Attachment 4

Cooling Water System
Findings Regarding Clean Water Act Section 316(b)
Diablo Canyon Power Plant
NPDES Permit Order RB3-2003-0009

APPLICABLE LAW

Section 316(b) states:

> "Any standard established pursuant to section 1311 of this title or section 1316 of this title and applicable to a point source shall require that the location, design, construction, and capacity of cooling water intake structures reflect the best technology available for minimizing adverse environmental impact."

There are no state or federal regulations interpreting section 316(b) that apply to DCPP. The United States Environmental Protection Agency (EPA) adopted regulations interpreting section 316(b) in 1976 but, they were invalidated on procedural grounds. EPA did not attempt to adopt regulations again until the 1990's. In December 2001, EPA issued final 316(b) regulations that apply only to new facilities (66 Fed. Reg. 65256, 40 C.F.R. Part 125, Subpart I.) These regulations do not apply to DCPP. In April 2002, EPA issued proposed regulations that would apply to existing facilities, including DCPP but EPA does not plan to issue final regulations until February 2004. (67 Fed. Reg. 17122.) Although the final and draft regulations do not apply to this proceeding, they represent EPA's most recent analysis of section 316(b). The Federal Register preambles to the final and draft regulations are also useful for the same reason.

EPA has directed:

> "Until the Agency promulgates final regulations based on today's proposal, Directors should continue to make section 316(b) determinations with respect to existing facilities, which may be more or less stringent than today's proposal on a case-by-case basis applying best professional judgment." (67 Fed. Reg. 17124 col. 3.)

EPA advised that an EPA 1977 draft guidance on section 316(b) still applies to existing facilities pending adoption of final regulations. (67 Fed. Reg. 17125, col. 1.) The draft guidance is entitled, *Guidance for Evaluating the Adverse Impact of Cooling Water Intake Structures on the Aquatic Environment; Section 316(b) (May 1, 1977) (1977 Draft Guidance).*

The legal standards applied here are based on assembling a mosaic of EPA administrative decisions, opinions, the 1977 draft guidance, federal court opinions and reference to the final 316(b) regulations for new facilities, the draft regulations for existing facilities and their preambles in the Federal Register.

There are four basic steps in a Best Technology Available (BTA) analysis:

1) whether the facility's cooling water intake structure may result in adverse environmental impact;

2) if so, what alternative technologies involving location, design, construction and capacity of the cooling water intake structure can minimize adverse environmental impact;

3) whether alternate technologies are available to minimize the adverse environmental impacts; and

4) whether the costs of available technologies are wholly disproportionate to the environmental benefits conferred by such measures.

The following legal principles were applied in the Board's 316(b) analysis:

- Adverse environmental impacts occur whenever there will be entrainment or impingement damage as a result of the operation of a specific cooling water intake structure.

- Minimize does not mean to completely eliminate adverse impacts. New regulations define minimize to mean to reduce to the smallest amount, extent, or degree reasonably possible. EPA also views increases in fish and shellfish as an acceptable alternative to reduction in entrainment.

- Alternatives that must be considered are location, design, construction and capacity of a cooling water intake structures that minimize adverse environmental impacts.

- Although closed-cycle cooling systems are not cooling water intake structures they can be required indirectly by limiting the capacity of the intake by restricting the volume of water flow.

- A determination on whether a technology is "available" could be made on any number of grounds based on site-specific conditions. The 1977 Draft Guidance states,

  "It is accepted that closed cycle cooling is not necessarily the best technology available, despite the dramatic reduction in rates of water used. The appropriate technology is best determined after careful evaluation of the specific aspects at each site." (1977 Draft Guidance p. 12.)

- The standards for determining whether the costs of a technology are wholly disproportionate to the environmental benefited conferred by such measures are set forth in findings below.

SUMMARY OF CONCLUSIONS

- Because of sketchy legal authority interpreting Clean Water Act Section 316(b), which addresses entrainment and impingement impacts, the Board must exercise its best professional judgment to reach a reasonable conclusion based on site-specific conditions.

- Impingement of adult and juvenile fish on the traveling screens in front of a cooling water intake structure at DCPP amounts to only a few hundred fish per year. This impact is so minor that no alternative technologies are necessary to address impingement at DCPP, and the cost of any impingement reduction technology would be wholly disproportionate to the benefit to be gained.

- Entrainment of smaller organisms (like fish larvae) occurs in once-through cooling water systems. Entrainment losses at DCPP are significant for certain species, and represent an adverse impact. However, the technologies that may reduce entrainment at DCPP are either experimental (screens and filters) or are only conceptually available at this site (saltwater cooling towers). Therefore the Board cannot conclude that these systems are available at DCPP under the meaning of Section 316(b) of the Clean Water Act, which requires best technology "available." There are no demonstrated applications of these technologies at facilities similar to DCPP, and there are many significant problems associated with their potential use at DCPP.

- The costs associated with the potential technologies ranges from $650 million for fine mesh screens to $1.3 billion for saltwater cooling towers, based on independent estimates. Because of the experimental nature and/or uncertainty associated with the technologies the costs may be significantly higher than these estimates.

- This Net Present Value of entrainment losses as estimated by PG&E's consultant is $15,786 to $1,905,757. However, the Regional Board's independent scientists agree that this estimate is probably significantly underestimated because it does not include the majority of entrained organisms. The Regional Board's independent scientists believe that the actual value is likely to be in the ten million dollar range. This "value" range can be compared to the cost of saltwater cooling towers. Tetra Tech 2002 estimated the Net Present Value of saltwater cooling towers at $1.3 billion. Using these values, the cost of cooling towers is wholly disproportionate to benefit to be gained (regardless of whether the entrainment losses are valued in the million dollar or ten million dollar range). The same comparison can be made for fine mesh screens ($650 million), although fine mesh screens have not been demonstrated to be effective to minimize entrainment at DCPP. Assuming for the purpose of analysis that fine mesh screens are effective, the cost of fine mesh screens is also wholly disproportionate to the assumed benefit to be gained.

- The Regional Board's 316b analysis evaluates intake structure technologies (screens, filters) and closed cooling systems (cooling towers, dry cooling) and concludes that the potential technologies are either infeasible, experimental, or the costs are wholly disproportionate to the benefit to be gained for this facility. This conclusion is supported by independent evaluations (Tetra Tech, 2003; EPRI, 1999; SAIC, 1994, and other references discussed below). The existing cooling water intake structure is best technology available under Clean Water Act section 316(b) and no changes to the cooling water intake structure location, construction, design or capacity are required by this Order.

DETAILED ANALYSIS

Under the monitoring and reporting program amendments approved in February of 1995, the Regional Board required the Discharger to perform a comprehensive section 316(b) study. At the direction of the Regional Board, a technical workgroup was formed to oversee the 1995-1999 study. Workgroup members included the Regional Board's staff and independent scientists, the Discharger's staff and consultants, California Department of Fish and Game, USEPA, and the League for Coastal Protection (an environmental group). Currently, the Regional Board's independent scientists on this project are Dr. Greg Cailliet, Moss Landing Marine Laboratories, and Dr. Pete Raimondi, UC Santa Cruz. Note that during the technical workgroup process, Dr. Raimondi represented the League for Coastal Protection. Dr. Raimondi is now an independent consultant to the Regional Board. These scientists are independent from, and have never worked for, the Discharger. Dr. Cailliet and Dr. Raimondi have extensive experience as independent scientists on several power plant projects in California.

Dr. Cailliet is a professor of ichthyology, marine ecology, population biology, and fisheries biology, with main interests in community and population ecology, biological oceanography, marine plankton and nekton, and estuarine ecology.

Dr. Raimondi is a professor of ecology and evolutionary biology whose research emphasizes nearshore marine communities. He also has substantial experience on the design, evaluation and analysis of marine monitoring programs, with particular expertise on the evaluation of marine discharges. Dr. Raimondi is currently directing the largest intertidal monitoring program in the world (through the Partnership for Interdisciplinary Studies of Coastal Oceans, or PISCO).

The Regional Board also hired Dr. Alan Stewart-Oaten and Dr. Roger Nisbet from UC Santa Barbara as independent scientists on the technical workgroup. Dr. Stewart-Oaten and Dr. Nisbet are leading scientists in ecological modeling and statistical analysis. The workgroup reviewed and approved each phase of the study, as well as the final report. Phases of the study included review and assessment of target organisms, sampling locations, sampling methods, gear testing, data analysis and presentation. The technical workgroup reviewed all aspects of the study, including sampling equipment, sampling periods, target species selection, larval identification, and analyses of the results via a process that continued for almost five years.

Entrainment and Impingement

The Discharger submitted its *Diablo Canyon Power Plant 316(b) Demonstration Report,* in March 2000 (hereafter 316b Demonstration). The 316b Demonstration includes an overview of the report process, a description of the results, and an evaluation of alternative technologies to minimize entrainment and impingement. The entrainment and impingement study results are also discussed in Regional Board staff's testimony for this Order.

The purpose of the 316(b) Demonstration study at DCPP was to 1) estimate the number of larvae lost due to the power plant, 2) convert the larval loss to adult fish, and 3) estimate the proportion of larvae lost relative to the amount of larvae available in species-specific source water bodies, and 4) estimate impingement losses.

Entrainment

Entrainment Studies at Diablo Canyon began in October 1996, and continued through June 1999 (about 2 ½ years of sampling in front of the intake structure). In addition to entrainment sampling in front of the intake structure, the study included an offshore sampling program. The offshore sampling area consisted of a grid approximately 17.4 kilometers long and 3 kilometers miles wide, centered on the power plant. The offshore grid sampling began in June 1997, and continued through June 1999 (approximately two years of sampling).

The study used three methods to analyze the data: 1) Empirical Transport Model, or ETM; 2) Fecundity hindcasting, or FH; and 3) Adult Equivalent Loss, or AEL. Each of these methods has advantages and disadvantages as described in the 316(b) Demonstration report.

The ETM approach estimates the proportion of larvae lost relative to the amount of larvae available in a given source water body. <u>Source water bodies are different for each species.</u> The size of the source water body for a given species is based on the age of entrained larvae and current speed. For <u>nearshore</u> species, the size of the source water body is expressed as length of coastline. For example, if the average age of an entrained larval species is 5 days, and the net current speed of coastal waters is 10 kilometers per day, then the size of the source water body from which the larvae may have come is 5 days x 10 kilometers/day = 50 kilometers of coastline. The size of the source water bodies for nearshore species ranges from tens to hundreds of kilometers.

For <u>offshore</u> species, the source water body is expressed as ocean area, using the same parameters (larval age when entrained and ocean current speed). For offshore species, the sizes of the source water bodies typically range from hundreds to thousands of square kilometers, with larger areas for some species.

The FH and AEL approaches convert larvae to adults using life history information for each species. The major limiting factor with each of these approaches, and most fishery impact assessments, is our lack of knowledge about species life histories (such as larval stage duration, longevity, fecundity, mortality at various larval stages, etc.). The lack of available life history information for most species requires us to make assumptions to fill in the gaps. The results from the FH and AEL approaches have very large statistical errors, so there is a great deal of uncertainty associated with these methods. The assumptions used for the FH, AEL, and ETM approaches were based on the best professional judgement of the technical workgroup members. The consensus of the technical workgroup members was that the ETM approach was the most rigorous, robust, and defensible of the three methods.

The entrainment sampling program identified and enumerated all species collected. The target species (fish and crabs) were selected by the technical workgroup after reviewing the entrainment data. Species were selected based on a list of criteria, such as abundance in samples, threatened or endangered status, etc., as described in the 316(b) Demonstration final report (page 4-1).

The results of the analyses (amounts entrained and equivalent adults lost) are shown in Table 1. The last column lists the size of the source water bodies for each sampling period and species for the ETM method. The ETM method calculates the percentage of larvae taken from these source water bodies for each of the two sampling periods (labeled S1 for year one and S2 for year two). Larval losses are shown for two scenarios, mean larval age and maximum larval age of the species entrained. The age of entrained larvae is critical to the analysis because it determines the duration of exposure and the size of the source water body. Larvae with longer larval duration are at greater risk of entrainment because they are exposed to entrainment for a longer period of time. Longer larval duration also increases the time that larvae are traveling with the ocean current, and thus the size of their source water body. There is debate over whether the mean or maximum larval age should be used in the ETM approach. Both values were used in this evaluation, and results based on mean and maximum larval duration are presented.

The results show that proportional larval losses for offshore (deeper water) species, including sport and commercial species, are relatively low (with the exception of halibut, which had relatively high proportional losses in S1 (year one) and very low proportional losses during S2 (year two). Halibut were included in the analysis because they are an important commercial species, even though the total number of larvae collected was very low relative to other species (378 total larvae collected). Although the ETM approach indicates potentially high proportional entrainment for halibut, the number of larvae entrained only represents 9 and 18 adult fish for the two sampling periods. The FH estimates for halibut were a rough approximation because there is no larval survival data for this species. Nevertheless, since so few larvae were entrained, the FH, AEL, and ETM results for halibut have little no meaning. The other offshore species include sand dabs, rockfish, white croaker, Pacific sardine, and northern anchovy. The relatively low entrainment numbers for offshore taxa make sense because the intake structure is located at the shoreline.

Larvae from near-shore (relatively shallow water) species are entrained in significantly higher numbers. The nearshore species include smoothhead sculpin, monkeyface prickleback, clinid kelpfishes, snubnose sculpin, and blackeye goby. Again, this makes sense because of the location of the intake structure.

<u>The proportional larval loss values (ETM values) in Table 1 cannot be interpreted without the context provided by the source water body size</u>. For example, the loss of 5% of the larval fish in a source water body that is 1000 km of coastline in size is likely to be a greater loss (in abundance) than a proportional larval loss of 20% from a source water body of that is 50 km of coastline is size. The proportional larval loss estimates below must therefore be considered with the corresponding source water body sizes. In the Table, each value of proportional loss corresponds directly to a specific source water body size. For painted greenling, the proportional larval loss in sampling period one, or

S1, is listed as 0.9% for mean larval duration and 1% for maximum larval duration. These are percent larval losses from source water bodies of 360 and 830 kilometers (length of coastline), respectively. The largest proportional larval losses occur with clinid kelpfish, up to 41% from a source water body of 127 kilometers (length of coastline).

Table 1: Estimated losses due to entrainment at Diablo Canyon.
PG&E's 316(b) Demonstration Report, Pages 7-23 and 7-24, 2000.

	FH Method (adults lost)	**AEL Method (adults lost)**	**ETM[1] (proportion of larva entrained from source water body)** **S1= 1st sampling year** **S2= 2nd sampling year**		**Source Water Body size expressed as <u>length of coastline</u> for Coastal Taxa**	
NEARSHORE TAXA			ETM Based on Mean Larval Duration	ETM Based on Maximum Larval Duration	Length Based on Mean Larval Duration	Length Based on Maximum Larval Duration
Painted greenling	No calculation[3]	No calculation	S1: 0.9% S2: 1%	S1: 1% S2: 0.4%	S1: 360 km S2: 180 km	S1: 830 km S2: 1112 km
Smoothhead sculpin	No calculation	No calculation	S1: 10% S2: 15%	S1: 15% S2: 20%	S1: 49 km S2: 52 km	S1: 127km S2: 143 km
Snubnose sculpin	No calculation	No calculation	S1: 4% S2: 12%	S1: 2% S2: 2%	S1: 122 km S2: 45 km	S1: 684 km S2: 971 km
Cabezon	No calculation	No calculation	S1: 0.7% S2: 0.8%	S1: 0.6% S2: 0.9%	S1: 158 km S2: 42 km	S1: 379 km S2: 77 km
Monkeyface prickleback	No calculation	No calculation	S1: 16% S2: 11%	S2: 23% S2: 11%	S1: 52 km S2: 42 km	S1: 120 km S2: 139 km
Clinid Kelpfishes	No calculation	No calculation	S1: 32% S2: 29%	S1: 41% S2: 39%	S1: 54 km S2: 47 km	S1: 127 km S2: 108 km
Blackeye goby	No calculation	No calculation	S1: 19% S2: 17%	S1: 23% S2: 22%	S1: 35 km S2: 23 km	S1: 150 km S3: 43 km

Table 1 Continued…

	FH Method (adults lost)	**AEL Method (adults lost)**		**ETM[1] (proportion of larva entrained from source water body) S1= 1st sampling year S2= 2nd sampling year**		**Source Water Body Size Expressed as Area of Marine Habitat for Offshore Taxa**	
OFFSHORE TAXA				ETM Based on Mean Larval Duration	ETM Based on Maximum Larval Duration	Area Based on Mean Larval Duration	Area Based on Maximum Larval Duration
Pacific sardine	3,170–8,460/yr	2,600–7,000/yr		S1: 0.03% S2: No calculation[2]	S1: 0.007%	S1: 2,469 km^2 S2: no calculation	S1: 56,272 km^2
Northern anchovy	16,000–45,000/yr	43,000–120,000/yr		S1: 0.06% S2: 0.2%	S1: 0.008% S2: 0.02%	S1: 861 km^2 S2: 397 km^2	S1: 35,652 km^2 S2: 23,700 km^2
Blue Rockfish	20 – 43/yr	164 – 353/yr		S1: 0.09% S2: 2%	S1: 0.04% S2: 0.3%	S1: 485 km^2 S2: 240 km^2	S1: 2,198 km^2 S2: 3,132 km^2
KGB Rockfishes	497/yr – 617/yr	905 – 1,120/yr		S1: 1.5% S2: 2%	S1: 1% S2: 0.5%	S1: 376 km^2 S2: 230 km^2	S1: 1,540 km^2 S2: 2,813 km^2
Sand dabs	92 – 426/yr	511 – 1,450/yr		S1: 0.5% S1: 5%	S1: 0.4% S2: 1%	S1: 610 km^2 S2: 141 km^2	S1: 1,170 km^2 S2: 966 km^2
CA Halibut	No calculation	No calculation		S1: 0.08% S2: 12%	S1: 0.08% S2: 5%	S1: 465 km^2 S2: 182 km^2	S1: 1,874 km^2 S2: 51,712 km^2
CRABS				**ETM[1] (proportion of larva entrained from source water body) S1= 1st sampling year S2= 2nd sampling year Larval duration base on literature for crabs**		**Source Water Body Size Expressed as Area of Marine Habitat for Crabs Taxa**	
Brown rock crab	91,000–117,000/yr	182,000-234,000/yr		S1: 0.00186% S2: 0.0146%		S1: 135,200 km^2 S2: 21,767 km^2	
Slender crab	8,950–27,300/yr	17,900– 54,600/yr		S1: 1% S2: 0.08%		S1: 12,366 km^2 S2: 5,950 km^2	

[1] Percent ranges are based on mean larval age and maximum larval age, which determines the duration of exposure to entrainment and source water body size. The older the larvae, the longer their exposure to entrainment, the greater the risk of being entrained, and the larger the source water body.
[2] ETM Calculations not possible due to large variation in sampling abundance.
[3] FH and AEL calculations not possible for species with little or no life history information.

The conversion of larvae to equivalent adult fish could not be calculated (using the Fecundity Hindcasting and Adult Equivalent Loss methods) for several species due to the lack of life history information (as noted above, results using the FH and AEL methods have large statistical errors). These results show that the number of equivalent adults lost due to entrainment of fish larvae for offshore species is relatively small. Northern anchovies were the highest (up to 120,000 adults lost per year). However, this represents a small fraction of the commercial landing for this species. The number of equivalent anchovy adults lost equates to about two metric tons, with a value of approximately $576/yr. The value of Pacific sardines lost to the commercial fishery is about $700/yr. The commercial loss to the rockfish fishery (blue and KGB rockfish complexes combined) is approximately $21,000/year. The dollar values of the other harvested species in terms of commercial landings are generally small. The dollar values given above do not represent ecological value and are provided for reference only. From an ecological perspective, the workgroup considered these losses to be of minor importance, even considering the large statistical errors associated with the AEL and FH methods.

However, the results also show that the amount of larvae lost for nearshore species is relatively high. The larval losses for nearshore taxa cannot be converted into equivalent adults because very little is known about these species. Also, these non-harvested near shore species have no direct dollar value in terms of commercial fisheries, but do have ecological value. For several nearshore species (sculpins, kelpfish, blackeye goby, monkeyface prickleback), the amount of larvae taken by the power plant is large relative to the amount of larvae available in the source water body (large proportional losses).

As shown in Table 1 above, the source water bodies (measured as length of shoreline) were specific to each species. Data to determine the source water bodies were collected as part of each larval sampling survey. For each sample survey period, larval duration periods were determined for each species. Then, using current data collected prior to the sampling survey period, the range of up coast and down coast movement was calculated. This was done by taking the maximum up coast and down coast current vectors measured during each survey period and adding them together to obtain an estimate of the total along shore movement.

As shown in Table 1 above, the average proportional larval loss for nearshore taxa is 12 to 14%. There are no additional data that can be used to determine if this larval loss affects nearshore fish populations or communities. Local population trend data for some species are discussed in the 316(b) Demonstration report, however, there are no data from before the power plant came on-line, and no data from control stations. Therefore, there is no way to determine if any trend is natural or caused by some other factor.

PG&E conducted plankton tows in front of the intake structure from 1990 to 1998 (separately from the required entrainment study work). These data show a potential decline in the amount of snubnose sculpin and clinid kelpfish larvae near the intake structure for the sampling period. The potential trend in larval density could also be due to natural variation. No data are available from before the power plant came on-line, and no control station sampling was done, so the data are inconclusive.

Data from the south control station for the thermal effects monitoring program also indicate a possible decline in clinid kelpfish. The number of adult clinid kelpfish counted at the south control station during fish surveys declined between 1976 and the late 1990's. This sampling method does not provide good estimates of small, cryptic fishes, such as clinid kelpfishes. The data for these species are highly variable and their abundance is commonly recorded as zero even though they are most likely always present. However, there are no controls for this data and therefore no way of knowing if the potential decline is natural. These data are inconclusive.

In conclusion, the available data cannot be used to indicate any population declines due to entrainment. However, the relatively large proportional larval losses for nearshore taxa represent an adverse impact because the larval loss itself, regardless of any resulting population or community level affect, is a loss of resources.

PG&E disagrees with the Regional Board's position. PG&E concludes that given the low entrainment estimates for offshore species, the conservative nature of the higher nearshore estimates, and the limited nature of the population trend data, the entrainment data do not indicate any adverse environmental impact.

There are uncertainties in this entrainment study (and all other entrainment studies) because several assumptions are made in the data analysis, and the sampling results are highly variable. The major assumptions include:

1. That adequate sampling was done to estimate larval densities in the field.
2. That simple ocean current measurements can be used to estimate the size of source water bodies.
3. That 100% of the entrained larvae are killed.

Although there are uncertainties, and the entrainment results should be considered within the context of the uncertainties, the results are the best estimates of the technical workgroup, and are accepted by this Regional Board.

Impingement

In addition to entrainment of larvae by the intake system, adult and juvenile fish are impinged on travelling screens in front of the intake structure. The travelling screens are designed to remove debris before it enters the cooling water system. Adult fish can become trapped, or impinged, in the debris. PG&E conducted an impingement study during 1985 and 1986. The results of that study show that very few adult fish are actually impinged on the travelling screens. This is due to the low velocity of the water as it passes through the traveling screens. The water velocity is slow enough (1 ft/sec) so that fish inhabit the intake structure and swim onto and off of the travelling screens. The study showed that the DCPP intake structure impinged a total of about 400 fish (about 60 pounds) and 1,300 crabs during the sampling period (April 1985 through March 1986).

For comparison, the Huntington Beach Power Plant, with flow volumes about one fourth the flow volumes of DCPP, and with an offshore intake structure, impinges up to 21 tons of fish per year. The El Segundo Power Plant, also with flow values about one fourth DCPP flows and using an offshore intake, impinges about 15 tons of fish per year. Both of the offshore intakes noted above are about 2000 feet offshore in about 35 feet of water. The amount of fish impinged at DCPP (about 60 pounds during the sampling period) is a tiny fraction of the amount impinged at these other power plants. The minor impingement losses at DCPP are so insignificant that they do not justify implementation of alternatives to the cooling water intake structure to further reduce the losses (the losses are already minimized).

Alternative Technologies

Since impingement losses are insignificant at DCPP, only technologies that may reduce entrainment are relevant to this analysis. There are two potential ways of addressing entrainment losses:

1. Intake Structure Technologies
    a. Screening or filtering systems
    b. Changing the intake location
2. Reduced Cooling Water Volume Withdrawal
    a. Variable speed pumps
    b. Seasonal flow limitations
    c. Closed cooling systems (cooling towers, dry cooling)

The Administrative Record includes several references for this evaluation of alternative technologies, including:

a. PG&E's Assessment of Alternatives to the Existing Cooling Water System, 1982, by Tera Corporation.
b. PG&E's *316(b) Demonstration Report,* March 2000 (hereafter 316(b) Demonstration).
c. Tetra Tech's independent report to the Regional Board, *Evaluation of Cooling System Alternatives, Diablo Canyon Power Plant*, November 2002 (hereafter Tetra Tech 2002).
d. PG&E 's comments on Tetra Tech 2002, dated September 2002.
e. USEPA information for the new and proposed 316(b) regulations, including USEPA's Phase II Technical Development Document and supporting references.
f. *Preliminary Regulatory Development, Section 316(b) of the Clean Water Act, Background Paper Number 3: Cooling Water Intake Technologies,* 1994 (hereafter Background Paper No. 3).
g. *Fish Protection at Cooling Water System Intakes: Status Report,* EPRI, 1999 (hereafter EPRI 1999).
h. *Feasibility of Retrofitting Cooling Towers at Diablo Canyon Power Plant Units 1 and 2,* Burns Engineering, April 2003 (hereafter Burns 2003).
i. PG&E's *Estimation Of Potential Economic Benefits Of Cooling Tower Installation At The Diablo Canyon Power Plant,* April 2003, ASA Analysis & Communication, Inc (hereafter ASA 2003).
j. Review of the ASA 2003 report by Stratus Consulting, an independent Consultant to the Regional Board (hereafter Stratus 2003).
k. Review of the ASA 2003 report by Dr. Raimondi (hereafter Raimondi 2003).
l. Other power plant case studies and reports in the record.

Intake Structure Technologies (Screens, Filters)

Intake structure technologies are evaluated in detail in Background Paper No. 3. This report was prepared by Science Applications International Corporation (SAIC), an independent consultant to the EPA. The EPA suggests that agencies use Background Paper No. 3 when implementing section 316(b) of the Clean Water Act. Background Paper No. 3 describes all potential intake structure technologies, including ten types of intake screens and five types of passive intake systems.

Background Paper No. 3 includes a description of each technology and corresponding Fact Sheets that describe where the technology is being used (if it is being used), advantages and disadvantages, research findings, and design considerations. The conclusions of Background Paper No. 3 are summarized below.

Regarding intake screen systems Background Paper No. 3 states: "The main finding with regard to intake screen systems is that they are limited in their ability to minimize adverse aquatic impacts." The report also states that "there has also been an interest in the use of fine-mesh mounted on traveling screens for the minimization of entrainment. However, the use of fine-mesh mounted on traveling screens has not been demonstrated as an effective technology for reducing mortality of entrainment losses." This is an important issue. Both once-through cooling and screening technologies cause mortality of organisms. The net benefit of a screening technology must be measured as a reduction in overall mortality. If the screening technology prevents entrainment of larvae and eggs, but simply replaces entrainment mortality with screening induced mortality, there is no benefit. The screening technologies are currently experimental. Site-specific and species specific research must be done to determine their potential effectiveness at a particular power plant.

With respect to passive screens, Background Paper No. 3 concludes: "The main findings for passive intake systems are that available technologies that effectively reduce fish eggs and larvae entrainment are extremely limited." Radial wells and wedgewire screens are the only alternatives considered to have potential for reducing entrainment mortality, but they are not used on large scale systems such as DCPP. Radial wells are literally ground water wells, and are used on small-scale applications, not on facilities like DCPP Units 1 and 2, which require a total cooling capacity of 2,500 million gallons per day (mgd). Wedgewire screens are also limited in their application, as discussed later in this report.

A comprehensive review of intake technologies is also provided in EPRI 1999. EPRI is the Electric Power Research Institute, Inc., of Palo Alto, California. Utility companies fund EPRI, which in turn sponsors research on utility industry issues. The conclusions of EPRI 1999 are similar to the conclusions of Background paper No. 3, that is, more research is needed on the various intake structure technologies before their applicability can be determined.

Tetra Tech 2002 illustrates that fine mesh screens have been used at other facilities with varying degrees of success (see also 316(b) Demonstration, EPRI 1999, and Background Paper No. 3). However, fine mesh screens have not been used at a facility similar to DCPP.

The Board concurs with the conclusions of Background Paper No. 3. The data collected on intake technologies to date are limited, highly variable, site-specific, and species-specific. The only technologies that may apply to DCPP for the purpose of reducing entrainment mortality are certain screening technologies, such as fine mesh screens, but they are considered experimental. A major problem with fine mesh screens is biofouling and mortality of larvae that are impinged on the screen. It is also difficult to determine the survivability of larvae that are impinged and then washed of the screens. Tetra Tech reports that survival rates for impinged larvae varies greatly based on studies at other facilities. The 316(b) demonstration report also provides highly variable survivability (or mortality) results from studies done at other facilities. The only way to determine the effectiveness of a screening technology at DCPP is to conduct site-specific research, with independent scientific experts overseeing all aspects of the work. Such research would likely take years to complete, and the total costs are unknown. Therefore, fine mesh screens are not a demonstrated "available" technology for DCPP. Tetra Tech estimates the total cost of installing fine mesh screens at Diablo Canyon at $650 million. The major component of this cost is the Power Plant downtime necessary to install the screens.

Filter Technology: Tetra Tech 2002 concludes that an aquatic filter-barrier is not feasible at Diablo Canyon due to the massive size of the filter that would be needed, the ocean conditions at the site, and the experimental nature of the technology. A filter area of approximately 160,000 square feet would be needed, which would be 8,000 long by 20 feet deep. Such a system could not be installed in a highly dynamic ocean environment, and has never been used in a setting like that at DCPP or for a facility of this size. The aquatic filter barrier is therefore not available for Diablo Canyon.

Screening and filtering technologies are experimental at this time, and there are no known applications of these technologies at facility similar to DCPP.

Intake Structure Location

Changing the vertical location of the intake structure in the water column is not possible at Diablo Canyon. The intake structure is located in Intake Cove, a relatively shallow (about 35 feet) cove constructed to protect the intake structure from wave and debris. The size of the intake opening takes up most of the vertical depth of the cove.

The potential benefit of moving the location of the intake structure offshore would be to decrease the larval losses for nearshore species. The disadvantage would be greater impingement and entrainment of offshore species, including groundfish species, whose populations are in decline along the west coast. The DCPP intake structure currently impinges an insignificant number of fish per year (a few hundred fish per a year). For comparison, as noted above, the Huntington Beach Power Plant, with flow volumes about one fourth the flow volumes of DCPP, and with an offshore intake structure, impinges up to 21 tons of fish per year. The El Segundo Power Plant, also with flow volumes about one fourth DCPP flows and using an offshore intake, impinges about 15 tons of fish per year. Both of the offshore intakes noted above are about 2000 feet offshore in about 35 feet of water. This information is from Documents filed with the Energy Commission by the utility companies. It should be noted that fish return systems are available, such as the system used at the San Onofre Nuclear Generating Station (SONGS). The overall efficiency of the SONGS fish return system is about 68%, making that offshore intake structure more favorable.

However, entrainment of larvae cannot be reduced in an offshore intake system. Some of the offshore taxa that would be impinged and entrained in an offshore intake at Diablo Canyon are currently heavily impacted to the point of near collapse. The National Marine Fisheries Service and California Department of Fish and Game recently implemented emergency “no-take” measures for certain species of groundfish, which may apply to an offshore intake structure. Therefore, an offshore intake would simply move the impacts offshore. In addition, the physical construction of an offshore intake system would cause major impacts on a significant amount of marine habitat, including an area of one-hundred feet wide by thousands of feet in length, through intertidal zone and subtidal kelp beds (Tetra Tech 2002).

Tetra Tech, the Regional Board’s independent consultant regarding alternatives at DCPP, estimates the cost of an offshore intake system at $300 to $455 million, which does not include preparing the ocean floor for construction or other contingencies that could only be determined by a comprehensive assessment of this alternative (Tetra Tech, 2002). Further, an offshore intake structure may not be possible at DCPP due to the steep offshore slope and rocky subtidal habitat. The Board has no information indicating there are any offshore intake structures in an environment such as that found at DCPP, although Board staff searched for such information. Offshore intakes (or discharges) are typically found where there is a gentle offshore slope in a sandy bottom environment.

In conclusion, an offshore intake structure would not provide an environmental benefit, is not a demonstrated available alternative for a facility like DCPP, and would cost a minimum of $300 to $455 million. Therefore, this alternative cannot be considered available, feasible, or beneficial at DCPP.

Reduced Cooling Water Volume Withdrawal

Variable Speed Pumps: In theory, variable speed pumps may reduce entrainment rates in some cases by decreasing cooling water flows relative to fixed speed pumps. DCPP is a nuclear power plant and is designed to operate as a base load facility with minimal changes in power output over long periods of time (316(b) Demonstration). Accordingly, variable speed pumps are not applicable to DCPP, and independent cost estimates are not available. PG&E’s 316(b) Demonstration estimates that the maximum possible benefit of variable speed pumps would be to reduce cooling water flows by 2 to 10%, and estimates the cost of installing variable speed pumps at $6.7 million. However, this cost estimate does not include the cost of power plant shut down time, which would be in the hundreds of millions of dollars. The existing pumps are embedded in the concrete of the intake structure, so replacement of the pumps would be a major construction project (as with fine mesh screen installation). This alternative would offer little or no benefit, and the costs due to power plant down time are very high. Therefore this alternative is not reasonable at DCPP.

Seasonal Flow Limitations: Seasonal flow limitations are applicable in cases where one or more particularly important species (such as endangered or threatened species) are being entrained during specific times of the year. This is not the case at DCPP, where no threatened or endangered species were identified in the entrainment sampling program (316(b) Demonstration). At DCPP, larvae are available and entrained throughout different seasons, and seasonal flow limits would require choosing some species over others for protection. This alternative is not recommended at DCPP as there is no practical way to choose certain taxa as being more important than others unless there are threatened or endangered species present. The cost (lost revenue) of seasonal flow restrictions depends on the duration and magnitude of the seasonal limitation and energy prices. The costs could range into the hundreds of millions per year depending on these factors.

Tetra Tech 2002 included total revenue estimates for DCPP. Based on an estimated revenue of $900,000 per Unit per day, annual revenue is estimated at $657 million at DCPP. Therefore, any significant reduction in cooling water flows (such as 20% annual reduction) will result in a cost in the hundred million-dollar per year range. As noted above, there is no biological argument for seasonal flow limitations based on the species entrained. Therefore, this alternative is not reasonable at DCPP.

Closed Cooling Systems

Closed cooling systems are of two main types: wet and dry. Wet cooling systems recirculate fresh or saltwater through towers. Make-up water is needed to replace losses due to evaporation. Dry cooling systems recirculate fresh water in a truly closed system (like the radiator in an automobile); no evaporation occurs and therefore no makeup water is needed. These systems follow the general hierarchy below:

Closed Cooling Systems
- I. Wet Cooling (saltwater or freshwater)
  - a. Mechanical Draft Cooling Towers
  - b. Natural Draft Cooling Towers
- II. Dry Cooling
  - a. Air Condensers
- III. Hybrid Cooling (saltwater or freshwater)
  - a. Mechanical Draft Towers and Air Condensers Combined

Availability of Wet Cooling Systems

In a mechanical draft system, heated water from the power plant is pumped to the top of cooling towers where it is then sprayed downward inside the tower. Air is forced upward through the tower by large fans (this makes them “mechanical draft”). The forced air transmits heat from the water to the atmosphere. The cooled water collects at the bottom of the tower where it is recirculated back to the power plant. Some water is lost to evaporation, and “make-up” water is needed to keep the volume constant. Mechanical draft cooling towers can be designed to handle all or part of the cooling load. Mechanical draft towers using freshwater are the most common cooling systems, and are being installed on the majority of new non-nuclear power plants in California (California Energy Commission 2002). All of the newly constructed and planned power plants in California use natural gas to generate electricity. No nuclear power plants are planned.

Mechanical draft towers using freshwater could theoretically reduce cooling water withdrawal from the Pacific Ocean to zero. However, fresh water cooling towers at Diablo Canyon would require approximately 50,000 gallons per minute, or 72 million gallons per day of fresh water to replace the water evaporated in the cooling towers (make-up water). This quantity of fresh water is not available at Diablo Canyon or anywhere in the vicinity. Conceptually, a desalination system could be constructed to provide the necessary fresh water supply. However, sufficient Ocean water or brackish ground water would have to be withdrawn in a volume sufficient to provide 72 million gallons per day of fresh water after desalinization. Additionally, the cost of cooling towers alone, without a massive desalination system, is in the billion dollar range (see estimate below for saltwater cooling towers). Finally, it is unlikely that there is enough space available at DCPP to build both a very large desalination facility and the very large mechanical draft cooling system (Tetra Tech 2002). The surrounding land is in the Coastal Zone and is zoned for agricultural use. Burns 2003 maintains that there is not enough available space around DCPP to build the mechanical draft cooling towers alone, without the desalination facility.

Mechanical draft towers that use <u>saltwater</u> could reduce cooling water withdrawals by up to about 95%. Tetra Tech estimates 132 towers would be required @ 60 ft wide x 60 ft long x 65 ft high. Tetra Tech estimates the total net present value of costs for this system to be $1.3 billion. This cost includes revenue losses for a shut down period of six months (which could be significantly longer). Burns 2003 states that the minimum downtime for DCPP would be one year, which would result in significantly higher costs than estimated by Tetra Tech 2002. There are significant issues associated with retrofitting DCPP with cooling towers, including available space, relocation of existing structures and utilities to another location (which may not be possible), rezoning, and permitting by other agencies. The cooling towers would have to be located where the parking lot, service road, and large warehouse (475 ft x 207 ft) are currently located. There does not appear to be adequate space within the industrial zoned area to relocate these facilities, thus requiring rezoning of nearby land and approval by various permitting agencies. In addition, no facility of this size has ever been retrofitted with a closed cooling system. The cost estimate of $1.3 billion should be considered within the context of the project, which is conceptual, unprecedented, and highly complex. The costs could therefore be significantly higher than the estimate presented by Tetra Tech, and the retrofit may not be physically possible. Accordingly, retrofitting DCPP with salt water cooling towers is a conceptual option only, with unknown actual costs.

Tetra Tech also considered natural draft cooling towers. This system would require 10 towers, 200 feet in diameter by 450 feet in height. The total cost would be over $2 billion when lost revenue due to down time is considered. Further, the performance of a natural-draft cooling tower is dependent on relative humidity. In the vicinity of the DCPP, the relative humidity falls below 68 percent about 10 percent of the time (when the wet bulb temperature is 61°F). When this occurs, tower performance will be reduced and plant efficiency will be further impacted. The visual impacts of ten 450-foot high towers would also be significant. Further, the seismic zoning at DCPP precludes the construction of such tall structures (Tetra Tech, 2002). Accordingly, natural draft cooling towers are not available at DCPP.

Availability of Dry Cooling Systems

Dry cooling technology is similar to the cooling system in an automobile. Heated water is pumped from the power plant to a large external "'radiator" or condenser. Large fans force air over the condensers and heat is thereby transferred from the condenser to the atmosphere. Dry cooling systems can be totally closed, requiring no make-up water. USEPA has found that dry cooling is not "best technology available" for new power plants on a national basis but might be feasible in limited cases based on site-specific circumstances (66 Fed. Reg. p. 65305, col. 3; USEPA has tentatively made the same determination for existing power plants 67 Fed. Reg. p. 17168). In California and elsewhere, dry cooling is used where fresh water supplies are very limited. No nuclear power plants have been retrofitted with dry cooling systems.

Tetra Tech concluded that dry cooling is not an available alternative at Diablo Canyon. Tetra Tech determined that eight air-cooled condensing systems would be required, each occupying an area of 316 feet by 197 feet with an overall height of 119 feet. Each condenser would use forty, 150 hp fans; and the resulting turbine back pressure would be in the range of 3.5 to 4 inches HgA, considerably higher than the Power Plant's design value of 1.5 inches HgA. GEA Energy Technology Division, a leading designer of dry cooling systems, maintains that the length of duct from a power plant to an air-cooled condenser should be limited to a distance less than or equal to 200 feet. It is not physically possible to place eight very large dry cooling units within 200 feet of the Power Plant. At Diablo Canyon, duct lengths of 500 to 1000 feet would be required. Since these specifications for dry cooling cannot be met at Diablo Canyon, Tetra Tech did not provide costs estimates for this system. However, the USEPA estimates that dry cooling systems cost approximately three times more than wet cooling systems, which would result in a cost of several billion dollars at Diablo Canyon. Dry cooling is not an available alternative at Diablo Canyon.

Availability of Hybrid Systems

Hybrid systems are simply a combination of dry and wet cooling technologies. The proportion of cooling assigned to each technology depends on site-specific conditions, such as the amount of make-up water available. A hybrid system that uses both dry cooling and fresh water mechanical draft towers would reduce cooling water withdrawals to zero. A hybrid system that uses dry cooling and saltwater mechanical draft towers could reduce cooling water flows by 95% or greater. However, hybrid systems use the same technologies discussed above (wet and dry systems), and therefore are not currently available at DCPP for the reasons noted above. The same issues apply to a hybrid system: lack of available space, unproven applicability at a site like Diablo Canyon, lack of fresh water, and extreme costs.

Other Cooling Technology

Cooling Ponds: There are two types of cooling ponds: "passive" and "spray." These systems are not available at Diablo Canyon because of the massive size needed. The ponds would have to be thousands of acres in size to provide the cooling capacity needed at DCPP (PG&E's 316(b) Demonstration Report, 2000).

Wholly Disproportionate Cost Test

Legal Background

EPA interpretations of section 316(b) have consistently implemented a "wholly disproportionate" cost test as established in a 1977 Decision of the Administrator. (*Public Service Company of New Hampshire, et al. Seabrook Station, Units 1 and 2*, (June 10, 1977 Decision of the Administrator) Case No. 76-7, 1977 WL 22370 (E.P.A.) "*Seabrook I.*") In *Seabrook I*, the EPA Administrator ruled that EPA was not required to perform a cost/benefit analyses when applying section 316(b) on a case-by-case basis. However, the Administrator reasoned that cost must be considered otherwise "the effect would be to require cooling towers at every plant that could afford to install them, regardless of whether or not any significant degree of entrainment or entrapment was anticipated." (*Id*. pp. 6-7.) The Administrator ruled "I do not believe it is reasonable to interpret Section 316(b) as requiring use of technology whose cost is wholly disproportionate to the environmental benefit to be gained." The "wholly disproportionate" test was affirmed by the federal First Circuit Court of Appeals in *Seacoast Anti-Pollution League v. Costle* (1st Cir. 1979) 597 F.2d 306.)1

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1. *Seabrook I* was appealed and remanded based on some procedural issues. (*Seacoast Anti-Polution League* v. *Costle*, 572 F.2d 872.) On remand, the Administrator cured the procedural flaws and readopted all the findings in *Seabrook I*. (*Public Service Co. of New Hampshire, et al.* v. *Seabrook Station Units 1 and 2* (August 4, 1978 Decision of Administrator.) The Court of Appeal in *Seacoast Anti-Pollution League* v. *Costle,* 597 F.2d 306, cited in text above, affirmed the Administrator's decision on remand.

The First Circuit Court clarified the "wholly disproportionate test" was one of incremental cost. The Court stated: "[t]he Administrator decided that moving the intake further offshore might further minimize the entrainment of some plankton, but only slightly, and that the costs would be 'wholly disproportionate to any environmental benefit'." (*Id*. at 311.) The wholly disproportionate test has continued to be used by EPA when applying section 316(b) since the *Seabrook I* decision. It does not appear in the 1977 Draft Guidance because that document was issued in May 1977 before the *Seabrook I* ruling.

While EPA has continued to use the wholly disproportionate test, there does not seem to be any consistency in how the test is used. In *Seabrook I*, the Administrator considered various construction/design alternatives and the alternative to locate the intake offshore. Concluding that these alternatives would provide minimal environmental benefit, the Administrator rejected them. The First Circuit Court of Appeals affirmed that the cost of the offshore outfall location was wholly disproportionate to this minor additional minimization of entrainment.

When EPA drafted the New Plant Final Rule, it determined that closed-cycle cooling was best technology available for all new facilities but provided for site-based alternatives justified by use of alternative technologies and restoration projects. (66 Fed. Reg. 65314, cols. 2-3; 65315 cols. 1-2.). Nonetheless, the New Plant Final Rule preserves a form of the wholly disproportionate test. It provides that if the discharger demonstrates that facility-specific data shows the cost of compliance would be wholly disproportionate with costs considered by EPA when establishing a compliance requirement, a less costly alternative may be permitted. (40 C.F.R. § 125.85(a).)

Application of the Wholly Disproportionate Test to DCPP

A wholly disproportionate cost test compares the cost of technology alternatives to the benefit to be gained by implementing alternatives. The EPA provides information on entrainment valuation methods in their supporting documentation for the proposed 316(b) rule for existing facilities. The valuation methods basically attempt to put a dollar value on entrainment losses. EPA acknowledges that this is a difficult process because there are few actual values, such as commercial fishing values, associated with entrained larvae. Assumptions must therefore be made about larval losses with no associated economic value.

PG&E submitted a report titled *Estimation Of Potential Economic Benefits Of Cooling Tower Installation At The Diablo Canyon Power Plant,* April 2003, ASA Analysis & Communication, Inc (hereafter ASA 2003). The report discusses four categories of benefits: market benefits, nonmarket direct use benefits, indirect use benefits, and nonuse benefits. Benefits were estimated according to methods used by the EPA in its benefits case studies for the proposed Phase II rulemaking under § 316(b) of the Clean Water Act (see Chapters A5, A9, and A10 of Part A of the Case Study Document available at: http://www.epa.gov/waterscience/316b/casestudy/).

ASA 2003 estimates that the total annual benefit expected due to implementing cooling towers at DCPP would range from $1,755 to $110,647 per year. To estimate the Net Present Value of the series of annual benefits ASA 2003 assumed that the cooling towers would not be in operation until 2008 (due to design, permitting, construction, and tie-in). ASA 2003 assumed the use of cooling towers would end in 2023, the mean year of license expiration for the two DCPP units. For purposes of bounding the expected benefits, discount rates of 2 percent (applied to upper bound values) and 7 percent (applied to lower bound values) were used.

Under these assumptions, ASA 2003 estimated the Net Present Value of expected benefits to the target species from implementing closed cycle cooling at DCPP would range from $11,045 to $1,334,030. Since the target species represent approximately 70 percent of the total entrainment of fish larvae, ASA 2003 assumed that the overall economic benefits could be estimated by dividing by 0.7 and, thus, range from $15,786 to $1,905,757.

The Regional Board's independent consultant regarding entrainment valuation, Stratus Consulting Inc., reviewed the ASA 2003 report and concluded that in general, ASA 2003 may significantly underestimate the actual value of entrainment losses because most of the entrained taxa are not accounted for in the analysis (Stratus 2003). The Regional Board's independent scientists agree. Dr. Raimondi's review of ASA 2003 indicates that the larval losses could be valued in the ten million dollar range, depending on the assumptions made. Stratus 2003 also states that the Habitat Recovery Cost (HRC) method could also be used to estimate the entrainment value losses, which would result in a much higher valuation for the losses. The HRC method estimates the cost of creating or restoring habitat that would produce the losses caused by entrainment. Stratus notes the HRC approach is not true benefit "valuation" method, and therefore cannot be taken as a measure of economic benefits. However, Stratus states that the HRC method can be used in a policy context or in permit negotiations as a point of reference for evaluating technology costs. The Regional Board acknowledges this potential approach, but notes that no habitat restoration work appears to be viable for the DCPP area.

This Net Present Value of entrainment losses as estimated by ASA 2003 ($15,786 to $1,905,757) or the higher estimate by Raimondi 2003 (ten million dollar range) can be compared to the cost of salt water cooling towers. Tetra Tech 2002 estimated the Net Present Value of saltwater cooling towers at $1.3 billion. Using these values, the cost of cooling towers is wholly disproportionate to benefit to be gained.

The only other potential technology for reducing entrainment at DCPP is fine mesh screening. If for the purpose of analysis fine mesh screens are assumed to be as effective as cooling towers at reducing entrainment, which is highly unlikely based on the limited data available from the references noted in this Order, then the same economic benefit as above can assumed. That is, a Net Present Value of $15,786 to $1,905,757, or up to the ten million dollar range, for the resulting benefits of fine mesh screens can be compared to the Net Present Value of the cost of the screens, which is $650 million based on Tetra Tech 2002. Using these values, the minimum cost of this experimental technology is wholly disproportionate to the benefit to be gained.

The Regional Board realizes that the estimated value of reduced entrainment (the benefit) is subject to qualitative evaluation and there are uncertainties involved in the methodology. However, even if the higher Net Present Value of the benefits is used (the ten million dollar range) the costs of technologies would still be wholly disproportionate to the benefits to be gained.