CARLSBAD DESALINATION PLANT
FISH RETURN FEASIBILITY ANALYSIS

March 31, 2009

Joseph Raulli[1]
John Balletto[2]
ARCADIS, Inc.

1. Fish Return Conceptual Design Introduction

In his "Initial review of impingement study and mitigation assessment – Carlsbad Seawater Desalinization Project," dated March 22, 2009 (at page 6) – Dr. Raimondi suggested that "the costs of some impingement technologies particularly, a fish return system (FRS) may be reasonable [for the Carlsbad Desalination Project]. At SONGS[3] the FRS routinely returns 70% of the individuals that would have been impinged." We respectfully disagree with Dr. Raimondi's suggestion.

The installation of a FRS would not reduce impingement losses at the Encina Power Station (EPS) because the impingement mortality at the EPS intake is approximately 100%. This is due to the fact that EPS uses unmodified through-flow vertical traveling screens (vertical traveling screens)[4] that are washed intermittently. Installation of a fish return system would not reduce the impingement mortality; it would merely return dead, or seriously damaged, fish to the ocean.

EPS is located in Carlsbad, California at the southern end of Aqua Hedionda Lagoon (AHL). EPS withdraws cooling water from AHL and discharges the cooling water to the ocean through a discharge canal that travels under Carlsbad Avenue. The existing cooling water system configuration is described in greater detail in the EPS Impingement Mortality and Entrainment Characterization Study.[5]

2. Current Encina Power Station Cooling Water Intake System

The Carlsbad Desalination Plant (CDP) will use the EPS cooling water for the desalination process. This water will be taken from the EPS cooling system downstream of the EPS condensers. CDP is designed to withdraw approximately 304 million gallons per day (MGD). CDP will supply approximately 50 MGD of potable water, producing approximately 50 MGD of brine, which will be diluted with approximately 200 MGD prior to discharge. That combined approximately 250 MGD will be discharged through the existing EPS outfall and discharge canal into the ocean.

---

[1] Mr. Raulli has over 28 years of engineering experience associated with fossil fueled power plants. His experience has included numerous alternate intake technology studies for 316(b) compliance and the engineering of several fish return systems.

[2] Mr. Balletto has 35 years of experience in evaluating impacts of cooling water system operations on aquatic ecosystems including impingement and entrainment effects and was the technical lead in the largest mitigation project for offsetting cooling water intake impacts with wetlands mitigation and fish ladders.

[3] San Onofre Nuclear Generating Station

[4] EPS in their filings refer to these screens as the fine screens.

[5] Cabrillo Power I LLC Encina Power Station: Clean Water Act Section 316(b) Impingement Mortality and Entrainment Characterization Study: Effects on the Biological Resources of Agua Hedionda Lagoon and the Nearshore Ocean Environment. January 2008

In order to address Dr. Raimondi's comment, a feasibility analysis and conceptual design was performed. Poseidon retained ARCADIS, Inc. to assess the feasibility of retrofitting the existing EPS screens to include a FRS.

Under a stand-alone scenario, the total intake flow will be 304 MGD. (We understand that the stand-alone scenario is a conservative scenario relative to the co-located condition being considered for approval by the agency.) All intake flow entering the intake structure will pass through a set of four trash racks[6] with vertical bars spaced at approximately 3½ inches ("). Each trash rack is 10 feet (ft) wide. After passing through the trash racks, the intake water flows through a series of tunnels to the seven existing traveling water screens. Two screens serve the circulating water system for Units 1, 2 and 3; two screens serve Unit 4; and three screens serve Unit 5. Although the intake water flow is significantly reduced from previous operation, all seven screens will remain in operation for the purpose of minimizing the water velocity through the screens. All screens have ⅜" mesh screen baskets, except for the three screens for Unit 5, which have ⅝" mesh baskets. Since all seven screens will remain in operation, FRSs would need to be installed for all screens, under Dr. Raimondi's proposal. Due to the separate locations of the screens, one FRS would originate at the two screens for Units 1 through 3, one will start at the screens for Unit 4, and one will begin at the three screens for Unit 5.

Since a FRS must carry both fish and debris, the minimum trough or pipe size should not be less than 12". Installing a trough less than 12" wide or a pipe less than 12" in diameter will increase the likelihood that the system will plug with debris. For the purpose of a conceptual design, it is also assumed that the water depth in the pipe or trough would be 6" and the velocity should be maintained at 3 feet per second (fps) to prevent fish from swimming against the return system flow. It is also estimated that the screen wash flow for a standard traveling screen with a single spray wash header is approximately 30 gallons per minute (gpm). To maintain the proper water depth and velocity, an additional 600 gpm (0.8 MGD) would have to be added to the return system, which would add to the expected entrainment and impingement impact. This water supply is assumed to come from a new make-up water pump. This water and the associated impingement and entrainment losses has not been considered by Dr. Raimondi in either his comment or his analysis of the estimated CDP mitigation acreage.

From the information provided, the deck elevation for all screens is 9.8 ft above mean sea level (MSL). If the fish and debris collection trough is 1 ft above the deck elevation, the fish and debris are collected from the screens at approximately 9 ft above MSL, or 4-6 ft above the water surface elevation at high tide. From the Unit 5 screens, the distance to the cooling water discharge channel is approximately 1,200 ft (1,700 ft to the outlet of the discharge channel). If a 12" to 18" wide trough were utilized with 6" water depth and a velocity 3 fps, a slope of 0.004 (0.048 inch/ ft) to 0.007 (0.084 inch/ft) would be required. To maintain a gravity flow return system, a difference in elevation of approximately 5-12 ft would be required between the fish and debris collection trough and the water surface level at high tide. This elevation difference depends on the required slope and the point of discharge. Therefore, it may not be technically feasible to apply a gravity return system from the Unit 5 screens to the discharge channel. Since the distance from the Unit 4 screens to the discharge channel is only 150 ft less than the distance from the Unit 5 screens, a gravity return system from the Unit 4 screens may also not be technically feasible. Since the screens for Units 1 through 3 are considerably closer to the discharge channel, the elevation difference at high tide may be sufficient to maintain the necessary velocity in the return trough or pipe for these screens.

[6] EPS refers to these as coarse screens in their filings.

A second option to attempt to implement Dr. Raimondi's proposal would be to take each return system directly to the ocean by directional drilling under Carlsbad Boulevard and the beach area. Since the shoreline is approximately 350 ft from the screens, the off-shore discharge point would be limited to a distance of 500 to 600 feet off-shore under a gravity flow scenario. With the requirement for the discharge point to be elevated off the ocean bottom to prevent the accumulation of sand in the discharge pipe, this distance off the shore may not provide sufficient depth during times of low tide. It is also anticipated that permitting such a system would present significant challenges.

A third option to try to implement Dr. Raimondi's proposal would be to install a fish return pump. With the addition of a pump, a WEMCO-Hidrostal® or similar style pump, the length and configuration of a return system is more flexible. This type of pump has been tested and demonstrated to be capable of transporting fish with minimally induced mortality. Due to the need to transition from an open trough to the pump suction, the pump must be installed at an adequate depth below the trough elevation to achieve proper pump suction conditions. The design must also accommodate the transition without creating an area where the fish accumulate and cannot move through the system. Although the fish return pumps have been demonstrated to achieve high rates of survival, some additional mortality (to the extent any fish survive impingement in the first instance), would likely occur.[7]

The cost for the installation of a return system with a fish pump can be significantly higher than a system without a pump. Assuming a suitable location for a below grade pump can be located, an order-of-magnitude estimate for a return system with open troughs above grade, HDPE pipe below grade, fish pump with variable frequency drive, pump structure, pump controls, pumps for additional make-up water to the system, and a discharge location at the outlet of the discharge channel is at least $3 million. . This lower-bound estimate is based on some assumed site conditions, previous estimates for above grade troughs, HDPE pipe and directional drilling for similar projects. Pump costs and associated structures, electrical, mechanical and control systems are estimated from previous experience. The estimate also includes a 35 percent contingency due to the preliminary nature of the return concept and the many unknown field conditions.

3. Assessment of the Efficacy of a Fish Return System in Reducing Fish Impingement
    a. Current impingement mortality

Based on studies performed at the existing EPS CWIS during 2004 and 2005[8], an estimate of the impingement losses utilizing three separate techniques including and excluding outlier impingement values for CDP was made and submitted as part of this effort. The weighted average, flow-proportioned approach provides a conservative estimate of the potential for impingement from the Project which is 4.70 kilograms (kg)/day (Actual impingement likely will be much lower). Subsequent analysis indicated this approach (encouraged by RWQCB staff) may overweight outliers, and the more likely potential for impingement is likely to be no more than about 2.2 (kg)/day.

In addition to the fact that the existing screens have almost a 100% impingement mortality, the existing EPS CWIS is configured so that all of the material collected in the screen wash process is

[7] Electric Power Research Institute (EPRI). Fish Protection at Cooling Water Intakes. TR-114013. December 1999. Palo Alto, California.

[8] Cabrillo Power I LLC Encina Power Station: Clean Water Act Section 316(B) Impingement Mortality and Entrainment Characterization Study: Effects on the Biological Resources of Agua Hedionda Lagoon and the Nearshore Ocean Environment. January 2008

collected in a basket. Therefore, impingement mortality at EPS is 100% for all individuals impinged.

b. Potential impingement mortality reduction

i. Screen mortality

Through-flow vertical traveling screens, as installed at EPS, are one of the most common types of screens at power plants.[9] They are designed to prevent objects from entering the cooling system and damaging or plugging the system. Impingement means the entrapment of aquatic organisms on the outer part of an intake structure or against a screening device during periods of intake water withdrawal.[10]

Impingement mortality has been a subject of study and monitoring for the power industry for decades. Many factors contribute to this mortality including species type, life stage, physiological condition and the characteristics of the CWIS. The CWIS characteristics that influence impingement mortality are screenwash frequency, screen travel time and whether modifications to the basic technology have been made to reduce mortality.[11] Studies have found that impingement mortality generally increases with decreased time between screen wash cycles.[12] EPRI indicates that very long impingement durations, such as would occur on traveling screens washed only very infrequently, lead to near-complete mortality for most species. EPS traveling screens are normally washed once per eight hour shift, or if screens become clogged with material and trigger an automatic screen wash. Partial clogging of the screen with debris, which initiates the automatic screen wash cycle, would result in increased velocities through the screen, further increasing the physical stress on the impinged organism.

In sum, the current EPS configuration has unmodified vertical traveling screens that are operated intermittently (once every eight hours or if the screens become loaded with debris), which is the industry standard. In addition, all of the screenwash is collected in baskets. These conditions result in virtually 100% impingement mortality. Assuming the EPS NPDES permit can be modified and the screenwash could be returned directly to the ocean, the current vertical traveling screens would deliver dead and possibly some seriously damaged organisms to the FRS.[13] Increased frequency of the screen washing, which would not be industry standard for these screens, might somewhat reduce this mortality, but only by some small percentage because the screens have no mechanism to keep the fish submerged.

ii. Fish return mortality

Installation of a properly designed FRS has the potential to return aquatic organisms to the waterbody with minimal mortality, but this cannot be the case at EPS. Studies of the reductions of impingement mortality are usually performed when FRSs are coupled with screening technologies designed to reduce impingement mortality and not independently. Salem

[9] Electric Power Research Institute (EPRI). Fish Protection at Cooling Water Intakes. TR-114013. December 1999. Palo Alto, CA.
[10] 40 CFR125.83.
[11] EPRI. Fish Protection at Cooling Water Intakes. TR-114013. December 1999. Palo Alto, CA.
[12] EPRI. Impingement and Entrainment Survival Studies: Technical Support Document. TR-1011278. 2005. Palo Alto, CA.
[13] USEPA. Development Document for Proposed Best Technology Available for Minimizing Adverse Environmental Impact of Cooling Water Intake Structures. EPA 440/1-74/015. 1973. Washington, DC.

Generating Station studied the FRS independently from the improved screen system.[14] Studies consisted of modeling of the hydraulic flow in the FRS, construction study of fish survival in a full size model and monitoring in the circulating water intake structure proper. All of these studies demonstrated that the FRS did not contribute additional impingement mortality.

Since the present configuration of the EPS may not allow for a gravity flow return system, a pump would have to be incorporated into the design of the system. Testing and operational monitoring of various designs of pumps for the collection and transportation of fish have successfully demonstrated the efficacy of this, but only under certain operational conditions. Numerous studies with a wide variety of juvenile fish resulted in survival rates of 90-100%,[15] but since the current EPS screen impingement mortality rate resulting from the design of the vertical traveling screens and their intermittent screen wash operation is almost 100%, the installation of the best fish return system will not result in a reduction of fish mortality in this case.

iii. Mortality associated with discharge canal

1. Temperature

In order to maximize the impingement survival resulting from a FRS, fish are returned to an area of the waterbody not under the influence of the power station thermal discharge. CDP, while operating in a stand-alone mode, will not be adding heat to the discharge, so this factor is insignificant.

2. Increased salinity

As part of the NPDES permit application, estimates were made of the toxicity of the increased salinity that would be discharged and the amount of flow required for adequate dilution to meet conservative permit limits.[16] The results show that the permit limit, 40 parts per thousand (ppt), is below the No Observed Effect Concentration of 42 ppt. The lethal concentration for 50% of the test population was 58.57 ppt. Therefore, no additional mortality is expected to occur from discharging the FRS into the discharge channel, but again, this fact will not support the concept of a fish return system here since the existing screen impingement mortality is approximately 100%.

3. Predation

Due to the fact that the EPS impingement mortality is essentially 100%, predation would not be a concern in increasing impingement mortality.

iv. Resulting reduction in impingement mortality

The current EPS configuration has unmodified vertical traveling screens that are operated intermittently (once every eight hours or if the screens become loaded with debris). In addition, all of the screenwash is collected in baskets. This results in 100% impingement mortality. Even if EPS could get its NPDES permit modified to allow the discharge of the screenwash water and

---

[14] PSEG. Renewal Application New Jersey Pollutant Discharge Elimination System Permit for the Salem Generating Station, NJPDES No. NJ0005622. 2006. Newark, NJ

[15] Electric Power Research Institute (EPRI). Fish Protection at Cooling Water Intakes. TR-114013. December 1999. Palo Alto, CA.

[16] Revised Flow, Entrainment and impingement minimization Plan Attachment 2 dated June 1, 2007. Submitted to the San Diego Regional Water Quality Control Board.

material washed from the screens directly to the ocean, this will not result in a substantial decrease in impingement mortality. This is due to the fact that the fish that become impinged on the screens are likely to remain impinged for a long enough period of time, such that impingement mortality will be high, even with an effective fish return system. The design of the existing screens and the intermittent rotation are simply not conducive for an effective collection and return system.

Merely reducing the interval between screen washings will not substantially reduce impingement mortality. Vertical traveling screens have no mechanism to keep fish submerged until they are washed off the screens. During the screen wash process, as fish are raised out of the water while impinged on a screen, they react by flipping off the screen into the water and becoming reimpinged. They repeat this process until they are so stressed that they are unable to flip off the screen and are raised up to the area of the screen being washed. This has been identified as a major source of impingement mortality.[17] This phenomenon would occur even if the screens were washed continuously.

This type of screen was not designed for continuous operation. Their operational reliability would be significantly detrimentally impacted if they were to operate continuously. These screens have many rotating and parts subject to wear. Screens designed to operate continuously have these parts designed for the substantially increased wear that would occur, but these screens are not so designed.

In addition, the FRS has the potential of minimally increasing impingement mortality due to the effects of pumping fish that have already been exposed to the stress of impingement and returning them to the discharge channel.

The proposed operation of the CDP in a stand-alone mode will reduce the cooling water velocity at the CWIS and at the screens, potentially reducing the impingement rate well below the projected rate based on the EPS monitoring study.

4. Conclusion

Poseidon retained ARCADIS, Inc. to assess the feasibility of retrofitting the EPS intake screens to include a FRS. This assessment included a conceptual order of magnitude and an evaluation of the efficacy of its reduction of impingement mortality. The feasibility study concluded that due to the elevations of the screens and the water level and the horizontal distances required to be transited, it may not be technically feasible to rely on gravity to move the screen wash water. A fish pump would be required to raise the screen wash water sufficiently to flow to the discharge channel.

A review of the individual components in the potential FRS indicated that there may even be a slight increase in the mortality rate of the handled fish primarily resulting from the fish pump. However, the current operation of the EPS vertical traveling screens results in 100% mortality rate, so an FRS would be returning dead fish to the ocean in this case. Therefore, the installation of an FRS is infeasible, and, in this case, does not provide an available technology to increase fish survival.

---

[17] John White and Morris Brehmer, Eighteen month evaluation of the Ristroph Traveling Screens, in Third National Workshop on Entrainment and Impingement Section 316(b)-Research and Compliance Loren Jensen (ed.) 1976, Ecological Analysts, Inc. Melville NY