SWR-05

Diablo Canyon

Once Through Cooling

Pacific Gas and Electric Company™

Facilities Using OTC

- **539 Power Plants Nationwide and 19 Plants in California**

- **California Facilities -**
  - 40% of generating capacity
  - 22% of generation
  - Baseload, Intermediate, and Peaking Resources
  - DCPP & SONGS

- **Nationwide - 38 Nuclear Plants Use OTC**
  - 61-Units (59% of Fleet)
  - 20-Units (19.5% of Fleet) Use Saltwater/Brackish-Water OTC.

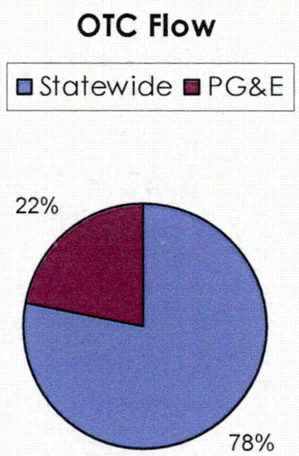
- **No Other Closed-Cycle, Saltwater-Cooled Nuclear Plant in the World**

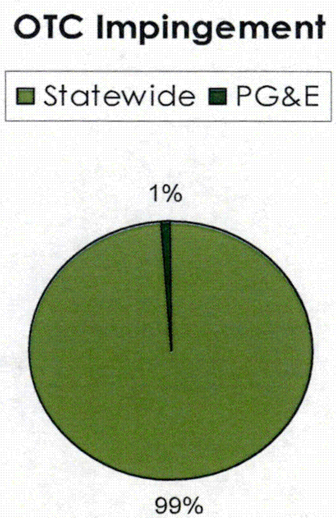
Pacific Gas and Electric Company

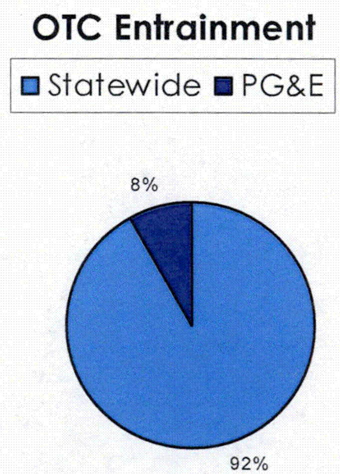
Eliminating Once-Through Cooling

- **Diablo Canyon OTC**
  - Circulates 2.5 billion gallons of seawater per day
  - Technology options to minimize impacts
    - No effective modifications to existing system available
    - Alternative cooling systems assessed
  - Dry Cooling - Infeasible (Space & Engineering Limits)
    - Natural Draft Towers - Infeasible (Space & Seismic Issues)
    - Mechanical Draft Towers - Likely Infeasible (Adverse Impacts & Permitting)

Diablo Canyon – Percentage of flow vs. impact



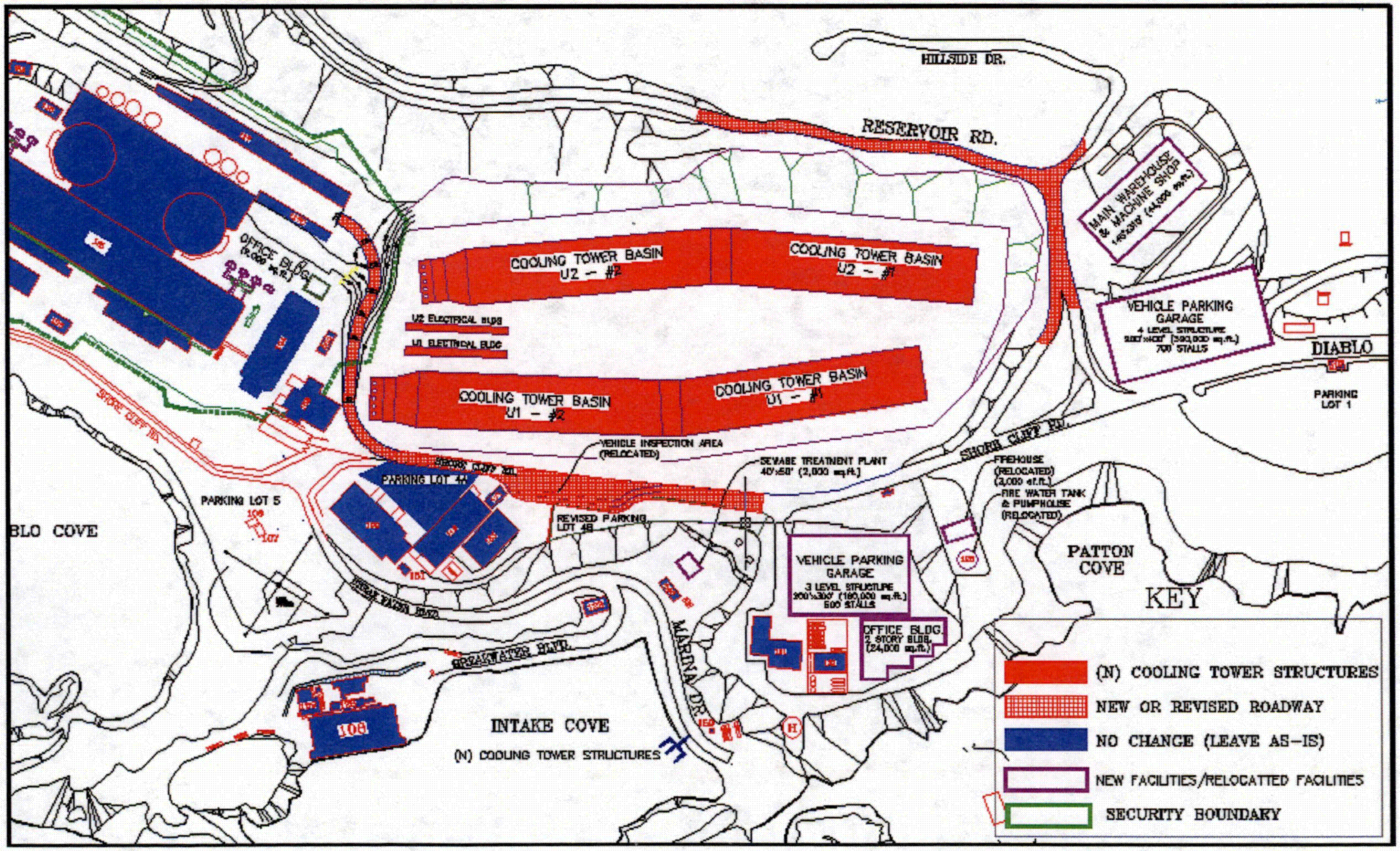




Data taken from SWRCB's Substitute Environmental Document.

Retrofit Feasibility - Conceptual Model

Retrofit Feasibility: Possible Cooling Tower Layout



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Retrofit Feasibility: Adverse Environmental Impacts

- **GHG Emissions for Replacement Power**
  - 8-10 Million Metric Tons During 17-month Outage
  - 282,000 Metric Tons/Year Ongoing
- **Significant Visible Plumes**
  - Plumes 2/3 to 5 Miles in Length (50% of Winter 41% of Summer)
  - Visible From SLO 18% of the Year
- **Salt Drift 7,600 Tons/Year**
  - 15,200,000 Pounds Minimum of PM_{10} Emissions
- **Fossil Fuel Combustion for Implementation**
  - Approximately 4.5 Million Gallons of Diesel
- **Thermal Discharge Limit Challenges—Diffuser Required**
  - Remaining 72 Million Gallon-Per-Day Discharge Will be Warmer, Saltier

Retrofit Feasibility: Engineering Challenges

- **Plume Abatement Towers Are <u>Infeasible</u>**
- **Auxiliary Salt Water (ASW) & Service Cooling Water (SCW) Must Remain on OTC.**
  - <u>43-mgd once-through cooling flow to existing discharge</u>
- **2 20-Cell Back-to-Back Tower Sets per Unit (80-Cells Total)**
  - 5 Circulating Water Pumps Per Unit Located @ Tower Basin/Pit
  - New Conduits Tie Into Old (Major Excavation Effort)
  - Main Condensers Replaced With Modular Welded Bundles
- **Existing Intake Structure Maintained but Reconfigured**
- **Tower Blowdown to New Off-Shore Diffuser System**

Retrofit Feasibility: Cost/Schedule Challenges

- **Require 17-Month Dual Unit Outage**
  - Necessity to Upgrade/Replace Main Condensers
  - Extensive Excavations West of Turbine Building
- **Initial Costs (2008 Dollars)**
  - Capital Project Costs $2,656,000,000
  - Replacement Power (Construction) $1,805,700,000

    @ $70MW - 1155MW/Hr * 24Hr *517 Days * 2 Units * 0.9 Capacity Factor **4.46 Billion Dollars**
- **Average Lost Capacity Post-Retrofit ("Derate")**
  - 56MW (23MW per Unit)
- **Post Implementation Costs (2008 Dollars)**
  - Decommissioning Fund Increase $66,400,000
  - Replacement Power Derated Capacity $36,200,000/year
  - Additional O&M $7,400,000/year

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Diablo Canyon – Retrofit Cost Estimate

In Millions by Category of Work:

$325	Site Work – excavation, retaining walls
$316	Demolition, replacement of buildings, roads, parking
$298	Recirculating water/make-up water pumps, tunnels
$269	Permitting, engineering, project management, security
$242	Cooling Towers
$199	Electrical systems, process/instrumentation, utility relocation
$189	Worker transportation, commute wages, parking
$131	Upgrades – condensers, sewage treatment, SCW
$ 56	Blowdown water treatment, mixing station, diffuser
$ 50	Plant shutdown and start-up
$2,075	**Total Direct Costs**
$ 614	Project Indirect Costs and Contingency
$2,689	**Total Capital Costs**
$1,800	Replacement Power (at $70 MWh)
$4,500	**TOTAL PROJECT COSTS**

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Retrofit Feasibility: Nuclear Safety Challenges

- **ASW Must Remain on OTC**
  - Infeasible to Retrofit to CCC due to Elevated Inlet Temperatures as High as 83-Farenheit
- **Turbine Building Flooding**
  - Elevated System Configuration, Correctable But Costly
- **Salt Deposition on Transmission System**
  - Significant Arcing Risk, Loss of Power
  - Several Levels of Redundant Backup, But Tripping is NRC Concern
- **ASW System Interruption During Implementation**
- **ISFSI Haul Road Rerouting**

Retrofit Feasibility: Permitting Challenges

- **NPDES Permit for New/Altered Discharge(s)**
  - Reconfigured Remaining Discharge and Offshore Diffuser
- **Army Corp of Engineers CWA Section 404 Permit**
  - Discharge, Diffuser and Intake Construction
- **New State Lands Commission (SLC) Lease**
  - Required for Diffuser Installation
- **Air Emissions Permit-To-Operate (APCD PTO)**
  - Necessary Credits Not Currently Available
- **Coastal Development Permit (CDP)**
  - Significant Level of On-Site Construction [more?]

Retrofit Feasibility: Adverse Environmental Impacts

- **Significant Visible Plumes**
  - Plumes 2/3 to 5 Miles in Length (50% of Winter 41% of Summer)
  - Visible From SLO 18% of the Year
- **Salt Drift 7,600 Tons/Year**
  - 15,200,000 Pounds Minimum of PM_{10} Emissions
- **GHG Emissions for Replacement Power**
  - 12-15 Million Tons During Shut Down
  - 282,000 Tons/Year Ongoing
- **Fossil Fuel Combustion for Implementation**
  - Approximately 4.5 Million Gallons of Diesel
- **Thermal Discharge Limit Challenges**

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Mitigation at Diablo Canyon

- **Original Construction Began Prior to Implementation of the Coastal Act**

- **Subsequent Projects Have Included Significant Mitigation**
  - Training Building
    - Creation of the Pecho Coast Trail
      - 7 mile docent-led public bluff top trail
  - Independent Spent Fuel Storage Installation
    - Creation of the Pt. Buchon Trail on the North Ranch
      - 3.5 mile public bluff top trail
  - Steam Generator Replacement
    - Preservation of 1200 acres on the South Ranch
    - Additional Public Access Enhancements on the Pecho Coast Trail
    - Elimination of Water Use From Diablo Creek

Tentative Settlement with Central Coast Board

- **Settlement Reached in 2000 Resolved All Issues Involving OTC – Both Thermal and Impingement/Entrainment**
- **Board Approved Settlement in March 2003, Signed by Parties in June 2003**
- **Settlement Included:**
  - 2013 Acre Conservation Easement Along 5.7 miles of Coastline, BMPs on Additional 547 Acres and $200K Oversight Fund
  - $4.0 Million Fund for Environmental Projects
  - $1.5 Million Fund for CCAMP
  - $350K for CDF&G Abalone Restoration Project
  - $150K for Bio-lab Facility Oversight and Additional Funds for Upkeep
- **At July 2003 Permit Renewal Hearing, Board Requested Additional Information on Mitigation Options and Did Not Renew the Permit**

Nuclear Review Committee Concerns
Bechtel Response Revision 1

Comment set 1:

1. As well as looking at desalination as a supplemental supply of makeup water for closed cycle cooling with other sources from WWTPs etc. the Bechtel Study should look at desalination water as being the only source of makeup water.

   BECHTEL RESPONSE:

   The use of desalination as a makeup source for the CCW wet systems was added to the report in several areas (DCPP Sections 3.2.1, 3.22.1, 4.1.1.1, 4.1.1.2, and 4.5.1 SONGS 3.2.1, 3.2.2.1, 4.1.1.1, 4.1.1.2, and 4.5.1), the design and location of the desalination units will be evaluated as part of Phase 2.

2. Page 8 incorrectly uses the acronym CCRWQCB as Coastal Commission Regional Water Quality Control Board rather than Central Coast Regional Water Quality Control Board.

   BECHTEL RESPONSE:

   This has been corrected in the report.

3. The last sentence on page 17 should say "they" rather than "hey".

   BECHTEL RESPONSE:

   This has been corrected in the report.

4. Page 18 states, "In addition to this federal permit, there is a somewhat parallel state regulatory review process, which culminates in the issuance of a Clean Water Act Section 401 Water Quality Certificate by the SWRCB. No separate application is required for this permit and it generally is issued shortly after the Section 404 permit is issued."

   BECHTEL RESPONSE:

   We could not identify this issue on page 18 on either the DCPP or SONGS reports. The text has been revised on pages 58, 64, and 72 of the DCPP report and pages 52, 60, and 70 of the SONGS report to reflect that the 401 Water Quality Certificate will be issued by the RWQCB prior to the issuance of the Section 404 permit by the Army Corps of Engineers.

5. The RWQCB normally issues the 401 Water Quality Certification and it is required before the 404 permit can be authorized by the ACOE.

BECHTEL RESPONSE:

The text has been revised to reflect that the 401 Water Quality Certificate will be issued by the RWQCB prior to the issuance of the Section 404 permit by the Army Corps of Engineers.

6. Not sure if the report used the 1-2 mm wedge wire screens as well as the 6 mm wedge wire screens

BECHTEL RESPONSE:

The report followed the technical evaluation to support a Phase 1 recommendation for a 6 mm slot opening wedge wire screens. However, the report also is open to the use of smaller slot opening sizes of 2 mm slot if the in-situ testing of wedge wire screens for 2 mm slot and 6-mm slot can demonstrate 2 mm slot is the optimum size addressing effectively entrainment/impingement reduction while not resulting in operation difficulty due to debris clogging or biofouling.

Comment set 2:

There were four issues or concerns raised by the Nuclear Committee in the last two meetings regarding the Phase 1 draft reports that Bechtel agreed to address including:

1. The possibility that back pressure issues would eliminate dry cooling as an option for SONGS, but not for Diablo Canyon.
2. The screen size for wedgewire screens.
3. Vertical wells as an alternative to horizontal substrate filtering.
4. The impingement and entrainment reductions associate with different levels of derate of the facilities.

The back pressure issues appear to have been adequately addressed in the revised SONGS report on p. 12.

There appear to be some remaining issues associated with the other alternatives as presented below:

Wedgewire Screens:

- For both Diablo Canyon and SONGS, Bechtel indicated in the last Committee meeting that it was uncomfortable with using a slot size for wedge wire screens lower than

6-8 mm and that they believed there is a significant improvement in entrainment with a 6 mm slot size.

BECHTEL RESPONSE:

Cylindrical wedgewire screens are a well-established intake screen technology that has a track record of successfully minimizing the loss of aquatic organisms at water intake structures, including those used for cooling purpose. The successful application of wedgewire screen technology depends on three factors in determining site-specific performance of wedgewire screens (William Dey 2003):

1. The slot width relative to the size of aquatic organisms that need to be protected;
2. Through-slot velocity; and
3. Velocity of water currents sweeping across the face of screen.

In the final reports for both plant sites the 2nd and 3rd factors have been clearly discussed. The low through slot velocity (0.5 fps or lower) is a key sizing criterion for the screens and that there is sufficient water current velocity to sweep potentially entrained or impingement organisms along the face of the wedgewire screens. The importance of the first factor, the screen slot width, was also discussed but additional details are added here and in the final report. While it is well recognized that the smaller the slot width, coupled with low through screen velocity and high sweeping current velocities tend to have a higher success rate in entrainment reduction. The ever decreasing slot width will also drastically increase the potential of screen fouling which could result in reduced or even total stoppage of cooling water flow through the intake. Once fouling is developed over and within the slot openings the effectiveness with respect to the entrainment reduction benefits will quickly diminish due to much increased through slot velocity. The key challenge is to find an acceptable slot size that will not only significantly reduce the entrainment and impingement of aquatic organisms and at the same time not result in severe operational difficulty or unintended plant shutdown. This is precisely the reason why Bechtel is not comfortable in endorsing the use of a narrow slot screen such as a 2 mm slot opening at this time. A final slot size needs to be determined through a site-specific testing program that would be carried out for the DCPP and SONGS sites for both 2-mm slot width and the 6-mm slot width if this technology is selected for installation at either site. Additionally, there are a wide range of industry tests that are ongoing that will be also factored into the final slot size selection.

Testing on effectiveness of various slot widths (0.5 mm, 1 mm, 2 mm and 3 mm) were conducted and summarized (William Dey 2003) on three species in the Hudson River

Estuary, American shad, Striped bass and Bay anchovy. Owing to their relatively large eggs, length at hatch, and rapid growth rates all these slot widths result in substantial reduction in the Age 1 equivalent American shad lost to entrainment. The shad entrainment reduction of 87-99 percent for the 3 mm slot width wedgewire screen as compare to 99 to 100 percent reduction with 0.5-mm slot width screens was measured. The striped bass exhibited greater variability in protection from entrainment across slot width and intake location, with entrainment reduction from 26 to 39 percent at 3 mm slot width to 97-99 percent at 0.5 mm slot width. Therefore, depending on the aquatic species, 3-mm slot width as presented in the reference (William Dey 2003) can be very effective too.

Similarly, Enercon conducted alternative intake technologies evaluation for Indian Point 2 &3 (Enercon 2010) and concluded that use of the wedge wire screens can be effective in reducing entrainment up to 89.8 percent and impingement up to 99.9%. It also concluded that use of both 2 mm slot and 9 mm slot would achieve substantial EA1 (Equivalent Age 1) impingement and entrainment reduction. EA1 is defined as the number of age 1 fish that eggs, larvae, and juveniles lost to entrainment would have been expected to produce had they not been entrained. Due to the uncertainty with ice buildup on screen and debris clogging for narrow slot openings (2 mm slot or lower), Indian Point also intends to conduct site specific testing using two slot sizes, 2 mm slot and 9 mm slot. This approach is consistent to our recommendation to DCPP and SONGS to conduct the testing for 2 mm slot as well as 6 mm slot opening.

<u>References:</u>

William Dey, 2003, "Optimum Slot-Width Selection for Wedge Wire Screens," Proceedings Report, Symposium of Cooling Water Intake Technologies to Protect Aquatic Organisms, May 6-7, 2003, Arlington, VA.

Enercon 2010, Evaluation of Alternative Intake Technologies at Indian Points Units 2 & 3, Enercon Services, February 2010.

- SWRCB staff in our last meeting indicated that part of the OTC Policy is protecting organisms of 1 mm in size from entrainment and that 6 mm slot size for the screens may not be adequate to meet the OTC policy. This element of the policy should be included in the discussion of the policy in both reports.

BECHTEL RESPONSE:

Aquatic organism, egg, larval, juvenile and adult fish, can be effectively protected by the use of wedge wire screens. Both final reports provide a long list of advantages of wedgewire screens over the existing intake scheme at both plants. These advantages are low intake velocity, sweeping currents, hydrodynamic shape and fish deterrent screen body shape. The challenge is to find an optimum wedge wire screen slot size that can greatly reduce the entrainment and impingement of these aquatic organisms and at the same time, does not result in severe fouling or clogging by debris. Once fouling is developed over and within the narrow slot openings, the effectiveness with respect to the entrainment reduction benefits will quickly diminish due to much increased through slot velocity that will entrain (pull) the aquatic organisms in from surrounding flow fields and through the slot opening.

At this time, Bechtel can not endorse the narrow slot screens (2 mm or smaller) other than a 6 mm slot width. Prior to the procurement of the screens the selection of the slot size would be determined based on insitu testing at each plant site and available industry test results at the time.

- The SWRCB and other staff believed that additional information, including quantification of impacts, on the both the larger and smaller slot size was necessary. In the meeting Bechtel indicated that they would look into it and respond to comments.

BECHTEL RESPONSE:

Bechtel has looked into this and will add additional details into Section 4.2.8 of the final reports adding quantification of impacts on both the larger and smaller slot sizes, as follows:

(a) In the cited reference below (SCWR 2011), Tenera Environmental performed the Open Ocean Intake Effects study, a pilot study for the evaluation of a narrow-slot cylindrical wedgewire screen. The pilot study examined the following operational characteristics of the screen in situ:

- Larval entrainment
- Impingement
- Screen corrosion/biofouling
- Hydrodynamics around the screen during pumping.

The pilot scale intake screen had a 2 mm slot opening and was sized to ensure a maximum through-screen velocity of 0.33 fps. Results of the pilot studies testing showed that Z-alloy proved to be resistant to biofouling over 13-months, and the qualitative evaluation of dye in water moving around the cylindrical wedge wire screens showed currents and wave motion helping to clean the screen. That together with a low intake velocity prevented impingement of small organisms.

The intake effects assessment study as presented in the cited reference below compared the screened intake with an unscreened intake to study the operational effectiveness of the screen on larval entrainment. The data from the pump samples were analyzed to determine if any differences could be detected between concentration of fish, caridean shrimp, and cancrid carb larvae from the screened and unscreened intake. The analysis showed: 1) the standard 2 mm narrow-slot wedge wire screen intake screen excluded 100% of adult and juvenile fish species in the area. 2) The unscreened intake entrained juvenile and adult fishes, and 3) while no statistically significant reduction in entrainment was found, annualized screen-test results demonstrated that the screen resulted in 20% reduction in total annual fish entrainment.

(b) In addition, Zeitoun, et al (1981), in the below cited reference, studied the effectiveness of both 2 mm narrow slot and 9.5 mm slot opening wedge wire screens in reducing entrainment. Juvenile fish and fish larvae sense the screens and avoid entrainment and they are less sensitive to the slot size. Zeitoun, et al. conducted field entrainment experiments with samples of ichthyoplankton collected through 2.0-mm and 9.5-mm-slot opening cylindrical wedge-wire screens in June, July, and August off the southeast shore of Lake Michigan at a depth of 10.7 m. Ambient composition and density of ichthyoplankton were determined by net tows. Rainbow smelt (*Osmerus mordax*), alewife (*Alosa pseudoharengus*), and yellow perch (*Perca flavescens*) larvae were common in both entrainment and tow collections. Eggs were found almost exclusively in entrainment collections. Ambient larval fish densities were about 11 times greater than those found in entrainment collections. Total entrainments through either screen [slot size] were not statistically significant. Larval avoidance and, to a lesser extent, screen exclusion were responsible for the low entrainment. These field experiments estimated that about 90% of native fish larvae at the site avoided pumping.

(c) Testing on effectiveness of various slot widths (0.5 mm, 1 mm, 2 mm and 3 mm) were conducted and summarized (William Dey 2003) on three species in the Hudson River Estuary, American shad, Striped bass and Bay anchovy. Owing to their relatively large eggs, length at hatch, and rapid growth rates all these slot widths result in substantial reduction in the Age 1 equivalent American shad lost to entrainment. The shad entrainment reduction of 87-99 percent for the 3 mm slot width wedgewire screen as compare to 99 to 100 percent reduction with 0.5-mm slot width screens was measured. The striped bass exhibited greater variability in protection from entrainment across slot width and intake location, with entrainment reduction from 26 to 39 percent at 3 mm slot width to 97-99 percent at 0.5 mm slot width. Therefore, depending on the aquatic specifies, 3-mm slot width as presented in the reference (William Dey 2003) can be very effective also.

(d) Enercon conducted alternative intake technologies evaluation for Indian Point 2 &3 (Enercon 2010) and concluded that use of the wedge wire screens with slot sizes of 9.0, 6.0, 3.0, 2.0, 1.5 and 1.0 mm can be effective in reducing EA1 (Equivalent Age 1) entrainment loss up to 89.8 percent and impingement loss up to 99.9% from the regulatory baseline. It also concluded that use of both 2 mm slot and 9 mm slot sizes would achieve substantial EA1 impingement and entrainment reductions. According to Enercon, the regulatory baseline is a regulatory construct that employs certain operation and survival assumptions, which have been used by the New York State Department of Environment Conservation (NYSDEC) in State Pollutant Discharge Elimination System (SPDES) permit proceedings for other New York power plants.

Potential percent reduction of monthly and annual EA1 impingement and entrainment losses from the regulatory baseline due to use of wedgewire screens with through slot velocity of 0.5 fps was listed in the below table.

Month	EA1 Entrainment Loss Reduction						EA1 Impingement Loss Reduction
	9.0 mm	6.0 mm	3.0 mm	2.0 mm	1.5 mm	1.0 mm	
January	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	9.6%
February	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	10.5%
March	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	13.1%
April	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	8.2%
May	8.3%	8.3%	8.3%	8.3%	8.3%	7.9%	10.0%
June	28.2%	28.2%	28.2%	28.3%	28.2%	27.7%	12.7%
July	26.5%	26.5%	26.5%	26.5%	26.6%	26.6%	5.5%
August	14.8%	14.8%	14.8%	14.8%	14.8%	14.8%	5.7%
September	6.4%	6.4%	6.4%	6.4%	6.4%	6.4%	6.0%
October	4.9%	4.9%	4.9%	4.9%	4.9%	4.9%	5.1%
November	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.7%
December	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	7.8%
Annual	89.6%	89.6%	89.7%	89.8%	89.7%	88.8%	99.9%

As can be seen, for the Indian Point Units 2 & 3 assessment, use of wedgewire screens of 1 mm to 9 mm all exhibit high and comparable improvement of equivalent age 1 (EA1) impingement and entrainment loss reductions from the regulatory baseline.

In summary, it is prudent to conclude that, smaller slot opening wedge wire screens, including narrow slot sizes, results in same or better performance in entrainment reduction than coarser slot opening wedgewire screens. More dependable measure would be the EA 1 impingement and entrainment reduction, in which Enercon shows that use of either 1 mm, 2 mm, 6 mm, or 9 mm makes no practical differences for Indian Point Units 2 & 3. Nonetheless, actual quantification impacts to the in-situ aquatic organism conditions for each of the two plants need to be conducted before a conclusion is drawn on the optimum slot opening (whether 2 mm slot or 6 mm slot). This certainly needs to consider the potential effect of debris clogging and fouling to the operation of wedge wire screens.

References:

SCWR 2011, City of Santa Cruz Water Control Board, Evaluation of a Screened Open Ocean Intake and Subsurface Intake Options for a Seawater Desalination Facility in Santa Cruz, California, November 2011.

Zeitoun et al, 1981: I. H. Zeitoun, J. A. Gulvas, D. B. Roarabaugh, Effectiveness of Fine Mesh Cylindrical Wedge-Wire Screens in Reducing Entrainment of Lake Michigan Ichthyoplankton, Canadian Journal of Fisheries and Aquatic Sciences, 1981.

William Dey, 2003, "Optimum Slot-Width Selection for Wedge Wire Screens," Proceedings Report, Symposium of Cooling Water Intake Technologies to Protect Aquatic Organisms, May 6-7, 2003, Arlington, VA.

Enercon 2010, Evaluation of Alternative Intake Technologies at Indian Points Units 2 & 3, Enercon Services, February 2010.

- There is a very limited discussion of the smaller slot size that has been added in the final report, but it is quite superficial and doesn't really address the issues raised.

- For example, in both report there is a short discussion of some field experiments (Zeitoun 1981) that looked at 2 mm to 9 mm wedge wire screens. (It appears in two places: on p. 37 of Diablo Canyon Report and, p.35 of SONGS Report). However, the discussion makes no distinction between entrainment/impingement impacts associated with the smaller vs. larger screens. As a result it doesn't really provide any useful information to help understand impacts from the either larger or smaller slot size. (As currently written one might conclude from this discussion that the size of the screen doesn't matter in that the impacts for 2-9 mm slot size are the same.) This discussion is not very responsive to the Committee's request for additional information (including quantitative info) on the smaller slot size for wedge wire screens.

- There is a minimal mention of 2 mm slot size in a couple of places in both reports. This is not very responsive to the Committee's request for additional information about the vertical wells and their possible use.
- In the wedge wire discussion of entrainment/impingement design (starting on p.85 in the SONGs report and p.39 of the Diablo Canyon report) it isn't clear whether you are talking about 6 mm or smaller. This would have been one place where Bechtel could have included additional information on the smaller slot size.

BECHTEL RESPONSE (for the four bullets above):

Bechtel has looked further into this and has added additional details into the final reports on smaller slot sizes, specifically various testing reports we found over the web with comparison of effectiveness of various screen sizes including narrow slot sizes (2 mm and smaller). However, we want to clarify that the Committee is requesting additional information on narrow slot sizes (2 mm and lower) in this section and not about the vertical wells and their possible use which is addressed elsewhere in this document and in the final reports.

In addition to the Zeitoun et 1981 reference, Bechtel has evaluated additional references (SCWR 2011, Dey 2003, and Enercon 2010) that provide support on equal or better performance of finer slot opening than coarse slot opening such as 9 mm slot as related to the entrainment reductions. The discussion below will be added to Section 4.2.8.

Testing on effectiveness of various slot widths (0.5 mm, 1 mm, 2 mm and 3 mm) were conducted and summarized (Dey 2003) on three species in the Hudson River Estuary, American shad, Striped bass and Bay anchovy. Owing to their relatively large eggs, length at hatch, and rapid growth rates all these slot widths result in substantial reduction in the Age 1 equivalent American shad lost to entrainment. The shad entrainment reduction of 87-99 percent for the 3 mm slot width wedgewire screen as compare to 99 to 100 percent reduction with 0.5-mm slot width screens was measured. The striped bass exhibited greater variability in protection from entrainment across slot width and intake location, with entrainment reduction from 26 to 39 percent at 3 mm slot width to 97-99 percent at 0.5 mm slot width. Therefore, depending on the aquatic species, 3-mm slot width as presented in the reference (Dey 2003) can be very effective also.

The pilot scale intake screen conducted by Tenera Environmental (SCWR 2011) had a 2 mm slot opening and was sized to ensure a maximum through-screen velocity of 0.33 fps. Results of the pilot studies testing showed that Z-alloy proved to be resistant to biofouling over 13-months, and the qualitative evaluation of dye in water moving around the cylindrical wedge wire screens showed currents and wave motion helping to clean the screen and together with a low intake velocity prevented impingement of small organisms.

The intake effects assessment study as presented in this reference compared the screened intake with an unscreened intake to study the operational effectiveness of the screen on larval entrainment. The data from the pump samples were analyzed to determine if any differences could be detected between concentration of fish, caridean shrimp, and cancrid carb larvae from the screened and unscreened intake. The analysis showed: 1) the standard 2 mm narrow-slot wedge wire screen intake screen excluded 100% of adult and juvenile fish species in the area. 2) The unscreened intake entrained juvenile and adult fishes, and 3) while no statistically significant reduction in entrainment was found, annualized screen-test results demonstrated that the screen resulted in 20% reduction in total annual fish entrainment.

More dependable measure in impingement and entrainment reduction would be to look at equivalent age 1 (EA 1) conditions. Enercon studies for Indian Point 2 & 3 indicated that use of the wedge wire screens result in substantial EA1 impingement and entrainment reduction from the regulatory baseline. Potential percent reduction of monthly and annual EA1 impingement and entrainment losses due to use of wedgewire screens with through slot velocity of 0.5 fps was listed in the below table.

Month	EA1 Entrainment Loss Reduction						EA1 Impingement Loss Reduction
	9.0 mm	6.0 mm	3.0 mm	2.0 mm	1.5 mm	1.0 mm	
January	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	9.6%
February	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	10.5%
March	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	13.1%
April	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	8.2%
May	8.3%	8.3%	8.3%	8.3%	8.3%	7.9%	10.0%
June	28.2%	28.2%	28.2%	28.3%	28.2%	27.7%	12.7%
July	26.5%	26.5%	26.5%	26.5%	26.6%	26.6%	5.5%
August	14.8%	14.8%	14.8%	14.8%	14.8%	14.8%	5.7%
September	6.4%	6.4%	6.4%	6.4%	6.4%	6.4%	6.0%
October	4.9%	4.9%	4.9%	4.9%	4.9%	4.9%	5.1%
November	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	5.7%
December	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	7.8%
Annual	89.6%	89.6%	89.7%	89.8%	89.7%	88.8%	99.9%

As it can be seen, for the Indian Point Units 2 & 3 assessment, use of wedgewire screens of 1 mm to 9 mm all exhibit high and comparable improvement of equivalent age 1 (EA1) impingement and entrainment loss reduction from the regulatory baseline.

Again, it can be concluded that smaller slot opening wedge wire screens, including narrow slot sizes, results in the same or better performance in entrainment reduction of aquatic organisms than coarser slot opening wedgewire screens. The actual impingement and entrainment performance on a EA 1 basis would be quite similar, as in the case of Indian Point 2 & 3. Actual quantification impacts to the in-situ aquatic organism conditions for each of the two plants needs to be tested before a conclusion is drawn on the optimum slot opening. This testing certainly needs to consider the potential effect of debris clogging and biofouling to the operation of wedge wire screens.

References:

SCWR 2011, City of Santa Cruz Water Control Board, Evaluation of a Screened Open Ocean Intake and Subsurface Intake Options for a Seawater Desalination Facility in Santa Cruz, California, November 2011.

William Dey, 2003, "Optimum Slot-Width Selection for Wedge Wire Screens," Proceedings Report, Symposium of Cooling Water Intake Technologies to Protect Aquatic Organisms, May 6-7, 2003, Arlington, VA.

Enercon 2010, Evaluation of Alternative Intake Technologies at Indian Points Units 2 & 3, Enercon Services, February 2010.

Zeitoun et al, 1981: I. H. Zeitoun, J. A. Gulvas, D. B. Roarabaugh, Effectiveness of Fine Mesh Cylindrical Wedge-Wire Screens in Reducing Entrainment of Lake Michigan Ichthyoplankton, Canadian Journal of Fisheries and Aquatic Sciences, 1981.

Substrate Filtering:

- SWRCB staff indicated that Bechtel should look at vertical (Rainey(?) wells). Bechtel agreed to look into the issue.

  BECHTEL RESPONSE:

  Bechtel will add additional details on vertical wells (traditional and radial collector wells) to the final report; see response to the next bullet.

- A very short and superficial discussion (1/2 page) of vertical wells is presented on p. 49 of the Diablo Canyon report and on p. 42-43 of the SONGS report. It mentions that there is another type of source water collection system and concludes it as being less efficient for production of large quantities of water as the horizontal substrate filtering. There is no real discussion of why it is more efficient or substantiation for the conclusion.

  BECHTEL RESPONSE:

  Revised discussion has been provided, see below, explaining in greater details that the horizontal substrate filtering scheme is relatively more efficient for the production of large quantities of water as compare to the collection of individual vertical wells scheme. Horizontal substrate filtering scheme is based on a collection of flows collected via arrays of offshore horizontal laterals to various piping manifolds and eventually to the central pumping station on shore. However, vertical wells (conventional or Rainey wells) will be on-shore and have individual pumping system, and each well tends to have very limited pumping capacity. The revised discussion will show that, in order to produce 1.7 million gpm once through cooling flows, vast numbers of onshore vertical wells will be needed. Due to the spacing requirements to reduce interference effects between screens for the vertical wells, greater vertical penetrations and limitation of natural formation of hydraulic conductivity, spacing large number of vertical wells on shore, with individual pumping systems to a central circulation water pumping station would not be practical. In any case, both substrate filtering system using laterals or vertical wells system are fatal flaws in terms of first-of-kind-to-scale, operability or maintenance.

Improved writeup which has been added to Section 3.8 of both reports is provided below:

The source water substrate filtering collection system is more efficient for production of large quantities of water as compared to onshore wells (either conventional vertical wells or radial collector wells). Conventional vertical wells are placed in vertically oriented boreholes and consist of a well screen and blank casing. In general, the maximum yield of a typical vertical well is approximately 6,000 gpm for a 30 inch diameter well (Sterrett, 2007), which is about the practical well size limit of conventional drilling equipment. For a 1.7 million gpm design capacity, approximately 280 vertical wells and associated pumping stations would be required if the maximum yield exists from each well. This maximum yield assumes that a highly permeable material, such as a gravel deposit, is present in the subsurface, which is not the case at either DCPP or SONGS; hence the total number of vertical wells needed to meet the design flow rate capacity would be significantly greater than 280. The vast network of pumping station delivering flows to a central collection point will not be practical onshore. Radial collector wells (also known by the proprietary name Ranney Wells) consist of a central caisson and associated pumping skid, with well screens extending laterally outward beneath the water source. Radial collector wells have been designed with capacities from 2 to 80 mgd (Riegert, 2006) or 1,400 to 56,000 gpm. Using this range of capacity, it would require between 30 to 1400 radial collector wells and associated pumping installations to meet the design flow rate capacity, assuming ideal subsurface conditions, i.e. a gravel deposit. The subsurface conditions at DCPP and SONGS suggest that high numbers of radial collector wells would be required.

Onshore vertical and radial collector wells have the following limitations:

- Greater horizontal spacing requirements to reduce interference effects between conventional wells or to allow lateral placement for radial collector wells.
- Greater vertical penetration to produce optimum flow to well.
- Well production rate limited to natural formation hydraulic conductivity.
- Geological conditions at DCPP indicate the presence of shallow bedrock not conducive to large flows.
- Geological conditions at SONGS indicate the presence of shallow sandstone bedrock that may be conducive to large flows but additional study is needed to

confirm. Pumping information at the SONGS site is not available due to salt water intrusion concerns.

These limitations would be expected to result in a larger well field area and a more complex pumping system and on an onshore installation, it is not really practical. As a result the vertical or radial collector wells were not considered in this evaluation.

REFERENCES

Sterrett, R.J., 2007, *Groundwater and Wells*, 3rd edition, Johnson Screens, New Brighton, MN.

Riegert, D.S., 2006, Reassessing Ranney Wells, *Public Works*, April.

- Both reports states the due to a number of limitations (listed as bulleted items) that would be expected to result in larger well system and a more complex pumping system, and hence a greater environmental impact than for substrate filtering, vertical wells were not considered in the evaluation. However, there is no substantiation for why environmental impacts would be a fatal flaw.

BECHTEL RESPONSE:

Discussion has been revised to focus on the technical impracticality of using vast number of onshore vertical wells and associated pumping scheme over the offshore substrate filtering scheme as the reason of rejecting the vertical well system from further evaluation in this section. Revised section writeup below will be added to Section 3.8 of the report.

Improved writeup to be added to Section 3.8 of both reports:

The source water substrate filtering collection system is more efficient for production of large quantities of water as compared to onshore wells (either conventional vertical wells or radial collector wells). Conventional vertical wells are placed in vertically oriented boreholes and consist of a well screen and blank casing. In general, the maximum yield of a typical vertical well is approximately 6,000 gpm for a 30 inch diameter well (Sterrett, 2007), which is about the practical well size limit of conventional drilling equipment. For a 1.7 million gpm design capacity, approximately 280 vertical wells and associated pumping stations would be required if the maximum yield exists. This maximum yield assumes that a highly permeable material, such as a gravel deposit, is present in the subsurface, which is not the case at either DCPP or SONGS; hence the total number of vertical wells needed to meet the design flow rate capacity would be significantly greater than

280. The vast network of pumping station delivering flows to a central collection point will not be practical onshore. Radial collector wells (also known by the proprietary name Ranney Wells) consist of a central caisson and associated pumping skid, with well screens extending laterally outward beneath the water source. Radial collector wells have been designed with capacities from 2 to 80 mgd (Riegert, 2006) or 1,400 to 56,000 gpm. Using this range of capacity, it would require between 30 to 1400 radial collector wells and associated pumping installations to meet the design flow rate capacity, assuming ideal subsurface conditions, i.e. a gravel deposit. The subsurface conditions at DCPP and SONGS suggest that high numbers of radial collector wells would be required.

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- Greater horizontal spacing requirements to reduce interference effects between conventional wells or to allow lateral placement for radial collector wells.
- Greater vertical penetration to produce optimum flow to well.
- Well production rate limited to natural formation hydraulic conductivity.
- Geological conditions at DCPP indicate the presence of shallow bedrock not conducive to large flows.
- Geological conditions at SONGS indicate the presence of shallow sandstone bedrock that may be conducive to large flows but additional study is needed to confirm. Pumping information at the SONGS site is not available due to salt water intrusion concerns.

These limitations would be expected to result in a larger well field area and a more complex pumping system and on an onshore installation, it is not really practical. As a result the vertical or radial collector wells were not considered in this evaluation.

REFERENCES

Sterrett, R.J., 2007, *Groundwater and Wells*, 3rd edition, Johnson Screens, New Brighton, MN.

Riegert, D.S., 2006, Reassessing Ranney Wells, *Public Works*, April.

Variable Speed Pump (or Operational Strategies):

- Bechtel agreed to provide information on the impingement and entrainment impacts associated with different levels of derate (by percentage) of the plants. The only place a possible derate of either plant is discussed is in relation to the variable speed pump technology.

BECHTEL RESPONSE:

The impingement and entrainment impacts associated with different levels of derate (by percentage) can be found in Sections 4.2.8, for both plants, related to the evaluation of Variable Speed Pump technology.

- For Diablo Canyon, on p. 56 the report states that flow rate reductions are "proportional" to reductions in impingement/entrainment improvement. But this doesn't address the question of what impingment/entrainment impact reductions can be expected from different levels of derate (percentages).

BECHTEL RESPONSE:

Section 3.9 for both reports provide the general description of the variable speed pump technology under consideration and what this technology can do. The full evaluation of entrainment and impingement design as related to impingement and entrainment reduction should be found on Section 4.2.8 of both reports. The specific generation output under different de-rating scenarios vs. flow can be determined based on acceptable condenser back pressure, design condenser inlet temperature, condenser cleanliness factor. However, the calculated generation outputs for different condenser flow rate will show a much higher condenser temperature rise with reduced flow as compare to the base load condition. For this assessment, it is necessary that the condenser temperature rise be kept constant for different plant de-rating conditions, so not to cause thermal discharge permitting and thermal impacts issue at discharge. In which case, the amount of plant de-rate will closely match the amount of condenser flow reduction.

In summary, one can conclude that the plant percent de-rate will approximately equal to the percent condenser flow reduction and proportional to the reduction in impingement/entrainment improvement.

- Both reports say that for variable speed pumps to reduce flow to 0.5 fps or more requires reduction of 83% or more, which would render the pumps inoperable due to the current practical limit of 15-30% flow reduction achievable with pumps this size. Even if practical, the reduction in output would be over 50%. Again, this could be a place to add discussion about other levels of derate.

BECHTEL RESPONSE:

In Section 4.2.8 of both reports, it was stated that, in order to reduce flow to 0.5 fps or more will require de-rate of 83% for SONGS and derate of 75% for DCPP, respectively. In both cases, this level of derating will not be achievable or practical as it would render the pumps in-operable due to min flow requirements for continuous pump operation. Also in Section 4.2.8, it was discussed that the practical range of flow reduction of the large scale circulating water pumps would be about 15 to 30%. This range of flow reduction will directly result in the equal percentage of the entrainment reduction and appreciated reduction on impingement reduction. Impingement reduction associated with flow reduction can not be quantified or estimated linearly as would be the case for the entrainment reduction, since through screen velocity would be still above 0.5 fps after 15 to 30% flow reduction.

Bechtel will update Section 4.2.8 to add clarification of percent entrainment reduction vs. percent derate from 0 to 30%. As discussed in the last bullet, with the assumption that the condenser temperature rise must be kept constant under different plant de-rate conditions so not to cause additional adverse environmental impact to the circulating water discharge temperature, the percent plant de-rate will roughly be in the same order as the percent condenser flow rate reduction. Therefore, a condenser flow reduction of 0 to 30% due to use of variable speed will result in approximate plant de-rate of up to 30%.

- Finally, both reports (SONGs report on p. 89, Diablo Canyon on p. --) state "Finally, an EPRI study (EPRI 2007) concludes that such reduction in load may have significant impacts on the electric generation supply to the grid when most needed." The EPRI Report contains dated information on the supply and demand conditions in California, which have changed significantly, especially with both SONGS units currently offline. This sentence should be deleted.

BECHTEL RESPONSE:

The sentence states a conclusion derived from a valid EPRI study which we believe is accurate. A large reduction in load from any one of the studied units will have an impact on the grid that must be accounted for. Therefore, we have not removed the sentence from the reports.

Comment set 3:

On the Closed-Cycle Cooling Report of Bechtel

It is recognized that Bechtel has found that none of the alternatives proposed for Phase 2 have "fatal flaws", yet they may all have extreme environmental and cost implications for Californian's. Absent objections from California's permitting agencies, it believed that Phase 2 should proceed to investigate the full costs of each alternative; including realistic time estimates for permit approval and legal challenges.

California, and in some cases the federal government, may need to give permission to do many of the following:

- Build ten 570 ft. towers in the coastal zone
- Lease additional federal (military land)
- Place miles of pipes underground for water
- Find fresh water in an area often near or in drought conditions
- Use reclaimed water that could better serve agriculture, industry and residential
- Buy fresh or reclaimed water
- Move and/or reconstruct buildings on the east side of highway101
- Mitigate particulate matter from steam
- Take over state park land
- Reduce parking space
- Wait 8-15 years for alternatives
- Allow continued degradation of marine life until 2020 to 2022 (current end of operating permit)
- Adopt Phase 1 without the benefit of expert Marine Biologist input
- Purchase from a list of out-of-state vendors
- Rely on the NRC process for approval of safety-related components
- Require additional energy to operate generators in a currently constrained area.
- Invest in technology that has not been tested at any other California coastal facilities, much less nuclear facilities (SONGS Steam Generators)
- Increase water use and emissions during construction
- Litigate years of disagreements in what has historically been a very costly legal process for nuclear investments.

While the above list of negative impacts for alternatives cooling is not all-inclusive it does highlight issues that have been historically unpopular with the coastal communities and/or have found their way into lengthy court challenges. In addition, many cost estimates related to nuclear projects have resulted in major cost overruns. For this reason, it's encouraged that Phase 2 reviewers leave no economic or environmental stone unturned, allowing for a recommendation that is factually based and in the best interest of California residents and utility ratepayers.

BECHTEL RESPONSE:

Bechtel intends to work closely with the utilities and the Review Committee to develop workable conceptual designs for each of the Phase 2 technologies that pass criterion 10 to develop an estimate that meets the Class 3 based on AACE Recommended Practice No. 17R-97: "Cost Estimate Classification System" and 18R097 "Cost Estimate Classification System-as Applied in Engineering, Procurement, and Construction for the Process Industries". This process will result in a cost estimate and a design and installation schedule that should support the Review Committee needs in evaluating the viability of each of the Phase 2 technologies.

Comments of Pacific Gas and Electric Company
September 12, 2014

Alternative Cooling Technologies or Modifications to the Existing Once-Through Cooling (OTC) System for Diablo Canyon Power Plant

Prepared by Bechtel Power Corporation
for the
State Water Resources Control Board – Nuclear Review Committee

GENERAL COMMENTS

Costs

As requested in our earlier comments, Bechtel has incorporated PG&E projected additional owner's costs into the various options. While these costs still do not reflect the full cost of each option, as by design some of the costs do not include inflationary escalation factors, they do provide an overall sense of the magnitude of the initial project costs in current (2013) dollars which would be borne by our customers: $8.6 to $14.1 billion for freshwater wet or dry cooled towers, $6.2 to $8.0 billion for saltwater towers, and $456 to $675 million for the screening technology options.

However, the costs in the report represent project installation and other initial costs, but do not reflect ongoing additional costs due to increased annual plant operations and maintenance burdens, and replacement power due to generating unit derates (a reduction in net power to the grid due to parasitic load and reduced generating efficiency). For the freshwater tower options, these additional costs are estimated to be between $50 to $86 million annually, and for the saltwater tower option, this number is projected in the range of $98 to $120 million given the significant unit derates, higher routine maintenance costs due to salt drift, and the ongoing need to bus employees to the plant site due to the permanent loss of a significant portion of existing parking areas.

Bechtel also acknowledges that mitigation costs for these large-scale industrial projects are difficult to estimate and there are no consistent figures included within the report. However, Bechtel does state that costs in the range of 5% of project costs may be possible -- and this would suggest mitigation on the order of several hundred million dollars.

Permitting

As we have commented previously, Bechtel's estimate of roughly four to five years to develop permit applications and receive all the necessary approvals/authorizations is likely not sufficient. While these timeframes may make sense based on agency guidelines or some past experience, we believe that permitting any of the options will be a tremendous undertaking and thus, the estimated permitting schedules are at significant risk. All of the options, but especially the cooling tower options, will require detailed and time-consuming permit application documentation, many governmental approvals, and are likely to face substantial challenges from various organizations.

Although Bechtel does not agree, PG&E continues to believe that a Nuclear Operating License Amendment Request (LAR) would be necessary for all but the fine-mesh screening technology option -- and this will add time and complexity to the permitting process.

Additionally, developing permit applications and working with the various agencies through final approval is likely to cost more than twice what Bechtel estimates. PG&E's experience with permitting projects at Diablo Canyon suggests permitting costs on the order of $10 to $15 million - not $3 to $4 million.

Lastly, for the saltwater tower option, the ability to permit PM-10 emissions through offsets via road paving is speculative. While it has been done before, the number of tons projected to be offset at Diablo Canyon is substantially larger, and the San Luis Obispo County (SLO) Air District would need to go through an involved regulatory process to formally adopt a rule and a formula for determining how many miles of road would need to be paved to achieve the offset. This will be a lengthy and time-consuming process - and it is not at all clear that there are enough qualified unpaved roads in the county to meet the very substantial offset requirement.

COMMENTS ON EACH TECHNOLOGY

Fine Mesh Screens

Bechtel modified the final report text to reflect the revised Tenera Report (10/29/13) information but continues to suggest that this technology would be effective. While entrainment losses could theoretically be reduced by at most 39.7% for 1-mm slot sized screens, and only 8.4% for 2-mm slot sized screens, larval survivability after initial impingement is unclear. Bechtel does not address or acknowledge Tenera's additional report developed for the Review Committee (Evaluation of Fine-mesh Intake Screen System for the Diablo Canyon Power Plant [08/2013]) assessing larval survivability associated with this screening technology. This evaluation concludes that "studies at DCPP show that the vast majority of the fishes entrained were very small and based on other studies, the probability of these larvae surviving impingement, screen-wash systems and fish return would be very low." Further, operational issues regarding biofouling and clogging have not been adequately addressed. PG&E believes that these issues, when evaluated together, demonstrate that this technology would not achieve the OTC policy's objective.

There also continues to be some difference of opinion regarding the seismic qualification of the plant intake structure, and what would be necessary to support the structure during the proposed modifications to implement the fine-mesh screen option. While PG&E believes that the best approach would be a 12-month dual-unit outage, there remains the possibility, as posed by Bechtel, that additional cross-bracing of the existing structure during modification may sufficiently resolve the concern and eliminate the need for dual-unit outages. However, this issue requires further engineering evaluation.

Wedgewire Screens
It must be noted that there are no existing open ocean installations of wedgewire screens and thus, there are serious concerns regarding operability and effectiveness of the technology at Diablo Canyon.

Bechtel has revised the report to adequately address permitting for the proposed technology Pilot Study. However, PG&E continues to believe that a Pilot Study must be conducted for at least two or more years in order to appropriately assess potential operability, debris loading, and corrosion issues in an open ocean saltwater environment. One year is simply not enough time to adequately evaluate these types of issues.

There continues to be a difference of opinion on the installation of the wedgewire screens. PG&E believes that an 8-month dual-unit outage is necessary, and thus substantial replacement power costs would also be incurred during project implementation. An outage of this magnitude would add $560 million in replacement power costs.

Closed-Cycle

Freshwater – North
PG&E continues to believe that these options are likely not feasible given the enormous cost and excavation. Permitting for the excavation and the installation will be incredibly difficult, if not impossible, given the tremendous environmental footprint and adverse impacts.

These options all essentially require the removal of a mountain – with excavation between 190 million and 316 million cubic yards – to create a 62 or 109 acre level pad for the cooling towers. To put the size of the proposed excavation in perspective, the Panama Canal required an excavation of approximately 240 million cubic yards for the 48-mile long passage. The excavation would require approximately 310 acres of canyon area north of the plant to be filled to a height of between 320 and 500 feet. Thus, at a minimum, these approaches would irreversibly impact roughly 400 acres north of the current plant site.

Further, though requested for evaluation by the committee, PG&E believes that the reclaimed water component of this option is unworkable. Given the state's drought situation, there are far better uses for this reclaimed water than providing less than 10% of the water needed for Diablo Canyon freshwater cooling towers, and the adverse environmental impacts of building the piping system must be considered as well.

Saltwater – South
Although less costly than the freshwater options, the estimated installation costs of between $6 – $8 billion, along with significant unit derates and permitting challenges, suggest that these options are likely not feasible at the Diablo Canyon site.

As noted in the general comments, air permitting for PM-10 presents a potentially significant challenge and the permitting process would take time for SLO-APCD to develop. While there are examples of air districts within California that have used road paving as an offset to PM-10 emissions, the scope of the examples are not similar to the proposed saltwater cooling tower retrofit of Diablo Canyon, and the scale of emissions offsets approved are significantly less than what would be required. Additionally, many factors such as traffic counts, vehicle speed, and road composition must be estimated and evaluated to calculate the required road miles that must be paved to provide sufficient offsets. It is not realistic to use Mojave Desert area data to estimate needed road miles in San Luis Obispo County. Lastly, the process to develop and approve offsets at the local air district level would be considerable, and pre-construction approval of a Prevention of Significant Degradation of Air Quality (PSD) permit would require approval of Federal EPA.

The saltwater cooling tower installation would derate the power plant between 192 and 244 MWs. This is a significant derate, and would cost between $78 to 100 million (2013 dollars) in replacement power on an annual basis following retrofit.

The towers will contribute significant salt drift and the report notes only that there will be an "additional level of effort" needed to address detrimental effects. The actual impact of salt drift, including the potential for adverse impacts to generating unit operability in certain conditions, has not been fully defined. Though prevailing winds at the plant site are generally from the northwest, which would drive the salt plume away from the plant during those periods, 14-15% of the time during an average year the wind direction would drive the salt drift immediately over and onto the exposed high-voltage electrical system infrastructure of both Unit 1 and Unit 2, potentially causing plant trips due to flashover, and thereby adversely impacting reliability. Our estimates indicate that increased annual operations and maintenance costs, a significant portion of which would be required specifically to address the salt drift, would be at a minimum in the range of $9 million annually. Further, additional maintenance activities may not be sufficient to reduce elevated risks of electrical system flashovers and potential unit/reactor trips due to those faults.

The report does not address the total additional costs for ongoing plant operations following retrofit, which will likely be in the range of $98 to $120 million a year; including increased operations and maintenance, the replacement power costs for the significant plant derate noted above, and costs to shuttle employees to the site from offsite parking locations.

OTC Special Studies Draft Scope

Objective

The objective of this document is to satisfy the requirement established by the State Water Resources Control Board (SWRCB) for Southern California Edison (SCE) and Pacific Gas and Electric (PG&E) to jointly create a scope document containing criteria to be used by an independent third-party engineering consultant to conduct evaluations to assess compliance alternatives to once-through cooling for the San Onofre Nuclear Generation Station (SONGS) and the Diablo Canyon Nuclear Power Plant (DCPP).

Background

The SWRCB's "Statewide Water Control Policy on the Use of Coastal and Estuarine Waters for Power Plant Cooling" (herein referred to as "the Policy") contains unique provisions for the state's two existing nuclear-fueled power plants that use once-through cooling water technology, SONGS and DCPP.

The Policy provisions require the owner or operator of a nuclear facility to undertake "special studies" to investigate alternatives for the facility to meet the Policy requirements. The Policy requires the establishment of a Review Committee (Review Committee for Nuclear-fueled Power Plants—RCNFPP) to oversee the special studies. The eight-member Review Committee includes representatives from affected state agencies, the nuclear plant owners, the environmental community, and staffs of the State Water Board, appropriate Regional Water Boards, and an IPP lobbying organization.

The Review Committee was convened by the Executive Director of the State Water Board (as required by the Policy) to oversee the special studies, which will investigate ability, alternatives, and cost for SONGS and DCPP to meet the Policy requirements.

The special studies review will be conducted by an independent third party with sufficient experience and expertise within the state of California directly related to nuclear power plant design, engineering, construction, licensing, environmental permitting; scope, cost and scheduling, and other requisite qualifications that ensure all significant areas related to the special studies technologies are rigorously addressed.

Consultant Criteria

In order to ensure that an independent third party has the appropriate qualifications to be considered for completing this scope of work, a consultant criteria list was developed by representatives from PG&E and SCE. The list included the following:

- Do We Have A Current Contract With Them?
- Are They a USA/STARS Supplier? (cooperative of nuclear plant operators)
- Do They Have a California Presence?
- Could There Be a Conflict of Interest?
- Do They Have Relevant Design Experience?
- Do They Have Relevant Build Experience?
- Specifically, Do They Have Relevant Cooling Tower Experience?
- Specifically, Do They Have Relevant Cooling Tower Alternatives Experience?
- Do They Have Relevant Environmental Experience?
- Specifically, Do They Have Relevant §316(b) Experience?
- Do They Have Relevant Project Management Experience?
- Do They Have Relevant Nuclear Experience?
- Do They Have Contemporary DCPP or SONGS Experience?

Criteria Checklist Guidance for Feasibility Determination

The decision-making process is a systematic approach to ensure that all impacts of each conceptual technology are identified and assessed for feasibility. Every criterion for each conceptual technology must be determined to be clearly feasible for the technology to be considered feasible as a whole. To reach a conclusion of feasibility, the independent third party performing this assessment must clearly and comprehensively demonstrate and document the basis for such a conclusion, and not rely on a perception or suggestion that it is possibly feasible. "Not feasible," for purposes of this work product, will be defined as it is in the Policy; that is, "Cannot be convincingly demonstrated to be accomplishable due to any of the following: space constraints or the inability to obtain necessary permits due to public safety considerations, unacceptable environmental impacts, local ordinances, regulations, and other criteria in the Criterion Checklist included herein."

CRITERION

GENERAL TECHNOLOGY ASSESSMENT CRITERION:

1. FIRST OF A KIND TO SCALE Ensure that the proposed technology is commercially obtainable and has been demonstrated in a commercial nuclear power plant-scale proven application considering the unique nature of the site settings and physical characteristics; particularly from the perspective of cooling tower retrofit or alternative cooling retrofit. Concept-only or laboratory-scale technologies that cannot be directly evaluated through existing industrial operational experience cannot be determined to be feasible.

2. EXTERNAL APPROVAL AND PERMITTING (NON-NUCLEAR LICENSING) All external organizations other than the Nuclear Regulatory Commission (such as the California Coastal Commission, local Air Pollution Control District/AQMD with jurisdiction, etc.) that must approve the technology installation project have been identified. The process for obtaining the approval has been identified. There is reasonable assurance, either by correspondence (preferred) or verbal agreement, that formal approval of the potential project will be successful. Consider site specific topographical constraints, including plant site and adjacent land ownership, use, and control issues.

3. OPERABILITY GENERAL SITE CONDITIONS Assess operability and operational issues to determine if it can be comprehensively and convincingly demonstrated that the proposed technology change is acceptable/feasible to operate in site specific environmental conditions. Assessment should consider such issues as existing cooling source water conditions including currents, temperature ranges, occurrence of detrimental ocean storm/high-swell conditions, range of water column debris loading conditions, and marine biofouling concerns.

4. IMPINGEMENT/ENTRAINMENT DESIGN Determine the feasibility in the effectiveness of the technology to reduce cooling water impingement and entrainment losses, either alone or in combination with another technology, to the levels required for compliance with Track 2 of the Policy (i.e. 83.7% reduction of impingement and entrainment of marine life for the facility). Evaluate the potential or probability that reduction in one detrimental cooling water use impact would likely be offset by an increase in another impact with known or unknown consequences (i.e. plant entrainment reduction through screening technology application could result in significantly increased impingement losses).

5. OFFSETTING ENVIRONMENTAL IMPACTS Evaluate the potential the technology installation would create additional and/or offsetting detrimental environmental impacts. Specifically, the assessment should consider impacts beyond water quality issues (i.e., significant increases in facility air emissions would result in order to achieve reductions in source cooling water withdrawals, etc.)

6. SEISMIC ISSUES Assess if the proposed technology could reasonably be constructed and operated in a seismically active zone, and/or what specific seismic upgrades or requirements must be considered. (i.e. could natural draft cooling towers effectively be installed when considering the seismic characteristics of the plant site)

7. STRUCTURAL Identify the critical loading conditions and determine that there is reasonable assurance that new structures and impacts to existing structures can be accommodated during a detailed design phase of the technology.

8. CONSTRUCTION Ensure that a conceptual technology installation design is sufficiently detailed to determine that fabrication, required access and availability of space for installation and staging activities, installation, and associated physical modifications to the plant can be accomplished.

9. MAINTENANCE Identify maintenance activities to ensure that the design will not create a personnel hazard, and/or an unrealistic (non-commercially viable) operational maintainability burden.

NUCLEAR SPECIFIC ASSESSMENT CRITERION:

10. LICENSING NUCLEAR SPECIFIC Perform a 10CFR50.59 feasibility assessment to determine whether approval by the Nuclear Regulatory Commission (NRC) would be required. Scope the Nuclear Design Change Criteria that must be considered and addressed to develop a comprehensive and complete Operating License Amendment Request (LAR). Assess the potential, and consider what reasonable assurances may exist, that the proposed change will be approved by the NRC.

11. SEISMIC NUCLEAR SPECIFIC Identify all seismic issues and determine if there is reasonable assurance that all aspects of seismic design and potential seismic interaction with Seismic Category I structure systems and components (SSC's) can be addressed in the detailed design phase. Potential impact on plant reliability for a seismic event that is less than the design basis earthquake must be considered.

12. OPERABILITY NUCLEAR SPECIFIC Assess if operation of the technology at the plant site would potentially increase nuclear unit trip risks, and/or design or operational issue that must be addressed to ensure additional risks are not realized. Assessment should consider, but not be limited to, issues such as reliability of main and auxiliary electrically transmission systems, reliability of emergency diesel generator systems, potential for increased corrosion and degradation of plant equipment and control systems, and potential for plant flooding (i.e. resulting from elevated cooling system configurations).

13. TRANSIENT ANALYSES Perform a transient analysis to assess plant impacts considered in the design to determine if all impacts have been explicitly identified and are appropriately conservative to determine plant impact and response to the transients.

14. NUCLEAR FUEL (ACCIDENT ANALYSES) Perform a feasibility assessment of the UFSAR Accident Analyses and determine that the impact due to the proposed design change is acceptable.

15. SINGLE FAILURE Identify Updated Final Safety Analysis Report (UFSAR) Single Failure Analyses issues and determine that there is reasonable assurance that these are acceptable.

16. HYDRAULIC DESIGN Identify impacts to hydraulic designs and ensure that sufficient analysis has been performed to determine that the systems will function within sufficiently conservative design parameters.

17. PROBABILISTIC RISK ASSESSMENT Identify Probabilistic Risk Assessment issues and determine their acceptability.

18. INSTRUMENTATION, CONTROLS, AND ALARMS Ensure that conceptual design is sufficiently detailed to determine what instrumentation, controls and alarms are required. Ensure that the proposed instrumentation, controls and alarms can be installed, provide adequate monitoring and are acceptable to support safe, correct and efficient operation of the units.

19. DETAILED COST AND SCHEDULE Produce a detailed cost and schedule, required as part of any major project, to be used as additional criteria to provide reasonable assurance of project feasibility.

Scope of Work

The selected independent third party will conduct a detailed evaluation to determine feasibility based on detailed criteria of each technology, on a site specific basis, based on their independent assessment. Prior studies are provided for reference and made available for review by the independent third party. The independent third party must clearly document the basis on which any portion of these prior studies are used in any way as part of their independent and comprehensive assessment of feasibility.

Evaluation Process

The criteria checklist will be used in such a manner as to afford the special study independent party an opportunity to conduct an efficient assessment process. The technology assessment should progress in two distinct phases. The general assessment criterion list provided should be considered first. Those technologies that are determined not feasible due to failure to meet the entire general criterion should not be considered for further, more detailed assessment. The nuclear specific assessment criterion should only be evaluated in the event a technology clearly and comprehensively has been demonstrated feasible in the initial phase.

The criteria checklist for each technology therefore may not need to have every item evaluated. Additionally, for certain technologies, all criteria in the initial assessment (general criteria) may also not need to be evaluated to reach a conclusion the technology is not feasible for a specific site.

The check list will be previewed for each technology, and an agreement established with the independent party as to an organized, efficient and systematic approach conducive to an optimized cost and schedule approach. A single point of contact from each utility will assist in this preview.

Reports, Evaluations and Documents

For each facility, review and assess the following documents, reports and regulatory agency evaluations:

- San Onofre Nuclear Generating Station (SONGS) Appendix A
- Diablo Canyon Power Plant (DCPP) Appendix B

Conclusions

Each technology's conceptual design must be determined to be completely feasible for installation and operation at either DCPP or SONGS per the complete Feasibility Determination Criteria Checklist, if not, then it is by default determined to be not-feasible. Determination regarding the available technologies which are not-feasible for either facility shall not be considered for further evaluation by the RCNFPP or the SWRCB.

Deliverables

There are two distinct types of deliverables for this effort; progress reports and a final work product.

Progress reports are required bi-monthly and/or after any single technology evaluation has been fully completed. Progress reports necessitate detailed status, schedule updates, and identification of barriers to completing evaluations as expected.

The final work product is to be provided in both written and electronic report format, with supporting references that sufficiently and succinctly address the feasibility of each of the technologies evaluated for each facility. Due to the plausible dissimilarities between each unit's operating designs and sitings, opportunities for possible misperceptions will be avoided by producing an individual detailed report addressing each facility. An executive summary will be produced describing the overall conclusion of the special study for each site. This will include a tabular listing of all the technologies evaluated with a corresponding determination of feasible or not-feasible for implementation.

Individual summary evaluations of each technology feasibility assessment and associated conclusions will also be provided. This will include a tabular listing of the entire criteria check list items evaluated with a corresponding determination of feasible, not-feasible, or not evaluated for each. Include or reference relevant supporting information from existing technology feasibility assessments, and any additional application specific assessments conducted in support of the determinations. A 'not evaluated' determination is appropriate/applicable to criteria after a not-feasible determination is assessed for any one of the criteria on the check list.

Technologies to be Evaluated

Evaluation will be limited to the following industrial technologies as addressed in the reports and evaluations listed for each nuclear site:

1) Closed-Cycle Cooling Systems (Cooling System Retrofit)
   a) Passive Draft Dry / Air Cooling System
   b) Mechanical (Forced) Draft Dry / Air Cooling System
   c) Hybrid Wet (*) / Dry Cooling System (Evaporation Enhanced Dry Cooling Radiator System)
   d) Wet (*) Natural Draft Cooling Tower System
   e) Wet (*) Mechanical (Forced) Draft Cooling Tower System
      i) Surface freshwater or groundwater resources
      ii) Reclaimed freshwater resources

(*) For wet closed-cycle cooling systems, evaluate site-specific makeup water restrictions for evaporative or blow-down loss replenishment. Determine any primary dependency on a specific makeup water source, i.e. seawater or freshwater. Evaluate the general availability of freshwater resources in proximity to each plant. The assessment shall include availability of any infrastructure that would be necessary to deliver sufficient freshwater (if such sources exist).

2) Inshore mechanical (active) intake fine mesh screening systems. Include site specific screen sizing requirements. Assess probable operational efficacy of an installed fine mesh screening system:
   - Structural survivability and reliable operability in site-specific environmental conditions.
   - Probable/Potential screened marine organism impingement survivability and subsequent viability.
   - Probable operational issues associated with screen loading (debris accumulation and/or differential pressures).

3) Offshore modular wedgewire or similar exclusion screening systems. Include site specific screen sizing requirements. Assess probable operational efficacy of installed wedgewire screening arrays or similar system:
   - Evaluate site specific current regimes (reliable currents necessary for successful screen back-flushing operations).
   - Structural survivability and reliable operability in site-specific ocean and environmental conditions.
   - Probable/Potential screened marine organism impingement survivability and subsequent viability.
   - Potential operational issues associated with offshore screening array reliability (fouling control and thru flow).

4) Initial intake relocation; offshore intake (DCPP), shoreline intake (SONGS).
5) Deep water offshore intake (point of initial intake to piping/conveyance systems).
6) Variable speed cooling water pumping systems.
7) Source water substrate filtering/collection systems
   a) Shoreline (beach) sand well collection system.
   b) Benthic substrate filtration collection system.

APPENDIX A

<u>Note: Nuclear Review Committee Chair provided preference for newer (last decade) study information & documents</u>.

San Onofre Nuclear Generating Station (SONGS)

Reference Documents Provided in Chronological Order:

1) *Final Report of the Marine Review Committee to the California Coastal Commission*, MRC Document 89-02, August 1989. (http://marinemitigation.msi.ucsb.edu/documents/MRC_reports/final_report/mrc-final-rpt_to_ccc.pdf)

2) Southern California Edison Company's (SCE) coastal development permit for the San Onofre Nuclear Generating Station (SONGS) Units 2 and 3 (permit no. 6-81-330A, formerly 183-73).

3) *Comprehensive Demonstration Study for Southern California Edison's San Onofre Nuclear Generating Station* Final Report, January 2008.

4) *California's Coastal Power Plants: Alternative Cooling System Analysis*. Tetra Tech Inc., February 2008. Chapter-7 Facility Profiles, Section N. San Onofre Nuclear Generating Station [Pages N-1 through N-42]. *(Report Independently Prepared for the California Ocean Protection Council)*

5) *Feasibility Study for Installation of Cooling Towers at San Onofre Nuclear Generating Station*. Enercon Services Inc., September 2009.

<u>Additional Relevant Documents for Consideration:</u>

Assessment of Marine Review Committee Recommendations for SONGS Units 2 and 3, prepared by PLG, Inc. (formerly Pickard, Lowe, and Garrick) as part of a multi-year study by the independent Marine Review Committee (MRC), February 1990.

Issues Analysis of Retrofitting Once-Through Cooled Plants with Closed-Cycle Cooling California Coastal Plants, Electric Power Research Institute [EPRI], 2007
Substantial for San Onofre Section B.15 & General Technologies Info; DCPP Only Brief w/References Section 6.3.2.

Preliminary Costs and Benefits of California Draft Policy on the Use of Coastal and Estuarine Waters for Power Plant Cooling, prepared by NERA Economic Consulting, September 2009

APPENDIX B

Note: Nuclear Review Committee Chair provided preference for newer (last decade) study information & documents.

Diablo Canyon Power Plant (DCPP)

Reference Documents Provided in Chronological Order:

1) Diablo Canyon Power Plant Cooling 316(b) Demonstration Report. Tenera Environmental Services, 2000. Section 6.0 Evaluation of Alternative Intake Technologies [Pages 6-1 through 6-36].

2) Evaluation of Cooling Systems Alternatives, Diablo Canyon Power Plant. Tetra Tech Inc., 2002. (*Report Independently Prepared for the Central Coast Regional Water Quality Control Board*)

3) Feasibility of Retrofitting Cooling Towers at Diablo Canyon Power Plant Units 1 & 2. Burns Engineering Services Inc., 2003.

4) Staff Testimony for Regular Meeting of July 10, 2003 Pacific Gas and Electric Company's (PG&E's) Diablo Canyon Power Plant Renewal of NPDES Permit. Central Coast Regional Water Quality Control Board (CCRWQCB), 2003. [Pages 1-18].

5) California's Coastal Power Plants: Alternative Cooling System Analysis. Tetra Tech Inc., 2008. Chapter-7 Facility Profiles, Section C. Diablo Canyon Power Plant [Pages C-1 through C-40]. (*Report Independently Prepared for the California Ocean Protection Council*)

6) Feasibility of Installation of Closed-Cycle Cooling Towers at the Diablo Canyon Power Plant. Enercon Services Inc., 2009.

Additional Relevant Documents for Consideration:

Assessment of Alternative Intake Technologies for the Diablo Canyon Power Plant, Tera Corp., 1982.
Older Comprehensive Study Used as Reference in All Primary Listed Documents

Issues Analysis of Retrofitting Once-Through Cooled Plants with Closed-Cycle Cooling California Coastal Plants, Electric Power Research Institute [EPRI], 2007
Substantial for San Onofre Section B.15 & General Technologies Info; DCPP Only Brief w/References Section 6.3.2.