Air (Dry) Cooling – April 2000 Case	Air (Dry) Cooling – Real World Today Case
Site Preparation	1.4	1.6
Cooling System Equipment Package	48.0	49.4
Installation	15.4	16.3
Demolition / Relocations	n/a	4.1
Transmission Line Relocation	n/a	3.5
Mitigation Costs	n/a	n/a
Total Capital Costs	64.8	74.9

Environmental Analysis

Noise

The noise evaluation used the conceptual layout for this alternative, coupled with manufacture-supplied noise predictions. At the distances to the nearest pertinent CEC receptor locations, approximately 800 feet to Receptor 5 (to the southwest) and approximately 1,600 feet to Receptor 1 (to the northwest), the predicted noise levels (assuming only spherical spreading loss for propagation attenuation) attributed to the Dry Draft Cooling System were 54 dBA at Receptor 1 and 60 dBA at Receptor 5. The measured ranges of 10-minute Leq at these locations were 53 to 64 dBA (Location 1) and 71 to 79 dBA (Location 5). Again, it should be noted that at both these locations nearest to the MLPP Units 1&2, no contributions from Units 1&2 was audible or measurable.

Since the incremental contribution from the Air-Cooled Condenser system was near the lower end of the range of measured noise at Location 1 and more than 10 dB below the lowest measured values at Location 5, Duke concluded that this cooling alternative would not produce a discernible difference to the compliant conditions at these two nearest receptor locations. The other CEC assessment locations were not evaluated since they are two to five times more distant and any potential incremental cooling system noise contributions would be even less consequential, compared to the current conditions. It should be noted, however, that noise levels at other locations around the MLPP site that are adjacent to the new cooling systems, primarily just to the south of the plant along Dolan Road, may increase discernibly. However, to the south of the MLPP is another heavy-industrial land use, a mineral processing facility, that is not considered a sensitive receptor. These facts, coupled with the significant influence of traffic noise sources along Dolan Road, indicate that there would not be significant impacts along the MLPP property boundary that is adjacent to the prospective cooling system.

Since all potential noise impacts from the Air-Cooled Condenser system are deemed to be insignificant, no noise mitigation is called for and no noise-related additional costs would be involved in the implementation of this cooling alternative.

Air quality

Technical assumptions

The dry cooling system is assumed to have the following characteristics:

Table D-38
Cooling Tower Design Parameters
Dry Cooling System

Parameter	Value
Number of condenser arrays	2
Number of cells per array	25
Overall length, per array (feet)	220
Overall width, per array (feet)	230
Elevation at top of array (feet above grade)	102
Elevation at fan deck (feet above grade)	62
Exhaust stack diameter (feet)	N/A
Circulating water flow rate (gal/min)	N/A
Circulating water flow rate (lbs/hr)	N/A
Drift rate (%)	N/A
Drift rate (lbs water/hr)	N/A
Makeup water TDS level (ppmw)	N/A
Cycles of concentration	N/A
Basin TDS level (ppmw)	N/A
PM_{10} Emissions	
Grams/second (per cell)	0.0
Pounds/hour (per tower)	0.0
Tons/year (total, all towers)	0.0
Exhaust gas flow rate (per cell; acfm)	N/A
Exhaust gas temperature (°F)	N/A

Direct emissions

As noted above, the dry cooling system will have no direct PM_{10} emissions.

Direct air quality impacts

Table D-39 shows the current permit limits for the combined cycle units, and the increase in emissions (above those limits) associated with the dry cooling system.

Table D-39
Current Emission Limits and Changes
Dry Cooling System (tons/year)

	VOC	CO	NOx	SOx	PM_{10}
Current Emission Limits	347.8	7,191.0	659.1	55.2	508.2
Increase due to Dry Cooling System	0.0	0.0	0.0	0.0	0.0
Revised Emission Limits Required	347.8	7,191.0	659.1	55.2	508.2
BACT required?	No	No	No	No	No
Offsets required?	No	No	No	No	No
Note: Emission limits apply to the combined emissions from all power generation equipment at the Moss Landing facility, including Units 6&7 and the combined cycle units. Emissions are limited on a calendar quarter basis, but are shown here in units of tons/year for purposes of simplification.					

As shown in Table D-39, the addition of a dry cooling system will not trigger requirements for best available control technology (BACT) or emission offsets.

The air quality impacts of the dry cooling alternative were assessed using the same dispersion models as were used in the application for certification for the combined cycle units. This assessment indicated that the dry cooling system would not affect the dispersion of pollutants from the existing combined cycle units or boilers. As a result, there is no change to local air quality impacts associated with the dry cooling alternative.

Indirect air quality impacts

As discussed above, the dry cooling alternative will reduce the plant's output by between 20 MW and 28 MW, depending on the ambient temperature. This will result in the need to generate additional power from other power generation sources. Since the Moss Landing combined cycle units are among the cleanest generating units in the country, it is unlikely that the replacement energy will be provided by a lower emitting source. Consequently, the emissions increase associated with this replacement power are conservatively estimated based on the pounds of emissions per megawatt hour (lbs/MWh) produced by the Moss Landing combined cycle units. This increase in emissions is shown in Table D-40.

Table D-40
Indirect Emission Increases
Dry Cooling System

	VOC	CO	NOx	SOx	PM_{10}
Maximum Annual Emissions from Moss Landing Combined Cycle Units (tons/year)	89.4	1,326.4	284.5	21.8	151.2
Lbs/MWh emission rate[1]	0.020	0.301	0.065	0.005	0.034
Indirect emission increases[2] (tons/year)	1.7	25.3	5.5	0.4	2.9

Notes:

1. Calculated based on 8400 hours per year of full load operation at 1060 MW, consistent with the assumptions used for maximum annual emissions.
2. Calculated based on 168,000 MWh of energy lost due to parasitic and/or efficiency losses associated with the sea water mechanical draft cooling system. This is based on a 55°F ambient temperature; actual energy losses will be greater during warmer months.

Visible water vapor plumes

The dry cooling system will not result in the formation of visible plumes.

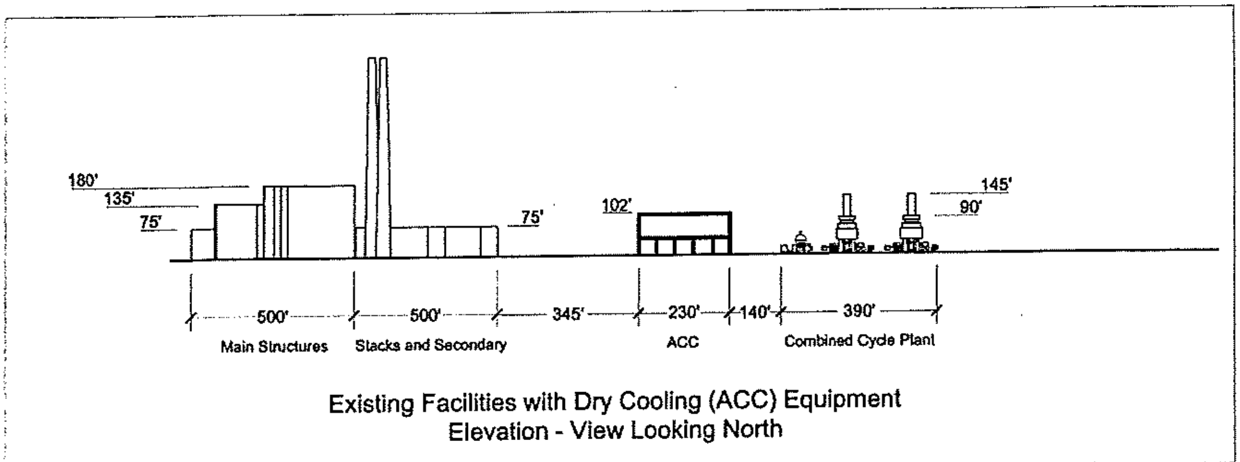
Visual

The Air Cooled Condensers are housed in two structures that are 220 feet by 230 feet and 102 feet high. Twenty-five ACC fan modules are arranged in a 5 x 5 configuration in each structure. The location of the ACCs requires close proximity to the steam turbines, which are located on the western side of Units 1&2 directly to the west of the 145 foot tall HRSG stacks. This places the Dry Cooling System between the new combined cycle Units 1&2 and the older generation facility of Units 6&7.

Equipment size in relation to existing infrastructure

Figure D-12 below shows the elevation of the Dry Cooling System alternative in relation to the existing infrastructure that is currently on the Project site. The ACC buildings are taller (102 feet) than the combined cycle HRSGs (90 feet), which are located directly to the east. As can be seen below the existing infrastructure of Units 6&7 to the west is considerably larger. The ACC buildings would occupy the space between the older equipment and the new combined cycle equipment, which is now occupied by the new oily water separator and other essential equipment.

Figure D-12:
Elevations of the Dry Cooling System



Source: DFD/EDAW, Inc. April 2003

Discussion of Key Observation Points

Please see Appendix F for the following KOP's showing existing conditions and dry cooling system (ACCs are in a 5 x 5 configuration).

KOP 12: NW View from Dolan Road at MLPP Entrance Gate

The Dry Cooling System is a prominent visual feature in the viewshed from Dolan Road. However, since other publicly accessible viewpoints are at such a distance the ACC structure isn't a major visual feature from other perspectives. Therefore, KOPs 6, 8, and 9 are not analyzed for the Dry Cooling System as the structures would not be visible from any of these locations. To show the Dry Cooling System, a new KOP was created. KOP 12 was taken from the MLPP Dolan Road entrance gate and a full size 11 x 17 enlargement is provided as Figure VIS L in the Visual Appendix F.

This photo point is located immediately southwest of the Project site along the southern shoulder of Dolan Road and is approximately 800 feet away from the proposed ACC equipment. The features that are visible from this KOP consist of the existing infrastructure on site, which includes the recently installed Units 1&2 (approximately 1,400 feet away), transmission towers and lines, support infrastructure, as well as the proposed Dry Cooling System alternative. The two large square ACC structures would be clearly evident from this KOP as seen in the simulation. They reinforce the industrial character of the MLPP landscape and make this particular view appear much more urban, or developed in character.

Plume Size and Frequency

The size and frequency of the water vapor plume is not applicable for this alternative cooling option, as no plume would be emitted.

Number of viewers & duration of view

The viewers of the Dry Cooling Alternative from, or near KOP 12 would be travelers along Dolan Road. According to the AFC, approximately 3,300 vehicles pass by the Project site on any given day. Due to the extremely close proximity of the ACC equipment to Dolan Road the structure would appear quite large, but the duration of view would be short. The moderate number of viewers, in combination with the short duration view, would contribute to a less than significant visual impact for the Dry Cooling System alternative.

Summary

The ACC structures do not appear as a dominant visual element from any of the KOPs in the viewshed, except from the nearby KOP 12. The existing infrastructure on the Project site enables the ACC structures to effectively blend into the industrial surroundings, and therefore the ACC alternative is not visually significant. Only to a nearby viewer on Dolan Road, do the ACC structures become visually prominent. Mitigation measures, such as landscaping, and selection of appropriate paint colors, could be implemented to lessen the nearby visual effects as seen from KOP 12. No water vapor plumes would be emitted from the ACC structures.

Cumulative Impacts

What was recently an industrial site with two massive stacks and an extensive oil tank farm, has now has been cleaned up. Old stacks and the tank farm have been removed and replaced with a new smaller, more compact combined cycle facility. The compactness of that facility, however, will be diminished by the addition of larger, visually obvious, power generation equipment, such as the ACC structures.

The incremental addition of new large equipment on the MLPP site would create a completely urbanized industrial complex. More development on the Project site would draw attention to the amount of development on the site, and change the visual character of the viewshed, particularly in relationship to the Elkhorn Slough and the views from Dolan Road. Overall, dry cooling causes an adverse, but less than significant visual impact.

Land use

Conflicts with the County of Monterey Definition of Costal Dependent

The MLPP site is zoned for heavy industrial use in the coastal zone (HI (CZ)). However, multiple policies in the County land use planning documents require any new development or expansion of existing development to be a coastal dependent use (LUP Policies 4.3.6.F.1 and 5.5.2.10 and Coastal Implementation Plan policies 20.144.140.B.5.c.1 and 20.144.160.C.1.k). The Coastal Implementation Plan uses the Coastal Act definition for the term "Coastal-Dependent", consistent with Section 30101 of the Coastal Act, as an area for uses that must be "located on or adjacent to the sea in order to function." (page NC-3) Elimination of the seawater cooling system would render the facility non-coastal dependent and create a project that is inconsistent with these policy requirements. .

Conclusions

The following table summarizes Duke's conclusions about dry cooling.

Table D-41: Air (Dry) Cooling System

Question	Answer
Is this alternative potentially effective at reducing entrainment at MLPP? To what extent?	Yes. Seawater use and therefore entrainment would be reduced completely for Units 1&2.
Is the alternative proven and available (i.e. it has demonstrated operability and reliability at a cooling water intake having a similar size and environmental setting to that at the MLPP).	Duke is not aware of other facilities that have installed dry cooling system to avoid entrainment impacts. Generally, dry cooled systems are in operation elsewhere for other site-specific reasons, principally lack of water supply.
Are there reasons that this alternative may not be feasible? Alternatively, is the alternative feasible at MLPP site, based on site-specific conditions and considerations of engineering, operations, efficiency and reliability?	Yes. There are significant efficiency losses. Also, there is no obvious ways to overcome land use zoning restrictions.
What are the costs of this alternative relative to once-through cooling?	The PV of the April 2000 case is $75.8 million. The incremental PV of the April 2000 case over-and-above the once-through system is $19.7 million. The PV of the real world today case is $139.9 million. The incremental PV of the real world today case over-and-above the once-through system is $83.8 million.
What are the environmental benefits of this alternative? Can the alternative be applied at MLPP in a way that is consistent with all applicable laws, ordinances, regulations and standards? Will the technology cause or increase significant adverse environmental impacts relative to once-through cooling?	There are no net environmental benefits to this alternative compared to the existing program. The economic value of the entrained species is minor. For example, using EPA's trophic transfer rule, the maximum estimated benefit of reduced entrainment arising from a reduction of entrained goby biomass that became harvested halibut would create a benefit worth approximately $2,900. The Elkhorn Slough enhancement program is preferable to the alternative of avoiding the entrainment. Also, this system would create the following impacts: Land use zoning violations Significant efficiency losses
Is the cost of the alternative wholly disproportionate to the environmental benefit?	Yes.

Hybrid (Parallel) Wet/ Dry Cooling System

General Description

This closed-cycle cooling water alternative would replace the existing once-through seawater cooling water system plant with a parallel condensing wet/dry system. This option utilizes a parallel condensing cooling system where the steam turbine exhaust is condensed simultaneously in both a standard steam surface condenser (SSC) and in an air cooled condenser (ACC). This hybrid cooling system is sometimes called a parallel system. Figure D-13 presents a schematic flow sketch for this type of cooling system.

The amount of steam condensed in each device depends on the overall heat load, availability of makeup water for the cooling tower, and ambient conditions. During operation, the condensing pressures in both the SSC and ACC constantly equilibrate due to self-adjustment of steam flows entering each device. For each combination of plant operating load and ambient conditions, the steam flow will split between each device such that the pressure drop across the ACC matches the pressure drop across the SSC. As ambient temperatures become cooler, the steam flow to the ACC will automatically increase as the condensing temperature decreases and vice versa as ambient temperature warms.

Hybrid condensing is most often used when water is available, but not enough to supply the entire plant. Another occasional use of hybrid condensing is for icing abatement of cooling tower plumes in cold climates, because at very cold conditions, a smaller ACC can be used to handle the entire plant condensing load.

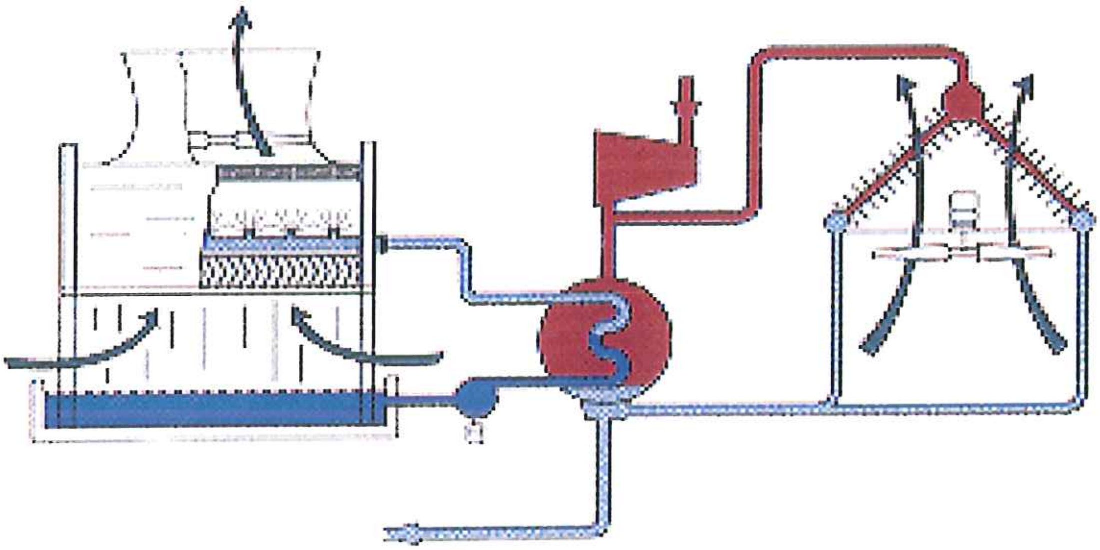
According to one supplier of hybrid condensing systems, hybrid condensing is normally used only when sufficient, economic water is not available or other special circumstances apply, such as plume icing safety concerns. Use of even partial air condensing on warm days will still significantly reduce the plant thermal efficiency.

Design and Sizing

The split between wet and dry cooling for a hybrid condensing system is normally determined by the total condensing load on a warm day and the maximum amount of cooling water available. Alternately, the split can be determined by the dry cooling capacity available on a warm day from an ACC sized for the entire plant cooling load on a very cold day.

Once the cooling load split has been established, the ACC and SSC/mechanical draft cooling tower are designed as previously described (see design discussion in the preceding sections on seawater mechanical draft cooling and ACC).

Figure D-13: Hybrid Schematic Flow Sketch (Courtesy of GEA)



Moss Landing Design Considerations

No obvious design basis has been identified for application of hybrid condensing to the Moss Landing combined cycle units. A 100% seawater mechanical draft cooling tower alternative (without ACC) would eliminate about 97% of the current once-through cooling water use at the plant. Reducing the capacity of wet cooling even further to achieve another one or two percent reduction has insignificant incremental benefits in terms of entrainment. The only limit to fresh water use is that, in practice, none is available. No finite amount of fresh water at a reasonable cost has been located.

In the event that partial PM_{10} offsets were identified, but not in sufficient quantities for a full-sized wet cooling tower, a seawater cooling system could be theoretically sized to match the PM_{10} drift emissions with the available emission offsets. The ACC would then be sized to take up the shortfall in plant cooling requirements. But Duke does not believe that it is realistic to assume that PM_{10} offsets can be purchased.

For these reasons, an arbitrary 50 percent wet cooling, 50 percent dry cooling is selected for the following MLPP hybrid condensing evaluation.

Cooling Tower Location and Supporting Facilities

The condensing alternative would consist of two seawater mechanical draft cooling towers and two ACCs, each approximately one-half the capacity of the previously described systems. One cooling tower/ACC set would serve each existing steam turbine generator.

The new ACCs and cooling towers would be located approximately as shown in the previous descriptions (refer to seawater mechanical towers and ACC plot plan drawings), the ACCs immediately to the west of the existing units and the cooling towers immediately to the east.

The supporting facilities would be as previously described for the separate systems, except that the cooling water pumps and lines, steam ducts, etc. would be sized for half the flows. The existing, full-sized SSCs would be removed to make room for a new steam turbine exhaust duct which would split the exhaust flow to the new ACCs and to new approximately 50 percent capacity SSCs. The areas below and adjacent to the existing steam turbines are fairly congested with existing equipment and plant utility systems. Installation of the new steam ducts and new SSCs would require significant relocation of existing facilities with resulting increased construction costs.

Use of Existing Facilities

Use of existing plant facilities would be similar to the previously described separate cases, the once-through cooling water system could be partially reused for the cooling tower makeup water and blowdown discharge. As mentioned above, the existing SSCs would be removed and replaced with smaller condensers.

Plant Performance

A parallel condensing system would reduce the existing once-through cooled plant capacity by an incremental amount somewhere between the degradation identified for seawater cooling and the ACC cases. For the purpose of this evaluation, the loss in plant capacity at annual average site conditions is assumed to be about 31 MW. The annual average heat rate is assumed to be about 7000 Btu/kW-hr.

Environmental Features

The environmental features are the same as described for the separate cases.

Cost Analysis

The overall capital and operating costs associated with hybrid cooling are evaluated in Appendix E. Providing a cost estimate for the hybrid system is a challenge because it is not obvious how the hybrid system would alleviate some of the fatal flaw considerations of wet towers deployed at MLPP. The logic of using a hybrid system is that it can mitigate the water needs of the system, but in the case of MLPP, there are few options to use either seawater (because of particulate concerns) or freshwater (due to inadequate supply or cost of creating supply). Nonetheless, and for argument's sake, Duke has estimated the likely capital costs of the hybrid system assuming a 50/50 split in cooling load between the dry and wet portions of the system. Table D-41 shows likely capital costs for both the April 2000 and the Real World Today cases. (Appendix E also describes the differences between the two cases.)

Table D-41: Capital Costs for 50/50 Hybrid System ($ millions)

	Hybrid System – April 2000 Case	**Hybrid System – Real World Today Case**
Site Preparation	3.3	3.3
Cooling System Equipment Package	48.7	49.5
Installation	17.6	17.7
Demolition / Relocations	n/a	10.6
Transmission Line Relocation	n/a	3.5
Mitigation Costs	3.5	3.5
Total Capital Costs	73.1	88.1

Environmental Analysis

Noise

A hybrid system would essentially be a half-and-half combination of part of the Dry Cooling Air-Cooled Condensers and part of the Wet Cooling Tower system. Given that the noise evaluations for each of those other alternatives showed similar levels at each pertinent receptor (within 3 dB) and predicted insignificant incremental impacts, the Hybrid System, by extension, is also predicted to have indiscernible noise effects at the CEC assessment locations.

Since all potential noise impacts from the Hybrid Cooling System are deemed to be insignificant, no noise mitigation is called for and no noise-related additional costs would be involved in the implementation of this cooling alternative.

Air quality

Technical assumptions

The mechanical draft/hybrid cooling system using fresh water is assumed to have characteristics somewhere in between those shown above for the fresh water mechanical draft cooling tower and the dry cooling system. The physical dimensions of the tower will be larger than that of the fresh water mechanical draft cooling tower, but the emissions will be lower, in direct proportion to the lower circulating water flow rate and fewer annual hours of operation of the wet section of the tower.

Direct emissions

Based on the above assumptions, the fresh water mechanical draft/hybrid cooling system will have direct PM_{10} emissions somewhere between zero and the 5 tons per year estimated above for the fresh water mechanical draft cooling system. By way of comparison, the maximum allowable direct PM_{10} emissions from the combined cycle power plant are 151 tons/year (total for all four turbines). Thus, the use of the fresh water mechanical draft/hybrid cooling alternative would increase the PM_{10} emissions associated with the combined cycle units by less than 3.5%.

Direct air quality impacts

Table D-42 shows the current permit limits for the combined cycle units, and the increase in emissions (above those limits) associated with the fresh water mechanical draft/hybrid cooling system.

Table D-42
Current Emission Limits and Changes
Fresh Water Mechanical Draft/Hybrid Cooling System (tons/year)

	VOC	CO	NOx	SOx	PM_{10}
Current Emission Limits	348	7,191	659	55	508
Increase due to Fresh Water Mechanical Draft/Hybrid Cooling System	0.0	0.0	0.0	0.0	0 to 5
Revised Emission Limits Required	348	7,191	659	55	508 to 513
BACT required?	No	No	No	No	Yes
Offsets required?	No	No	No	No	Yes
Note: Emission limits apply to the combined emissions from all power generation equipment at the Moss Landing facility, including Units 6&7 and the combined cycle units. Emissions are limited on a calendar quarter basis, but are shown here in units of tons/year for purposes of simplification.					

As shown in Table D-42, the addition of a fresh water mechanical draft/hybrid cooling system will trigger requirements for best available control technology (BACT) and emission offsets. The use of drift eliminators with an efficiency of 0.0005%, already incorporated into the wet cooling system design, is expected to satisfy the BACT requirements. Emission offsets in the amount of up to 5 tons/year of PM_{10} would be required to satisfy Monterey air district requirements.

Table D-43 shows all of the PM_{10} emission reduction credits held within the Monterey air district at this time.[43] Not all of these credits are available for sale; based on Duke's experience in seeking offsets for the combined cycle units in 1999 and 2000, it is Duke's understanding that most of these credits are being held for future use by their current owners. However, it appears that there are sufficient credits available to satisfy Monterey air district requirements for this option.

The California Air Resources Board's Emission Reduction Credits Offsets Transaction Cost Summary Report for 2002 (http://www.arb.ca.gov/erco/erco.htm) indicates an average cost of \$19,690 per ton for PM_{10} credits in 2002 in the Monterey air district. Although this cost was based on a single transaction, the average cost per ton for PM_{10} credits in the Monterey air district in 2001 was comparable, at \$18,580 per ton. To estimate the cost of obtaining the necessary emission reduction credits for the sea water mechanical draft cooling alternative, an assumed cost of \$19,000 per ton was used. At this price, the cost of obtaining the required PM_{10} emission reduction credits would be up to \$200,000, depending on the location of the credit source.

[43] Credits for PM_{10} precursors, including SOx and NOx emissions, are shown as well, under the assumption that these could be used, at a 1.0:1 ratio, to satisfy Monterey Air District offset requirements.

Table D-43
Current Inventory of PM_{10} Precursor Emission Reduction Credits
Monterey Bay Unified APCD (tons/year)

ERC Holder	NOx	SOx	PM_{10}	Total
U.S. Army	1.5	2.0	0.3	3.8
Texaco USA	56.6	144.6	58.0	259.2
Tri Valley	3.8	0.1	0.3	4.2
Stone Container	1.9	0.0	0.0	1.9
AERA Energy	289.7	208.6	120.9	619.2
National Refractories	53.3	0.3	0.2	53.8
Salz Leathers	0.6	0.0	0.2	0.8
Totals	407.4	355.6	179.9	942.9
ERCs Required[1]			0 – 11	

Note:

1. The quantity of ERCs required reflect the application of Monterey air district offset ratios of 1.2:1 to 2.0:1, depending on the location of the ERC source.

The air quality impacts of the fresh water mechanical draft/hybrid cooling system were assessed qualitatively, based on the results of the modeling analyses shown above for the fresh water mechanical draft cooling system. The air quality impacts associated with the mechanical draft/hybrid cooling system are expected to be comparable to, or lower than, those associated with the mechanical draft cooling system. The modeling analysis indicates that 24-hour average and annual PM_{10} concentrations, and annual average NO_2 concentrations, will likely increase as a result of the fresh water mechanical draft/hybrid cooling tower. However, these increases would not change the conclusions regarding the air quality impacts of the project and would not cause any new violations of state or federal ambient air quality standards.

Indirect air quality impacts

As discussed above, the fresh water mechanical draft/hybrid cooling alternative will reduce the plant's output by an amount somewhere in between the losses associated with the fresh water mechanical cooling system and the dry cooling system. This will result in the need to generate additional power from other power generation sources. Since the Moss Landing combined cycle units are among the cleanest generating units in the country, it is unlikely that the replacement energy will be provided by a lower emitting source. Consequently, the emissions increase associated with this replacement power are conservatively estimated based on the pounds of emissions per megawatt hour (lbs/MWh) produced by the Moss Landing combined cycle units. This increase in emissions will be in between the values shown in Tables D-5 and D-40, above.

Visible water vapor plumes

The fresh water mechanical draft/hybrid cooling system will result in the formation of visible plumes under certain meteorological conditions. Based on similarities between this alternative and the mechanical draft cooling system analyzed above, it is expected that visible plume formation for the hybrid cooling system will be somewhat less frequent than is the case for the mechanical draft system. It is important to note that the term "hybrid" wet/dry cooling system is often used to refer to a cooling tower design that is specifically intended to reduce the potential for visible plume formation. That is not the sense in which the term is used here, however. In this instance, the hybrid wet dry cooling system is specifically intended to reduce the quantity of fresh water required to provide the plant with adequate cooling.

The implications of the visible water vapor plumes associated with the hybrid system with respect to visual resources are presented below.

Visual

The plumes for the hybrid cooling system may be smaller, and somewhat less frequent than those from the mechanical draft cooling options. Yet, because of the large area from which the plumes are emitted, and the potential height of the plumes, they will still be visible from many portions of the viewshed. Any increase in the number of plume sources creates an incremental cumulative impact which is against the stated intent of many LORS (see discussion below) of improving the overall quality of the viewshed. Furthermore, there is no effective mitigation available to reduce the visual effects of the plumes.

Land use

Visual LORS Conflicts

The hybrid option requires both cooling towers and a dry cooling structure to be placed next to the existing Units 1&2. Given the size presented by this option there are several conflicts with existing land use LORS.

There are multiple policies in the Costal Act, Certified Land Use Plan and Coastal Implementation Plan, as well as the North County Area Plan, and County General Plan that call for protecting and improving the visual corridors in Moss Landing. For example, Section 30251 of the Coastal Act states:

> The scenic and visual qualities of coastal areas shall be considered and protected as a resource of public importance. Permitted development shall be sited and designed to protect views to and along the ocean and scenic coastal areas, to minimize the alteration of natural land forms, to be visually compatible with the character of surrounding areas, and, where feasible, to restore and enhance visual quality in visually degraded areas. New development in highly scenic areas such as those designated in the California Coastline Preservation and Recreation Plan prepared by the Department of Parks and Recreation and by local government shall be subordinate to the character of its setting.

Section 20.144.140.B.5.c of the Coastal Implementation Plan states, "Development of new or expanded industrial facilities shall only be permitted where… [t]he development shall meet visual resource, environmentally sensitive habitat, and other development standards of this ordinance." Similarly, the LUP policy 2.2.2 states "views to and along the ocean shoreline from Highway One, Molera Road, Struce Road and public beaches, and to and along the shoreline of Elkhorn Slough from public vantage points shall be protected."

Placing these structures on the MLPP site is not consistent with state and local visual policies due to the cumulative nature of the visual impacts.

Conclusions

The following table summarizes Duke's conclusions about hybrid cooling.

Table D-44: Hybrid System

Question	Answer
Is this alternative potentially effective at reducing entrainment at MLPP? To what extent?	Yes. Seawater use and therefore entrainment would be reduced at least 95%.
Is the alternative proven and available (i.e. it has demonstrated operability and reliability at a cooling water intake having a similar size and environmental setting to that at the MLPP).	Yes.
Are there reasons that this alternative may not be feasible? Alternatively, is the alternative feasible at MLPP site, based on site-specific conditions and considerations of engineering, operations, efficiency and reliability?	Yes mostly due to environmental constraints. This system has all the challenges of both the freshwater and seawater mechanical draft systems AND the dry cooling system (particulates, or freshwater supply, visual mitigation, efficiency losses). Hybrid cooling systems are used where there is some ability to use a substantial amount of water for a substantial portion of the facility's cooling load. In this case, there is no obvious way of either securing even half the particulate offsets (for a seawater based system), or alternatively half the freshwater supply.
What are the costs of this alternative relative to once-through cooling?	The PV of the April 2000 case is $73.1 million. The incremental PV of the April 2000 case over-and-above the once-through system is $17 million. The PV of the real world today case is $88.1 million. The incremental PV of the real world today case over-and-above the once-through system is $32 million.
What are the environmental benefits of this alternative? Can the alternative be applied at MLPP in a way that is consistent with all applicable laws, ordinances, regulations and standards? Will the technology cause or increase significant adverse environmental impacts relative to once-through cooling?	There are no net environmental benefits to this alternative compared to the existing program. The economic value of the entrained species is minor. For example, using EPA's trophic transfer rule, the maximum estimated benefit of reduced entrainment arising from a reduction of entrained goby biomass that became harvested halibut would create a benefit worth approximately $2,900. The Elkhorn Slough enhancement program is preferable to the alternative of avoiding the entrainment. Also, this system would create the following impacts: Particulate emissions and salt deposition Near constant visual plumes Land use zoning violations Prohibition on additional freshwater use.
Is the cost of the alternative wholly disproportionate to the environmental benefit?	Yes.

Spray Ponds

General Description

This closed-cycle cooling water alternative would replace the existing once-through seawater cooling water system with recirculating cooling water spray cooling ponds. Spray ponds provide another method for lowering the temperature of cooling water by evaporative cooling. A spray pond uses a number of nozzles that spray water into contact with the surrounding air, like a sprinkler irrigation system. Cooling occurs through partial evaporation of the water as the droplets fall through the air into the pond, similar to the heat transfer that takes place inside a cooling tower. Spray ponds are sometimes used in lieu of cooling towers where land is relatively inexpensive and the cost of power is high. Spray cooling ponds have also been considered for nuclear power plant cooling, since a large reservoir of emergency cooling capacity is required for these plants in addition to the normal steam condenser heat rejection load. The incremental cost of spray drying in the nuclear case is reduced because the emergency cooling reservoir would be required regardless of the normal cooling technology selected.

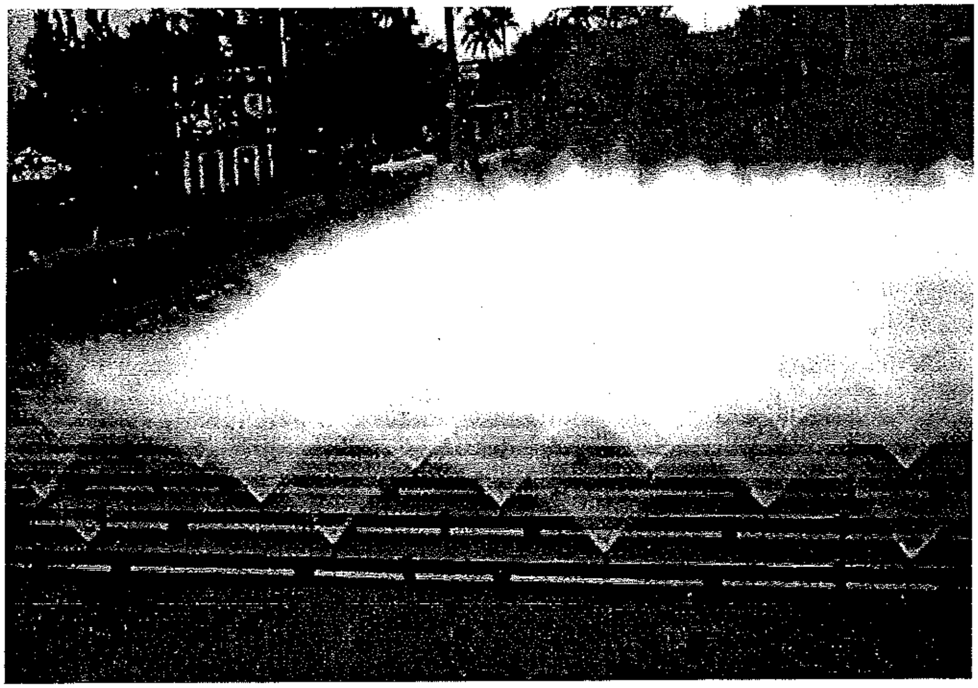
Figure D-14 presents a photograph of a spray cooling pond. The spray nozzles are typically installed four to six feet above the water surface. The water spray from the nozzles may extend 10 to 15 feet above the pond surface. A louvered fence perhaps 10 to 15 feet high also would probably be installed around the perimeter of the pond for drift emission control, which would also effectively screen the water spray "fountains" from view.

Due to the lack of an identified firm source of fresh water, this evaluation considers a seawater-based design for a spray pond heat rejection system serving the Units 1&2. The estimated ocean water required for makeup is about the same as for the seawater cooling tower alternatives. Consequently, the reduction in entrainment is also about the same as the cooling tower alternatives.

Design and Sizing

The basic parameters used for the design of a spray cooling pond are the same as used for the cooling tower options, namely the amount of heat to reject, cooling water flow, cooling water temperature rise, and the site maximum wet bulb temperature. These criteria determine the number and size of spray nozzles required (thousands would be needed for the cooling load considered here), the water droplet/air contact time and hence the spray height, and the size of the pond.

Figure D-14: Photograph of a Spray Cooling Pond



Moss Landing Design Considerations

The water usage rates (i.e., makeup water rates) are about the same for the spray pond as for the seawater cooling tower options, since the amount of heat to be removed through cooling water evaporation is the same. Similarly, the blowdown discharge to the ocean would also be about the same as for the cooling towers.

A spray pond cooling system for Units 1&2 would consist of two circular ponds, each pond about 620 feet in diameter, with many vertical spray nozzles per pond. Large cooling water pumps, similar to those needed for the cooling towers, would circulate the cooled water from the pond to the steam condensers and back.

It is assumed that the spray cooling ponds would require an impervious or very low permeability liner material with a leak detection system to prevent the migration of concentrated seawater into groundwater.

Cooling System Location and Supporting Facilities

The only feasible location for the spray cooling ponds is the large vacant area to the east of Units 1&2, which is the largest unused area on the site. However, several significant equipment systems, such as the firewater pump house and the incoming natural gas meter station, would probably need relocation in order to install the spray cooling ponds.

The supporting plant facilities for the spray pond option are the same as for the seawater cooling tower options, including cooling water circulation pumps, large underground cooling water lines to and from the condensers, and blowdown tie-in to the existing once-through cooling water return line.

Use of Existing Facilities

The use of existing facilities for this option is the same as for the natural draft cooling tower option. The existing surface condensers would be reused as well as a small portion of the once-through cooling system. The majority of the once-through cooling system would be abandoned in place (in accordance with applicable regulations and after being secured for long term safety considerations).

Plant Performance

The spray cooling pond would achieve about the same cooling water supply temperature as the natural draft cooling tower, hence the steam turbine generator efficiency will be about the same as well. Thus, the spray cooling pond alternative will reduce the net plant output by about 26 MW, which is a significant decrease in thermal efficiency (see cooling tower discussions for a description of the resulting adverse impacts).

Environmental Features

The environmental features incorporated into the spray cooling pond conceptual design include:

The maximum practical salinity was chosen for the circulating cooling water stream to minimize seawater withdrawal and discharge of blowdown back to the ocean. (both in relation to minimizing marine biological effects)

A louvered fence will be provided for drift removal. With this device, the spray drift from the pond is expected to be no greater than that of the cooling towers and, therefore, PM10 emissions would also be the same as, or lower than, that associated with the sea water cooling towers.

The drift control fence around the ponds will also reduce visual impacts by shielding the water sprays from view. Condensed plumes would probably be frequently visible above the pond enclosures.

Cost Analysis

A detailed cost analysis of the spray pond alternative has not been performed due to the impracticality of this approach in relation to site constraints. However, capital costs would most likely be at least as high as the mechanical draft systems, based on the limited vendor data available to Duke's consultants. Also, the efficiency impact would be comparable to the performance of the natural draft tower, because of the cooling characteristics of this system.

The estimated erected price for the two spray cooling pond systems, including the ponds and liners, piping, and nozzles suitable for seawater service is about $12 million. This price excludes supporting facilities such as the cooling water circulation pumps, cooling water supply and return lines to and from the condensers, electrical service, etc. The comparable supplier's price for the seawater mechanical draft cooling towers, erected without the supporting facilities, is about $5.8 million (see Appendix F), less than half the spray pond estimated price. (This $5.8 million is a component of the equipment package cost provided in Appendix F.)

Environmental Analysis

Noise

Noise emissions into the surrounding community from a spray pond system would be produced by the large water circulating pumps, similar in size to the other cooling alternatives, that would move the water from the ponds to the plant and back to the ponds. Also, the spray nozzles would produce noise as they mist the water for evaporative cooling. Although this alternative does not include fan drive motor assemblies of a mechanical draft system, the individual, spatially-dispersed spray nozzles in a spray pond system may, as a collection, produce noteworthy noise energy. However, given the wide area over which they would be placed, the noise levels at any particular receptor location would not be expected to be significant from just the spray assemblies.

The large water pumping system would produce noise comparable to a mechanical draft or natural draft system, but with prudent choices for water pump characteristics and pump system positioning, pump noise emissions could easily be controlled to acceptable levels. Given the roughly comparable noise energy production between a water mechanical draft tower system and a spray pond system and given that the former was indicated to remain compliant with the local noise LORS, then a spray pond system, with proper engineering design, would also be expected to maintain overall plant compliance with CEC noise requirements.

Air Quality

The spray cooling pond effects a cooling of the circulating water through the same mechanism as a cooling tower – contact of the cooling water with air. The two mechanisms for water loss found in mechanical and natural draft cooling towers – evaporation and mechanical drift – are similarly present for spray cooling ponds. While there are no data available regarding PM_{10} emissions from spray cooling ponds, it is expected that they will be comparable to, or somewhat less than, those associated with cooling towers for a comparable heat rejection load. As a result, PM_{10} emissions are expected to be comparable to, or somewhat lower than, those estimated for the sea water mechanical and natural draft cooling tower options, based on the assumption that the spray cooling pond will use sea water and that the sea water will be concentrated by roughly a factor of two.

The constraints discussed above for those options with respect to the need for and availability of sufficient emission offsets are expected to be present for this option as well. Ambient PM_{10} concentrations due to the spray cooling pond are expected to be comparable to, or greater than, those associated with the mechanical draft sea water cooling tower alternative. Any reductions in PM_{10} emissions associated with the spray cooling pond alternative would be more than outweighed by the poorer dispersion characteristics of the cooling pond.

Visual

The fifteen foot tall louvered fences surrounding the two 620 foot diameter spray ponds would be visible from Dolan Road. The louvered fences would be unlike any other agricultural fences, and considerably taller. These fences, and the plumes emitted from the spray ponds, would effectively extend the industrial character of MLPP farther to the east. With the spray ponds the source of the plumes would be the largest (1,240 feet) of any of the cooling alternatives. Each of the plumes would originate at the ground, and during certain meteorological conditions, could cloud driving on Dolan Road, thereby creating a potential safety hazard.

Land Use

Spray ponds require low profile, large structure –and would take up approximate 15 times more space that the other alternatives – almost all of the remaining space on the MLPP site. This alternative may not be able to fit on the MLPP site, creating a site control issue.

As discussed in previous sections visual impacts from the plume will conflict with several local LORS and may cause significant safety issues on Dolan Road which will cause additional conflicts with local LORS.

Conclusions

The following table summarizes Duke's conclusions about spray ponds.

Table D-45: Spray Pond Cooling System

Question	Answer
Is this alternative potentially effective at reducing entrainment at MLPP? To what extent?	Yes. Seawater use and therefore entrainment would be reduced approximately 95%.
Is the alternative proven and available (i.e. it has demonstrated operability and reliability at a cooling water intake having a similar size and environmental setting to that at the MLPP).	Duke is not aware of any power plant that has been required to install spray ponds to eliminate entrainment. Also, spray pond cooling are typically used in remote locations that do not have plant size restrictions, and where land is inexpensive. At MLPP, this system offers no obvious benefits over the mechanical draft systems or dry cooled systems.
Are there reasons that this alternative may not be feasible? Alternatively, is the alternative feasible at MLPP site, based on site-specific conditions and considerations of engineering, operations, efficiency and reliability?	Yes mostly due to environmental constraints. There are no obvious ways to secure particulate offsets, to mitigate for visual resource impacts, or to overcome land use restrictions. Squeezing the large ponds onto the site may also create other unknown impacts such as in the area of terrestrial biology, and the significant cost to relocate existing equipment. This system would also create unknown impacts from salt deposition through the local area, including in and around the PG&E switchyard. There is a chance of creating fogging conditions over Dolan Road due to low elevation of the visible vapor plume formation and this could be a safety concern.
What are the costs of this alternative relative to once-through cooling?	Given the impracticality and environmental consequences of spray ponds, Duke did not calculate the PV costs of this alternative.
What are the environmental benefits of this alternative? Can the alternative be applied at MLPP in a way that is consistent with all applicable laws, ordinances, regulations and standards? Will the technology cause or increase significant adverse environmental impacts relative to once-through cooling?	There are no net environmental benefits to this alternative. The economic value of the entrained species is minor. For example, using EPA's trophic transfer rule, the maximum estimated benefit of reduced entrainment arising from a reduction of entrained goby biomass that became harvested halibut would create a benefit worth approximately $2,900. The Elkhorn Slough enhancement program is preferable to the alternative of avoiding the entrainment. Also, this system would create the following impacts: Particulate emissions and salt deposition Near constant visual plumes Land use zoning violations
Is the cost of the alternative wholly disproportionate to the environmental benefit?	Yes.

Appendix E

Appendix E: Cost and Economic Evaluation

Duke has substantially updated the economic analysis originally presented in the 316(b) study published in April 2000 for the technologies shown in Table E-1.

Table E-1: Alternative Cooling System Technology Summary Table

Intake Technology Area	Technology	Economic Analysis updated from Existing 316b study
Closed Cycle Cooling	Fresh water mechanical draft cooling	Yes
	Seawater mechanical draft cooling	Yes
	Natural draft cooling (freshwater and seawater)	Yes
	Air (dry) cooling	Yes
	Hybrid cooling (wet/dry system)	Yes
	Spray Ponds	Yes

For these technologies, Duke performed an economic analysis for two scenarios: An **"April 2000 Case"** and a **"Real World Today Case"**. The April 2000 Case represents the costs of implementing the alternatives prior to the construction of MLPP Units 1&2 as the decision made have looked at the time the original 316(b) study was completed. The Real World Today Case represents the costs of implementing the alternative today now that Units 1&2 have been built and the units are in active operation. Duke has further refined the analysis by looking at all the capital costs associated with the once-through system, and then considering only those portions of the once-through system relating to the intake portion of the system, consistent with 316(b) statutory requirements.

While Duke performed an evaluation of each alternative shown in Table E-1 above, it was not reasonable to extend the evaluation into an in-depth economic evaluation for the hybrid and the spray ponds due to the impracticality of these options. For these two technologies, an expanded cost discussion is provided without the corresponding detailed summary present value (PV) cost tables. Figure E-1 below summarizes each of the technology scenarios and the cases evaluated, along with an indication of the level of detail performed.

Figure E-1 – Level of Detail for Each Economic Case Evaluated

Technology	April 2000 Case	Real World Today Case
Once Through Cooling	●	●
Once Through Cooling, Intake Expenditure Only	●	●
ACC (Dry Cooling)	●	●
Seawater Mechanical Draft Cooling	●	●
Freshwater Mechanical Draft Cooling	●	●
Natural Draft Cooling	●	●
Hybrid Cooling	⍓	⍓
Spray Ponds	⍓	⍓

● = detailed economic evaluation

⍓ = expanded cost discussion without full evaluation

Based on previous guidance from the CCRWQCB, and consistent with the requirements of 316(b), Duke has expressed these costs in terms of the incremental cost of deploying the technology for both scenarios. Each scenario has two components: the capital cost and the on-going costs. Costs are also expressed on an after-tax basis to account for the important impact of depreciation effects on the associated capital expenditures for each of the cases and technologies. This is done consistently for all the technologies, and so it does not bias the analysis except to narrow the overall cost differences due to efficiency penalties, and as such makes the analysis more conservative.

Because each alternative is evaluated against the existing once-through system, it is necessary to first establish its costs.

Once Through System Capital Cost

This section describes the physical modifications and costs associated with the once through seawater cooling system. Because the plant has been built, these costs are sunk and are the same for both the April 2000 and the Real World Today cases. In the Real World Today case, however, these costs impact the comparative costs of alternatives because, as sunk costs, they represent an on-going economic burden associated with having to make an economic return on this investment.

The once through sea water cooling system Units 1&2 involved the following physical modifications, distinguished here among those items associated with the intake side of the system, those items associated with the discharge side, and those items associated with both.

Intake system related modifications

Upgrade decommissioned intake structure erected in the mid-1950s for Units 1-5 to accommodate the new once through cooling system for Units 1&2 including installation of traveling screens.

Removal of decommissioned pumps and miscellaneous equipment from Units 1-5 pump pit to accommodate newly designed pumps and piping systems for once through cooling system for Units 1&2.

Excavation for and installation of 6,000 feet of 84" diameter concrete intake cooling water pipe installed from the newly refurbished pump pit to the new combined cycle power plant Units 1&2.

Discharge system related modifications

Excavation for and installation of 1500 feet of 120" diameter concrete discharge pipe to connecting to the disengaging basin.

Erection of a disengaging basin and underground gravity flow tunnels to connect Units 1&2 discharge to the Unit 6 & 7 outfall tunnels.

Installation of new recirculator pumps for Units 6&7 due to high back pressure demand from added outfall flow from Units 1&2.

Items common to both

Installation of miscellaneous mechanical piping, electrical systems and controls for operations of new systems.

Purchase and installation of two surface mounted condensers, for fore each STG, condensate pumps, and miscellaneous piping and electrical cable.

The approximate total capital cost associated with these improvements is $60.7 million in total, with $36.9 million associated with the intake side of the system. Duke also paid mitigation funds associated with the entrainment impacts and studies in the amount of $8.4 million.

Table E-2: Capital Costs of Once-through system

Item	Once through cooling $ Millions	Once through cooling, Intake expenditure only
Once-through seawater cooling system,	$60.7	$36.9
Mitigation	$8.4	$8.4
Total Capital	$70.5	$45.3

On-going Costs

Duke is performing this analysis on an after-tax basis for consistency and accuracy. Accordingly, the capital charges that appear above in Table E-2 would be depreciated overtime, and there would be a resulting tax depreciation-related benefit on an on-going basis. The capital cost for the once through was depreciated using a 20 year MACRS and then annualized and the results shown in Table E-3 for purposes of the 30 year analysis requirement. Table E-3 represents the annualized after tax benefit of asset depreciation. The figure is shown as negative because as a benefit it lowers the effective cost of the once-through system on an after-tax basis.

Table E--3: PV of After Tax Depreciation (Benefit) of Once-through system

Item	Once through cooling $ Millions	Once through cooling, Intake expenditure only
Capital Expenditure Depreciation Benefit	**(13.1)**	**(8.6)**

Present Value of Once-Through System

For comparison purposes with the alternative technologies, it is necessary to combine the results of Table E-2 and Table E-3 in the form of a present value, computed over a 30 year period at a 7% discount rate.

Table E-4: Present Value Costs of Once-through system

Item	Once through cooling $ Millions	Once through cooling, Intake expenditure only
Present Value (PV)	**56.1**	**36.7**

Costs of Closed Cycle Cooling Alternatives

Process used for design and capital cost estimating

The preliminary conceptual design of the cooling alternatives is based on the installed equipment as it exists today. For each technology alternative, the design and estimation approach evaluated the impact to the existing system design along with any modifications to the support systems as appropriate and necessary to match the cooling technology being evaluated. In some cases this resulted in modifying and reusing portions of the cooling system. In other cases, it resulted in abandoning the element system and installing new systems and equipment.

In addition to the new equipment required, the conceptual design also considers the need and cost for demolition and/or relocation of existing electrical and mechanical equipment in order to secure adequate space for each cooling option consistent with locating the new equipment in accordance with good engineering practice. Working within the constraints of an existing facility, certain less than optimal approaches may be required (e.g., longer than normal piping lengths). When appropriate, some of these costs are apportioned to the Real World case only, since it might have been possible to avoid these costs, if they were part of the original design

With the conceptual design established, a scope of work (SOW) was developed for each alternative to be estimated. This SOW defined the new equipment to be installed and any demolition or relocation required for each alternative. The equipment was priced based on either budgetary quotations from equipment suppliers or using in-house data for similar equipment included in the contractor's data base of historical projects.

The equipment was located on the plot plan. The quantities of piping, electrical, control systems, foundations, and steel supports were developed. These quantities were used to establish the overall cost of the material required and the number of construction craft hours needed to perform the installation. The scope for demolition or relocation and the associated quantities were similarly developed.

The cost for craft labor for installation is based on the quantities and the cost of labor plus any necessary adjustments to reflect the actual productivity experienced during construction of the new facility. The cost of field support is based on the estimated schedule for installation and the required level of supervision based on the craft labor staffing. Home office engineering and support hours were estimated based on the scope of work. Finally, the overall cost is adjusted to include the contractors fee, sales tax, and a contingency allowance for unknown work scope. These are typical items in any construction bid and contract award, and are required to represent as accurately as possible the total cost to the customer, based of course with this preliminary and conceptual design.

Process used to evaluate Additional Annual Energy Cost

Each of the closed-cycle cooling options is less efficient at condensing steam than a once-through seawater cooling system. This leads to increased steam-turbine back-pressure, reducing the efficiency of the steam turbine, and therefore degrading the efficiency of the plant.

There are actually several effects of the lessened efficiency of the closed cycle cooling systems when compared to the once-through system. First, the net power output available from the existing Units 1&2 combined cycle units is decreased. For example, for the Fresh Water Mechanical Draft Cooling System, the net power output decreases by approximately 9 MW at annual average ambient conditions. Units 1&2 can currently generate about net 1048 MW at annual average site conditions, but with a freshwater mechanical draft system this capacity is degraded to 1039 MW. This power output loss would be even greater at higher ambient temperatures.[44] It is also greater for the other alternatives.

Second, not only is there less electrical generating capacity at any given time, but this capacity also operates at a lower thermal efficiency in terms of utilization of fuel. This illustrated by the heat rate[45], measured in terms of the fuel energy consumed in Btu's for each unit of electrical energy produced in kW-hrs. Power generation at this lower capacity (i.e., 1039 MW in the freshwater mechanical draft cooling example) occurs at an increased heat rate, meaning the plant would consume more fuel per unit of *net* electricity generated as compared to the present once-though cooled system. The once-through system burns fuel at a heat rate of about 6,794 Btu/kW-hr, whereas the mechanical draft system would consume fuel at a heat rate of about 6,852 Btu/kW-hr.) Likewise, the efficiency penalty in terms of the heat rate is greater for the other options. The practical implication of this penalty is that the production costs to generate *net* power to the grid increases on a per unit basis.

There is also an additional cost to both Duke and the system. Duke experiences less revenue and profit due to less generation capacity and the lost opportunity to sell power to the grid. From the system perspective, this reduction in capacity will have to be made up by other, probably less efficient and more polluting power sources located elsewhere. With the recent increase in natural gas prices, this may have an adverse affect on the cost of electrical power to the California consumer. Additionally, as the efficiency loss is magnified by higher ambient air temperatures greater amounts of make-up power will be required of other, more polluting generation at the very time air quality concerns are at their greatest.

For purposes of this analysis, Duke is being conservative by only considering a portion of the cost aspects discussed here namely the incremental cost of production required to run the facility at the lower capacity. Specifically:

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[44] The plant internal electrical load is greater for the alternative systems than for the once-through cooling system because of such things as the cooling tower circulation pumps as well as the cooling tower fans require more power than the existing once-through cooling pumps they replace. The plant performance computations supporting this analysis, however, take into account for these parasitic electrical loads by evaluating gross and net power output. In this way it is factored into the resulting net electrical capacity value and the net plant heat rate value.

[45] Heat rate is a measure of efficiency, expressed using either the higher heating value (HHV) or a lower heating value (LHV) of the fuel, and measured in terms of fuel Btu's consumed per kW-hr of electricity generated. The difference between HHV and LHV has to do with the water content of the fuel combustion products. Throughout this analysis, Duke expresses the efficiency considerations in terms of HHV.

Increased Operating Cost	=	[Heat Rate for Alternative System – Heat Rate for Once-through System]	X	annual kW-hrs assuming lower capacity of alternative	X	cost of fuel

The starting point then for this analysis is to determine the relative efficiency of the once through plant and the alternative. This is accomplished by running heat-balance simulations[46] on each of the options at 55°F and 88% relative humidity. The results of these heat-balance simulations are presented in Appendix I.

The gas costs used in this study were based on those from the California Energy Commission's "2002 - 2012 Electricity Outlook Report", published in February of 2002. As these prices are stated in "real" terms, they were grossed up to reflect one year's worth of inflation. Otherwise the prices were used unchanged. Beyond 2012, gas prices are assumed to increase at 1% each year. These prices are shown in Appendix L. The fuel price was multiplied by the incremental fuel calculated in the previous step to determine the incremental annual fuel cost based on a 60% annual capacity factor assuming the lower capacity of the alternative.

April 2000 Case

Capital Cost

First Duke has accounted for the upfront capital costs in aggregate (Table E-5) for each alternative. Capital costs for each were estimated by using preliminary design information, by soliciting input from vendors, and by utilizing engineering judgment that includes experience designing and building similar system's elsewhere. Relevant costs to include are: all equipment, installation and erection costs, site preparation, and interference and relocation costs. If applicable, one-time environmental costs are also included.

Table E-5: Closed Cycle Cooling Capital Costs

April 2000 Case ($ millions)

	Air (Dry) Cooled Condenser	Natural Draft Cooling Towers (Saltwater)	Mechanical Draft (Seawater)	Mechanical Draft (Freshwater)
Site Preparation	1.4	1.7	3.7	3.9
Cooling System Equipment Package	48.0	31.7	22.5	19.7
Installation	15.4	7.7	13.8	13.9

46 Heat balance simulations were performed using GTMaster from Thermoflow.

	Air (Dry) Cooled Condenser	Natural Draft Cooling Towers (Saltwater)	Mechanical Draft (Seawater)	Mechanical Draft (Freshwater)
Mitigation Costs[47]	n/a	7.0	7.0	n/a
Total Capital Costs	64.8	48.1	47.0	37.5
Capital Expenditure Depreciation Cost (Benefit)	(12.2)	(9.1)	(8.9)	(7.1)
Capital Cost Net of Depreciation	52.6	39.0	38.1	30.4

Mitigation costs for systems using saltwater include the cost of particulate offsets. It is doubtful Duke would be capable of buying Emission Reduction Credits at the necessary amounts, due to the nature of the credits, the need for their verification, and the fact that multiple owners hold them presently and may have no interest in selling them at any price. Nonetheless, based on other recent credit sales, Duke estimates the costs of credits would be potentially $7 million.

Depreciation Benefit

Duke is performing this analysis on an after-tax basis for consistency and accuracy. Accordingly, capital charges would be depreciated, and there would be a resulting tax depreciation-related benefit on an on-going basis. The present value of this benefit is shown in Table E-5 above.

Additional Annual Energy Cost

The net power output available from the new combined cycle units is decreased for each of the closed cycle alternatives. Units 1&2 can currently generate about 1048 MW at annual average site conditions, but with the alternatives the power output varies from 1,022 to 1,039 MW. This power output loss would be even greater at higher ambient temperatures.[48]

As a result of there being less electrical generating capacity at any given time, but the plant would consume more fuel per unit of *net* electricity delivered to the grid as compared to the

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[47] This item is placeholder for potential costs to mitigate resource impacts. For example, there would be unknown feasibility and cost associated with mitigating for visual impacts. When possible, an estimate of the mitigation cost for known items – like particulate offsets – is provided.

[48] The plant internal electrical load is greater for the alternative cooling system alternative than for the once-through cooling system because the cooling tower circulation pumps plus the cooling tower fans require more power than the existing once-through cooling pumps they replace. The plant performance computations supporting this analysis, however, take into account for these electrical loads by evaluating gross and net power output. In this way it is factored into the resulting net electrical capacity value and the net plant heat rate value.

present once-though cooled system. The once-through system burns fuel at a heat rate of about 6,794 Btu/kW-hr, whereas the alternatives would consume fuel at a heat rate ranging from 6,852 to 6,967 Btu/kW-hr. The results of these heat-balance simulations are presented in Appendix I.

This efficiency loss increases the cost of each MWh to both Duke and the system. Duke experiences a higher production cost function for each unit of electricity delivered to the system. Duke also experiences less revenue and profit due to less generation capacity and the lost opportunity to sell power to the grid. For purposes of this analysis, however, Duke is being conservative by only considering gas cost aspects discussed here, namely the production cost associated with running the facility at the lower efficiency and capacity. Finally, and like the other costs, this cost has to be expressed on an after-tax basis for consistency and to be consistent with creating a conservative analysis.

Additional Annual Operating and Maintenance Costs

In addition to the annual energy cost there are also incremental on-going costs over-and-above the costs of running the plant today. Relevant costs to consider for both the power plant and the theoretical desalination plant, as appropriate, include (on an incremental basis): labor, additional maintenance parts and supplies, additional station power or electricity to run pumps, motors and other ancillary equipment, and on-going supplies such as chemicals. Except for the freshwater mechanical draft cooling system, these costs are most likely small on an incremental basis over the base case of once-through cooling. They will not have an appreciable impact on the analysis, and are accordingly not factored into it.

For the freshwater mechanical draft cooling system, however, it is necessary to estimate the theoretical cost of securing a freshwater supply. This system requires 5,200gpm of fresh water supply. This supply is not available from the plant wells. Assuming that a desalination plant was constructed nearby to supply these needs, the capital and operating cost for the mechanical draft cooling system would be significant. Assuming that another entity builds this system, and Duke pays for water service with an on-going fee that reflects both capital repayment and on-going operating costs of the water service provider, Duke estimates that the price of the water would be $3.69 / 1,000 gallons. Using this price, and assuming a reasonable capacity factor of 60% for power plant operations, Duke estimates that this water cost is approximately $6 million per year on a pre-tax basis or $3.74 million on an after tax basis. See Appendix J for a description of how these costs were calculated.

This cost would also be required in any of the cooling options using the equivalent amount of freshwater. For example, the natural draft cooling system could utilize either fresh or salt water. For purposes of Duke's analysis, Duke has decided to model the natural draft tower assuming that saltwater is used, simply because this presents a more conservative cost estimation than assuming freshwater could be used.

Table E-6: Incremental Ongoing Costs of Each Option compared to Once Through Sea Water Cooling ($ millions) – 60% Capacity Factor

	Air Cooled	Natural Draft Using Seawater	Mechanical Draft (Seawater)	Mechanical Draft (Freshwater)
Energy Cost: Incremental Cost of Production ($/yr)	1.87	2.51	0.90	0.85
Cost of Water Provision / Year	n/a	n/a	n/a	3.74
On-going Cost / yr	1.87	2.51	0.90	4.59
PV of On-going Costs	23.2	31.1	11.14	57.0

April 2000 Case Economic Conclusion

To estimate the life cycle costs of these alternatives, Duke assumed a project life of 30 years and discount rate of 7%. Using these assumptions and the costs outlined in tables E-5 and E-6 the present value (PV) analysis produced the results in Table E-7.

Table E-7: April 2000 Case Present Value Analysis ($ millions)
Cost of Alternatives

	Air (Dry) Cooled Condenser	Natural Draft Cooling Water Towers	Mechanical Draft Using Seawater	Mechanical Draft Using Freshwater
Present Value (PV)	75.8	70.1	49.2	87.4

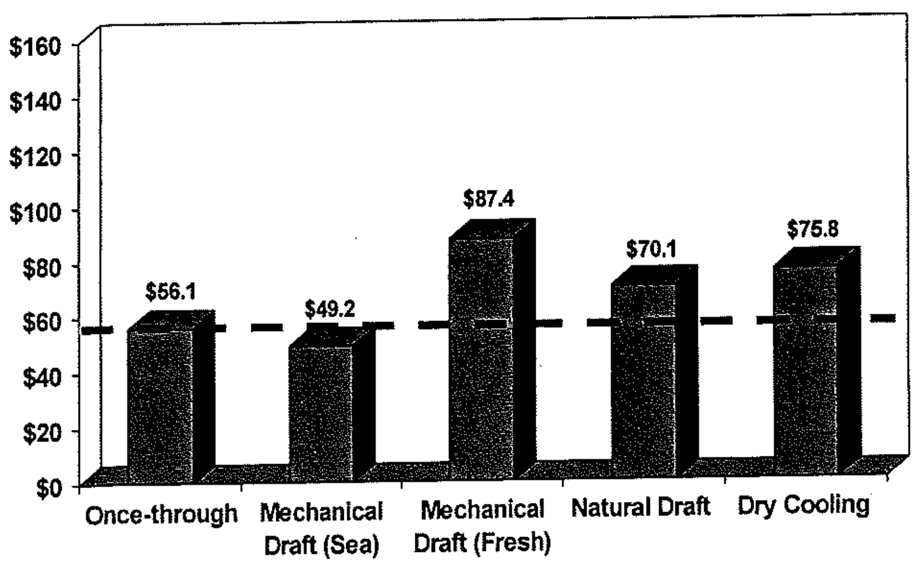
Furthermore, by subtracting the results found in Table E-4 from the results in Table E-7, the incremental PV cost of each alternative compared to the current once through system can be determined. This represents that cost, on a PV basis, of the alternatives over and above the cost of once-through cooling.

Table E-8: April 2000 Case Incremental Cost of Alternatives (millions)

	Air (Dry) Cooled Condenser	Natural Draft Cooling Water Towers	Mechanical Draft Using Seawater	Mechanical Draft Using Freshwater
Incremental Present Value (PV) Compared to Once through Cooling System	19.7	14.0	(6.8)	31.3
Incremental Present Value (PV) Compared to Once through Cooling System, Intake Expenditure Only	39.1	33.4	12.5	50.7

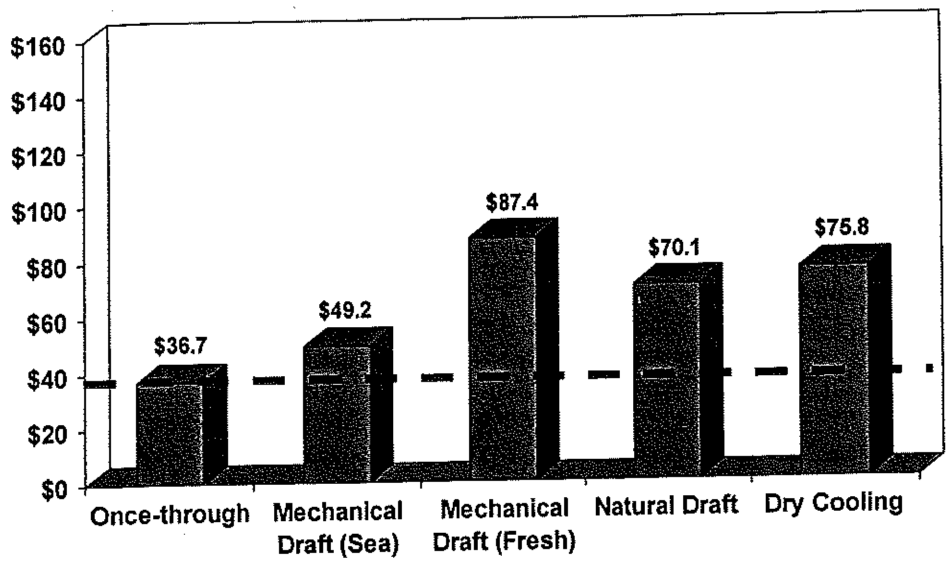
These results can be seen graphically in Figure E-2.

Figure E-2a: April 2000 Case PV Costs (in millions)



Note: The value above the dashed line is the incremental cost of the alternative compared to once-through cooling

Figure E-2b: April 2000 Case PV Costs
Intake Expenditure Only
(in millions)



Note: The value above the dashed line is the incremental cost of the alternative compared to once-through cooling

Real World Today Case

The Real World Today Case includes all costs associated with changing the existing plant from its current configuration, once through sea water cooling. Each of the sections that follow outline each of the costs and the final analysis represents the additional cost that will be incurred to implement the option.

Capital Cost

The capital costs consists of all cost incurred during the design, modification and construction of each option. These costs represent the incremental cost to be spent going forward the costs spent on the existing once through cooling system are considered to be sunk costs.

In some instances, capital costs are incurred due the specific existing layout of MLPP today. For example, the facility's steam turbines are located on the west side of the power blocks. Because of efficiency considerations, it is impractical to put the dry cooled condensers on the eastern side of the power blocks. To place the dry cooled condensers on the western side, however, requires that some equipment like the oily water separator be relocated. Overhead transmission lines also need to be relocated. These items appear separately in Table E-9 below.

Mitigation costs are for the purchase of particulate offsets, assuming that they are available in the market. Otherwise, it is a placeholder for unknown mitigation costs associated with any identified significant adverse impacts, such as those suggested by the occurrence and frequency of visible emission plumes.

Table E-9: Closed Cycle Cooling Capital Costs
Real World Today Case ($ millions)

	Air (Dry) Cooled Condenser	Natural Draft Cooling Water Towers	Mechanical Draft Using Seawater	Mechanical Draft Using Freshwater
Site Preparation	1.6	1.7	3.7	3.8
Cooling System Equipment Package	49.4	32.6	22.3	19.2
Installation	16.3	6.8	13.8	14.0
Demolition / Relocations	4.1	6.6	6.8	7.0
Transmission Line Relocation	3.5	n/a	n/a	n/a
Mitigation Costs	n/a	7.0	7.0	n/a
Total Capital Costs	74.9	54.8	53.6	44.0
Capital Expenditure Depreciation Cost (Benefit)	(14.2)	(10.4)	(10.1)	(8.3)
Capital Cost Net of Depreciation	60.7	44.4	43.5	35.7

Depreciation Benefit

As with the April 2000 Case, Duke is performing this analysis on an after-tax basis for consistency and accuracy. Accordingly, capital charges would be depreciated, and there would be a resulting depreciate-related tax benefit on an on-going basis. The present value of this benefit is shown in Table E-9 above.

Ongoing Annual Costs

The ongoing costs in the Real World Today Case are the same as the costs used in the April 2000 analysis except for two important items. First, the tax related depreciation benefit is recomputed based on the unique capital expenditure for each alternative in question. Second, for each alternative in this Real World Today Case, Duke still needs to payback the original investment (net of the tax-related depreciation benefit) in the once-through cooling system. This is a real economic burden of any real world alternative under consideration. This cost was calculated by assuming a 7% annual return on the un-depreciated investment (i.e. the $56.1 million and $36.7 million shown in Table E-4). This value was then annualized and is included in Table E-10. It is also shown as a present value, which is just the original amount shown in Table 2.

Table E-10: On-Going Economic Burden of Once-through system

Item	Once through cooling $ Millions	Once through cooling, Intake expenditure only
Capital Burden / year	4.52	3.65
PV of Capital Burden	56.07	45.3

Note that as with the April 2000 Case, Duke is choosing to ignore the incremental operating and maintenance expenses because Duke believes these are not material to the analysis.

The reason Table E-10 appears in this section and not under the section on once-through cooling, is that this is a cost that must be added to each of the alternatives, as opposed to a cost or benefit of the once through system. This cost reflects the real world abandonment cost implication of the once through system should an alternative technology be deployed at MLPP. This cost is additive to these alternative scenarios.

Table E-11: Incremental Ongoing Costs of Each Option Compared to Once Through Sea Water Cooling ($ millions)
60% Capacity Factor

	Air Cooled	Natural Draft Using Seawater	Mechanical Draft (Seawater)	Mechanical Draft (freshwater)
Energy Cost: Incremental Cost of Production ($/yr)	1.87	2.51	0.90	0.85
Cost of Water Provision / Year	n/a	n/a	n/a	3.74
On-going Cost / year	1.87	2.51	0.90	4.59
PV of On-going Costs	23.2	31.1	11.14	57.0

Real World Today Case Economic Conclusion

Table E-12 represents the Present Value analysis of the Real World Today Case. It uses the same term and discount rate assumptions as the April 2000 Case (30 yrs, 7%). It assumes the need to pay back the sunk investment in the existing once-through system that would have to be abandoned (hence the distinction between the entire once-through investment and only the intake portion of the investment). It also accounts for transmission and demolitions costs at the site because of the retrofit nature of the work. Using these assumptions and the costs outlined in Tables E-9, E-10 and E-11, this yields the results in Table E-12.

Table E-12: Real World Today Case Present Value Analysis ($ millions)
Cost of Alternatives

	Air (Dry) Cooled Condenser	Natural Draft Cooling Water Towers	Mechanical Draft Using Seawater	Mechanical Draft Using Freshwater
Present Value (PV) Factoring in Entire Once through Cooling System Investment	139.9	131.6	110.7	148.7
Present Value (PV) Factoring In Intake portion of once through Cooling System Investment	120.6	112.2	91.3	129.4

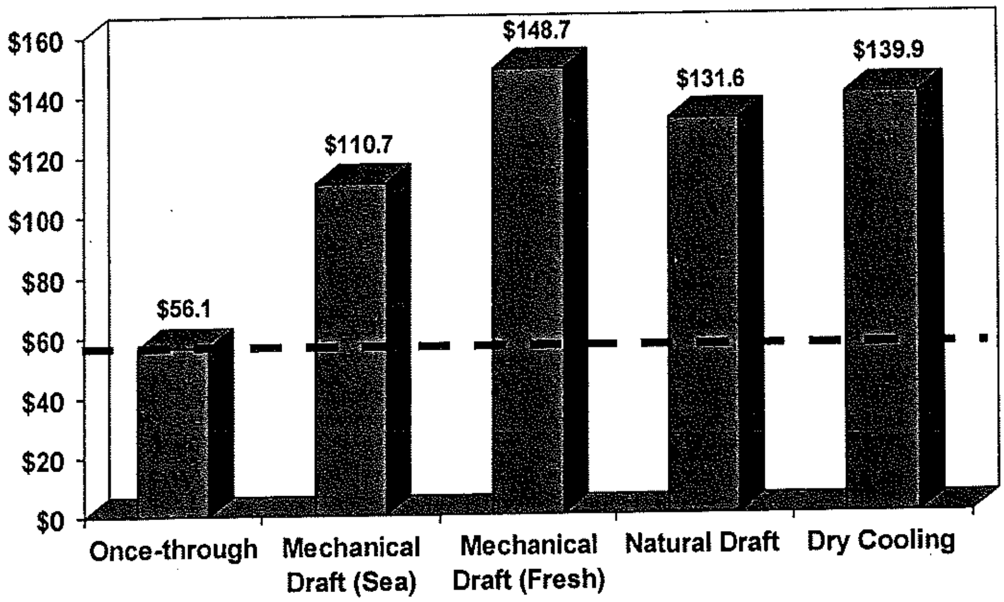
Furthermore, by subtracting the results found in Table E-4, from the results in Table E-12, the *incremental* PV cost of each alternative compared to once through can be determined. This represents that cost, on a PV basis, of the alternatives over and above the cost of once-through cooling.

Table E-13: Real World Today Case
Incremental Cost of Alternatives ($ millions)

	Air (Dry) Cooled Condenser	Natural Draft Cooling Water Towers	Mechanical Draft Using Seawater	Mechanical Draft Using Freshwater
Incremental Present Value (PV)	83.9	75.5	54.6	92.7

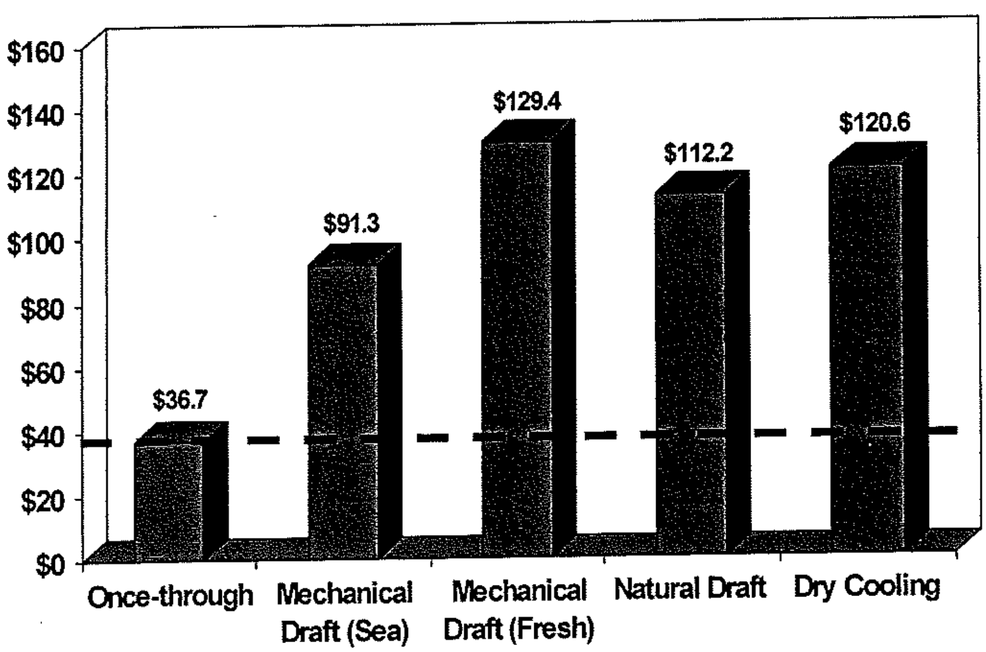
These results can be seen graphically in Figures E-3a and E-3b.

Figure E-3a: Real World Today Case PV Costs (in millions)



Note: The value above the dashed line is the incremental cost of the alternative compared to once-through cooling

Figure E-3b: Real World Today Case PV Costs Intake Expenditure Only (in millions)



Note: The value above the dashed line is the incremental cost of the alternative compared to once-through cooling

Sensitivity Analysis

Duke also performed additional analyses to determine the sensitivity of the certain factors that affect the present value of each option. These sensitivities were completed on the Real World Today Case and not completed on the April 2000 case. Duke ran sensitivities on unit capacity factor and average annual fuel cost per MMBtu.

The annual capacity factor was varied by ± 15% and the analysis was redone. The results from this change are included in Table 14. The average annual fuel cost was varied by ± $1.00/MMbtu and the results from this change are included in Table 15.

Table E-14: Real World Today Present Value Impact for Capacity Factor Change ($ millions)

	Air (Dry) Cooled Condenser	**Natural Draft Cooling Water Towers**	**Mechanical Draft Using Seawater**	**Mechanical Draft Using Freshwater**
Incremental Present Value (+15%) Impact	5.8	7.8	2.8	14.2
Incremental Present Value (-15%) Impact	(5.8)	(7.9)	(6.0)	(17.3)

Table E-15: Real World Today Present Value Impact for Fuel Cost Change ($millions)

	Air (Dry) Cooled Condenser	**Natural Draft Cooling Water Towers**	**Mechanical Draft Using Seawater**	**Mechanical Draft Using Freshwater**
Incremental Present Value (+$1.00/MMBtu) Impact	5.3	7.1	2.5	2.4
Incremental Present Value (-$1.00/MMBtu) impact	(5.3)	(7.1)	(2.5)	(2.4)

Economic Evaluation of Hybrid Case

Providing a cost estimate is a challenge for the hybrid system, because it is not obvious how the hybrid system would alleviate some of the fatal flaw considerations of wet towers. Duke does not believe that a hybrid system is feasible because there would remain significant costs and challenges of either using seawater or freshwater in the wet portion of the system.

For arguments sake, Duke has estimated the likely capital costs of the hybrid system assuming a 50/50 split in cooling load between the dry and wet portions of the system. Table 16 shows likely capital costs for both the April 2000 and the Real World Today cases.

Table E-16: Capital Costs for 50/50 Hybrid System ($ millions)

	Hybrid System – April 2000 Case	Hybrid System – Real World Today Case
Site Preparation	3.3	3.3
Cooling System Equipment Package	48.7	49.5
Installation	17.6	17.7
Demolition / Relocations	n/a	10.6
Transmission Line Relocation	n/a	3.5
Mitigation Costs	3.5	3.5
Total Capital Costs	73.1	88.1
Capital Costs Net of Depreciation Related Benefit	59.3	71.4

It is also reasonable to expect that the efficiency of the system on a heat rate basis would lay somewhere between that of the air cooling and the wet cooling systems. Accordingly, the overall on-going costs would be comparable to a proportional allocation of costs. Duke has not chosen to fully model these costs as was done with the other alternatives for the following reasons:

Total capital costs of the hybrid system are most likely more expensive than either of the "100%" systems of either air (dry) or wet cooling towers.

Efficiency and operating costs are roughly equivalent.

The overall economic impact of the hybrid system will most likely be slightly less than the dry cooling alternative but more than the seawater mechanical draft alternative.

The hybrid approach is still impractical because it does not overcome the feasibility constraints associated with provision of fresh water or provision of emission offsets (depending on source of water)..

Economic Evaluation of Spray Ponds

A detailed cost analysis of the spray pond alternative has not been performed due to the impracticality of this approach due to site constraints. However, capital costs would most likely be at least as high as the mechanical draft systems, based on the limited vendor data available to

Duke's consultants. Also, the efficiency impact would be comparable to the performance of the natural draft tower, because of the cooling characteristics of this system.

> Total capital costs of the spray pond system are most likely more expensive than mechanical draft systems. They would not be less.
>
> Efficiency and operating costs are roughly equivalent to the natural draft system.
>
> The spray pond is impractical because it does not overcome the feasibility constraints associated with provision of fresh water or provision of emission offsets (depending on source of water).

Appendix F

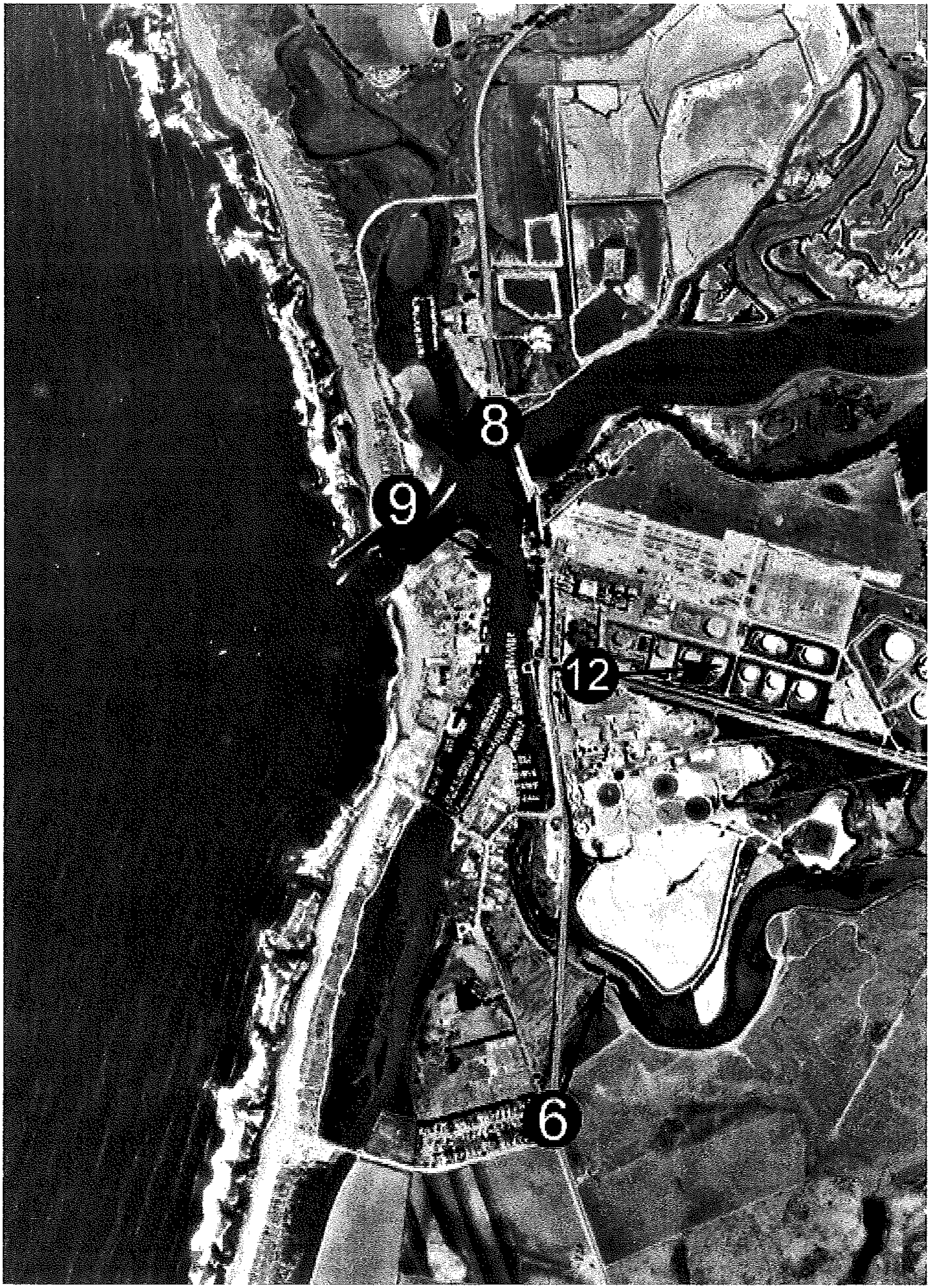


Figure VIS A: KOP Locations on Aerial Photo

EDAW

April 2003

KOP 6 - View from Highway 1 Looking North

Summary of Visual Conditions:	•Distance to MLPP is approximately 4,900 feet •Large traffic volume (24,500 ADT) on Highway 1 is focused directly on MLPP •Tall stacks and plume of Units 6 & 7 are the most prominent visual features of the area •Four shorter stacks of Units 1 & 2 appear above the horizon in center of photograph

Proper viewing distance is 18"

KOP 6 - Existing Conditions
Figure VIS B

EDAW

APRIL 2003

KOP 6 - View from Highway 1 Looking North

Summary of Visual Conditions:	•Mechanical draft plume is lower than that from Units 6 & 7, but nearly as large •Nearly consistent plume is generated from twenty-two, large diameter cooling fans •Tops of mechanical draft cooling towers are visible above horizon •Plume size portrayed in this simulation is a statistical average •Larger plumes would occur during certain meterological conditions

Proper viewing distance is 18"

KOP 6 - Mechanical Draft Cooling
Figure VIS C

EDAW

APRIL 2003

KOP 6 - View from Highway 1 Looking North

Summary of Visual Conditions:	•Natural draft cooling tower becomes the dominant feature on the landscape •Stacks from Units 6 & 7 become subordinate, even though they are slightly taller •Form of the tower suggests a nuclear power plant at Moss Landing •Plume size portrayed in this simulation is a statistical average •Larger plumes would occur during certain meterological conditions

Proper viewing distance is 18”

KOP 6 - Natural Draft Cooling Tower
Figure VIS D

EDAW

APRIL 2003

KOP 8 - SSE View from Highway 1 Bridge over Elkhorn Slough

Summary of Visual Conditions:

- Distance to MLPP is approximately 4,000 feet
- Large traffic volume (24,500 ADT) on Highway 1 is focused directly on MLPP
- 500' tall stacks and plume of Units 6 & 7 are the most prominent visual features of the viewshed
- One of four stacks from Units 1 & 2 is visible among vegetation in the left third of image

Proper viewing distance is 18"

KOP 8 - Existing Conditions
Figure VIS E

EDAW

APRIL 2003

KOP 8 - SSE View from Highway 1 Bridge over Elkhorn Slough

Summary of Visual Conditions:

- Mechanical draft plume rises above vegetation in the left third of image
- Nearly consistent plume is generated from twenty-two, large diameter cooling fans
- Plume size portrayed in this simulation is a statistical average
- Larger plumes would potentially be visible during certain meterological conditions

Proper viewing distance is 18"

KOP 8 - Mechanical Draft Cooling
Figure VIS F

EDAW

APRIL 2003

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KOP 8 - SSE View from Highway 1 Bridge over Elkhorn Slough

Summary of Visual Conditions:	•Natural draft cooling tower is the dominant feature on the landscape •Stacks from Units 6 & 7 are subordinate, even though they are slightly taller •Form of the tower suggests a nuclear power plant at Moss Landing •Plume size portrayed in this simulation is a statistical average, larger plumes would be visible during certain meterological conditions

Proper viewing distance is 18"

KOP 8 - Natural Draft Cooling
Figure VIS G

EDAW

APRIL 2003

KOP 9 - SE View from Moss Landing State Beach at Elkhorn Slough

Summary of Visual Conditions:	•Distance to MLPP is approximately 3,500 feet •Units 1 & 2 are not visible from this perspective •Tall stacks and plume of Units 6 & 7 are the most prominent feature in the viewshed •The Moss Landing Harbor is in the middle ground to the right, Highway 1 bridge is to the left

Proper viewing distance is 18"

KOP 9 - Existing Conditions
Figure VIS H

EDAW

APRIL 2003

KOP 9 - SE View from Moss Landing State Beach at Elkhorn Slough

Summary of Visual Conditions:

- Nearly consistent plume rises above buildings in the center of the image
- Mechanical draft equipment not visible from this perspective
- Plume size portrayed in this simulation is a statistical average
- Larger plumes would potentially be visible during certain meterological conditions

Proper viewing distance is 18"

KOP 9 - Mechanical Draft Cooling
Figure VIS I

EDAW

APRIL 2003

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KOP 9 - SE View from Moss Landing State Beach at Elkhorn Slough

Summary of Visual Conditions:	•Natural draft cooling tower adds a new co-dominate element with the Stacks from Units 6 & 7 •Form of the tower suggests a nuclear power plant at Moss Landing •Plume size portrayed in this simulation is 870 feet, a statistical average •Larger plumes would rise up to approximately 1,150 feet above the ground

Proper viewing distance is 18"

KOP 9 - Natural Draft Cooling
Figure VIS J

EDAW

APRIL 2003

KOP 12 - NW View from Dolan Road at MLPP Entrance Gate

Summary of Visual Conditions:

- Units 1 & 2 are approximately 1,200 feet away, the four stacks are 145 feet tall
- The switchyard is visible behind and to the left of Units 1 & 2
- New entry landscaping is visible in the foreground view

Proper viewing distance is 18"

KOP 12 - Existing Conditions
Figure VIS K

EDAW

APRIL 2003

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KOP 12 - NW View from Dolan Road at MLPP Entrance Gate

Summary of Visual Conditions:

- Air Cooled Condensers (ACC) simulated in this image are 102 feet tall
- ACC buildings are in a 5x5 configuration, measuring 220 feet x 230 feet
- ACC equipment must be co-located with steam turbins on west side, necessitating relocation of overhead transmission lines and new oily-water separator, among other equipment
- Blue color matches color selected by community and approved by County for MLPP Units 1 & 2

Proper viewing distance is 18"

KOP 12 - Air Cooled Condensers
Figure VIS L

EDAW

APRIL 2003

Appendix G

Appendix G: Land Use Summary Table

LAND USE PLANS AND POLICIES THAT CONFLICT WITH ALTERNATIVE COOLING OPTIONS AT MOSS LANDING POWER PLANT

POLICY #	POLICY TEXT	CONFLICT	Mechanical Draft (seawater)	Mechanical Draft (fresh water)	Natural Draft System	Hybrid Cooling System	Dry Cooling System
CALIFORNIA COASTAL ACT (PRC Section 30000 et seq.)							
30255	Coastal-dependent developments shall have priority over other developments on or near the shoreline.	Installing either the freshwater mechanical draft or dry cooling towers to the MLPP will make it a non coastal dependent facility.		✖			✖
MONTEREY COUNTY COASTAL IMPLEMENTATION PLAN (PART 1 - TITLE 20, ZONING ORDINANCE)							
Chapter 20.28: Regulations for Heavy Industrial Zoning Districts (HI/CZ)							
20.28.070.A .1	The maximum structure height is 35 feet unless superceded by a structure height limit noted on the zoning map. Additional height may be allowed subject to a Use Permit (ZA).	While the modernization and replacement project, as approved by the CEC, complies with the height requirement, compliance of natural draft system could be challenged as the additional structures could be considered a new facility and therefore a non conforming use due to the height limit.			✖		
Chapter 20.62, Height Exceptions							

POLICY #	POLICY TEXT	CONFLICT	Mechanical Draft (seawater)	Mechanical Draft (fresh water)	Natural Draft System	Hybrid Cooling System	Dry Cooling System
20.62.030.C	Any structure in an Industrial District may be erected to a greater height than the district allows, provided that the *cubical contents* of the structure shall not be greater than that possible for a structure erected within the height limit, and provided the design, exterior lighting, siting and landscaping plan for the project is approved by the Planning Commission.	It is not feasible to construct a 35-foot high natural draft cooling tower.			✖		
MONTEREY COUNTY COASTAL IMPLEMENTATION PLAN (PART 2 - REGULATIONS FOR DEVELOPMENT IN THE NORTH COUNTY LAND USE PLAN AREA) REFERENCING MOSS LANDING COMMUNITY PLAN							
Land Use and Development Standards							

POLICY #	POLICY TEXT	CONFLICT	Mechanical Draft (seawater)	Mechanical Draft (fresh water)	Natural Draft System	Hybrid Cooling System	Dry Cooling System
20.144.140. B.5.c:	Development of new or expanded industrial facilities shall only be permitted where able to meet the following criteria: 1. The industry shall be coastal-dependent. 2. The industry shall not use quantities of water that will exceed or adversely impact the safe, long-term yield of the local aquifer. 3. Where not preempted by the exclusive authority of a state or federal agency, the County shall require that the industry contribute only low levels of air and water pollution and reduce project pollution to the lowest levels possible for the particular industry. As a condition of approval, all available and feasible mitigation measures shall be incorporated into project design to minimize the amount of air and/or water pollution. 4. The industrial use shall incorporate appropriate buffer zones where located adjacent to agricultural areas, as per Section 20.144.080.D.6. 5. The development shall meet visual resource, environmentally sensitive habitat, and other development standards of this ordinance. (Ref. Policy 4.3.5.6 and 4.3.6.F.1 and F.4)	Freshwater mechanical draft and dry cooling will make the project non-coastal dependent. Additionally, all of the alternatives (except dry cooling) will not meet the visual resource and other development standards of this ordinance.	✖	✖	✖	✖	✖

POLICY #	POLICY TEXT	CONFLICT	Mechanical Draft (seawater)	Mechanical Draft (fresh water)	Natural Draft System	Hybrid Cooling System	Dry Cooling System
20.144.140. B.5.c.	Development of new or expanded industrial facilities shall only be permitted where able to meet the following criteria: 1. The industry shall be of a coastal or agricultural –dependent type. 2. The industry shall not use quantities of water that will exceed or adversely impact the sage, long-term yield of the local aquifer, as determined through a hydrologic report prepared in accordance with Section 20.144.070.D. 3. The development shall meet the visual resource, environmentally sensitive habitat, and other development standards of this ordinance.	Freshwater mechanical draft and dry cooling will make the project non-coastal dependent. Additionally, all of the alternatives (except dry cooling) will not meet the visual resource and other development standards of this ordinance. Lastly, freshwater mechanical draft cooling will use an unreasonable amount of the County's water resources.	✖	✖	✖	✖	✖
Moss Landing Community Development Standards							
20.144.160. C.1.c	Future expansion, improvement or other development including fuels conversion at PG&E, National Refractories and any other heavy industry in the area shall be considered in accordance with the Master Plan and associated Environmental Impact Report which has been developed for these facilities. This Master Plan requirement shall not apply to emergency or administratively approved developments under Section 30624 of the Coastal Act.	The additional of alternative cooling technologies is not anticipated by and does not conform with the current MLPP Master Plan	✖	✖	✖	✖	✖
	The Master Plan must have been developed by the applicants and submitted to Monterey County for review and approval prior to approval by the County of any development permits for these industries.	The additional of alternative cooling technologies is not anticipated by and does not conform with the current MLPP Master Plan	✖	✖	✖	✖	✖

POLICY #	POLICY TEXT	CONFLICT	Mechanical Draft (seawater)	Mechanical Draft (fresh water)	Natural Draft System	Hybrid Cooling System	Dry Cooling System
	The Master Plans shall address the long-range development and operation of the facilities including: 1) Physical expansion and new construction; 2) Major operational changes in fuels or fuel delivery systems; 3) Circulation or transportation improvements; 4) Electrical power transmission; 5) Alternative development opportunities; 6) Environmental considerations; 7) Potential mitigation of adverse environmental impacts; and 8) Conformance to all other policies of the North County Land Use Plan and other State and Federal regulations. Subsequent to approval of these Master Plans, permit request not in conformity with the Master Plans shall be considered only upon completion and approval of necessary amendments to the Master Plan. This requirement shall not be construed to require disclosure in the Master Plans of trade secrets, proprietary or confidential information, but only location of buildings and other land use matters necessary for planning purposes. (Ref. Policy 5.5.2.2 Moss Landing Community Plan.)	The additional of alternative cooling technologies is not anticipated by and does not conform to the current MLPP Master Plan. Additionally, the Master Plan could not be revised in such a way to conform to the policies of the North County Land Use Plan and other State and Federal regulations.	✖	✖	✖	✖	✖

POLICY #	POLICY TEXT	CONFLICT	Mechanical Draft (seawater)	Mechanical Draft (fresh water)	Natural Draft System	Hybrid Cooling System	Dry Cooling System
20.144.160. C.1.d	For onsite modernization and upgrading of existing facilities, the least environmentally damaging alternative shall be selected. This determination shall be made with background information in such documents as the Planning Department deems necessary to determine the actual affect of the development upon the project site habitat and the surrounding area. These documents may be in the form of, but not limited to, biological/botanical reports pursuant to Section 20.144.040.A, a forest management plan pursuant to Section 20.144.050.B, or an Environmental Impact Report of the appropriate level. When selection of the least environmentally damaging alternative is not possible for technical reasons, adverse environmental effects of the preferred alternative shall be mitigated to the maximum extent. The mitigation shall be identified by a document such as a focused EIR which more closely determines the effect of an alternative plan which was not identified as environmentally damaging in previous studies required for the proposed development. (Ref. Policy 5.5.2.3 Moss Landing Community Plan)	The addition of cooling towers to MLPP will have significant impacts to visual resources and conflict with multiple land use policies listed in this table. The project, as proposed, is the least damaging alternative.	✖	✖	✖	✖	✖
20.144.160. C.1.e	Modernization and expansion of industrial facilities shall be compatible with existing community land use patterns and circulation system capacities, planning objectives and local air quality regulations in effect at the time of the granting of such approval for said expansion by the appropriate agencies. (Ref. Policy 5.5.2.4 Moss Landing Community Plan)	The addition of cooling towers to MLPP will cause significant visual impacts and therefore is not consistent with the County's planning objectives.	✖	✖	✖	✖	

POLICY #	POLICY TEXT	CONFLICT	Mechanical Draft (seawater)	Mechanical Draft (fresh water)	Natural Draft System	Hybrid Cooling System	Dry Cooling System
20.144.160. C.1.f	Potentially hazardous industrial development (that development which is shown to be, through the various required and available documents, to be harmful to the environment of the area or is shown that the establishment, maintenance or operation of the use applied for will be detrimental to the health, safety, peace, morals, comfort and general welfare of persons residing or working in the neighborhood of such a proposed use or be detrimental or injurious to property and improvements in the neighborhood or general welfare of the County) shall not be located adjacent to developed areas. (Ref. Policy 5.5.2.5 Moss Landing Community Plan)	The addition of cooling towers to the MLPP will cause significant visual impacts that will disrupt the environment and it is detrimental to the health, peace, comfort and general welfare in the neighborhood of the Project.	x	x	x	x	
20.144.160. C.1.k	All new heavy industry must be coastal-dependent. (Ref. Policy 5.5.2.10 Moss Landing Community Plan)	Freshwater mechanical draft and dry cooling will make the project non-coastal dependent.		x			x
20.144.160. D.1.a	Visibility will be considered in terms of normal unaided vision in any direction for any amount of time at any season. The standard for review is the objective determination of whether any portion of the proposed development is visible from or impedes the visual access to the Moss Landing community, harbor and dunes from Highway 1 or any other public viewing area.	The addition of cooling towers to MLPP will cause significant visual impacts and therefore is not consistent with the County's planning objectives. The near constant plume of several of the alternatives will be visible from or impede the visual access to the Moss Landing community, harbor and dunes from Highway 1 or any other public viewing area.	x	x	x	x	

MONTEREY COUNTY GENERAL PLAN

Chapter IV: Area Development

POLICY #	POLICY TEXT	CONFLICT	Mechanical Draft (seawater)	Mechanical Draft (fresh water)	Natural Draft System	Hybrid Cooling System	Dry Cooling System
29.1.1	Industrial development which is compatible with Monterey County's environment shall be encouraged.	Freshwater mechanical draft and dry cooling will make the project non-coastal dependent. Additionally, all of the alternatives (except dry cooling) will not meet the visual resource and other development standards of this ordinance. Lastly, freshwater mechanical draft cooling will use an unreasonable amount of the County's water resources.	✖	✖	✖	✖	✖
29.1.2	The County shall require that industrial areas be as compact as possible and, where feasible, designate planned industrial park areas.	The addition of cooling towers to MLPP will add additional bulk to the existing facility and cause significant visual impacts and therefore is not consistent with the County's planning objectives.	✖	✖	✖	✖	✖
29.1.3	In order to maintain a healthy environment, the County shall allow only those industries which do not violate the County's environmental quality standards.	Freshwater mechanical draft and dry cooling will make the project non-coastal dependent. Additionally, all of the alternatives (except dry cooling) will not meet the visual resource and other development standards of this ordinance. Lastly, freshwater mechanical draft cooling will use an unreasonable amount of the County's water resources.	✖	✖	✖	✖	✖
NORTH COUNTY LAND USE PLAN							
Chapter 2, Resource Management							

POLICY #	POLICY TEXT	CONFLICT	Mechanical Draft (seawater)	Mechanical Draft (fresh water)	Natural Draft System	Hybrid Cooling System	Dry Cooling System
2.2.2.1	Views to and along the ocean shoreline from Highway One, Molera Road, Struve road and public beaches, and to and along the shoreline of Elkhorn Slough from public vantage points shall be protected.	The addition of cooling towers to MLPP will cause significant visual impacts and therefore is not consistent with the County's planning objectives.	✖	✖	✖	✖	
Chapter 4, Land Use and Development							
4.3.4	All future development within the North County Coastal Zone must be clearly consistent with the protection of the area's significant human and cultural resources, agriculture, natural resources, and water quality.	Freshwater mechanical draft and dry cooling will make the project non-coastal dependent. Additionally, all of the alternatives (except dry cooling) will not meet the visual resource and other development standards of this ordinance. Lastly, freshwater mechanical draft cooling will use an unreasonable amount of the County's water resources.	✖	✖	✖	✖	✖
4.3.5.6	The only industrial facilities appropriate for the area are coastal-dependent industries that do not demand large quantities of fresh water and contribute low levels of air and water pollution. Industries not compatible with the high air quality needed for the protection of agriculture shall be restricted.	Freshwater mechanical draft and dry cooling will make the project non-coastal dependent. Additionally, all of the alternatives (except dry cooling) will increase air quality impacts. Lastly, freshwater mechanical draft cooling will use an unreasonable amount of the County's water resources.	✖	✖	✖	✖	✖

POLICY #	POLICY TEXT	CONFLICT	Mechanical Draft (seawater)	Mechanical Draft (fresh water)	Natural Draft System	Hybrid Cooling System	Dry Cooling System
4.3.6.F.1	Lands designated for Heavy and Light industrial use in the North County Coastal Zone, shall be reserved for coastal-dependent industry as defined in Sections 4.3.1 L and M, and in the glossary of this plan. New Heavy or Light Industrial manufacturing or energy related facilities shall be located only in areas designated for these uses in this plan.	Adding freshwater mechanical draft or dry cooling towers to the MLPP will make it a non coastal dependent facility.		✖			✖
4.3.6.F.4	A basic standard for all new or expanded industrial uses is the protection of North County's natural resources. Only those industries determined to be compatible with the limited availability of fresh water and the high air quality required by agriculture shall be allowed. New or expanded industrial facilities shall be sited to avoid impacts to agriculture or environmentally sensitive habitats.	Freshwater mechanical draft and dry cooling will make the project non-coastal dependent. Additionally, all of the alternatives (except dry cooling) will increase air quality impacts. Lastly, freshwater mechanical draft cooling will use an unreasonable amount of the County's water resources.	✖	✖	✖	✖	✖
Chapter 5, Moss Landing Community Plan							
5.5.1	Existing coastal-dependent industries in Moss Landing have local, regional, statewide, and in some cases, national significance. Accordingly, the County shall encourage maximum use and efficiency of these facilities, and to allow for their reasonable long-term growth consistent with maintaining the environmental quality and character of the Moss Landing Community and its natural resources.	Freshwater mechanical draft and dry cooling will make the project non-coastal dependent. Additionally, all of the alternatives (except dry cooling) will increase air quality and visual impacts. Lastly, freshwater mechanical draft cooling will use an unreasonable amount of the County's water resources.	✖	✖	✖	✖	✖

POLICY #	POLICY TEXT	CONFLICT	Mechanical Draft (seawater)	Mechanical Draft (fresh water)	Natural Draft System	Hybrid Cooling System	Dry Cooling System
5.5.2.2	Future expansion, improvement, or other development including fuels conversion at PG&E or Kaiser Refractories, and any other heavy industry in the area shall be considered in accordance with master plans for these facilities. This master plan requirement shall not apply to emergency or administratively approved developments under section 30624of the Coastal Act. The master plans shall be developed by the respective industries and submitted to Monterey County for review and approval prior to approval by the County of any required permits for these industries. The master plans shall address long range development and operation of the facilities including physical expansion and new construction, major operational changes, changes in fuels or fuel delivery systems, circulation or transpiration improvements, electrical power transmission, alternative development opportunities, environmental considerations, potential mitigation of adverse environmental impacts and conformance to all other policies of the North County LCP and other State and Federal regulations. Subsequent to approval of these master plans, permit requests not in conformity wit the master plans shall be considered only upon completion and approval of necessary amendments to the master plan.	This policy applies only if the development is "coastal-dependent." Freshwater mechanical draft and dry cooling will not be coastal dependent and thereby would fail to satisfy this policy.		✖			✖

POLICY #	POLICY TEXT	CONFLICT	Mechanical Draft (seawater)	Mechanical Draft (fresh water)	Natural Draft System	Hybrid Cooling System	Dry Cooling System
5.5.2.3	The least environmentally damaging alternative should be selected for on-site modernization and upgrading of existing facilities. When selection of the least environmentally damaging alternative is not possible for technical reasons, adverse environmental effects of the preferred alternative shall be mitigated to the maximum extent.	On balance, the visual impacts from all of the alternative cooling options are significant (with the exception of dry cooling). Additionally, freshwater mechanical draft and dry cooling create land use conflicts by creating a non-coastal dependent use. None of the alternatives meet the CWA wholly disproportionate test. The current once-through cooling technology meets all of these criteria while mitigating any marine impacts through the habitat enhancement program.	✖	✖	✖	✖	✖
5.5.2.4	Modernization and expansion of industrial facilities shall be compatible with existing community land use patterns and circulation system capacities, planning objectives, and local air quality regulations in effect at the time of the granting of such approval for said expansion by the appropriate agencies.	The objective the County planning documents is to encourage only coastal dependent industrial uses in the coastal zone. This objective is not met by the freshwater mechanical draft and dry cooling options.		✖			✖
5.5.2.10	All new heavy industry shall be coastal dependent.	Freshwater mechanical draft and dry cooling create land use conflicts by creating a non-coastal dependent use.		✖			✖
5.6.3.6	Views through the Moss Landing community, harbor and dunes from Highway 1 should be protected through regulation of landscaping and siting of new development adjacent to the highway to minimize the loss of visual access.	The addition of cooling towers to MLPP will cause significant visual impacts (with the exception of dry cooling) and therefore is not consistent with the County's planning objectives.	✖	✖	✖	✖	

Appendix H

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Telephone: (303) 987-0123
Facsimile: (303) 987-0101

COOLING TOWER PROPOSAL SUMMARY & SCOPE OF SUPPLY

GEA PROPOSAL NO.: 0748 Rev.1
PCS – DFD MOSS LANDING SALT WATER OPTION

DATE: April 3, 2003

DESIGN CONDITIONS

CIRCULATING WATER FLOW, GPM	119,000
HOT WATER TEMPERATURE, °F	95
COLD WATER TEMPERATURE, °F	75
INLET WET BULB TEMPERATURE, °F	63
FAN POWER / FAN, BHP	236
TOTAL FAN POWER, BHP	2,360
PUMPHEAD, ABOVE CURB, FT	25.5

COOLING TOWER DIMENSIONAL INFORMATION

TYPE	COUNTERFLOW
NUMBER OF CELLS	11
CELL ARRANGEMENT	INLINE
CELL DIMENSIONS (LxWxH), FT	42 X 42 X 36
OVERALL TOWER DIMENSIONS (LxWxH), FT	462 X 42 X 46
BASIN DIMENSIONS (LxWxH), FT	464 X 48 X 4
FAN DIAMETER, FT	26
FAN STACK HEIGHT, FT	10

MATERIAL SUMMARY

STRUCTURE	DF – NO. 1 & BETTER
HARDWARE	SILICON BRONZE
MOTOR	1 SPEED, 1800 RPM
FILL TYPE	HIGH EFF. FILM
DISTRIBUTION	UPSPRAY

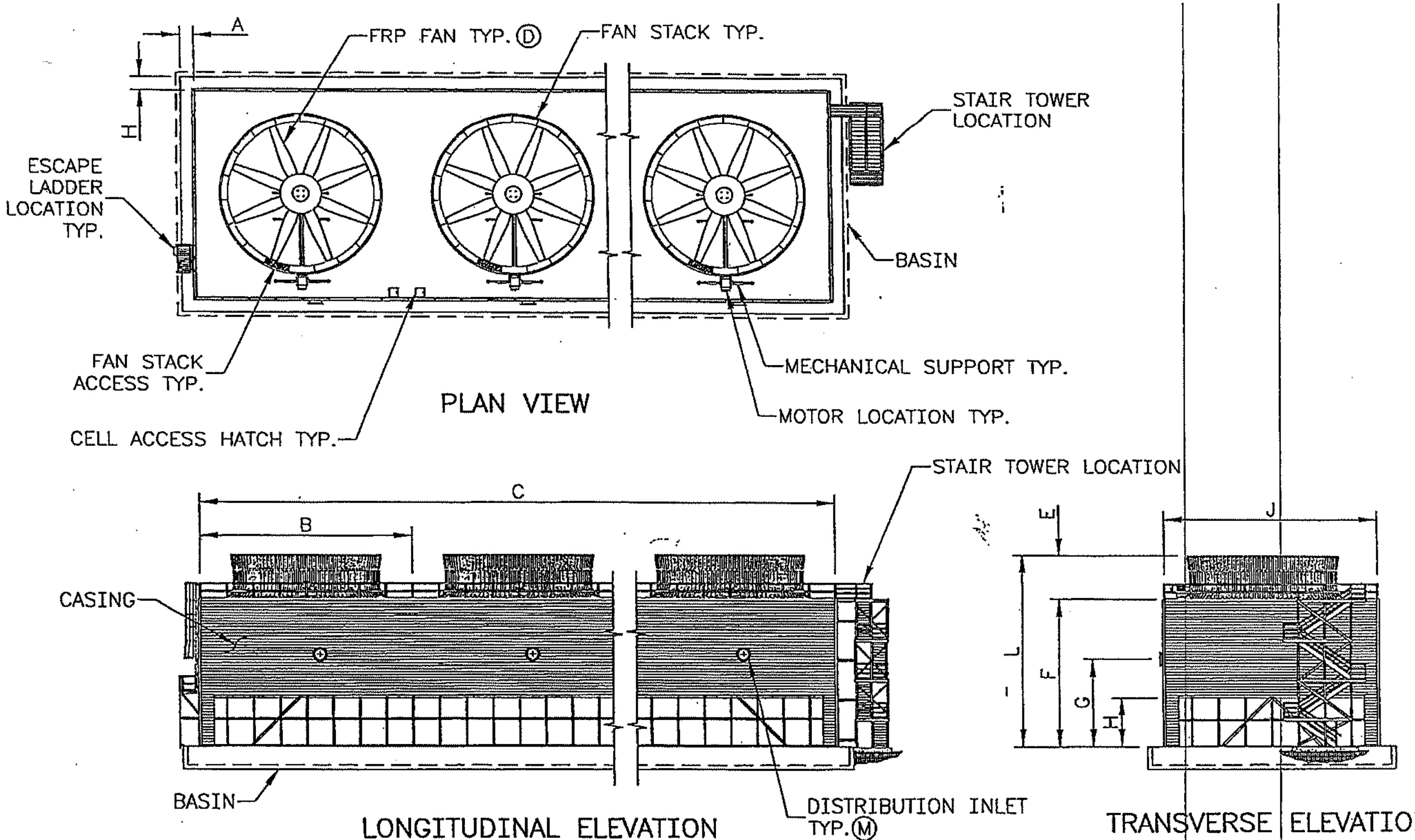
COMMERCIAL SUMMARY

MATERIAL PRICE	$1,648,650
LABOR PRICE (UNION)	$760,150
FREIGHT PRICE (TO JOBSITE)	$109,100
TOTAL PRICE	**$2,517,900**

OPTIONS

FIBERGLASS STRUCTURE IN LIEU OF WOOD (ADD)	$363,000

Pricing excludes all taxes, duties and fees. All terms and conditions to be mutually agreed.
Price excludes fire and lightning protection.



GEA
THERMAL TECHNOLOGY DIVISION
Integrated Cooling Technologies

WOOD OR FIBERGLASS STRUCTURE
COUNTERFLOW DESIGN TOWER
GENERAL ARRANGEMENT

COUNTERFLOW WOOD TOWER DIMENSIONS

Job Name: PCS - DFD Moss Landing Salt Water Option
Proposal Number: 0748 Revision: B
Model Number: 424236-11I-26-WCF Date: 4/3/2003

Number of Cells: 11

Item	Drawing AP-006 Reference Symbol	English	Metric
Cell Length:	B	42 ft	12.80 m
Cell Width:	J	42 ft	12.80 m
Tower Length:	C	462 ft	140.82 m
Tower Width:	K	42 ft	12.80 m
Fan Deck Height:	F	36 ft	10.97 m
Fan Stack Height:	E	10 ft	3.05 m
Air Inlet Height:	H	14 ft	4.27 m
Distribution Inlet Height:	G	24 ft	7.32 m
Overall Tower Height:	L	46 ft	14.02 m
Fan Diameter:	D	26 ft	7.92 m
Transverse Basin Extension:	I	3 ft	0.91 m
Longitudinal Basin Extension:	A	1 ft	0.30 m
Distribution Inlet Diameter:	M	24 in	610 mm

GEA

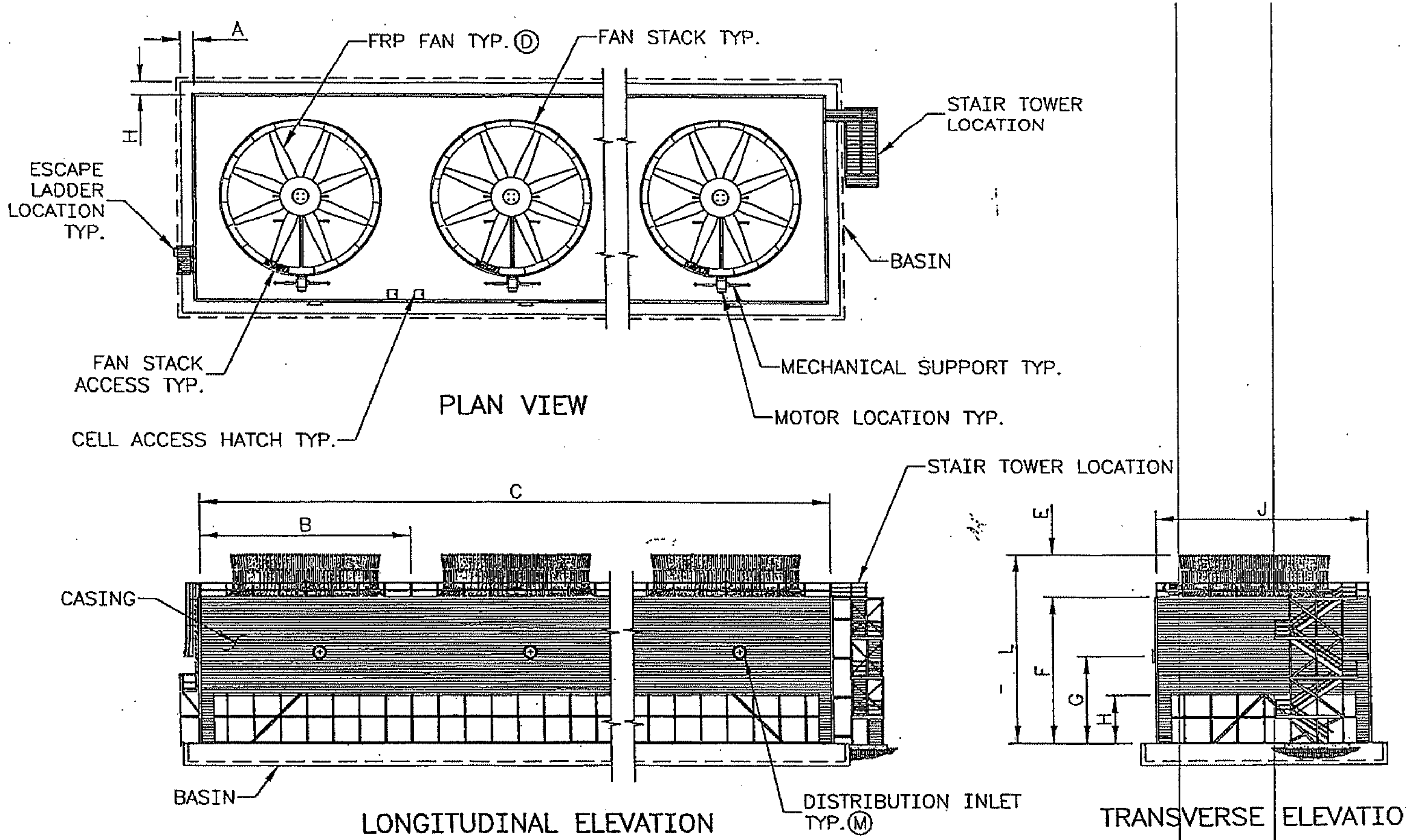
GEA Integrated Cooling Technologies, Inc.
143 Union Blvd., Suite 400
Lakewood, Colorado 80228
Telephone: (303) 987-0123
Facsimile: (303) 987-0101

COOLING TOWER PROPOSAL SUMMARY & SCOPE OF SUPPLY

GEA PROPOSAL NO.: 0748 Rev.1 | DATE: April 3, 2003
PCS – DFD MOSS LANDING FRESH WATER OPTION

DESIGN CONDITIONS	
CIRCULATING WATER FLOW, GPM	115,000
HOT WATER TEMPERATURE, °F	95
COLD WATER TEMPERATURE, °F	75
INLET WET BULB TEMPERATURE, °F	63
FAN POWER / FAN, BHP	197
TOTAL FAN POWER, BHP	2,167
PUMPHEAD, ABOVE CURB, FT	25
COOLING TOWER DIMENSIONAL INFORMATION	
TYPE	COUNTERFLOW
NUMBER OF CELLS	11
CELL ARRANGEMENT	INLINE
CELL DIMENSIONS (LxWxH), FT	42 X 42 X 36
OVERALL TOWER DIMENSIONS (LxWxH), FT	462 X 42 X 46
BASIN DIMENSIONS (LxWxH), FT	464 X 48 X 4
FAN DIAMETER, FT	26
FAN STACK HEIGHT, FT	10
MATERIAL SUMMARY	
STRUCTURE	DF – NO. 1 & BETTER
HARDWARE	304 SS
MOTOR	1 SPEED, 1800 RPM
FILL TYPE	HIGH EFF. FILM
DISTRIBUTION	UPSPRAY
COMMERCIAL SUMMARY	
MATERIAL PRICE	$1,368,300
LABOR PRICE (UNION)	$748,450
FREIGHT PRICE (TO JOBSITE)	$105,050
TOTAL PRICE	**$2,221,800**
OPTIONS:	
FIBERGLASS STRUCTURE IN LIEU OF WOOD (ADD)	$301,050

Pricing excludes all taxes, duties and fees. All terms and conditions to be mutually agreed.
Price excludes fire and lightning protection.



GEA
THERMAL TECHNOLOGY DIVISION
Integrated Cooling Technologies

WOOD OR FIBERGLASS STRUCTUR
COUNTERFLOW DESIGN TOWER
GENERAL ARRANGEMENT

GEA
Thermal Technology Division

Integrated Cooling Technologies, Inc.

COUNTERFLOW WOOD TOWER DIMENSIONS

Job Name: PCS - DFD Moss Landing Fresh Water Option
Proposal Number: 0748 Revision: B
Model Number: 424236-11I-26-WCF Date: 4/3/2003

Number of Cells: 11

Item	Drawing AP-006 Reference Symbol	English	Metric
Cell Length:	B	42 ft	12.80 m
Cell Width:	J	42 ft	12.80 m
Tower Length:	C	462 ft	140.82 m
Tower Width:	K	42 ft	12.80 m
Fan Deck Height:	F	36 ft	10.97 m
Fan Stack Height:	E	10 ft	3.05 m
Air Inlet Height:	H	14 ft	4.27 m
Distribution Inlet Height:	G	24 ft	7.32 m
Overall Tower Height:	L	46 ft	14.02 m
Fan Diameter:	D	26 ft	7.92 m
Transverse Basin Extension:	I	3 ft	0.91 m
Longitudinal Basin Extension:	A	1 ft	0.30 m
Distribution Inlet Diameter:	M	24 in	610 mm

NATURAL DRAFT COOLING TOWER PROPOSAL – MARLEY COOLING TECHNOLOGIES, INC.

Joseph.Padilla@marleyct.spx.com

03/24/03 03:54 PM

To: John.Ruud@Fluor.com

cc:

Subject: Natural Draft Selection - Moss Landing / Coastal Monterey County - Revised Design - REV. 1

John,

The attached e-mail reflects our revised proposal for the Moss Landing natural draft cooling tower.

Joe Padilla
Western Regional Manager - Power/Industrial Products

PLEASE NOTE NEW CONTACT DETAILS:

Marley Cooling Technologies, Inc.
P.O. Box 4665
El Dorado Hills, CA 95762-0022
Fax: (913) 693-9639
Cell Ph.: (916) 705-2369
joseph.padilla@marleyct.spx.com
www.marleyct.com

----- Forwarded by Joseph Padilla/MarleyCT/SPX on 03/24/2003 03:29 PM -----

Joseph Padilla

03/19/2003 09:12 AM

To: John.Ruud@Fluor.com

cc:

Subject: Natural Draft Selection - Moss Landing / Coastal Monterey County - Revised Design

John,

As requested, I have sized the natural draft cooling tower based on the revised flow rate of 230,000 gpm and an Approach Temperature of 22 deg. F. The results are as follows:

Design Conditions:
Flow Rate=230,000 gpm
Hot Water Temperature =105 F
Cool Water Temperature = 85 F
Cooling Water Range =20 F (hot water temp – cool water temp)
Ambient Wet Bulb Temp = 63 F

Ambient Dry Bulb Temp = 75 F
Relative Humidity = 51%
Approach to Wet Bulb = 22 F (cool water temp – wet bulb temp)

Tower Design:
Shell Height = 450 ft
Fill Diameter = 230 ft
Basin Diameter = 255 ft
Exit Diameter =170 ft
Min. Shell Diameter =150 ft
Air Inlet Height = 25 ft
Water Inlet Height = 35 ft
Pump Head = 45 ft (tower is designed with a higher full flow pump head in order to properly distribute flow at the 50% flow case)

Technical Data:
Air Exit Velocity = 670 ft/min
Exit Volumetric Flow Rate =15,222,000 ft^3/min
Drift Rate = Approx. 0.0005%
Exit Air Temperature = 98.3 F (Rev. 1)
Cold/Hot Water Temperature at 50% water flow rate = 76.5 F / 96.5 F

Budgetary Price: Approx. $15,000,000 (includes design, freight, material, basin, construction labor & equipment)

Joe Padilla
Western Regional Manager - Power/Industrial Products

PLEASE NOTE NEW CONTACT DETAILS:

Marley Cooling Technologies, Inc.
P.O. Box 4665
El Dorado Hills, CA 95762-0022
Fax: (913) 693-9639
Cell Ph.: (916) 705-2369
joseph.padilla@marleyct.spx.com
www.marleyct.com

GEA
Thermal and Energy
Technology Division

GEA Power Cooling
Systems, Inc.

ALL DRY AIR COOLED CONDENSER

Budgetary Information III

Date:	4/3/03	Ref. No.:	2964
Company:	Duke Fluor Daniel		
Project:	Moss Landing Power Project		
Contact:	John Ruud		
Phone No.:	949-349-5502	Fax No.:	949-349-2898

Selected case → Case 2

Condenser Design Requirements		Case 2	Case 3
Steam Flow	lb/h	1,533,010	1,061,000
Steam Enthalpy	Btu/lb	1098.5	1092
Turbine Back Pressure	" HgA	7.0	5.0
Inlet Air Temperature	F	85	85
Barometric Pressure	psia	14.69	14.69
Backpressure at 55 F and 1,098,550 lb/hr	"HgA	2.5	2.65

Condenser Preliminary Design			
No. of Bays		5	5
No. of Fan Modules/Bay		5	5
Fan Diameter	ft	34	32
Plot Area (W x L)	ft	230 x 220	200 x 195
Fan Deck Height	ft	62	55
Height to top of Steam Distribution Duct	ft	102	100
Fan Shaft Power (Total)	kW	3,240	3,320
Motor Rating	hp	200	200
Main Steam Duct Diameter	ft	21	21

Budget Information		
Budget Price:	**$12,300,000**	**$11,000,000**

Note: The budget price is based on all material and equipment delivered in the U.S. or Canada. Refer to the Scope of Supply.

Remarks

Delivery lead-time for this size Air Cooled Condenser is approximately 10 to 12 months after contract award.
Please see attached scope of supply for included equipment.
Budgetary pricing is valid for thirty (30) days only.

Appendix I

Client:	DENA	Contract:	04414001
Location:	Moss Landing, California	Revision:	D
Project:	Moss Landing Power Plant Project	Date:	10-Apr-03
Unit:	1&2	By:	C. Stacklin
Equipment:	Cooling Options	Chk:	P. Johnston Appv'd: A. MacKenzie
Case / Configuration:			

PLANT PERFORMANCE SUMMARY - COOLING OPTIONS

C:\Data\Projects\Moss Landing\[Plant Performance Rev D 030410.xls]Plant Performance

Cooling Configuration		Base Case Once Through Cooling			Air Cooled Condenser			Natural Draft Cooling Tower		Sea Water Cooling Tower		Fresh Water Cooling Tower	
Ambient Dry Bulb Temperature		75	55	55	75	55	55	55	55	55	55	55	55
Relative Humidity	%	52	88	88	52	88	88	88	88	88	88	88	88
STG Exhaust Pressure	inHgA	1.292	1.315	1.018	3.500	2.500	2.001	2.881	1.311	1.651	1.003	1.616	1.002
Unit # 1													
Number of GTG's Operating		2	2	1	2	2	1	2	1	2	1	2	1
Number of STG's Operating		1	1	1	1	1	1	1	1	1	1	1	1
GTG Capacity	%	100	100	50	100	100	50	100	50	100	50	100	50
Gross Power Per GTG	kW	160,000	171,300	85,600	160,000	171,300	85,600	171,300	85,600	171,300	85,600	171,300	85,600
Gross Power Per STG	kW	195,193	198,211	68,675	182,102	189,254	62,840	186,278	68,228	196,202	70,758	196,450	70,759
Gross Power Unit #1	kW	515,193	540,811	154,275	502,102	531,854	148,440	528,878	153,828	538,802	156,358	539,050	156,359
Fuel Heat Consumption, LHV	k Btu/h	3,054,400	3,212,196	1,042,608	3,054,400	3,211,875	1,042,608	3,211,875	1,042,608	3,211,875	1,042,608	3,211,875	1,042,608
Fuel Heat Consumption, HHV	k Btu/h	3,386,506	3,561,459	1,155,971	3,386,506	3,561,103	1,155,971	3,561,103	1,155,971	3,561,103	1,155,971	3,561,103	1,155,971
Unit # 2													
Number of GTG's Operating		2	2	0	2	2	0	2	0	2	0	2	0
Number of STG's Operating		1	1	0	1	1	0	1	0	1	0	1	0
GTG Capacity	%	100	100	50	100	100	50	100	50	100	50	100	50
Gross Power Per GTG	kW	160,000	171,300	0	160,000	171,300	0	171,300	0	171,300	0	171,300	0
Gross Power Per STG	kW	195,193	198,211	0	182,102	189,254	0	186,278	0	196,202	0	196,450	0
Gross Power Unit #2	kW	515,193	540,811	0	502,102	531,854	0	528,878	0	538,802	0	539,050	0
Fuel Heat Consumption, LHV	k Btu/h	3,054,400	3,212,196	0	3,054,400	3,211,875	0	3,211,875	0	3,211,875	0	3,211,875	0
Fuel Heat Consumption, HHV	k Btu/h	3,386,506	3,561,459	0	3,386,506	3,561,103	0	3,561,103	0	3,561,103	0	3,561,103	0
Moss Landing Power Plant Units 1 and 2													
Total Gross Power	kW	1,030,386	1,081,622	154,275	1,004,205	1,063,708	148,440	1,057,756	153,828	1,077,604	156,358	1,078,100	156,359
Auxiliary Load (1)	kW	33,230	33,230	16,095	34,832	34,832	17,228	35,428	17,268	38,672	19,491	38,642	19,476
Net Power Output	kW	997,156	1,048,392	138,180	969,372	1,028,875	131,212	1,022,328	136,560	1,038,932	136,867	1,039,458	136,883
Total Fuel Consumption, LHV	k Btu/h	6,108,800	6,424,392	1,042,608	6,108,800	6,423,750	1,042,608	6,423,750	1,042,608	6,423,750	1,042,608	6,423,750	1,042,608
Net Plant Heat Rate, LHV	Btu/kWh	6,126	6,128	7,545	6,302	6,243	7,946	6,283	7,635	6,183	7,618	6,180	7,617
Total Fuel Consumption, HHV	k Btu/h	6,773,011	7,122,918	1,155,971	6,773,011	7,122,206	1,155,971	7,122,206	1,155,971	7,122,206	1,155,971	7,122,206	1,155,971
Net Plant Heat Rate, HHV	Btu/kWh	6,792	6,794	8,366	6,987	6,922	8,810	6,967	8,465	6,855	8,446	6,852	8,445
GT Fuel HHV/LHV Ratio		1.1087	1.1087	1.1087	1.1087	1.1087	1.1087	1.1087	1.1087	1.1087	1.1087	1.1087	1.1087

Notes

(1) Auxiliary load is the total auxiliary load of Unit #1, Unit #2 and common plant.

Appendix J

Appendix J: Estimated Cost of Desalinated Water

(Based on Plan B Project Report, Moss Landing Desalination Component)

Capital Cost Summary (9 MGD Plant)

	$ millions
Seawater Supply Piping	1.3
Seawater Pump Station	0.8
Brine Discharge Pipeline	0.7
Subtotal Intake/Discharge	**2.8**
Pretreatment System	19.1
Pretreatment Storage	1.4
Reverse Osmosis System	18.5
Product Water Storage	0.8
Miscellaneous	1.9
Interconnecting Piping	3.8
Concrete Pads and Building	2.5
Subtotal Treatment Facility	**48.0**
Total Construction	**50.8**
Implementation Costs (@ 30%)	**15.24**
Land Acquisition Costs (estimate)	**1.0**
Subtotal	**67.0**
Project Contingency (@ 10%)	**6.7**
Total Estimated Capital Cost	**73.7**
Capital Recovery Factor (30 yrs @ 7%)	0.08059
Annualized Capital	**5.94**

Operating and Maintenance Cost Summary (purchased power @ $0.069/kWh)

Intake/Discharge O&M	0.02
Intake/Discharge Power	0.09
Pre-treatment O&M	0.53
Reverse Osmosis O&M	1.66
Reverse Osmosis Power	2.64
Clearwell O&M	0.02
Total O&M	**4.96**

Unit Cost of Water

Annual Water Production, af/yr	9075
Annualized Capital, $/af	$655
O&M, $/af	$547
Total Unit Cost of Water, $/af	**$1,201**
Total Unit Cost of Water, $/1000 gal	**$3.69**

Source: CPUC, *Carmel River Dam Contingency Plan, Plan B Project Report*, 2002. See Tables 20, 21 and 22 - Costs for offsite conveyance and storage omitted.

Appendix K

Appendix K: Capital Cost Split

DESCRIPTION	SITE PREP.	COOLING SYSTEM EQUIP. PKG.	INSTALLATION	DEMOLITION / RELOCATIONS	TRANSMISSION LINE RELOCATION	TOTAL
ACC Original	$1,440,000	$48,032,000	$15,360,000	$0	$0	$64,832,000
ACC Future	$1,600,000	$49,400,000	$16,295,000	$4,100,000	$3,500,000	$74,895,000
Seawater Cooling Tower Original	$3,730,000	$22,469,000	$13,800,000	$0	$0	$39,999,000
Seawater Cooling Tower Future	$3,700,000	$22,261,000	$13,800,000	$6,840,000	$0	$46,601,000
Fresh Water Cooling Tower Original	$3,850,000	$19,730,000	$13,930,000	$0	$0	$37,510,000
Fresh Water Cooling Tower Future	$3,800,000	$19,159,000	$14,000,000	$7,040,000	$0	$43,999,000
Natural Draft Original	$1,700,000	$31,695,000	$7,720,000	$0	$0	$41,115,000
Natural Draft Future	$1,700,000	$32,635,000	$6,837,000	$6,596,000	$0	$47,768,000
Hybrid - Original	$3,305,700	$48,661,800	$17,589,200	$0	$0	$69,556,700
Hybrid – Future	$3,297,400	$49,514,900	$17,736,400	$10,569,800	$3,500,000	$84,618,500

Site Prep. Includes all civil costs + prorate costs
Cooling System Equip. Pkg. Includes all equipment, S/C & bulk mat'l. costs + prorates
Installation includes all labor except civil + prorates
Demolition includes all demo. + prorates
Transmission Line does not incl. any prorates
Prorate costs include indirects, HO, Contingency & Fee

Appendix L

Appendix L: Derivation of average cost factor for natural gas fuel

Real $ in year	2000
Annual Escalation Factor	1%
Pricing Point	PG&E 1

Average = $ 4.37

Year	CEC 2002 Prices Real Price	Escalation	Nominal
2002	**3.09**	1.02	3.15
2003	**3.16**	1.03	3.26
2004	**3.22**	1.04	3.35
2005	**3.28**	1.05	3.45
2006	**3.34**	1.06	3.55
2007	**3.40**	1.07	3.65
2008	**3.47**	1.08	3.76
2009	**3.54**	1.09	3.87
2010	**3.61**	1.10	3.99
2011	**3.69**	1.12	4.12
2012	**3.76**	1.13	4.24
2013	3.76	1.14	4.28
2014	3.76	1.15	4.32
2015	3.76	1.16	4.37
2016	3.76	1.17	4.41
2017	3.76	1.18	4.45
2018	3.76	1.20	4.50
2019	3.76	1.21	4.54
2020	3.76	1.22	4.59
2021	3.76	1.23	4.63
2022	3.76	1.24	4.68
2023	3.76	1.26	4.73
2024	3.76	1.27	4.77
2025	3.76	1.28	4.82
2026	3.76	1.30	4.87
2027	3.76	1.31	4.92
2028	3.76	1.32	4.97
2029	3.76	1.33	5.02
2030	3.76	1.35	5.07
2031	3.76	1.36	5.12
2032	3.76	1.37	5.17
2033	3.76	1.39	5.22
2034	3.76	1.40	5.27

Data source: CEC, 2002 report

Appendix M

Appendix M: Backup Information on Elkhorn Slough Foundation Projects

Monitoring

In addition to these land acquisitions, Duke's funding is assisting the Foundation in providing background monitoring in support of the mitigation plan. The Foundation is working in close association with the Elkhorn Slough National Estuarine Research Reserve (ESNERR) to implement the Enhancement and Mitigation Plan background monitoring efforts. The Foundation now employs nine people that report to the Reserve on monitoring and education programs in the Reserve and also collaborate on data acquisition and interpretation. A number of key programs are in place to support an evaluation of the Duke MLPP mitigation program.

Another way the Board's current MLPP mitigation program is made most effective are the various other ongoing resource protection and monitoring activities of the Foundation.

1. <u>Water quality monitoring program</u>. The Foundation, ESNERR, Monterey County Water Resources Agency and the Elkhorn Slough Volunteers monitor, on a monthly basis, 24 stations throughout the lower watershed of the slough (see attached map). This program, initiated in 1988, is the longest continuous surface water-monitoring database in the central bay area. The dataset has provided insight into significant trends in surface water quality and provides an ongoing baseline against which to measure improvements following acquisition and restoration of key lands. Water quality parameters that are measured include: temperature, salinity, pH, turbidity, dissolved Oxygen, nitrate, phosphate and ammonia.

   The monitoring results have shown that,"Nitrate concentrations in the Elkhorn Slough watershed are extraordinarily high compared to other estuaries. Levels in the lower Salinas River and the Old Salinas River channel average almost 1,000 uM and sometimes exceed 5,000 uM, the highest measured for any estuary to date. These high concentrations are probably the result of the intensive agricultural production and drainage of agricultural ditches." (Caffrey, Brown, Tyler & Silberstein, in press). Hence the motivation of the Elkhorn Slough Environmental Enhancement and Mitigation Plan to acquire and retire steep agricultural fields and restoring key wetlands surrounding the Slough.

2. <u>Hourly Monitoring</u>. The Reserve monitors four stations on an hourly basis for the same parameters. These finer-grained data have been able to capture "spikes" in nutrient inputs associated with storm events and runoff. UC Santa Cruz, has expanded nutrient sampling into the upper drainages of slough tributaries to further track these inputs, and MBARI, initiated a study of oceanic inputs of nitrogen to the slough from upwelled water derived in the Monterey Canyon. These efforts will collectively help us understand, manage and improve slough water quality.

3. Ecological Change Estimation. The Elkhorn Slough National Estuarine Research Reserve and the Foundation have developed the most detailed and precise view of ecological change in the tidal wetland of the slough ever produced. A GIS tool allows a precise measure of changes in marsh and tideland cover in the Elkhorn Slough, so that for the first time changes in cover and habitat types associated with diking and restoration of tidal action to portions of the slough can be quantitatively identified.. The resultant maps and analysis are helping guide the restoration of wetlands under the ESEEP.

The Foundation is working with NRCS to develop a model to evaluate change in the sediment load following the retirement of steep, cultivated slopes. This work is being carried out in conjunction with the Agricultural Land Based Training Association (ALBA) in the upper slough on the 3M Ranch. The Foundation and ALBA are finalizing a management plan for this property that will further reduce erosion and runoff and restore 8 - 10 acres of wetlands along Carneros Creek. The model of sediment load will be applied to historic aerial photos and to images to estimate changes in sediment input from retired and restored lands.

Other Activities

In addition the land acquisition and monitoring, Duke's funding is assisting the Foundation in several other important activities directly benefiting the Slough and the entrained species.

1. Tidal Scour and Hydrography. Tidal scour, resulting from opening of Moss Landing Harbor in 1947 and subsequent breaching of dikes and levees, is one of the serious management issues facing the slough. The Elkhorn Slough National Estuarine Research Reserve is hiring staff to focus attention on this issue. Their goal is to assist in the coordination of research efforts for developing long-term solutions to the loss of habitat from scour. A part of this work will develop hand-held GIS units for field mapping and analysis that will be very useful in assessing the effectiveness of the mitigation implementation.

2. Biology in Support of Aquatic Health. The Elkhorn Slough Foundation has Dr. Kerstin Wasson to continue work on aquatic invasive species, and Dr. Gregory Cailliet completed a summary of the Status of Fish Assemblages in the Slough in a report to the Regional Board. This work will be useful in assessing the mitigation program in the slough.

3. Dissemination of information. The Foundation is publishing a book, summarizing over eighty years of scientific research in the Elkhorn Slough. "Changes in a California Estuary: A Profile of Elkhorn Slough" will be available in late spring and provides insight to the functioning of the slough from a variety of perspectives.

Appendix N

Appendix N: Expert Resumes

PROFESSIONAL SUMMARY

Alan D. MacKenzie
Project Engineering Manager

EDUCATION:
B.S., Chemical Engineering, California State Polytechnic University, Pomona

SUMMARY OF EXPERIENCE:

Project Engineering Manager for the Moss Landing Power Project, a 1060MW combined cycle plant constructed on an existing fossil generating station. Union construction.

Engineering Manager for the Frontera Generation Project, a 500MW combined cycle merchant power plant located in South Texas.

Project Management on a number of power generation proposals and small projects, both domestic and international.

Engineering Manager and Field Start-Up Manager for a 50 MW combined cycle cogeneration facility located at the Chevron El Segundo, CA, refinery.

Project Engineer on several proposals and studies ranging from small simple cycle power generation facilities to large scale repowering projects of up to 2400 MW.

Lead Process Engineering on a 670 MW repowering project of an existing fossil fired generating station.

Lead Process Engineer and Field Start-Up Engineer for the design and start-up on a 56 MW combined cycle cogeneration facility to generate power and provide steam to an existing paper mill.

Process engineering on a 1375 MW combined cycle cogeneration facility involving the conversion of an existing nuclear power plant using gas turbines/heat recovery steam generators to provide steam for the original plant steam turbines.

Process engineering on a composite materials plant expansion and facility consolidation project with an emphasis on an automated batch mixing process.

Process engineering on 100 MBPD and 32 MBPD oil and gas production projects on the Alaskan North Slope involving crude oil gathering, phase separation, produced water disposal and gas reinjection. This assignment also entailed the preparation of operating manuals.

Process engineering on various refinery units including crude and vacuum units, naphtha fractionation, coker fractionator and light ends plant, sulfur plant with tail gas treating and gas oil hydrotreating. Responsibilities included computer modeling, economic evaluation, and preparation of equipment specifications and flowsheets.

Process engineering on two separate linear low density polyethylene (LLDPE) plants, located in Saudi Arabia and Canada, with an emphasis on the materials handling portion of the plant including loading, packaging, and pneumatic conveying. Additional materials handling experience obtained on a project to add a fluid bed combustor to an existing shale oil processing plant. Plant Process Engineer for chlorinated hydrocarbons unit. Process and project engineering on small general projects.

SIGNIFICANT EXPERIENCE:

Duke/Fluor Daniel (1997 to Present)

Principal Project Engineer

Merchant Power Plant — Duke Energy North America, Moss Landing Power Project

Engineering Manager for a 1060MW plant built on the site of an existing fossil generating station. Involved extensive reuse of the existing station's seawater cooling system intake and connection to an existing outfall. Provided coordination of engineering between existing operations team and home office engineering. Developed procedure for interfacing with the California Energy Commission designated Chief Building Official, including the effect on the engineering schedule.

Merchant Power Plant — Odessa Ector Power Parters, Odessa Ector Power Project

Engineering Manager for a 1000MW combined cycle power plant. Extensive use of reference plant material to significantly reduce home office engineering hours. Coordination with owners sub-contractors supplying natural gas compression and plant make-up water. Overall responsibility for maintaining engineering deliverable schedule.

Merchant Power Plant — Frontera Generation Limited Partnership, Frontera Generating Project

Engineering Manager responsible for home office engineering activities from initial client contact through completion of engineering. Engineering responsibilities include assurance of technical quality, development of engineering schedules, and coordination of engineering activities with project controls, procurement, document control, and project management

Power Generation Proposals — Various

Proposal Manager for a number of lump sum EPC gas turbine based power projects. Responsible for developing scope of activities and proposal budget and schedule. Proposal execution includes coordination of engineering discipline activities and interface with sales and marketing team.

Fluor Daniel, Inc. (1980 to 1997)

Refinery Cogeneration Facility — Chevron U.S.A. Products Company, El Segundo, California

Engineering Manager responsible for all home office engineering activities including coordination of discipline activities, monitoring schedule and budget, and client interface on design and technical issues.

Principal Process Engineer

Refinery Cogeneration Facility — Chevron U.S.A. Products Company, El Segundo, California

Lead Process Engineer for detailed design of a 50 MW combined cycle facility to provide both power and steam to the Chevron refinery. Unique challenges integrating new facilities with existing cogeneration plant and handling of refinery fuels.

Refinery Cogeneration Facility — Rayong Refining Company, Map Ta Phut, Thailand

Process/Project responsibility for re-evaluation of proposed of steam and power plant for a new Shell refinery planned for construction in Thailand. Purpose of evaluation was to find ways to re-engineer the design to reduce project cost while maintaining a high degree of reliability. Redesigned facility resulted in 30% reduction in capital cost.

Senior Process Engineer

Repowering Project — CEA Rosarito, Rosarito, Mexico

Lead Process Engineer responsible for engineering to provide 2400 Mwe of electrical power from the repowering of six existing No. 6 oil fired fossil units, and the addition of two new stand-alone facilities. Project also included of 10 MGD of desalination capacity. Repowering design maximized re-use of existing equipment to minimize capital cost and integration of existing control systems into new plant DCS based control.

Cogeneration Facility — Hungarian Cogeneration, Budapest, Hungary

Lead Process responsibility for preliminary engineering to add combined cycle capacity to three existing district heating and power generation facilities located in Budapest, Hungary. Each site had distinct requirements for meeting thermal export demand, reliability and flexibility. Also unique challenges in working in socialist rather than market driven economy.

Combined Cycle Project — Doswell Cogeneration, Doswell, Virginia

Consulting role and general overall review of design for 660 MW daily dispatchable facility. Developed start-up plan, taking into account physical limitations of major mechanical equipment, that minimized start-up time required. This was then translated into the actual plant controls to develop a fully automated start-up system.

Repowering Project — Public Service Electric & Gas, Ridgefield, New Jersey

Lead Process Engineer for preliminary engineering and rollover into detailed design for two 600 MWe repowering projects at the existing PSE&G Bergen Station. Project involved repowering two existing 290 MWe cross compound reheat steam turbines. Repowering involved extensive investigation of the capabilities of the existing turbines as well as assessment of other balance of plant equipment for utilization in the repowered facility.

Reactivation Project | Duquesne Light Co.
Pittsburgh, Pennsylvania

Lead Process Engineer for the restart of an existing three train combined cycle facility (GE STAG 307). Design work involved specifying new HRSGs to replace existing aging boilers, and conversion from distillate fuel to natural gas. Also included extensive evaluation of the existing equipment for reuse in the reactivated facility.

Project Engineer

Cogeneration Facility | Selkirk Cogeneration
Bethlehem, New York

Combined project and lead process responsibility for preparation of an RFP for the Phase II addition of 252 MW of generating capacity. Included the addition of two GE Frame 7EA gas turbines, heat recovery boilers, a 110 MW condensing steam turbine, and integration of process steam in the GE plastic facility in Selkirk, New York. Unique engineering challenges involved in the integration of the two phases of the project. Also acted as owners engineer to oversee Phase 1 and provided support for permitting activities. Overall responsibilities included coordination of a multidiscipline task force between Irvine project team and the Philadelphia Operations Center, interface with client and outside consultants.

Process Engineer

Cogeneration Facility | Dexter Corporation
Windsor Locks, Connecticut

Lead Process Engineer for both the design and start-up of 56 MW combined cycle cogeneration facility. Plant included a GE Frame 6 gas turbine and two auxiliary boilers to supply steam to a steam turbine generator and the existing Dexter Paper Mill. Site start-up responsibilities included generating and maintaining overall and detailed start-up schedules, and preparation of start-up procedures and documentation. Provided training and supervision of plant operators during start-up and initial operation.

Cogeneration Facility | Midland Cogeneration Venture
Midland, Michigan

Process Engineer for power block section of a 1375 MW combined cycle cogeneration plant. This involved the conversion of an existing nuclear power plant using gas turbines/heat recovery steam generators to provide steam for the original plant steam turbogenerators and export steam to an adjacent Dow Chemical facility. Responsible for plant heat and material balances, P&ID development, and equipment specification.

Fluid Bed Combustor Project | Unocal
Parachute Creek, Colorado

Process Engineer on a cost estimating project to add a fluid bed combustor to the existing Unocal Shale Oil Plant designed to generate steam and power from spent shale. Responsible for process design and development of the materials handling systems for conveying raw shale fines to the combustor including development of P&IDs and equipment specifications for use in cost estimation.

Composite Materials Expansion Project — Ciba-Geigy, Anaheim, California

Process Engineer for a composite materials plant expansion and facility consolidation project. Work included process optimization and detailed design of a complex fully automated batch mixing operation and a hot oil heating system. Also included modification and relocation of existing equipment.

Light Ends Fractionation Revamp — ARCO Watson Refinery, Carson, California

Project to revamp and debottleneck a light ends fractionation unit to handle increases resulting from running NGL spiked North Slope crude. Involved preparation of as-built flow diagrams, revising flow diagrams, and evaluation of existing piping, equipment, and instrumentation for use in new services.

Production Facility Operating Manuals — Sohio Alaska Petroleum Company, North Slope, Alaska

Responsible for development of operating manuals for waterflood and gas lift plants at Sohio's Gathering Center No. 1, North Slope. Included preparation of flow diagrams and equipment descriptions.

Refinery Upgrading Study — Recope, Limon, Costa Rica

Process Engineer on 20 MBOPD refinery study aimed at increasing throughput and maximizing diesel production. Involved in simulation of crude and vacuum units, renovating existing equipment, and optimizing crude preheat exchanger train.

Milne Point Production Facility — Conoco, U.S.A., North Slope, Alaska

Process Engineer for 32 MBOPD, 32 MM SCFD oil and gas production facilities located on the Alaskan North Slope. Responsible for process design and development of mechanical flow diagrams and equipment specifications for the crude oil separation unit starting with client flow diagrams and specifications and subsequently carried through the detailed design phase.

Refinery Upgrading Study — Union Oil Company, Santa Maria, California

Process Engineer on 45 MBOPD refinery study. Involved in characterization of crude and computer simulation of crude and vacuum units for preparation of heat and material balances. Used results to evaluate existing equipment and instrumentation for operation with a different crude slate.

Lisburne Facilities Project — ARCO Alaska, Inc., Prudhoe Bay, Alaska

Process Engineer for 100 MBOPD, 300 MM SCFD oil and gas production facilities located on the Alaskan North Slope. Responsible for process design of the phase separation unit including crude oil characterization, preparation of mechanical flow diagrams, heat and material balances and estimate quality equipment specifications. Performed various computer studies and process simulations.

Naphtha/Gas Oil Fractionation Facility Revamp	Kern Oil and Refining Company Bakersfield, California

Process Engineer on 1000 BPD naphtha fractionation unit. Utilized computer modeling for evaluation of various distillation column configurations to produce several tight specification products. Checked available existing equipment for possible reuse in naphtha application.

Engineering Services for SFC Application Procedures (Keystone Project)	Westinghouse Electric Corporation Synthetic Fuels Division Waltz Mill Site Madison, Pennsylvania

Process Engineer on 30 TPD sulfur plant and tail gas treating unit. Overall responsibility for heat and material balances and preparation of equipment specifications for use in cost estimation.

Selexol Study	Fluor In-House Study

Process Engineer on a 150 MM SCFD gas treating process. Performed heat and material balance calculations, sized equipment and generated cost estimates for same.

Associate Process Engineer

Coker and Light Ends Plant Company (IVEC)	Independent Valley Energy Bakersfield, California

Process Engineer on delayed coking unit main fractionator and deethanizer directed at correcting flash point and water problems in the existing plant. Extensive use of computer distillation modeling and preparation of equipment specifications.

Polypropylene Plant Study	Confidential Client

Process Engineer on 300 MM LB/YR propylene plant comparison study. Prepared equipment specifications and preliminary equipment layouts of materials handling area for three different cases for use in cost estimate development.

LLDPE Plant Project	Novacor Alberta, Canada

Process Engineer on 600 MM LB/YR linear low density polyethylene plant. Prepared mechanical flow diagrams and equipment specifications for materials handling section including packaging, bulk loading, and pneumatic conveying systems. Participated in development of finishing area.

LLDPE Project — KEMYA, EXXON/SABIC, Al Jubail, Saudi Arabia

Process Engineer on 600 MM LB/YR linear low density polyethylene plant. Prepared mechanical flow diagrams and equipment specifications for materials handling section including bulk loading, packaging, and pneumatic conveying systems.

FCC Feed Desulfurization — Gulf Oil Company, Santa Fe Springs, California

Process Engineer on preparation of a type A process package. Performed heat and material balance calculations, prepared process flow sheets and equipment specifications.

Dow Chemical Company (1979 - 1980)

Plant Process Engineer

Process and project engineering on small projects in chlorinated products plant. Modified distillation tower to improve yield. Responsible for project to reduce corrosion. Optimization of methylene chloride plant.

Union Oil Company of California (1978 - 1979)

Engineer, Distillation and Cracking Department

General process engineering on distillation units. Economic evaluations. NOx emissions study of fired heaters and boilers. Strong emphasis on energy and utilities, particularly steam system.

PROFESSIONAL SUMMARY

Christopher Stacklin
Senior Process/Specialty Engineer

EDUCATION:
B.S., Chemical Engineering, California State Polytechnic University, Pomona

SUMMARY OF EXPERIENCE:

Process Engineer with 25 years of experience in Process Engineering, Power Plant Design, Computer Automation, Marketing Research and Planning, Reliability Availability and Maintainability (RAM) Engineering. Background includes:

Project development, process design and commissioning for: simple and combined cycle merchant and cogeneration plants, auxiliary boiler systems, refinery steam and condensate systems, flare systems, tankage and blending systems, crude and vacuum units, aromatics production units, refinery reformulated fuels program, Platformer start-up assistance, CSP/Butamer design, FCC revamp, on-site technical assistance of an oil production facility, water hammer and two phase network flow analysis of an oil production gathering system, conceptual design of an oil terminal, start-up and performance testing of cogeneration plants, in-field safety assessment of petrochemical complexes, computer programming and simulation.

Marketing research and strategic planning in the refining and chemical industries. Responsibilities include teaming with sector sales and operating heads in setting overall strategy, supporting specific proposal efforts by providing information on competitors, and proactively assisting individual salesmen with information on market trends and specific prospects.

RAM availability analysis of simple cycle, combined cycle, gasification combined cycle cogeneration plants, and first-of-a-kind plants; real-time RAM modeling of unit operations using expert systems; risk and hazard analysis; cause-consequence modeling of a chemical plant; computer programming.

Additional Experience: Project Controls Engineering Technician; Electrical and Control Systems Engineering and Engineering Technician; Structural/Architectural Engineering Technician. Also presented or published 12 technical papers.

SIGNIFICANT EXPERIENCE:

<u>**Duke/Fluor Daniel**</u> (1999 - Present)

Senior Process Engineer

Front End Engineering Design (2003) — Duke Fluor Daniel, Aliso Viejo, California, North America

Process engineer responsible for front-end engineering design of LM6000 simple and combined cycle power plants. Developed piping and instrument diagrams, line sizing and line stamp and system description of all systems for dual fuel application. Supported lump sum turnkey estimate.

Project Warrantee Support
(2002-2003)

Duke Fluor Daniel Projects
Various Locations, United States, North America

Process engineer providing warrantee support for OxyChem Taft, ConEd Newington, FPLE Forney and DENA Moss Landing Projects. Tasks include supporting field requests for heat and material balance data using Hysys process simulator, developing performance test methodology, cooling tower Copper Chromium Arsenic (CCA) effluent estimate, fuel gas dewpoint measurement, steam blows, freeze protection and pump troubleshooting. Also environmental permit support for plant cooling alternatives.

Front End Engineering Design
(2002-2003)

Florida Power & Light
Martin & Manatee County, Florida, North America

Process engineer for front end engineering design of two four-on-one combined cycle power plants. Developed automated heat and material balance datasheets, initial equipment sizes and process flow diagrams. Supported lump sum turnkey estimate. Designed gas turbine generator, circulating water and fuel gas systems up to client review detail. Saved $11 million total installed cost by using existing intake structure pump bays for circulating water system instead of new intake structure.

California Application for Certification
(2000-2003)

Florida Power & Light Energy
Tesla, California, North America

Process engineer responsible for California Application for Certification. Facility design for 1,120 MW combined cycle plant included startup, shutdown and constant load air emissions for combined cycle plant and auxiliaries, water balances and zero liquid discharge and cooling tower plume and noise abatement. Evaluated alternative cooling technologies and economics for dry and parallel air-cooled systems. Supported "Will-Serve" for water supply and permit from submittal through data adequacy and discovery phases.

FPLE Permit Management
(2001-2002)

Florida Power & Light Energy
Southeastern United States, North America

Process engineer responsible for permit development for multiple location combined cycle projects in Mississippi, Tennessee, Georgia and North Carolina. Activities included startup, shutdown and constant load air emissions for combined cycle plant and auxiliaries, water balance, wastewater discharge characterization, quantifying hazardous and non-hazardous waste streams and siting.

Plant Performance Test
(2002)

Duke Energy North America
Moss Landing, California, North America

Process engineer for evaluation of performance data against performance test guarantees for a 1,060 MW Combined-Cycle Electric Generation Facility. Activities included data collection, analysis and adjustment to guarantee conditions.

Chiller Retrofit
(2002)

Ultramar Refinery
Martinez, California, North America

Process engineer responsible for front-end cycle design study for chiller retrofit to two GE Frame 6B combustion turbine generators in combined cycle service. Chillers added net increase in performance to combustion turbine generators resulting in power sales revenue gain.

California Application for Certification (2000-2002) — Duke Energy North America, Various Sites, California, North America

Process engineer supporting California Application for Certification in Morro Bay and South Bay sites. Facility design included cycle design, heat and material balances and sized equipment list for a combined cycle configuration with once-through seawater cooling. Evaluated existing once-through cooling system capacity relative to new requirements. Supported site survey for visual impacts and on-site evaluation of existing infrastructure. Provided consultant support for Avenal site.

California Application for Certification (2000-2001) — Reliant Energy, Colusa, California, North America

Process engineer responsible for California Application for Certification. Facility design for 620 MW combined cycle plant included startup, shutdown and constant load air emissions for combined cycle plant and auxiliaries, water balance and zero liquid discharge, noise abatement and air-cooled condenser design. Evaluated alternative cooling technologies and economics for cooling tower and parallel air-cooled systems. Investigated laws, ordinances, regulations and statutes relative to water discharge issues and support permit from submittal through data adequacy and discovery phases.

California Application for Certification (2000-2001) — Florida Power & Light Energy, Rio Linda, California, North America

Process engineer responsible for California Application for Certification. Facility design for 560 MW combined cycle plant included startup, shutdown and constant load air emissions for combined cycle plant and auxiliaries, water balance and zero liquid discharge, noise abatement and cooling tower plume abatement. Evaluated alternative cooling technologies and economics for dry and parallel air-cooled systems. Supported "Will-Serve" for water supply and permit from submittal through data adequacy and discovery phases.

California Application for Certification (2000-2001) — Edison Mission Energy, Bakersfield, California, North America

Process engineer for California Application for Certification of Western Midway Sunset project. Facility design for 520 MW combined cycle plant included startup, shutdown and constant load air emissions for combined cycle plant and auxiliaries, water balance and wastewater discharge during construction and operation for NPDES, and integration with existing facility. Evaluated alternative cooling technologies and economics for air-cooled condenser and parallel air-cooled systems.

BHP Illawarra Cogeneration (2000-2002) — Duke Energy International, Port Kembla, NSW, Australia

Process engineer responsible for front-end design of a 185 MW cogeneration plant in Broken Hill Proprietory's steel mill. Developed design basis document, heat and material balances and water treatment for a plant configuration consisting of four blast furnace gas boilers and a single condensing steam turbine generator with extraction. Supported on-site steam security effort utilizing HAZOP approach, engineering specifications and P&ID review. Wrote whitepaper on desuperheating letdown (steam dump valve) field experience.

Project Development — Duke Fluor Daniel
(2000-2003) — Aliso Viejo, California, North America

Process engineer responsible for front-end design and optimization of simple and combined cycle merchant plants, cogeneration plants and integrated gasification combined cycle plant for cost estimates and permits. Project profit after expense for permit support was $400,000. Duties include cycle optimization using GE Cycledeck and Thermoflow software, equipment sizing and specification, systems engineering in support of plant air and water permit applications, pro forma support for external clients and maintenance of design reference systems. Also prepared performance correction curves for various projects. Created and presented training class for cycle design fundamentals.

Process Engineer II

Proposal Support — Duke Fluor Daniel
(1999-2000) — Irvine, California, North America

Process engineer responsible for lump sum turnkey design of simple and combined cycle merchant and cogeneration plants. Duties include configuration trade-off and heat and material balance analysis using Thermoflow software and generating a sized equipment list. Developed electronic equipment list and sizing using Visual Basic and Excel resulting in cost savings of $135,000 annually. Created object map of Thermoflow's GTMaster program to equipment sizing program to automate design process. Provided reliability analysis for equipment cost reduction. Supported Primary Energy on small power plant pro forma studies including LM6000PC Sprint. Created and presented training classes for automated equipment sizing and equipment list programs.

Fluor Daniel (1992 - 1999)

Sulfur Plant Projects — PEMEX
(1999) — Cactus, Mexico, North America

Local Zyqad Coordinator responsible for implementation of FrontRunner workshare between Irvine and ICA/Fluor Daniel office in Mexico City. Installed and tested client linkage to broker host in Mexico City. Provided training for Mechanical Engineering design team.

Sulfur Plant Projects — PEMEX
(1998) — Cuidad, Mexico, North America

Process engineer for front-end engineering design of sulfur plant offsites. Responsible for debottlenecking existing steam, boiler feed water, and condensate systems and integration with new cogeneration plant. Improved heat and material balance program to check-rate existing equipment and analyze new, low cost design alternatives for lump sum, turnkey packages.

Heavy Oil Upgrader — Sincor Downstream Project
(1998) — Jose, Venezuela, South America

Process engineer responsible for front-end engineering design of steam, boiler feed water, and condensate systems. Designed for four utility boilers producing three-pressure level steam system at 385,000 kg/hr BFW. Created heat and material balance program combining physical properties generator with equipment sizing and hydraulics for quick analysis using Visual Basic, Excel and WinSteam.

FrontRunner Knowledgebase Development (1998) — Fluor Daniel, Incorporated, Greenville, South Carolina, North America

Process engineer developing object model of equipment class structures and equipment datasheets for computer automation program. Program functionality includes equipment lists, equipment datasheets, process flow diagrams and material selection diagram that share the same database. Wrote object model code in LispWorks and generated datasheets using modified AutoCAD version 14. Also responsible for deployment and systems administration of FrontRunner in Irvine office, including sales support and server maintenance.

QuickPlant Automation Support (1997) — Fluor Daniel, Incorporated, Irvine, California, North America

Process engineer supporting development of computer automation programs that automatically route piping and create 3-D plant via process simulators AspenPlus, Hysim and ProII. Identified and mapped process simulation variables for use in QuickPlant datastructure. Streamlined single phase and two-phase hydraulic calculations for fast results.

Flare Improvement Study (1997) — Yukong Refinery, Ulsan, Korea, Asia

Process engineer for improvement of refinery flare system. Created object-oriented computer programs using Visual Basic and Excel for evaluation of individual flare loads and failure analysis using electric one-line diagrams. Results were used to optimize flare relief capacity by re-routing loads to flares with more capacity, take load credit for TMR where cost effective and establish smokeless operation saving $3-5 million total installed cost.

Process Engineer

Refinery Expansion (1996-1997) — Abu Dhabi National Oil Company, Abu Dhabi, UAE, Middle East

Process engineer for front-end engineering design of refinery offsites. Responsible for offsite interconnecting piping, marine terminal, shipping and blending pump sizing. Developed electronic data transfer scheme to expedite design process.

Flare System Study (1995 - 1996) — Yukong Refinery, Ulsan, Korea, Asia

Process Engineer responsible for detailed relief analysis of existing 800,000 BPSD refinery and petrochemical complex. Developed or modified heat and material balances using SIMSCI's PROII and PROVISION and analyzed towers and miscellaneous equipment. Developed relief valve sizing computer programs, databases, electronic data transfer, and reporting procedures for

700 relief valves in accordance with API-520 and API-521 using Lotus Notes, Lotus 123, Microsoft Excel to expedite project saving $100,000 per project.

BPX Cusiana — British Petroleum, Incorporated
(1995) — Cusiana, Colombia, South America

Process Engineer providing on-site technical services for troubleshooting, debottlenecking, and performance testing for 80,000 BOPD oil production facility. Raised crude oil capacity by 20,000 BOPD using Test Separator to unload gas from High Pressure and Medium Pressure Separators increasing production revenues by $146 million annually. Troubleshooting at Dehydration and Degassing Separators, Gas Dehydration, Fuel Gas, and Flare. Performance testing of Fuel Gas, Electric Generators, and Flare.

Karimun Oil Terminal — KUO International, Incorporated
(1995) — Kecil, Riau, Indonesia, Southeast Asia

Process Engineer responsible for engineering evaluation and cost estimate for an Oil Terminal and Offsites for a 50,000 BPSD refinery. Evaluation included basic design of tankage & pumping systems, asphalt handling, hot oil system and gasoline blending. PFD's and a sized equipment list were developed.

Reliance Refinery — Reliance, Incorporated
(1995) — Jamnager, India, Asia

Process Engineer responsible for preliminary design cost estimate of new aromatics portion of grassroots refinery including Naphtha Hydrotreater, CCR Platformer, Benzene-Toluene Fractionation Unit, PAREX Unit, TATORAY Unit, ISOMAR Unit, Xylenes Fractionation Unit for 1.2 MTA p-xylene production. Work effort included unit scale-up from Class A package, and development of ICARUS cost estimate model. Developed criticality rankings for Crude Unit, Hydrogen Plant, and CCR Platformer.

Midor Refinery — Midor Consortium
(1994-1995) — Alexandria, Egypt, Africa

Process Engineer responsible for front-end engineering design of 100,000 BPSD new Crude-Vacuum Unit with Debutanizer, Light Ends Unit, Naphtha Splitter and Sour Water Stripper. Design supported cost estimate and included extensive simulation using Hysim and EDSS computer programs.

Kuwait Petrochemical Joint Venture — Kuwait National Petroleum/ Union Carbide
(1994) — Charleston, West Virginia, North America

Process Engineer responsible for Summary of Design (Class A) packages for ethylene glycol non process areas including unit storage, flare, fire and safety systems. Cost saving development efforts utilizing past design experience resulted in client approval for detailed design. Used PALS, Overthruster computer programs, API 520, 521 and 2000.

CRAY Delayed Coker Project — Lagoven
(1994) — Amuay, Venezuela, South America

Process Engineer supporting pre-startup safety audit of 6 drum delayed coker unit. Provided process design assessment of relief and flare system for Exxon safety audit team. Evaluated/ proposed low cost design changes for field construction using Overthruster computer program.

Emerging Clean Fuels/Petroleum Technologies (1994) — Fluor Daniel, Incorporated, Irvine, California, North America

Process Engineer/System Administrator developing a worldwide database system for capturing and analyzing information on emerging petroleum and petrochemical technologies. System based on Lotus AmiPro and Lotus Notes. Added initial data of several technologies.

Reformulated Gasoline Program (1993 - 1994) — Chevron, El Segundo, California, North America

Process Engineer for checkout, commissioning and start-up support of a CCR Platformer Unit licensed by UOP. Project was fast-tracked to meet EPA and CARB deadlines and required re-use of existing reformer equipment. Issued Management of Change and Field Change Request documents and Safety Information Sheets in support of permitting. Provided process design evaluation of field changes, system walkdowns/punchlists, and as-built P&ID's.

Reformulated Fuels Program (1992 - 1993) — Unocal, Wilmington, California, North America

Process Engineer for detailed design of a CSP/Butamer Unit licensed by UOP, FCC Deethanizer check-rate, and offsites and utilities fieldwork. Work was fast-tracked to meet EPA and CARB deadlines and required re-use of existing equipment in addition to field verification and testing. Used SIMSCI's PROII simulator for check-rate and EDSS electronic data sheet system. Supported Unocal HAZOP. Routed and field-checked pipelines and tie-in locations for tank rundowns and utilities, developing as-built P&ID's.

Residual Oil Gasification Project (1992) — Agip Raffinazione, Venice, Italy, Western Europe

Process Engineer for front-end design including nitrogen oxides emission reduction survey and gas turbine performance study. Performed availability analysis of several gas turbine models using Texaco gasification process.

Refinery Fuel Gas Desulfurization Study (1992) — Fluor Daniel, Incorporated, Irvine, California, North America

Process Engineer evaluating commercial gas treating technologies for sulfur reduction of refinery fuel gas to 40 ppmv or lower. Required collection of speciated sulfur data for crude and vacuum units, delayed coker units, fluid catalytic cracking units. Developed low cost design strategies to maximize utilization of existing refinery equipment.

Pemex Safety and Environmental Assessment (1992) — Petroleos Mexicanos (Pemex), Coatzacoalcos, Mexico, South America

Process Engineer evaluating process design and supporting safety and environmental assessment for ammonia, para-xylene, hydrogen, acrylonitrile, and polyethylene units at Cosoleacaque and La Congrejera Complexes.

Fluor Corporation (1989 - 1992)

Senior Marketing Services Representative

Economic Indicators (1992)	Fluor, Incorporated Irvine, California, North America

Marketing Analyst support macroeconomic synopsis for Executive Committee. Collected and summarized indicators in petroleum and petrochemicals markets, competitor position, project wins and losses and sales prospects corporate-wide.

Engineering and Construction Industry Survey (1992)	Exxon and Mobil Princetown, New Jersey, United States

Marketing Analyst responsible for collection and development of information supporting Exxon and Mobil survey of contractors. Included information gathering, assessment and summary from all Fluor office locations for staff, utilization and projects.

Global Energy Leadership in the Energy E&C Industry (1991)	Confidential Client United States, North America

Marketing Analyst for evaluation of engineering and construction competitiveness in the Middle East and Asia. Analyzed the trends in energy demand growth, identified future mega-projects in the Middle East and Pacific Rim, factors affecting mega-project construction, and characteristics of E&C contractors.

EXOR IV Export Oriented Refinery (1990)	Pertamina Dumai, Indonesia, Southeast Asia

Lead Marketing Analyst for project congestion study. Analyzed the impact of mega-projects in the Pacific Rim on EXOR IV project execution including economic outlook, shop utilization and equipment cost escalation, transportation logistics, labor outlook and long lead time equipment procurement.

Eastern Europe Marketing Strategy (1990)	Fluor, Incorporated Irvine, California, North America

Marketing Analyst assisting VP of Eastern Europe, Chuck Pringle for development of corporate marketing strategy for Eastern Europe. Included assessment of economic, political, and social restructuring of USSR during Perestroika, business risk analysis, interviews with Gosstroi USSR Ministry of Construction and U.S. State Department officials.

Refining and Petrochemicals Study (1990)	Fluor, Incorporated Irvine, California, North America

Marketing Analyst responsible for World Refining and Petrochemicals Market Study. Study included calculating supply and demand curves, capacity utilization, major clients and business unit strategies reflective of current and future market conditions and intelligence gathering.

Pharmaceuticals Market (1989) — Fluor, Incorporated, Irvine, California, North America

Marketing Analyst developing assessment of Fluor market share, client profiles and competitors for Biotech and Pharmaceuticals VP Steve Tappan and CEO Les McCraw. Interviewed key Biotech and Pharmaceuticals contacts and used WINS system.

MTBE Spot Price (1989) — Fluor, Incorporated, Irvine, California, North America

Marketing Analyst determining MTBE spot price for Project Finance group. Included survey of suppliers, developing and analyzing supply-demand curves, capacity utilization, planned facilities and interviews.

Various Projects (1989 - 1992) — Fluor Daniel, Incorporated, Irvine, California, North America

Marketing Analyst supporting Executive Committee and Line Sales. Responsibilities include: meeting with marketing managers/ other internal clients to assess their informational needs and scope appropriate research, design strategies for implementing research projects; conducting research efforts, presenting research results in oral and written reports; supporting and maintaining internal marketing information systems, e.g. report files, WINS, LEXIS-NEXIS, Internet, strategic planning. Major projects are: world refining and petrochemicals study; regional business plans of Eastern Europe/ Asia-Pacific; mining, metals, metallurgy forecast; commodity chemicals price forecasts; company/ competitor profiles; world projects congestion study; economic indicators; acquisition studies; biotechnology and pharmaceuticals.

Fluor Daniel (1979 - 1989)

Process Specialist Engineer

1370 MW Gas Fired Cogeneration Conversion (1987 - 1990) — Midland Cogeneration Venture, Midland, Michigan, North America

Lead RAM Engineer for steam reliability and electrical availability studies and contractual availability measurement procedures for first-of-a-kind cogeneration conversion. Studies included: failure modes and effects analysis, Markov modeling for availability analysis, fault tree analysis and dynamic simulation for reliability. Computer programs include AVPROG, UNIRAM and FAULT-TAP. Provided design related trade-offs, critical spare parts, plant operation, and maintenance relative to base and dispatched loading. Developed availability measurement procedures providing in-field measurement of availability relative to contractual guarantees. Developed process system descriptions and plant start-up procedures.

Phased Integrated Gasification Combined Cycle Project (1986 - 1989) — Potomac Electric Power Company, Washington, D.C., North America

RAM team leader for availability analysis of a phased coal gasification combined cycle plant. The analysis supported trade-off, conceptual, and detailed design efforts and included reliability growth modeling, plant operability, steam cycle design, scheduled maintenance, equipment criticality for Texaco, Dow, and Shell gasification processes. The UNIRAM computer program was used in the analysis. Provided support for site licensing and environmental permitting.

50 MW Gas Cogeneration Combined Cycle (1989 - 1990)	Dexter Corporation Windsor Locks, Connecticut, North America

Process Engineer responsible for field performance testing procedures. Procedures for determining the overall plant heat rate, reliability, and net electrical generation were developed. Included in the scope were individual procedures to evaluate gas turbine, HRSG and steam turbine performance.

Various Power Cycle Studies (1986 - 1990)	Electric Power Research Institute (EPRI) Various Sites, North America

RAM Engineer responsible for availability studies in support of electrical power systems research. Studies include integrated and non-integrated gasification combined cycle plants using technologies from Dow and Texaco. Availability of advanced combustion turbine designs were also analyzed. The UNIRAM computer program was used in the analysis.

RAM Proposal Support (1986 - 1990)	Fluor Daniel, Incorporated Irvine, California, North America

RAM Engineer for proposal efforts, primarily in the Power Sector. Support ranged from writing qualifications to planning, estimating, and scheduling scope of work. Technical support for conceptual design studies was also provided.

Harbor Cogeneration Project (1989)	Harbor Cogeneration Company Wilmington, California, North America

Process Engineer assisting in start-up of an enhanced oil recovery cogeneration plant. Tasks include system checkouts, punchlists, development of field start-up procedures focusing on plant utilities including service water, instrument air, cooling water and water conditioning systems.

Madera Electric Power Project (1989)	Madera Power Plant Partnership Madera County, California, North America

RAM Engineer responsible for an availability analysis of an agricultural waste cogeneration plant. Component criticality ranking from the analysis established the basis for spare parts inventory. The ACE computer program was used to evaluate criticality.

Firewater Network Study (1986)	Arco Watson Refinery Carson, California, North America

Process Engineer responsible for field testing and debottlenecking of a refinery firewater network. Scope included extensive computer modeling using KYPIPEF-1800 for cost effective design modifications. The existing network was modeled and validated using data collected in field tests.

Expert System Analysis (1986 - 1989)
Fluor Technology, Incorporated
Irvine, California, North America

RAM Engineer for evaluation of expert system technologies for applications in real-time plant operations. A gas processing plant was modeled on a LISP machine for real-time simulation involving accident mitigation. PICON was used as an AI shell. Other work included artificial intelligence course work at the University of California, Irvine.

Hanford Waste Vitrification Project Phase I (1987)
United States Department of Energy
Richland, Washington, North America

RAM Engineer preparing risk assessment for a nuclear waste vitrification facility. The assessment included a failure modes, effects, and criticality analysis.

Process Facility Modification Project (1986)
United States Department of Energy
Richland, Washington, North America

RAM Engineer assisting in an availability analysis of control systems and remote handling equipment for detailed design. Additional work included a statistical analysis of auxiliary loads for sizing transformers.

High Level Nuclear Waste Repository in Salt (1986)
United States Department of Energy
Texas, North America

RAM Engineer for risk assessment of a nuclear waste repository in salt formations. The assessment included data collection in support of a hazards evaluation.

Safety/Hazards Evaluation (1986)
Betz Laboratory
Beaumont, Texas, North America

RAM Engineer assisting in cause-consequence modeling of a chemical plant using the EXCON computer program. Event sequence diagrams were developed from a HAZOP study.

Availability Modeling (1986 - 1988)
Fluor Technology, Incorporated
Irvine, California, North America

RAM Engineer responsible for restructuring an availability computer program, SF2. FORTRAN was used as the programming language. Tasks included program validation and verification. Also performed validations of the PC-AVPROG and PC-EXCON.

Pipeline Controls Modernization (1985 - 1986)
Marathon Pipeline
Findlay, Ohio, North America

Process Engineer assisting in the development of several Kalman Filter models for pipeline leak detection. A prototype on-line filter was programmed using FORTRAN. The filters were to be used in SCADA systems of a gas transmission pipeline.

Tulare Aquifer Project (1985) — Shell California Production, Incorporated, California, North America

Process Engineer for design and simulation of a two-phase pipeline gathering network. The MTRAN computer program was used to determine the flow pattern, pressure, and velocity distribution within the network. Additional work included water hammer simulation of a liquid gathering network using the DREM computer program to determine the effect of an interior pump failure on the network.

Gas Processing Facility (1984) — Shell Oil Company, Molino, California, North America

Process Engineer for developing heating and cooling curves for a hydrocarbon system. The goal was to provide and validate data for this application. SIMSCI's PROCESS program was used.

Process Systems Support (1984 - 1986) — Fluor Technology, Incorporated, Irvine, California, North America

Process Systems Engineer responsible for validation, verification, and documentation of liquid and gas line sizing programs; development of a flow regime computer program for two-phase flow; development and documentation of a water hammer computer program in FORTRAN; evaluation of vendor computer programs for hydraulics and process simulation; process and dynamic simulation; developing friction factor correlations; analyzing and fitting financial data to a set of curves for computer modeling of chemical plants.

Oil & Gas Production Facilities (1984 - 1985) — Arco Alaska, Incorporated, Prudhoe Bay, Alaska, North America

Control Systems Engineer assisting in: design and specification of emergency shutdown valves, analyzers, hydraulic and spring return actuators, and self-contained pressure regulators; developing computer programs to track in-line instruments and control devices. Tasks required special design considerations for arctic conditions.

North Field Gas Development Project (1984) — Qatar General Petroleum Corporation, North Dome Field, Qatar

Process Engineer assisting in material and energy balance study of a gas processing plant. General Process Simulator (GPS) P-001 was used to calculate the balances.

TRAINING:

Using Leadership Styles to Maximize Results, Duke Fluor Daniel, October, 2001
Presentation Skills, Duke Fluor Daniel, October, 2001
GE Power Systems Advanced Technology Combined Cycle, Duke Fluor Daniel, October, 2001
Combined Cycle Fundamentals Course, Duke Fluor Daniel, July, 2001
Bidding and Execution of Risk Projects, Duke Fluor Daniel, January, 2001
Process Engineering Training Program III C1, Utilities and Offsites, December, 2000
SIMSCI Process Simulation Course, Fluor Daniel, September, 1999
Icarus Process Evaluator Training, Fluor Daniel, September, 1999
Zyqad Technical Training Course, Nottingham, UK, November, 1997
Union Carbide Safety Certification, Charleston Technology Center, WV, September, 1994

Chevron Refinery Safety Certification, Fluor Daniel, November, 1993
Unocal Refinery Safety Certification, Fluor Daniel, January, 1993
Refinery Operations Course, Fluor Daniel, May, 1993
Process Utilities and Offsites Training Course, Fluor Daniel, January, 1992
Process Engineering Training Course, Fluor Daniel, October, 1988
Sales, Project Management and HAZOP Training Courses, Fluor Daniel, Irvine, California

ASSOCIATIONS:

American Institute of Chemical Engineers
Chemical Management & Resources Association
Toastmasters International

PUBLICATIONS:

"Self-Contained Seawater Reverse Osmosis Plants for Southern California ", presented at International Desalinization Association World Congress on Desalination, BAH03-149, Paradise Island, Bahamas, October 3, 2003.

"Improve Flare Management", published in Hydrocarbon Processing, (Gulf Publishing Company: Houston, Texas), Volume 76, No. 7, July, 1997.

"Expert System Reduces Downtime & Costs", published in PowerLines, (Fluor Daniel Publication), Volume 10, No. 1, March 1991.

"Pairing On-line Diagnostics With Real-time Expert Systems", published in Power, (McGraw-Hill Publication), Volume 134, No. 6, June 1990.

"Marketing Opportunities in the Soviet Union", presented at the Orange County Chapter of the AIChE, Santa Ana, California, May 22, 1990.

"Expert-control Accident Mitigation - Parts 1 & 2", published in Hydrocarbon Processing, (Gulf Publishing Company: Houston, Texas), Volume 68, No. 10 & 11, October & November, 1989.

"Guaranteeing Availability in First-of-a-Kind Plants: the Midland Experience", presented at the ASME Joint Power Generation Conference, 89-JPGC/Pwr-6, Dallas, Texas, 1989.

"Computer Support of Gas Line Operations", published in Pipe Line Industry, (Gulf Publishing Company: Houston, Texas), Volume 68, No. 4, April, 1988.

"Role of Risk Analysis in the Plant Design Process", presented at the ASME Winter Annual Meeting, SAF-3, Boston, Massachusetts, December 15, 1987.

"Use of Kalman Filters in Data Compression of Gas Transmission Pipelines", presented at the American Control Conference, Seattle, Washington, June 18, 1986.

"Microcomputer Use in Gas Transmission Pipelines", Technical paper No. 40E, presented at the National AIChE meeting, New Orleans, Louisiana, April, 1986.

"The Hazards of Developing a Water Hammer Program", presented at the Orange County Chapter of the AIChE, Santa Ana, California, July 30, 1985.

FLUOR
PROFESSIONAL SUMMARY

John E. Ruud
Manager, Process Engineering - Environmental Specialist

EDUCATION:

B.S., Chemical Engineering, California State Polytechnic University, Pomona
M.E., Chemical Engineering, California State Polytechnic University, Pomona

PROFESSIONAL LICENSES/CERTIFICATES:

Registered Professional Engineer, Colorado
Registered Chemical Engineer, California

SUMMARY OF EXPERIENCE:

Mr. Ruud serves as a Process Manager/Environmental Engineering Specialist with more than 29 years of Fluor experience in the areas of project management, environmental permitting, and environmental and process engineering. His primary experience includes the preparation of project environmental documentation for environmental impact assessments, air quality and Prevention of Significant Deterioration (PSD) permit applications, National Pollutant Discharge Elimination System (NPDES) permit applications and other permit documents. He has successfully directed/provided environmental engineering and permitting services for numerous petroleum refinery projects, power generation projects, a major crude oil marine terminal, and other energy related facilities. He is experienced in the analysis of facility atmospheric emissions and control equipment, air dispersion modeling, evaluation of wastewater treatment schemes, waste minimization studies, spill prevention plans, storm water pollution prevention, negotiations with environmental permitting authorities, testimony at public hearings and interpretation of environmental regulations related to projects. He is responsible for ensuring project environmental regulatory compliance during design, construction, and start-up/operations.

SIGNIFICANT EXPERIENCE:

<u>FLUOR</u> (1973 to Present)

PROCESS MANAGER

Moss Landing Power Plant Project
(1998 – 2002)

Duke Energy North America
Moss Landing, California

Mr. Ruud provided environmental and project engineering for this major combined cycle project at an existing power plant on the central coast of California. His responsibilities included direction and preparation of project and facility descriptions for project permit applications (California Energy Commission Application for Certification), evaluation of once through sea water cooling systems and alternative plant cooling technologies, direction of conceptual cost estimates for alternative project configurations, assistance in reviewing/directing client's environmental consultants, and participation in public workshops and hearings. Mr. Ruud also managed the post-startup emission compliance test program and CEMS certification testing in the field.

CARB3 Clean Fuels Project
(2000 – 2002)

Tesoro Refining & Marketing Company
Martinez, California

As Environmental Manager for this major refinery modification to produce reformulated gasoline, Mr. Ruud effectively directed the development of technical information for air quality and California Environmental Quality Act approval applications to the Bay Area Air Quality Management District and Contra Costa County. He and the Fluor project team worked closely with Tesoro's engineering and environmental staff to maintain the project schedule requirements while revising permit applications several times to reflect significant changes in the project scope.

Cherry Point Cogeneration Project
(2001)

BP Cherry Point Refinery
Blaine, Washington

Mr. Ruud was the environmental consultant for preliminary engineering of a nominal 700 MW Cogeneration Plant at a major West Coast refinery. His primary responsibilities included the direction and review of facility emissions and wastewater discharge stream estimates, evaluation of environmental regulations applicable to the project, permitting strategy development with client and client's environmental consultants, and general oversight of technical information development to support environmental permit applications.

Major Capital Projects
Clean Fuels Program
(2000 - 2002)

Shell Oil Products US
Wilmington, California

Mr. Ruud directed the fast-track preparation of project technical information and environmental analyses to support environmental permit applications for the major refinery modifications needed to comply with Phase III reformulated gasoline regulations. The Fluor team worked closely with the client's environmental staff and their consultants to obtain Permits to Construct and California Environmental Quality Act (CEQA) compliance determination from the South Coast Air Quality Management District (SCAQMD).

Mountainview Power Plant Project
(2000 – 2001)

ThemoEcoTek
San Bernardino, California

Mr. Ruud was the Lead Environmental Engineer for the preliminary engineering of this new 1000 MW combined cycle power plant to be constructed at the former Southern California Edison San Bernardino Generating Station. He prepared environmental analyses and other information to support project licensing applications to the California Energy Commission and the SCAQMD. He also evaluated innovative boiler design concepts to comply with the most stringent start-up emissions limits imposed to date in California.

Morro Bay Power Plant Project
(1998 – 2000)

Duke Energy North America
Morro Bay, California

Mr. Ruud performed environmental and project engineering for a nominal 1100 MW combined cycle project at the existing Morro Bay Power Plant on the central coast of California. He directed and prepared project and facility descriptions for project permit applications (California Energy Commission Application for Certification), evaluated once through sea water cooling systems and alternative plant cooling technologies, assisted in reviewing/directing client's environmental consultants, and participated in public workshops and hearings.

Power Generation Expansion Projects (1999 - 2000)
(Confidential clients)
California

Mr. Ruud was the environmental consultant for four large power generation expansion projects at privatized utility power plants in California, consisting of either 500 MW or 1000 MW of new combined cycle generation capacity at each of four separate plants. His responsibilities included evaluation of air pollution control technologies including SCR and oxidation catalysts, preparation of project and facility descriptions for project permit applications (California Energy Commission Application for Certification), and assistance in reviewing/directing client's environmental consultants.

PRINCIPAL ENVIRONMENTAL ENGINEER

Nitrogen Supply Project (1997 - 1999)
Compania de Nitrogeno de Cantarell
Campeche, Mexico

Mr. Ruud served as the Project Environmental Engineer for the power plant portion (320 MW, gas-turbine based) of this world class nitrogen production plant. He prepared emission and discharge inventories, provided regulatory analysis, performed air dispersion modeling, coordinated owner's environmental consultant, and assisted in negotiations with Mexican environmental agency staff. As result of the air dispersion modeling study, the Mexican environmental agency approved reduced HRSG stack heights that resulted in significant project cost and schedule savings.

Hamaca Crude Upgrading Feed Package (1997 - 1999)
Petrolera Ameriven
Jose, Venezuela

As Lead Environmental Engineer for this major Upgrading Facility for heavy Orinoco crude oil, Mr. Ruud's responsibilities included air emissions inventory, air pollution control, environmental assessment, regulatory analysis, and pollution prevention studies. He also directed the preparation of facility descriptions and analyses for environmental permitting purposes. These work products were used successfully by PA and their in-country consultants to obtain the project environmental approvals on schedule.

Assets Consolidation Project
Site Closure and Demolition
(1997)
Witco Corporation
Santa Fe Springs, California

Mr. Ruud was the on-site Environmental Compliance Manager for chemical cleanup, demolition, and closure of a multi-site surfactants manufacturing facility. He was responsible for day-to-day environmental compliance reporting and the closure of air quality, wastewater discharge, and storm water discharge permits. He also directed operation of the facility wastewater treatment system and coordinated the hazardous waste management subcontractor. Mr. Ruud negotiated a temporary wastewater discharge variance with the local sanitation district that saved the client about $10,000 in waste disposal fees.

Valdez Marine Terminal
Vapor Control Project
(1990 - 1992, 1994 - 1996)
Alyeska Pipeline Service Company
Valdez, Alaska

As Lead Environmental Engineer for this project to recover hydrocarbon and hazardous air pollutant emissions related to marine tanker loading, Mr. Ruud was responsible for preparation of the PSD (air quality permit) application. He performed or supervised the development of an emission inventory for the entire facility and a best available control technology (BACT) evaluation including cost effectiveness analysis. He also assisted

Alyeska in the direction of their air dispersion modeling consultant and in negotiation with the state environmental agency to successfully obtain the PSD approval.

Richmond Refinery Modernization Project (1990 - 1991) — Chevron USA, Inc., Richmond, California

Mr. Ruud was the Permitting Manager for this refinery modernization mega-project ($1 billion-plus), including 50,000 BPD Flexicoker and 142 MW Cogeneration System with SCR, located in the San Francisco Bay Area. He was responsible for the preparation of the California Energy Commission Application for Certification (equivalent to a California EIR), the air quality application to the Bay Area Air Quality Management District, and other environmental permitting documents. Additional work included the preparation of responses to numerous agency requests, participation in public meetings and workshops, and management of specialty consultants. Mr. Ruud managed an overall environmental permitting budget in excess of $2 million. Fluor received a $25,000 recognition bonus from Chevron for the extraordinary effort and excellent performance demonstrated by the environmental engineering team in meeting a key application submittal deadline.

Kalaeloa Cogeneration Project (1988 - 1990) — Kalaeloa Partners, L.P., Barbers Point. Hawaii

Mr. Ruud successfully managed the PSD permit application for a 200 MW, heavy oil-fired combined cycle facility (engineered and constructed by others) on the Island of Oahu, including extensive interface with the Hawaii Department of Health and EPA, Region IX. Responsibilities included BACT analysis, air toxics analysis, and technical coordination of dispersion modeling consultant.

Crockett Cogeneration Facility (1987 - 1989) (1991 - 1993) — Pacific Thermonetics, Inc., Crockett, California

Mr. Ruud was the Licensing and Environmental Manager for a highly-controversial, 240 MW combined cycle cogeneration project located in the San Francisco Bay Area. His responsibilities included the extensive revision of licensing and permitting documents for the California Energy Commission and the Bay Area Air Quality Management District to accommodate both dispatchable plant operation and significant project design modifications. He prepared responses to numerous CEC, BAAQMD and intervenor data requests. He also assisted in the addition of selective catalytic reduction to the project design, performed air quality impact analysis including dispersion modeling, contributed to extensive ammonia safety studies, and participated in numerous public workshops and agency hearings.

Cogeneration Facility (1985 - 1987) — ARCO Petroleum Products Company, Carson, California

As the Regulatory and Air Quality Specialist for this 385 MW combined cycle cogeneration project (with SCR), Mr. Ruud was responsible for the preparation of several licensing and permitting documents including the Application for Certification to the California Energy Commission and responses to numerous data requests from the CEC, the South Coast Air Quality Management District and other involved regulatory agencies. He participated in agency workshops and hearings, reviewed emission control technology, prepared emission offset analysis, performed air dispersion modeling, and prepared federal and local air quality permit application documents. Fluor received a $250,000 bonus from ARCO for obtaining the CEC approval in record time.

<u>OTHER ENVIRONMENTAL EXPERIENCE</u>

*Conceptual environmental engineering and analysis for a combined coal/sewage gasification project located in New Jersey (1989)

*Best Management Practices plan for wastewater treating at a major refinery - Ashland Petroleum, Catlettsburg, Kentucky (1987).

*Air quality permitting for bulk cement terminal in the San Francisco Bay area (1985).

*Environmental compliance auditing for 14 divisions of major Southern California aerospace firm (1985).

*Environmental assessments for nuclear waste repository in geologic salt formations (1984).

*Lead environmental engineer and permitting specialist - six major West Coast refinery expansion projects for Getty, Texaco, Pacific Refining, Champlin, and Independent Valley Energy Company. Responsibilities included air quality permitting; compliance with the California Environmental Quality Act; California Coastal Commission compliance; waste water permitting; and spill prevention, containment, and countermeasure (SPCC) plans (1978 - 1983).

*Conceptual engineering for petroleum coke gasification facility (1983).

*PSD air quality permitting for seven compressor stations included in the Alaska Natural Gas Transportation System (1980).

<u>PROCESS ENGINEER</u>

*Detailed process engineering and field checkout for the Trans-Alaska Pipeline System - pump stations and marine terminal (1974 - 1977).

*Detailed process engineering for a 100 M B/D grass-roots refinery in Cilacap, Indonesia (1973 - 1974).

PROFESSIONAL ASSOCIATION:

Air & Waste Management Association

PUBLICATIONS

"Application of Selective Catalytic Reduction (SCR) for NOx Reduction for Combustion Turbines," Presented to the Pacific Coast Electrical Association, 1990.

"SO2 Emission Reduction Alternatives for Catalytic Cracking Units," Presented to the Air Pollution Control Association, 1985.

PROFESSIONAL SUMMARY

Russell J. Poquette
Executive Project Director

EDUCATION:
BTME, University of Dayton, Dayton, OH (1974)

SUMMARY OF EXPERIENCE:

Over 27 years general management, program management, operations, engineering, and construction experience in oil production facilities, petroleum refineries, chemical, pharmaceutical, petrochemical and power plants with profit and loss emphasis in the execution of lump sum projects.

SIGNIFICANT EXPERIENCE:

DUKE FLUOR DANIEL (2000 - Present; Aliso Viejo, Ca)

Executive Project Director – Aalborg Financial Solvency/Exposure Mitigation (June 2002 – Present)

Responsible for directing a due diligence team to assess the financial solvency of a major supplier ($500MM) of equipment for DFD power plants. Focus was to determine DFD's options (buy the company, financially support the company, or let it go bankrupt) balanced against DFD's exposure ($100MM+) of projects missing their completion dates. The solution developed and selected was another alternative – sell the company to a third party and assist the new owner in mitigating the cash flow and open claims while transitioning to a new sustainable company.

Executive Project Director - Morro Bay Project (2001 – 2002)

Responsible for all activities including development and permitting for Morro Bay. This is a 1,200 MW gas-fired 4 on 2 combined cycle project located within a union labor market in Morro Bay, California. There are several critical execution aspects in terms of a local resort community, facilitating the influx of union labor along with significant logistical issues. The project is valued at $800MM.

Executive Project Director – Houston Operations (2000 – 2001)

Chairman of the "office expansion team" which was chartered with growing the office from 2000 – 3000 staff. Developed hiring targets matrix that focused on leadership acquisition tied to specific time lines that facilitated the learning curve on "how Fluor executes". This also included the integration of Global Engineering Center (GEC) needs.

Developed numerous proposals for projects in Saudi Arabia, Qatar, Emirates and China for confidential clients. Directed study and project estimate for a confidential client in Jubail, Saudi Arabia.

Directed the evaluation of numerous ethylene projects and respective technologies for cost comparison and applicability for future projects.

Performed audit of projects executed in Fluor's Calgary office.

PARSONS (1996 – 2000; Pasadena, Ca)

Vice President and Program Director – Kemya Project (1997 – 2000)

Responsible for profit and loss along with contract execution for a $1.2 billion petrochemical complex. Kemya is a joint venture between Exxon Mobil and SABIC. The program encompassed PMC services, EPC LSTK facilities and a major EPC revamp/expansion of a polymer plant.

Vice President and Program Director – Ibn Zahr Program (1999 – 2000)

Assumed overall responsibility mid-way through Home Office effort for overall direction and completion of a LSTK grass roots polypropylene plant. Responsible for all contractual phases including profit and loss.

Vice President and General Manager of Operations – (1996 – 1997)

Responsible for profit and loss and review/oversight on all projects. Responsible for the supervision, administration and acquisition of project staff through Project Managers level. Established consistency of systems and procedures for execution of projects. Operational responsibility for proposal development, pricing and business acquisition.

BROWN & ROOT (1989 – 1996; Alhambra, Ca)

Director Ethylene Operations – (1994 – 1996)

Responsible for development of lump sum proposals, execution of lump sum ethylene projects (grass-roots and revamps), coordinating business strategies and the advancement of the ethylene reference designs. Projects ranged from $100-500MM lump sum.

Deputy Program Director (Ook) - Saudi ARAMCO Ras Tanura Refinery Expansion Project (1992 – 1993)

Responsible for supervision and administration of project controls, material management and logistics, construction planning and contractual/financial execution for both U.S. and Saudi Arabia project operations.

Senior Project Manager - BP Oil, U.S. (1990 – 1992)

Responsible for the engineering procurement, construction planning and contractual execution for multiple projects in BP Oil's five U.S. refineries representing $650 million in investment.

Senior Project Manager - Novacor, Alberta, Canada (1989 – 1990)

Responsible for engineering, design, procurement and construction interface for a $1.1 billion grass-roots ethylene plant valued at $350 MM.

WALT DISNEY IMAGINEERING (1987 – 1989; Glendale, Ca)

Project Manager

Responsible for engineering, design and administration of material procurement contracts to provide simulator attractions in Florida (2), Tokyo and France. Attractions total value $450MM.

SANTA FE BRAUN (1981 – 1987; Alhambra, Ca)

Project Manager - Kuwait Petroleum Export, Holland (1986 – 1987)

Responsible for engineering, procurement, and transfer of the project from our US office to UK office. This was a $100MM lump sum expansion of a refinery/petrochemical facility.

Manager Cost Engineering (1985 – 1986)

Responsible for directing and implementing new procedures within the department to meet financial objectives. Also charged with expanding the staff and grooming a permanent Department Manager.

Project Manager (1983 – 1985)

Participated in a two-and-a-half-year program to rotate through scheduling, cost engineering, estimating, procurement and quality control to broaden and enhance my background for future project assignments.

Project Manager - Mobil Oil, Paulsboro, New Jersey (1981 – 1983)

Responsible for the development of selection criteria for potential contractors to perform engineering, procurement and construction on a lump sum basis for a grass-roots hydrogen plant as part of an overall lube dewaxing project. Upon contractor selection, continued on as the project manager for the lump sum contract valued at $30MM.

LURGI CORPORATION (1980 – 1981; Riveredge, NJ)

Project Engineer - Getty Oil, Synthetic Fuels Pilot Plant (1980 – 1981)

Responsible for directing, engineering, design and construction support on a $21MM lump sum project.

C.F. BRAUN (1975 – 1980; Murray Hill, NJ)

Design Engineer - (1975 – 1980)

Various assignments on polypropylene, polyethylene, flexicoker, and pharmaceutical projects.

FRANK C. ORTEGA
8892 Alphecca Way
San Diego, CA 92126
(858) 693-6087

SUMMARY OF EXPERIENCE:

19 years experience in the Power Industry (North America, Mexico and Pacific Rim). Nuclear project documentation training. Exposure to ISO-9001 quality assurance requirements. Assisted in the development of over one thousand power plant projects by providing design, performance and pricing information for various types of heat rejection systems. Have taken part in site visits, presentations, technical design review and contract negotiation meetings with Clients.

PROFESSIONAL HISTORY:

April 2001 to Present **Director of Sales and Marketing**
GEA Power Cooling Systems, Inc., San Diego, CA

Plans, controls and directs activities of the sales and marketing department. Manages Company relationships with domestic field sales representatives and international sales agents to meet new order objectives from all markets for the Company's products. Formulates, recommends and develops policies and procedures to ensure new order objectives are met.

February 1995 to April 201 **Business Development Manager**
GEA Power Cooling Systems, Inc., San Diego, CA

Handles the *complete* project development of projects within region of responsibility for this engineering company serving the worldwide power industry, including establishment and coordination of sales strategy. Has successfully negotiated equipment orders totaling over $200 million. Represents corporate interests by escorting Customers to existing system installations and by initiating and implementing an after market support program for the 50+ equipment installations in North America. Meets directly with Customers for the purposes such as evaluating and justifying extra equipment options for improved performance and operating capabilities for improvement of bid posture. Coordinates with other company divisions internationally for the purposes of corporate strategy, maximizing sales potential and strengthening of corporate image. Performed detailed analysis and comparison between two different types of dry cooling technologies in terms of cost, performance and operating characteristics under a variety of environmental, climatic and operational conditions.

January 1990 to October 1995 **Marketing Engineer**
GEA Power Cooling Systems, Inc., San Diego, CA

Responsible for early development of all power generation projects, including initial contact with client, submittal of applicable technical literature and equipment references, optimization of system design, system pricing, evaluation of system's environmental, climatic and operational characteristics and assessment of value engineered options. After sufficient project development, coordinates with Applications Department to ensure timely submittal of complete proposals to clients including required commercial terms, technical design data, drawings, performance data and specific reference material. Responsible for monitoring and updating system pricing data. Led site inspection and assessment of alternative system configurations, plant restrictions and space limitations for potential heat recovery system installation in Alaska.

August 1986 to January 1990 **Systems Engineer**
GEA Power Cooling Systems, Inc., San Diego, CA

In addition to duties as Engineering Aide, increased technical knowledge of all heat rejection systems offered by Company, including equipment specifications, design and operating criteria, applicable industry codes and standards, and operation of Company's proprietary computer sizing programs. Directed and performed air flow velocity tests over the heat exchange surface of air cooled steam condensers at installations located in San Diego and Fairbanks, Alaska.

February 1982 to August 1986 **Office Clerk /Engineering Aide**
GEA Power Cooling Systems, Inc., San Diego, CA

Regular duties included development of equipment drawings and figures, performance diagrams, and operation of equipment computer sizing programs. Coordinated development and assembly of proposal documents submitted to Customers. Responsible for complete organization, updating and production of all company literature and technical reference material. Completed Nuclear Project Documentation training. Wrote program (basic) for material quantity and cost analysis for wood framed mechanical draft cooling towers. Also responsible for miscellaneous duties such as document transmittals, generating artwork for marketing literature, assembly of proposals, catalogs and equipment O & M manuals.

EDUCATION:
B.Sc., Mechanical Engineering, San Diego State University (1989)

Kirk Marckwald

Mr. Marckwald is the founder and principal of California Environmental Associates (CEA), a twelve person environmental consulting firm formed in 1984. He has worked on California energy and environmental regulatory issues for over twenty years. Mr. Marckwald has led large-scale regulatory reform and strategic planning projects for major manufacturing and transportation companies, as well as trade associations and foundations. He has also represented clients before the executive branch, as well as the legislature and regulatory agencies in California and Washington, D.C.

From 1999 to Present, Mr. Marckwald has worked with Duke Energy on a variety of assignments relating to power plant siting issues, especially dealing with land use and other compliance matters. In the California Energy Commission's Proceeding on the Moss Landing Power Plant Modernization proposal, Mr. Marckwald sponsored the Land Use section of the AFC and helped ensure close cooperation between Duke and Monterey County on land use matters.

A principal focus of his work for from 1983 through 1989 was to assist private companies and public institutions interested in installing efficient, cogeneration technologies to understand to how to address and comply with air quality, local permitting and California Environmental Quality Act requirements.

From 1983 to 1984, Mr. Marckwald worked as a consultant to for the Environmental Defense Fund in Oakland, California to help implement advocacy programs in energy, water, and hazardous materials disclosure.

From 1979-83, Mr. Marckwald served as the Under Secretary of California's Natural Resources Agency. He was the principal architect of the Investing in Prosperity program that allocated $120 million per year to innovative technology development and natural resource protection programs. He was also responsible for managing budget and policy initiatives of the Agency's nine departments, and resolving policy conflicts between departments, cabinet officers, legislators, businesses and private citizens.

From 1977-1979, he was the first full-time Executive Director of California's Office of Appropriate Technology, the first state agency in the country mandated to evaluate and accelerate promising energy production and efficiency technologies. During his tenure, the office helped the State of California save over $30 million through investments in new energy technologies and conservation programs, as well as assisting thousands of individuals and businesses become more educated in natural resource and energy technology issues.

Prior to 1977, Mr. Marckwald held various positions at the U.S. Department of the Interior.

In July 1999, Governor Davis appointed Mr. Marckwald as a public member to the California Board of Forestry for a four-year term. The Board is responsible for passing regulations and hearing appeals on all aspects of logging on over 8 million acres of land in California.

Mr. Marckwald is also a Board Member of the Institute for Local Self-Reliance, one of the nation's leading policy and advocacy non-profit groups dedicated to promoting local economic development through aggressive implementation of sustainable technologies. He also serves on the Board of Advisors for the Resource Renewal Institute, a private non-profit organization that promotes business, government, and citizen cooperation to achieve the dual goals of environmental protection and economic vitality.

For the past seven years, Mr. Marckwald has assisted the Grand Traverse Regional Land Conservancy in Traverse City, Michigan design, fund and implement a landscape level agricultural preservation and conservation easement program throughout the Old Mission Peninsula

Mr. Marckwald holds a M.S. in Natural Resources Policy and Management from the University of Michigan and a B.A. from Trinity College in Hartford, Connecticut.

David L. Mayer

President, Tenera Environmental, LLC

Education

Ph.D. Fisheries and Quantitative Sciences, University of Washington, 1973

M.S.C. Environmental Biology, California State University, Hayward, 1970

B.A. Biology and Chemistry, California State University, San Jose, 1965

Experience

Dr. Mayer has extensive experience in marine and freshwater environmental studies. He specialized in the areas of aquatic temperature and flow regimes, and their effects on ecological systems, beginning with his doctoral research analyzing and modeling the relationships of water temperatures and hydrodynamics in northern Puget Sound aquatic communities. Since that time, Dr. Mayer has devoted a majority of his professional career and expertise to numerous thermal and hydraulic effects studies for California's two major utility companies, Southern California Edison (SCE) and Pacific Gas and Electric (PG&E). He has also provided similar expertise and experience in research and problem solving to freshwater issues associated with water intake location, screening technology, and discharge effects. Most recently, he designed and is directing the ongoing studies of cooling water intake systems including the recently installed larval fish screening technologies on the Delaware Riverand permitted for installation on the San Joaquin River..

Dr. Mayer's project results and conclusions have been submitted to the State Water Resources Board (SWRB), with several of these projects involving multiple years of research, the longest of which is still ongoing (started in 1975). He has testified before the Regional Water Quality Control Board (RWQCB, Central Coast and Los Angeles regions) in formal hearings and workshops on the results of water quality, thermal and ecological modeling, and aquatic resources impact studies. He recently appeared as an expert witness on the effects of diversions on flows, water temperatures, and fisheries in East Bay Municipal Utilities District's (EBMUD) defense of their US Bureau of Reclamation (USBR) contract for American River water. His work monitoring and modeling the American River continues as part of court-ordered studies. Dr. Mayer has been involved in a number of Natural Resources Damages Act (NRDA) actions in both marine and freshwater settings. He participated in the damage assessment and restoration of the upper Sacramento River following the July 1991 Southern Pacific chemical spill near Dunsmuir, California. Dr. Mayer and his staff conducted aquatic habitat and fisheries surveys to determine the relationships of these resources to instream flow, temperature and habitat characteristics above and below the Cantara Loop spill site.

Dr. Mayer presently directs a group of research scientists and engineers who provide contract services of environmental assessments and computer analysis in the disciplines of air quality, water quality, ecology, hazardous materials, and environmental risk assessment.

1975 - Present

Directed and participated in the preparation and submittal of marine biological and water quality sections of the successful Application for Certification to the California Energy Commission for power projects at the Contra Costa Power Plant, Potrero Power Plant, Moss Landing Power Plant and Morro Bay Power Plant.

Designed, directed and participated in three completed and one ongoing cooling water intake system (CWIS) resource assessments of the FCWA 316(b) type in support of the NPDES permitting requirement for Diablo Canyon Power Plant, Moss Landing Power Plant, Morro Bay Power Plant and Potrero Power Plant, respectively. These 12 to 24 month studies which included entrainment and source water surveys of ichthyoplankton, larval cancrid crabs and DNA-identified clam larvae have provide the most scientific information on the abundance and distribution of central California's coastal and bay meroplankton populations of important commercial and recreational species. Innovative impact modeling techniques develop in consultation and technical assistance from resource and regulatory agency representatives and independent experts were successfully employed in the assessment CWIS effects and framing mitigation efforts.

Designed, directed and participated in numerous studies of cooling water discharge thermal effects during the period of 1975 to 1995 and most recently at Moss Landing Power Plant (1998-99), Morro Bay Power Plant (1999-2001) and Potrero Power Plant 1999 and ongoing. Projections of biological effects of power project changes in discharge temperatures were based on field surveys of existing thermal conditions and receiving water communities and thermal plume modeling of the new discharge condition. Intertidal and underwater survey data of the receiving water communities were analyzed for patterns of thermal effects using various statistical ordination and pattern recognition techniques. These results were combined with coincident aerial thermal imagery and in situ temperature records collected in intertidal and subtidal survey areas. The results analytical results were then used in conjunction the results of thermal plume modeling to focus changes in the potential for thermal effects arising from the project's new discharge temperatures.

Consultant to the Bay Delta Interagency Ecological Studies Food Chain Group on behalf of the State Water Contractors in considering the matters of striped bass spawning, survival, feeding, growth, and recruitment related to Delta flows, water quality, and planktonic food resources. Studies have examined the importance of day flows and water exports on salinity, water quality, entrapment zone location, phytoplankton and zooplankton standing stocks, and introduced species. The group's research has focused on the question of Delta food supplies as a causative factor in the decline of the Delta's striped bass standing stocks.

Serves as standing member of the Estuarine Ecology Team (EET) of the Sacramento/San Joaquin Interagency Ecological Program. Principal investigator on analysis of Department of Water Resources 20-year benthic monitoring data, an assessment of the likely mechanisms underlying fish and salinity relationships, the trophic importance of dissolved organic carbon particles to larval fish nutrition, and contributor/reviewer to numerous EET working papers on issues of estuarine water quality, agricultural wastewater toxicity, fisheries biology (reproduction, growth, dispersion and mortality) and habitat quality (trophic, structure and predator-prey). Representative of state and federal agencies (EPA, USFW, USBR, DWR, CDF&G, SWCB, CCC and Romberg Tiburon Centers, SF Estuary Institute) meet monthly to research to design and conduct estuary research, discuss findings with invited experts, and assess implication of water management policy for California water contractors, managers and planners.

Expert preparation and testimony of plaintiff's water quality modeling evidence and conducted water quality modeling efforts in assessment of EBMUD's planned water diversions. Computer modeling efforts involved pseudo-steady state modeling of conservative and non-conservative water quality constituents, particularly related to the effects of water temperature on salmon egg survival and growth. Water contract was upheld and environmental assessments were continued under the authority of a court-appointed Special Master. Dr. Mayer continues the court's efforts to gather seasonal and annual river temperature and refine the predictive accuracy of TENERA's QUAL-2e computer model of the river. Dr. Mayer has received additional EPA training and certification in the use and interpretation of the EPA's QUAL-2e and is familiar with other commonly employed hydraulic models, including USFWS IFIM series models and the Better model.

Dr. Mayer designed and directed the installation of a computer-based telemetry system that provides real-time air and water temperatures measured at nine locations along the American River. Two of the locations, Nimbus Dam and Folsom Reservoir, are equipped with vertical arrays of water temperature sensors that provide real-time profiles. The on-line profiles of vertical temperature structure in the reservoirs enable water release planning to achieve specific downstream water temperatures.

Director of TENERA's Delaware River Estuary study of larval fish with respect to the performance of new water intake screening technology. The three-year investigation has included an intensive ichthyoplankton survey of the density and distribution of fish eggs and larvae in the project study area. Net collections were compared to pumped samples to determine sampling bias and performance of the two gear types. The 1995 studies compared net-collected river densities of fish eggs and larvae to pump samples collected from behind the intake screen to assess the performance and efficiency of the new screens to protect the river's various species of fish. TENERA participated in the design and ongoing evaluation of acoustic deterrent systems at another location on the Delaware River, involving water withdrawal rates of millions of gallons per minute where the application of fine porosity screens is not currently feasible.

Director of TENERA's Sacramento/ San Joaquin Estuary study of annual striped bass abundance and monitoring at PG&E's Contra Costa and Pittsburg power plants. The studies are designed to determine the densities of entrained striped bass eggs and larvae. The densities, as measured by ichthyoplankton pump sampling, are used directly by power controllers for real-time load management decisions. Larval fish data are subsequently input to a striped bass mortality model to estimate the losses of adult equivalents to be mitigated by hatchery plant replacements.

Director of TENERA's Sacramento/San Joaquin Estuary thermal effects study of the Contra Costa and Pittsburg power thermal discharges. The studies involved a yearlong assessment of the adult fish, ichthyoplankton, and zooplankton populations in the vicinity of the power plant cooling water discharges. Creel census surveys were used to assess the impacts of thermal discharges on local fisheries. On-site research included experimental tests of the effects of water temperature on the predator avoidance behavior of juvenile chinook salmon and striped bass. Field experiments on the migratory behavior of adult salmon and striped bass were conducted using sonic tags and long-range underwater tracking.

Director of the Millerton Lake survey of American shad spawning and egg and larval production as affected by release flow temperature and timing. Contract research was conducted in support of PG&E's licensing agreements with the Federal Energy Regulatory Commission (FERC) for their Helms pump storage project upstream of Millerton Lake.

Investigator in a yearlong study of PG&E's Sacramento/ San Joaquin Delta aquatic resources, regulatory environment, and generation development plans to prepare a forecast of the company's research and development needs. The study dealt extensively with PG&E's generating resources located in the Delta in light of the Delta's changing environment and ecology of introduced and protected species. The study included reviews of alternative intake and cooling system designs, intake screening technologies, new generation technology, and biological effects studies of critical aquatic resources.

Designed and conducted Elkhorn Slough (designated NEP Estuary) benthic, fisheries, wetlands, birds and wildlife, and water quality studies of the effects of the distribution and dilution of the Moss Landing Power Plant cooling water discharges. Studies were designed to gather temperature information on the existing discharge conditions, model the distribution and dilution of the excess temperature, and provide an integrated assessment of the effects on the biological communities of the Elkhorn Slough's fish, marsh wetlands, and other associated species. Elkhorn Slough studies involved the deployment of self-contained water temperature, tide and current recording instruments, synoptic water temperature surveys, aerial infrared thermal imaging, and computerized temperature mapping. The field temperature results were employed to develop unique thermohydraulic models of Elkhorn Sough.

Designed and directs the ongoing Diablo Canyon water temperature studies which have involved a 23-year study of discharge water temperatures on the natural populations and habitats of the surrounding area. Discharge studies have involved the use of in situ temperature recording instruments; the construction of a preliminary mathematical model; a 1 to 75 scale physical model at the University of California, Richmond Hydraulic Field Station; and a final three-dimensional computer model to simulate the operating prototype. The results of the three-dimensional temperature model were employed in an original shoreline and underwater temperature mapping analysis and assessment of discharge effects on populations of over 500 species found in the study area. The Diablo Canyon water temperatures studies were presented in a year-long hearing before the RWQCB, Central Coast, in which Dr. Mayer testified on predicted effects of the discharge from water quality, flows and temperature modeling, and the associated thermal effects. The discharge temperature effects have been continuously monitored, and summarized in numerous regulatory documents of analysis and assessment.

These studies and findings were summarized in the following reports:

An Assessment of the Likely Mechanisms Underlying the "Fish-X2" Relationships. Interagency Ecological Program for the San Francisco Bay/Delta Estuary. California Department of Water Resources. Technical Report 52, January 1997.

Moss Landing Power Plant, 316(a) Thermal Discharge Demonstration, RWQCB and SWRB, US Fish and Wildlife (USF&W), Environmental Protection Agency (USEPA), and California Department of Fish and Game (CDF&G).

316(a) Demonstration Work Plan, submitted to RWQCB and SWRB, USF&W, USEPA, US Nuclear Regulatory Commission (USNRC), and CDF&G.

Thermal Discharge Assessment Report, 316(a) Demonstration Work Plan, submitted to RWQCB and SWRB, USF&W, USEPA, USNRC, and CDF&G.

Assessment of Alternative Cooling Systems, submitted to RWQCB and SWRB, USF&W, USEPA, USNRC, and CDF&G.

Compendium of Thermal Effects Laboratory Studies, submitted to RWQCB and SWRB, USF&W, USEPA, USNRC, and CDF&G.

Thermal Effects Monitoring Program, Final Report, submitted to RWQCB and SWRB, USF&W, USEPA, USNRC, and CDF&G.

Sacramento/San Joaquin Delta water temperature studies and models of the effects of Pittsburg and Contra Costa power plant's water diversions and cooling water discharge temperatures. Reports assessing alternative cooling water systems and their effects on the temperatures and fish (striped bass) of the Delta were submitted to RWQCB, SWRB, and CDF&G.

Columbia River water quality and fisheries studies for the Washington Water Power Company (WWP) included seasonal surveys of river water temperatures, flows, current patterns, and a final three-dimensional analysis in application and hearings before the Washington State Energy Facility Site Evaluation Council.

Fisheries survey of Sullivan Creek, Washington for the WWP FERC relicensing of the company's hydroelectric facility involving the use of instream flow and snorkel survey techniques to assess trout populations and habitat utilization with respect to storage and release requirements.

Trifuno Creek surface and sub-surface water flow model estimation based on riparian evapotranspiration and meteorological modeling results, submitted to Adolph Schoepe, Fluidmaster, Inc.

Report on temperature studies of all US ocean-sited power plants' offshore discharges prepared for the Utilities Water Act Group and submitted to the USEPA as master 316(a) Demonstration study.

A two-year research study for the B. R. Morris Development Company of the ecology of Lake Sherwood, Ventura County, California provided an assessment of the underlying causes to the lake's declining bass fisheries and eutrophication, and specific recommendations for the restoration of the lake's water quality and fisheries.

1973 - 1975 Under contract to SCE, designed and conducted a number of studies to comply with the temperature assessment and modeling requirements of the California State Thermal Plan for the Control of Temperature in Inland and Marine Waters. These studies which required three-dimensional measurement and tracking of an offshore thermal discharge, involved temperature dye tracer studies, aerial infrared thermal imaging, ground-truth temperature data gathering, and long-term monitoring instrumentation. The results of field studies were analyzed and modeled for an integrated assessment of the thermal discharge effect's on fish and bottom-dwelling organisms. Authored Final Thermal Effects reports submitted to the SWRB included the following.

Thermal Effects Study, Final Summary Report, Huntington Beach Generating Station, RWQCB and SWRB.

Thermal Effects Study, Final Summary Report, Haynes/Alamitos Generating Station, RWQCB and SWRB.

Thermal Effects Study, Final Summary Report, Mandalay Generating Station, RWQCB and SWRB.

Thermal Effects Study, Final Summary Report, Long Beach Generating Station, RWQCB and SWRB.

Thermal Effects Study, Final Summary Report, Redondo Beach Generating Station, RWQCB and SWRB.

Gary S. Rubenstein

Education

1973, B.S., Engineering, California Institute of Technology

Professional Experience

August 1981 - Present	Senior Partner Sierra Research

As one of the founding partners of Sierra Research, responsibilities include project management, and technical and strategy analysis in all aspects of air quality planning and strategy development; emission control system design and evaluation; rulemaking development and analysis; vehicle inspection and maintenance program design and analysis; and automotive emission control design, from the initial design of control systems to the development of methods to assess their performance in customer service. As the Partner responsible for Sierra Research's activities related to stationary sources, he has supervised the preparation of control technology assessments, environmental impact reports and permit applications for numerous industrial projects, including over 8000 megawatts of electrical generating capacity, in the Western United States.

Mr. Rubenstein has worked on the following key projects while with Sierra: preparation of the 1986 ozone and carbon monoxide nonattainment plans for Kern County, California; preparation of the air quality portions of the EIR/EIS for the controversial expansion of operations at the South Lake Tahoe Airport; preparation and defense of the air quality permit applications for the ACE project, the first utility-scale (90 MW) coal-fired power plant built in California; development of the CALIMFAC and EMFAC99 models, California's motor vehicle emission factor models; preparation and defense of analyses of the air quality impacts of the proposed merger between Southern California Edison and San Diego Gas & Electric Company, which would have created the country's second largest electric utility; and preparation and defense of analyses of the air quality impacts of the proposed Eagle Mountain Landfill which, when constructed, will be the largest landfill in the United States.

Mr. Rubenstein has presented testimony and served as a technical expert witness before numerous state and local regulatory agencies, including the U.S. Environmental Protection Agency, California State Legislative Committees, the California Air Resources Board, the California Energy Commission, the California Public Utilities Commission, the South Coast and Bay Area Air Quality Management Districts, several rural California air pollution control districts, the Hawaii Department of Health, and the Alabama Department of Environmental Management. Mr. Rubenstein has also served as a technical expert on behalf of the California Attorney General and Alaska Department of Law.

Additional project experience includes the conduct and supervision of projects related to the development of emissions inventories for air quality planning purposes; the assessment of air quality trends; preparation of State Implementation Plans; the development and exercise of motor vehicle emission factor models; the analysis of motor vehicle emission data; and the preparation of legislative and regulatory analyses.

June 1979 - July 1981 Deputy Executive Officer
California Air Resources Board

Responsibilities included policy management and oversight of the technical work of ARB divisions employing over 200 professional engineers and specialists; final review of technical reports and correspondence prepared by all ARB divisions prior to publication, covering such diverse areas as motor vehicle emission standards and test procedures, motor vehicle inspection and maintenance, and air pollution control techniques for sources such as oil refineries, power plants, gasoline service stations and dry cleaners; review of program budget and planning efforts of all technical divisions at ARB; policy-level negotiations with officials from other government agencies and private industry regarding technical, legal, and legislative issues before the Board; representing the California Air Resources Board in public meetings and hearings before the California State Legislature, the California Energy Commission, the California Public Utilities Commission, the Environmental Protection Agency, numerous local government agencies, and the news media on a broad range of technical and policy issues; and assisting in the supervision of over 500 full-time employees through the use of standard principles of personnel management and motivation, organization, and problem solving.

July 1978 - July 1979 Chief, Energy Project Evaluation Branch
Stationary Source Control Division
California Air Resources Board

Responsibilities included supervision of ten professional engineers and specialists, including the use of personnel management and motivation techniques; preparation of a major overhaul of ARB's industrial source siting policy; conduct of negotiations with local officials and project proponents on requirements and conditions for siting such diverse projects as offshore oil production platforms, coal-fired power plants, marine terminal facilities, and almond-hull burning boilers.

During this period, Mr. Rubenstein was responsible for the successful negotiation of California's first air pollution permit agreements governing a liquefied natural gas terminal, coal-fired power plant, and several offshore oil production facilities.

October 1973 - July 1978 Staff Engineer
Vehicle Emissions Control Division
California Air Resources Board

Responsibilities included design and execution of test programs to evaluate the deterioration of emissions on new and low-mileage vehicles; detailed analysis of the effect of California emission standards on model availability and fuel economy; analysis of proposed federal emission control regulations and California legislation; evaluation of the cost-effectiveness of vehicle emission control strategies; evaluation of vehicle inspection and maintenance programs, and preparation of associated legislation, regulations and budgets; and preparation of detailed legal and technical regulations regarding all aspects of motor vehicle pollution control. Further duties included preparation and presentation of testimony before the California Legislature and the U.S. Environmental Protection Agency; preparation of division and project budgets; and creation and supervision of the Special Projects Section, a small group of highly trained and motivated individuals responsible for policy proposals and support in both technical and administrative areas (May 1976 to July 1978).

Certifications

Qualified Environmental Professional, Institute of Professional Environmental Practice, 1994

Professional Associations

Air & Waste Management Association
Society of Automotive Engineers

PROOF OF SERVICE

I declare that:

I am employed in the County of Sacramento, State of California. I am over the age of eighteen years and am not a party to the within action. My business address is ELLISON, SCHNEIDER & HARRIS L.L.P.; 2015 H Street; Sacramento, California 95814-3109; telephone (916) 447-2166.

Except as noted below, on April 12, 2003, I served the attached *Testimony of Duke Energy Moss Landing LLC* via overnight delivery, addressed to each of the following:

Michael Thomas
Regional Water Quality Control Board
Central Coast Region
895 Aerovista Place, Suite 101
San Luis Obispo, CA 93401

Randall J. Hickok
Duke Energy North America
1290 Embarcadero Road
Morro Bay, CA 93442

Deborah A. Sivas
Earthjustice Legal Defense Fund
Owen House – 553 Salvatierra Walk
Stanford, CA 94305-8620

[Via hand delivery on April 14:]
William M. Chamberlain
California Energy Commission
1516 9th Street, MS-14
Sacramento, CA 95814

I declare under penalty of perjury that the foregoing is true and correct. Executed at Sacramento, California.

Karen A. Munson

Karen Munson