PROPOSAL FOR INFORMATION COLLECTION
CLEAN WATER ACT SECTION 316(B)

EL SEGUNDO GENERATING STATION
EL SEGUNDO POWER, LLC

NPDES PERMIT NO. CA0001147

Project No. 1009724003

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List of Acronyms & Abbreviations

AEL	Adult Equivalent Loss
AFC	Application for Certification
BTA	Best Technology Available
CCC	California Coastal Commission
CDFG	California Department of Fish & Game
CDS	Comprehensive Demonstration Study
CEC	California Energy Commission
CEQA	California Environmental Quality Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
CWIS	Cooling Water Intake Structure
DCTP	Design & Construction Technology Plan
EAM	Equivalent Adult Model
EPA	Environmental Protection Agency
EPRI	Electric Power Research Institute
ESGS	El Segundo Generating Station
ESP	El Segundo Power, LLC
ESPR	El Segundo Power Redevelopment
ETM	Empirical Transport Model
FH	Fecundity Hindcasting
ft/s	feet per second
ft	feet
gpm	gallons per minute
HEA	Habitat Equivalency Analysis
hrs	hours
IM&E	Impingement Mortality and/or Entrainment
JWPCP	Joint Water Pollution Control Plant

LADWP	Los Angeles Department of Water & Power
LARWQCB	Los Angeles Regional Water Quality Control Board
MBC	MBC Applied Environmental Sciences
mgd	million gallons per day
min	minute
MLES	Marine Life Exclusion System
MLLW	Mean Lower Low Water
mm	millimeter
MW	megawatt
N	North
NMFS	National Marine Fisheries Service
NOAA	National Oceanic & Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRDA	National Resources Defense Council
O&M	Operation and Maintenance
OBGS	Ormond Beach Generating Station
PIC	Proposal for Information Collection
psig	pounds per square inch gauge
QA/QC	Quality Assurance/Quality Control
RP	Restoration Plan
RWQCB	California Regional Water Quality Control Board
SCE	Southern California Edison
SGS	Scattergood Generating Station
SMBRC	Santa Monica Bay Restoration Commission
TDD	Technical Development Document
TIOP	Technology Installation & Operation Plan
USFWS	U.S. Fish & Wildlife Service
W	West

1.0 INTRODUCTION

Section 316(b) of the Clean Water Act requires that cooling water intake structures (CWIS) reflect the best technology available (BTA) for minimizing environmental impacts due to the impingement of fish and shellfish on intake structures and the entrainment of eggs and larvae through cooling water systems. The Environmental Protection Agency (EPA) published regulations applicable to existing electric generating facilities (Phase II facilities) in the Federal Register on July 9, 2004. These regulations, codified in the Code of Federal Regulations (CFR) Chapter 40 Part 125 Subpart J, became effective September 7, 2004.

The Phase II regulations establish performance standards for CWIS of existing electric generating facilities that withdraw more than 50 million gallons per day of surface waters and use more than 25% of the withdrawn water for cooling purposes. The performance standards require an 80 – 95% reduction in impingement mortality (IM) and a 60 – 90% reduction in entrainment (E). The waterbody type on which the facility is located, the capacity utilization rate, and the magnitude of the design intake flow relative to the waterbody flow determine whether a facility will be required to meet the performance standards for IM or both IM&E. The final rule allows these performance standards to be met through a combination of technology improvements, operational measures, and/or restoration measures and provides an option for site-specific performance standards if economic conditions do not justify the full costs of meeting the standards.

The EPA 316(b) Phase II regulation requires that each affected facility develop and submit a Proposal for Information Collection (PIC) to the applicable permitting agency prior to implementation of data collection activities. The PIC must include:

- A description of the proposed and/or implemented technologies, operational measures, and/or restoration measures that will be evaluated to aid in developing a compliance strategy to meet the performance standards;
- A list and description of any historical studies characterizing IM&E and/or the physical and biological conditions in the vicinity of the cooling water intake structure and their relevance to the proposed study;
- A summary of any past or ongoing consultations with regulatory agencies and other stakeholders that are relevant to the study; and
- A sampling plan for any new field studies needed to estimate IM&E.

The PIC serves as the study plan for a Comprehensive Demonstration Study (CDS), which provides the information to:

- Determine the calculation baseline of IM&E which will be compared with compliance performance standards;
- Evaluate combinations of technologies, operational measures and/or restoration measures, which may be implemented to meet the performance standards; and
- Evaluate whether a site-specific BTA determination is warranted and can be justified using a cost/cost or cost/benefit test.

1.1 Regulatory Applicability

The El Segundo Generating Station (ESGS) is located on the Santa Monica Bay on the Pacific Ocean. Being located on an ocean, the facility is subject to the following national performance standards for the reduction of IM&E resulting from the operation of the CWIS:

Table 1-1: IM&E Performance Standards

STANDARD	REDUCTION REQUIREMENT
Impingement mortality	80 – 95%
Entrainment	60 – 90%

The EPA 316(b) Phase II Rule requires that facilities subject to the rule submit the CDS with the application for renewal of the National Pollutant Discharge Elimination System (NPDES) permit. The current ESGS NPDES permit expired on May 10, 2005. An application for renewal was submitted to the Los Angeles Regional Water Quality Control Board (LARWQCB) on September 24, 2004. Facilities with NPDES permits expiring prior to July 9, 2008 may request an extension for submittal of the CDS no later than January 7, 2008. As such, El Segundo Power, LLC (ESP) submitted a request to the LARWQCB on September 23, 2004 requesting the following schedule for submittal of reports required under the EPA 316(b) Phase II Rule:

- Proposal for Information Collection – submittal due August 1, 2005
- Comprehensive Demonstration Study – submittal due January 7, 2008

1.2 Purpose

The purpose of this document is to satisfy the requirement for the preparation and submittal of the PIC in accordance with 40 CFR 125.95(b)(1). This study plan is being submitted for agency review and comment in advance of implementation. However, information collection activities may be initiated prior to receipt of agency comments.

2.0 FACILITY DESCRIPTION

The ESGS is owned by El Segundo Power, LLC (ESP). The facility consists of four steam electric generating units. Units 1 and 2 are each rated at 175 megawatts (MW). Units 3 and 4 are each rated at 335 MW. Total design rated capacity of the station is 1,020 MW. The permitted repowering project, El Segundo Power Redevelopment (ESPR) will replace Units 1 and 2 with new combined-cycle units (Units 5, 6, and 7), utilizing the existing Unit 1 & 2 CWIS without increasing its design capacity or maximum operation. The following is a description of the facility and the Santa Monica Bay, from which the ESGS withdraws water for cooling purposes. A description of the design and operation of the CWIS and the rate of withdrawal of cooling water relative to the source waterbody is also included.

2.1 Facility Location

The ESGS is located in the city of El Segundo, California, on the Santa Monica Bay on the Pacific Ocean. The following figure shows the location of the facility on the Santa Monica Bay and the location of the cooling water intake and discharge points relative to the shoreline.

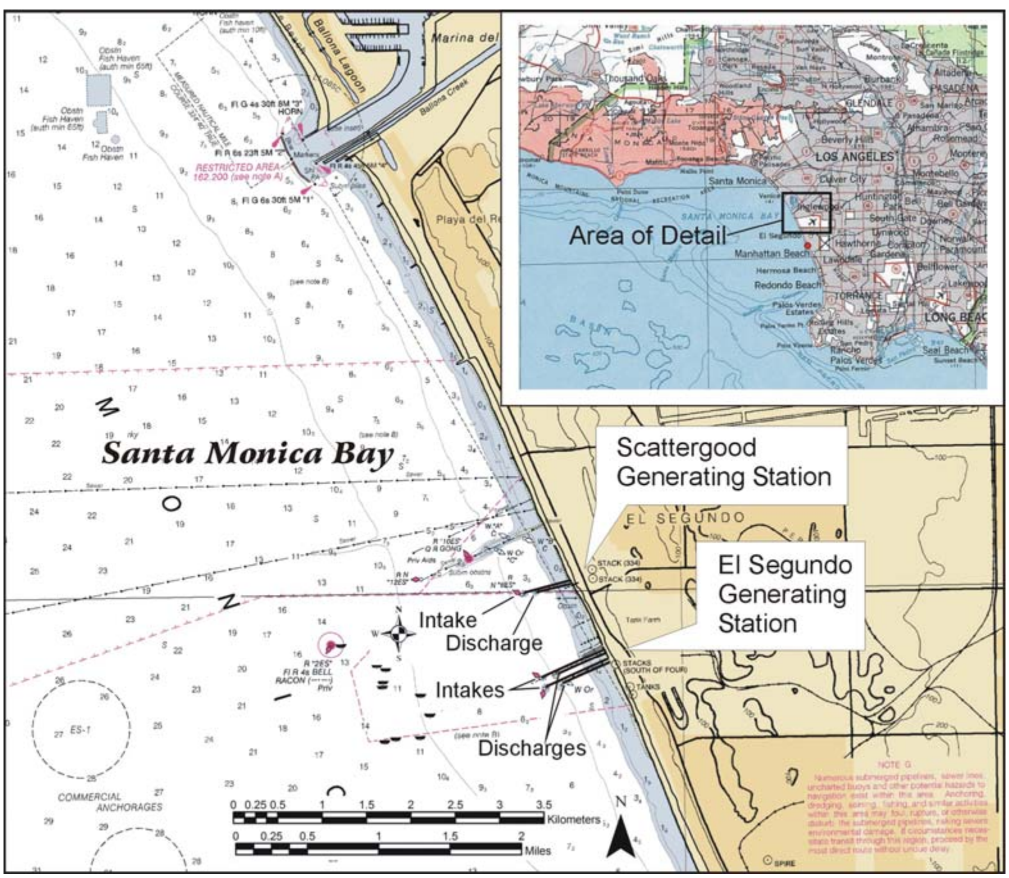

Figure 2-1: El Segundo Generating Station Location

2.2 Source Waterbody Description

The following is a description of the physical and ecological characteristics of the Santa Monica Bay, on which the ESGS is located.

2.2.1 Physical Characteristics

The Santa Monica Bay extends between Point Dume and the rocky headlands of the Palos Verdes Peninsula, and offshore to depths of approximately 1,600 feet (ft). The surface area of the Santa Monica Bay is approximately 266 $miles^2$ (MBC 1988). The Santa Monica Bay is an open embayment, characterized by a gently sloping continental shelf, which extends seaward to the shelf break at water depths of approximately 265 ft (Terry et al. 1956). In 1978-1979, net water current movement on the Santa Monica Bay shelf was downcoast at 0.072 feet per second (ft/s) (Hendricks 1980). In 2003, Hickey et al. modeled water flow on the Santa Monica shelf and confirmed the presence of counterflow between shelf and slope. Water currents over the slope, which set up the counterflow, were significantly correlated to remote wind conditions (near 27.5° - 30° N latitude) rather than to local wind effects.

2.2.2 Santa Monica Bay Ecological Characteristics

Santa Monica Bay is the submerged portion of the Los Angeles Coastal Plain, and includes several types of marine habitat that support more than 5,000 species of plants and animals (SMBRC 2004).

The metropolitan area adjacent to the Santa Monica Bay is one of the world's most populous urban areas (SMBRC 2004). There are 22 public beaches and 22 miles of bike paths along the 55-mile shoreline. Marina del Rey, located just upcoast from the ESGS, is the world's largest man-made small craft marina. Anthropogenic effects to the Santa Monica Bay include the discharge of treated wastewater, urban and storm water runoff, atmospheric deposition, and introduction of trash and litter to the Santa Monica Bay.

Most marine organisms within Santa Monica Bay and its watershed are temperate species with geographic ranges extending far beyond the immediate area. Most species are members of the San Diegan Province, which extends from Pt. Conception south to Magdalena Bay, Baja California Sur (Horn and Allen 1978). Fewer species belong to the Oregonian Province, which ranges from southern Canada to northern Baja California.

The pelagic habitat of Santa Monica Bay includes the entire water column with the bay, a volume of approximately 6,840 billion gallons (MBC 1993). Organisms found in this habitat include a myriad of planktonic organisms (phytoplankton, zooplankton, and ichthyoplankton) that have little or no swimming ability to resist ocean currents, and nektonic organisms, such as fishes and sharks that are freely mobile in local and oceanic currents. The pelagic habitat also supports large numbers of pinnipeds (including Pacific harbor seal and California sea lion), cetaceans (such as gray whale, bottlenose dolphin, and common dolphin), and birds, including California brown pelican, terns, and gulls (MBC 1988).

Intertidal habitat within the Santa Monica Bay is divided almost equally between sandy and rocky habitats (MBC 1988). Rocky intertidal habitat is comprised of both natural and artificial rocky substrate, such as the breakwaters at Marina del Rey and King Harbor. Natural rocky intertidal substrate occurs along the Malibu coast from Point Dume to Paradise Cove, along occasional patches from Paradise Cove to Big Rock Beach, and south along the Palos Verdes Peninsula.

Giant kelp beds occur on submerged rocky reefs in depths of about 20 to 70 ft. At present, kelp beds are limited to locations on the Palos Verdes Shelf and along Leo Carillo beach and the Malibu coast (SMBRC 2004). Current canopy coverage is relatively low compared to historic coverage, but the extent of kelp is considered stable at Palos Verdes. The kelp beds in the Malibu area have increased in recent years, due in part to recent restoration efforts, improved water quality, and favorable oceanic conditions.

Most of the seafloor in the Santa Monica Bay consists of unconsolidated (soft) sediments comprised of sand, silt, and clay. Most of the energy entering this habitat is in the form of detrital fallout and phytoplankton from the pelagic habitat, although detritus from surface runoff and discharged sewage may also be important (MBC 1988). A high proportion of soft-bottom benthos live most of their lives permanently in the sediments and are termed infauna; those which live on the surface of the seafloor are called epifauna. The soft-bottom habitat also supports several species of algae, macrofauna/megafauna (including crabs, snails, sea stars, urchins, and sea cucumbers), and fishes, including California halibut.

Ten brackish wetlands of various sizes and conditions located along Santa Monica Bay contribute larval and adult forms of marsh fish and invertebrates and vegetative organic production. The marshes range from small, seasonally-inundated river mouths (Zuma Beach west of Point Dume) to the larger Ballona Wetlands Complex at Marina del Rey. Historically, the Los Angeles River occasionally emptied into Santa Monica Bay at Ballona Creek instead of at its present-day mouth at Long Beach. The course of the River changed during unusually heavy storms from 1815-1825 and again in 1862 and 1884. The area between Ballona Creek and present-day Beverly Hills was often a vast swamp. In 1868, the Ballona Wetlands comprised 2,100 acres. Development of Marina del Rey, the Venice Canal system, and residential and commercial properties, and the channelization of Ballona Creek reduced this area to less than 160 acres of wetland habitat.

The wetlands at Ballona Creek support a number of transient fish species but only nine residents (Swift and Frantz 1981). Dominant species include arrow goby (*Clevelandia ios*), mosquitofish

(*Gambusia affinis*; a freshwater species), and topsmelt (*Atherinops affinis*). Numerous shorebirds, water fowl, and terrestrial birds are known to occur at Ballona wetlands, Marina del Rey, and Malibu Lagoon (MBC 1988). Diversity of birds is highest at Malibu Lagoon because it is adjacent to riparian woodland and chaparral habitats.

There are no major freshwater rivers that empty into the Santa Monica Bay, though there are some smaller streams. Small freshwater marshes occur at Malibu Lagoon and at Ballona Creek (MBC 1988). These marshes are home to numerous insects, amphibians, reptiles, and birds that live among the tules, cattails, and pond weeds (Jaeger and Smith 1966). Fresh water introduced by storm water and urban runoff has attracted increased attention in recent years. Control of pollutants from runoff has proven difficult due to the ubiquitous nature of the sources and current storm water regulations rely on compliance with best management practices instead of clearly defined effluent limits (SMBRC 2004).

Some of the important human uses of the Santa Monica Bay that have directly and indirectly affected its ecology include sport and commercial fishing, industrial uses, and coastal development. Approximately 48% of the Santa Monica Bay's watershed is characterized as developed (SMBRC 2004). Most of the remaining undeveloped area is located in the Santa Monica Mountains National Recreation Area. Commercial fishing was banned throughout most of Santa Monica Bay by the California Department of Fish and Game in 1933 (MBC 1985). Sport fishing is allowed throughout the Santa Monica Bay, and landings are currently operated out of Marina del Rey and King Harbor. Recreational fish are also caught by private boaters, from shore, and from piers. Several artificial reefs were introduced to the Santa Monica Bay beginning in 1958 to enhance marine life, and presumably fishing opportunities (MBC 1988).

Industrial uses of the Santa Monica Bay include cooling water supply, transport and refinery of oil/gas products, and waste disposal. Both the Joint Water Pollution Control Plant (JWPCP) and the Hyperion Treatment Plant discharge treated wastewater to the Santa Monica Bay. These facilities achieved full secondary treatment as of 1998 for Hyperion Treatment Plant and late 2002 for JWPCP (SMBRC 2004). Since 1971 there has been a steady decrease of contaminant inputs from these facilities to the Bay. Still, the Santa Monica Bay is listed as a Section 303(d) impaired waterbody largely due to sediment contamination resulting from the historic discharge of wastewater and sludge.

2.3 Cooling Water Intake Structure Design

Each of the four ESGS generating units utilizes a once-through cooling water system. Cooling water is supplied from the Santa Monica Bay through two separate submerged offshore intake systems equipped with velocity caps. One intake services Units 1 & 2, with a second intake servicing Units 3 & 4. Each CWIS includes onshore pump and screen structures. Characteristics and specifications of the two CWIS are presented in Table 2-1. A narrative description of each of the CWIS follows.

Table 2-1: Characteristics and Design of ESGS Cooling Water Intake Structure

	Units 1 & 2	**Units 3 & 4**
Latitude	33°54.478 N	33°54.428 N
Longitude	118°26.003 W	118°25.990 W
Design Flow	144,000 gpm (207.4 mgd)	276,800 gpm (398.6 mgd)
Distance from shore (sea wall)	2,600 ft	2,600 ft
Depth of withdrawal (MLLW)	- 17.2 ft	- 15 ft
Velocity cap – height above bottom	12 ft	12 ft
Intake conduit (internal diameter)	10 ft	12 ft
Number of circulating water pumps	4	4
Pump capacity (per pump)	36,000 gpm	69,200 gpm
Trash bar opening	4 ½ inch	3 5/8 inch
Number of traveling water screens	4	4
Screen type	Conventional	Conventional
Screen opening	3/8 inch	3/8 inch
Screen height (in water, high tide)	14 ft	14 ft
Approach velocity (calculated)	0.8 ft/s	0.8 ft/s
Through-screen velocity (calculated)	1.8 ft/s	2.0 ft/s
Screen rotation	Manual – 8 min/12 hrs Auto – based on differential pressure	Manual – 8 min/12 hrs Auto – based on differential pressure
Screenwash pressure	70 psig	70 psig

2.3.1 Units 1 & 2 CWIS

Cooling water for Units 1 & 2 is withdrawn from the Santa Monica Bay via a single CWIS serving both units. Cooling water is withdrawn through a velocity cap inlet located approximately 2,600 ft from the onshore seawall. The bottom of cooling water inlet is located at a depth of 12 ft above the bottom of the Santa Monica Bay and is equipped with a velocity cap that withdraws cooling water through a 2 foot deep opening. The top of the velocity cap is at a depth of approximately 17 ft below the water surface at mean lower low water (MLLW). The circulating water flow is conveyed to the onshore screen well structure via a concrete pipe with an internal diameter of 10 ft.

Water entering the screen well structure passes through a trash rack that removes larger debris from the cooling water before it enters the traveling screens. The trash rack removes larger debris from the cooling water before it enters the traveling screens. There are four conventional traveling screens (two per unit), each with 3/8 inch mesh. There are no fish handling or return systems. Cooling water is discharged approximately 1,900 ft offshore via a 10 ft diameter discharge pipe. Drawings of the Unit 1 & 2 intake and discharge piping configuration and screenwell structure are included in Attachment A.

2.3.2 Units 3 & 4 CWIS

The cooling water intake for Units 3 & 4 is very similar to that for Units 1 & 2. Cooling water for Units 3 & 4 is withdrawn from the Santa Monica Bay via a single CWIS serving both units. Cooling water is withdrawn through a velocity cap inlet located approximately 2,600 ft from the onshore seawall. The bottom of the cooling water inlet is located at a depth of approximately 10 ft above the bottom of the Santa Monica Bay. The top of the velocity cap is located at a depth of approximately 16 ft below MLLW. Water is drawn through an approximately 3 foot deep opening. The circulating water flow is conveyed to the onshore screen well structure via a concrete pipe with an internal diameter of 12 ft.

Water entering the screen well structure passes through a trash rack that removes larger debris from the cooling water before it enters the traveling screens. There are four conventional traveling screens (two per unit) with 3/8 inch mesh. There are no fish handling or return systems. Cooling water is discharged approximately 2,100 ft offshore via a 12 ft diameter discharge pipe. Drawings of the Unit 3 & 4 velocity cap inlet, intake and discharge piping configuration, and screenwell structure are included in Attachment A.

2.4 Cooling Water Intake Structure Operation

2.4.1 Units 1 & 2 CWIS

Units 1 & 2 ceased commercial operation on January 1, 2003. The CWIS remains in service and circulating water pumps operate to support other facility requirements. The four circulating water pumps at the Unit 1 & 2 CWIS have a total capacity of 207.4 million gallons per day (mgd). Currently, one to two pumps typically remain in operation, for a total intake flow of 51.8 to 103.7 mgd.

Traveling screens are rotated at least twice per day to remove impinged debris, which may include aquatic organisms. A screen-wash is generally initiated by operations personnel once per 12-hour shift. Screens are rotated for 8 minutes, and are washed with water at a pressure of 70 pounds per square inch gauge (psig). Screens are also rotated automatically if there is a substantial increase in the differential pressure across the screens. Fish and debris removed from the screens are washed into a collection basket in the screenwash sluiceway. The baskets are emptied into the trash by plant staff.

The ESPR Project will replace Units 1 and 2 with a new combined-cycle power facility made up of three generating units (Units 5, 6, and 7). Units 5 and 7 will be gas turbine generators, while Unit 6 will be a steam turbine of a smaller size than the combined capacity of the Units 1 and 2 steam turbines. The project will utilize the existing Unit 1 & 2 CWIS to provide cooling water for the new Unit 6 without increasing the design capacity of the CWIS. Because the ESPR project continues the operation of the Unit 1 & 2 CWIS, the PIC and CDS includes an assessment of the Units 1 & 2 CWIS.

2.4.2 Units 3 & 4 CWIS

The Unit 3 & 4 generating units are fully operational and utilize a separate CWIS. The four circulating water pumps (two per unit) at the Unit 3 & 4 CWIS have a total capacity of 398.6 mgd. When both units are operated at full loads, both circulating water pumps are operated for each unit.

Traveling screens are rotated at least twice per day to remove impinged debris, which may include aquatic organisms. A screen-wash is initiated by operations personnel once per 12-hour shift. Screens are rotated for 8 minutes, and are washed with water at a pressure of 70 psig. Screens are also rotated automatically if there is a substantial increase in the differential pressure across the screens. Fish and debris removed from the screens are washed into a collection basket which is emptied into the trash by plant staff.

The intakes that service the four units conduct heat treatments of the cooling water systems several times per year to remove mussels, barnacles, and other organisms which foul the cooling water intake conduit. The intake and discharge flow are reversed to discharge the warmer condenser effluent through the cooling water intake conduit to thermally shock, kill, and dislodge any fouling organisms.

2.5 Calculation Baseline

EPA, in its 316(b) Phase II rule for existing facilities, requires reductions in IM&E when compared against a “calculation baseline”. This calculation baseline is the level of IM&E that would occur if the CWIS were designed with the following characteristics:

- Once-through cooling system
- Opening of CWIS located at, and the face of the traveling screens is oriented parallel to, the shoreline near the surface of the source waterbody
- Conventional traveling screens with 3/8 inch mesh
- No structural or operational controls to reduce IM&E

Both CWIS at ESGS are offshore intakes equipped with velocity caps at the opening of the cooling water conduit. This design offers considerable reduction in impingement mortality when compared to a calculation baseline CWIS. Studies conducted on the Unit 1 & 2 CWIS during the year before and after a velocity cap was installed on the entrance to the intake conduit in 1957 demonstrated a 95% reduction in the amount of fish (measured in biomass) that enter the screenwell structure (Weight, 1958). EPA, in the Technical Development Document (TDD) for the Final Section 316(b) Phase II Existing Facilities Rule, states that efficiencies of velocity caps on West Coast offshore intakes have exceeded 90% and references a 1982 report by the American Society of Civil Engineers. In fact, page 4-18 of the EPA TDD specifically states that **"At the Huntington Beach and El Segundo stations in California, velocity caps have been found to provide 80 to 90 % reductions in fish entrapment."** Therefore, ESGS has demonstrated through site-specific studies of its existing, in-use intake velocity caps that the facility is in full compliance with the applicable performance standard for impingement mortality.

Entrainment of early life stages of fish may also be reduced, relative to a shoreline intake, due to the offshore location and depth of cooling water withdrawal. Compliance with the 316(b) Phase II rule's performance standards for reductions in entrainment will be evaluated with respect to the ESGS's entrainment baseline. It is anticipated that ESGS will either comply with the rule's entrainment performance standard or request compliance through use of site-specific BTA standards. Compliance may occur either through implementation of a combination of intake technologies, operational measures, and/or restoration measures. ESGS will closely evaluate the degree of compliance that will be achieved through implementation of flow reductions required under the conditions of the California Energy Commission (CEC) certificate for the ESPR facility construction. The results of ESGS's proposed entrainment characterization studies will be used to evaluate the degree of entrainment reduction achieved through flow reductions, taking into account diurnal and seasonal patterns of varying larval concentrations. If compliance with the standard for entrainment reduction cannot be achieved through reductions from the design CWIS flow, then ESGS will also assess the cost of compliance through restoration alternatives.

EPA demonstrates the cost-benefit evaluation of restoration in its new rule based on commercially or recreationally important species using a widely applied method, which assumes that scientifically valid population models exist for the species being evaluated. Although EPA is less certain about methods to evaluate the cost-benefits of restoring entrainment losses of non-use species, the assessment methods described in the entrainment study plan attached to this PIC can be used to determine the commensurate levels of benefits to be restored for both use and non-use species. The same assessment methods can also be used to determine a site-specific standard based on cost-benefit analysis of entrainment losses of both use and non-use species.

3.0 HISTORICAL STUDIES

EPA 316(b) Phase II regulation [40 CFR 125.95(b)(1)(ii)] requires that the PIC include a list and description of any historical studies characterizing IM&E, as well as physical and biological conditions in the vicinity of the facility CWIS.

The following identifies and summarizes previous entrainment and impingement studies conducted at the ESGS and within the Santa Monica Bay. These summaries are provided for informational purposes. Information is also presented for the Los Angeles Department of Water and Power (LADWP) Scattergood Generating Station (SGS) because it is located approximately 0.6 mile upcoast from the ESGS intake structures, and the organisms affected by entrainment and impingement at the two plants are similar (MBC 2003, 2005). In addition, both plants have offshore intake structures that are similar in design.

3.1 ESGS Impingement Mortality and Entrainment Characterization Studies

The following section summarizes previous IM&E characterization studies performed at the ESGS.

3.1.1 1978–1980 ESGS 316(b) Demonstration

In 1979, Southern California Edison (SCE) owned and operated eight coastal generating stations between Oxnard and San Onofre, California. Before conducting intensive 316(b) field studies, SCE studied the physical and biological characteristics of the different generating station intakes (Schlotterbeck et al. 1979). From this analysis, the “representative site concept” was derived. Five groups of intakes with similar characteristics were identified. One intake from each of these groups was used as a representative of all intakes in that group for determination of entrainment of fish larvae. However, impingement sampling of juvenile and adult fishes was conducted at each cooling water intake system. Impact analysis was limited to fishes (effects to invertebrates were not analyzed).

Prior to initiation of the 316(b) Demonstration, SCE examined the physical and biological characteristics of their eight coastal generating stations to detect similarities and design cost-effective sampling programs (Schlotterbeck et al. 1979). Analysis of physical intake characteristics determined that the Ormond Beach Generating Station (OBGS) represented the flush/normal flow velocity cap configuration. From a biological perspective, the OBGS intake was located in similar sandy substrate approximately 50 miles upcoast from the ESGS.

The biological communities (meroplankton, holoplankton, ichthyoplankton, and adult fish) at all facilities were standardized and compared by Bray-Curtis similarity analyses. A classification analysis, utilizing the Bray-Curtis measure of similarity, was performed on data from the Edison intake systems. Available data relating to the source water body nekton, ichthyoplankton, holoplankton, and meroplankton contributing communities, as well as fish impingement and heat treatment mortalities for the various intakes were standardized and tabulated for each facility. Standardized data were scaled to minimize disproportionate contribution by certain parameters due to their scale of measurement. Estimated scores were projected for areas of missing data. A matrix of similarity values was produced and portrayed as a dendrogram. Using this methodology, SCE determined that the ESGS was biologically similar to the OBGS. Impacts of cooling water system entrainment and impingement on fishery resources was determined by comparison of losses to available fishery stocks, which were estimated from collections of ichthyoplankton in the Southern California Bight and long-term adult fish monitoring at the generating stations. Results of entrainment studies conducted at the OBGS were used to assess fish losses at the ESGS (with adjustments made for differences in flow volumes between the plants). Target species used in the analyses were selected in consultation with the California Regional Water Quality Control Board (RWQCB) and the California Department of Fish and Game (CDFG).

Monthly entrainment samples were collected at the OBGS from August 1979 through July 1980 (SCE 1982a). Samples were collected by pump from the offshore intake riser during each of six periods (two day, two night, one sunrise, and one sunset) over a 24-hr period. On average, northern anchovy, white croaker, and queenfish comprised 84% of estimated entrained larvae during the entrainment study (Table 3-1).

Table 3-1: ESGS Daily Larval Fish Entrainment Estimates (August 1979-July 1980).

		Daily Larval Entrainment		**Percent**
Target Fishes		**Units 1 & 2**	**Units 3 & 4**	**of Total**
northern anchovy	*Engraulis mordax*	690,000	1,237,000	41.8
white croaker	*Genyonemus lineatus*	557,000	999,000	33.8
queenfish	*Seriphus politus*	135,000	243,000	8.2
Pacific butterfish	*Peprilus simillimus*	1,000	2,000	0.1
kelp bass	*Paralabrax clathratus*	2,000	3,000	0.1
barred sand bass	*Paralabrax nebulifer*	1,000	3,000	0.1
sargo	*Anisotremus davidsonii*	<1,000	<1,000	<0.1
black croaker	*Cheilotrema saturnum*	<1,000	<1,000	<0.1
yellowfin croaker	*Umbrina roncador*	<1,000	<1,000	<0.1
spotfin croaker	*Roncador stearnsii*	0	0	0
bocaccio	*Sebastes paucispinis*	0	0	0
Other Fishes				
unidentified larvae	unid. larval fish	90,000	162,000	5.5
bay goby	*Lepidogobius lepidus*	51,000	91,000	3.1
unid. yolk sac larvae	unid. larval fish	35,000	63,000	2.1
cheekspot goby	*Ilypnus gilberti*	32,000	58,000	2.0
unidentified goby	Gobiidae	11,000	20,000	0.7
unidentified goby	Gobiidae	8,000	15,000	0.5
Cal. halibut/fantail sole	*P. californicu X. liolepis*	5,000	1,000	0.3
other larvae		29,000	52,000	1.7
Total		**1,649,000**	**2,956,000**	**100.0**

Impingement samples were collected at the ESGS from October 1978 through September 1980 (SCE 1982a). Queenfish and walleye surfperch were the dominant species in the impingement study, comprising 64% and 11%, respectively, of total impingement abundance (Table 3-2).

Table 3-2: ESGS Fish Impingement Estimates (October 1978-September 1980)

		Daily Impingement Units 1 & 2		**Daily Impingement Units 3 & 4**		
Target Fishes		**N.O.**	**H.T.**	**N.O.**	**H.T.**	**Percent of Total**
northern anchovy	*Engraulis mordax*	0.42	0.12	0.42	2.47	1.0
white croaker	*Genyonemus lineatus*	2.36	2.25	1.85	19.96	7.4
queenfish	*Seriphus politus*	12.70	45.51	14.07	157.30	63.9
Pacific butterfish	*Peprilus simillimus*	0.37	0.42	0.21	0.44	0.4
kelp bass	*Paralabrax clathratus*	0.38	3.12	0.05	4.03	2.1
barred sand bass	*Paralabrax nebulifer*	0.07	0.81	0.07	1.02	0.5
qargo	*Anisotremus davidsonii*	0.02	0.57	0	1.17	0.5
spotfin croaker	*Roncador stearnsii*	0	0	0	0	0.0
bocaccio	*Sebastes paucispinis*	0	0.01	0	0.04	0.0
black croaker	*Cheilotrema saturnum*	0.01	0.27	0.01	0.59	0.2
yellowfin croaker	*Umbrina roncador*	0	0	0.01	0.02	0.0
shiner perch	*Cymatogaster aggregata*	1.02	1.82	2.02	15.65	5.7
black perch	*Embiotoca jacksoni*	0.10	0.93	0.11	0.42	0.4
walleye surfperch	*Hyperprosopon argenteum*	8.66	17.37	1.56	10.53	10.6
white seaperch	*Phanerodon furcatus*	0.78	11.56	4.96	8.41	7.2
Total		**26.89**	**84.76**	**25.34**	**222.05**	**100.0**

N.O. = Normal Operations, H.T. = Heat Treatments.

Impact analyses based on the proportional entrainment approach of MacCall et al. (1983) was used to calculate the magnitude of loss for all life stages. The probability of mortality due to entrainment and impingement by the cooling water intake systems at the ESGS was calculated through the first five years of the life cycle for each target species. The source water population was considered to reside in the Southern California Bight (from Pt. Conception to the U.S./Baja California border) between shore and the 256 ft isobath (SCE 1982b). The probability of a fish surviving IM&E through a specific age (R_c) was used to calculate the percent probability of mortality due to operation of the cooling water intakes. Values for R_c were calculated individually for each size class and also accumulated to represent the total cooling water intake system mortality for each species. The probability of mortality could only be calculated for seven of the target species due to low abundances of other species. At Units 1 & 2, the probability of mortality values ranged from 0.10% to 0.36%, with the highest value calculated for queenfish (Table 3-3). At Units 3 & 4, values ranged from 0.18% to 0.76%, with the highest value estimated for white seaperch. Impacts to fish populations from the operation of the cooling water system at the ESGS were not determined to be significant, indicating that observed losses would have no effect on the dynamics of the source water populations for these fishes. Regardless, SCE examined nine alternative cooling water intake technologies and/or devices potentially applicable at the ESGS (LMS 1982). It was determined that the velocity-capped cooling water intake in place at the time represented the best technology available. The results of this study have been used as the basis for 316(b) compliance at the ESGS.

Table 3-3: Probability of Mortality Estimates for Target Fishes at ESGS (1978-1980)

	Probability of Mortality (%)		
Target Fishes	**Units 1 & 2**	**Units 3 & 4**	**Impact**
northern anchovy	0.10	0.19	not significant
white croaker	0.18	0.33	not significant
queenfish	0.35	0.64	not significant
kelp bass*	0.17	0.27	not significant
shiner perch	0.15	0.76	not significant
white seaperch	0.23	0.45	not significant
Pacific butterfish	**	**	not significant
sargo	**	**	not significant
spotfin croaker	**	**	none
bocaccio	**	**	none
black croaker	**	**	not significant
yellowfin croaker	**	**	none
black perch	**	**	not significant
walleye surfperch	**	**	not significant

* - Includes barred sand bass
** - Probability of mortality not calculated due to low level of impingement and/or entrainment

3.1.2 1972-2004 ESGS Fish & Macroinvertebrate Impingement Monitoring

Composition, abundance, and biomass of juvenile and adult fish and macroinvertebrates entrapped and impinged on traveling screens at the ESGS have been monitored since the early 1970s, and this monitoring is still continuing. Fish impingement sampling was conducted during representative periods of normal operation and during all heat treatment procedures. The data were used to calculate estimates of total impingement for each year. A normal operation survey is defined as a sample of all fish and macroinvertebrates entrained by water flow into the generating station intake and subsequently impinged and removed by traveling screens during a 24-hr period. Due to downtimes for maintenance and seasonal fluctuations in power demand, the plant usually does not operate 365 days per year and thus there are decreased cooling water flows during these periods. Normal operation abundance and biomass for a given study year were estimated by extrapolating the monitored abundance and biomass based on the percentage of the annual cooling water flow into the generating station during sampling days. For example, if the flow volume entrained during a 24-hr impingement survey was 100 mgd, and the total flow for the month was 1,000 mgd, the impingement results would be multiplied by 10 to estimate the monthly impingement.

Heat treatments are operational procedures designed to eliminate mussels, barnacles, and other fouling organisms growing in the cooling water conduit system. During a heat treatment, heated effluent water from the discharge is redirected to the intake conduit via cross-connecting tunnels until the water temperature rises to approximately 105°F (40.5°C) in the screenwell area. This water temperature is maintained for at least one hour, during which time all biofouling organisms, as well as fish and invertebrates living within the cooling water system, succumb to the heated water. During heat treatment surveys, all material impinged onto the traveling screens were removed from the forebay. Fish and macroinvertebrates were separated from incidental debris, identified, and counted. Up to 200 individuals of each species were measured, examined for external parasites, anatomical abnormalities, and other abnormalities. Aggregate weights were taken by species. Impingement totals from the heat treatment surveys were combined with the normal operation impingement estimates to calculate total annual impingement losses. (MBC 2003).

The composition of fish monitored during both normal and heat treatment impingement surveys from 1972-2004, and macroinvertebrates from 1990-2004 was examined to assess a baseline for future studies at the ESGS. An annual average of approximately 4,550 individual fish and macroinvertebrates were observed in impingement surveys from 1972-2004. Queenfish and Pacific rock crabs were the most abundant species of each class of organisms over their respective monitoring periods. Although it is clear that the amount of water flow through the station is a substantial factor affecting impingement rates, it is also apparent that natural population variation and environmental factors contributed to the fluctuations in fish and macroinvertebrate abundance and biomass.

Heat treatment monitoring accounted for the largest proportion of annual estimated impingement from 1999-2004, the time frame during which both normal operations and heat treatments were monitored. Annual estimated normal operation impingement abundances, which represent observed abundances extrapolated over the entire year in reference to water circulation volumes, accounted for approximately 12 and 8 percent of the total estimated annual impingement of fishes at Units 1 & 2 and 3 & 4, respectively. At Units 1 & 2, annual impingement averaged 405 fish weighing 241 lbs (Table 3-4). At Units 3 & 4, annual impingement averaged 2,211 fish weighing 963 lbs (Table 3-5). Annual estimated normal operation impingement biomass, which represent observed abundances extrapolated over the entire year in reference to water circulation volumes, accounted for approximately 34 and 32 percent of the total estimated annual impingement of fishes at Units 1 & 2 and 3 & 4, respectively. The percentages for biomass are larger than the percentages based on numbers of fishes because a large fish, such as a thornback or a torpedo ray, can skew the biomass estimates when the other fish collected in the impingement sample are small and few in number. Since there are more normal operations surveys there is also a greater chance that a large fish will be collected. Mean monthly peaks in impingement abundances occurred in November, followed by January and December. The intake for Units 3 & 4 accounted for 60% of the total fish impingement abundance at ESGS from 1972 to 2004.

Table 3-4 shows a comparison of total annual estimated numbers and biomass (lbs) of fishes impinged at Units 1& 2 during normal operations and heat treatments from the 1999 through 2004 NPDES reporting periods (October through September). The single fish collected in normal operations in 2002 was a bat ray (*Myliobatis californica*) that was subsequently released. However, it's final disposition was unknown so it was included in the impingement total. Dashes indicate no heat treatments were conducted during the year.

Table 3-4: ESGS Unit 1 & 2 Fish Impingement Monitoring (1999 – 2004)

Year	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**Average**
Abundance							
Normal Operations	31	0	205	1	52	0	
Heat Treatment	135	271	1,732	5	-	-	
Number of Heat Treatment Surveys	2	5	3	2	0	0	
Total	166	271	1,937	6	52	0	
Normal Operation % of Total	19%	0%	11%	17%	-	-	12%
Biomass (lbs)							
Normal Operations	4	0	287	49.6	410	0	
Heat Treatment	87	84	525	0.4	-	-	
Number of Heat Treatment Surveys	2	5	3	2	0	0	
Total	91	84	812	50.4	410	0	
Normal Operation % of Total	5%	0%	35%	98%	-	-	35%

Table 3-5 shows a comparison of total annual estimated numbers and biomass (lbs) of fishes impinged at Units 3 & 4 during normal operations and heat treatments from the 1999 through 2004 NPDES reporting periods (October through September).

Table 3-5: ESGS Unit 3 & 4 Fish Impingement Monitoring (1999 – 2004)

Year	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**Average**
Abundance							
Normal Operations	110	420	124	116	35	152	
Heat Treatment	1,054	4,574	2,673	1,301	1,669	1,037	
Number of Heat Treatment Surveys	1	6	4	5	4	4	
Total	1,164	4,994	2,797	1,417	1,704	1,189	
Normal Operation % of Total	9.5%	8.4%	4.4%	8.2%	2.1%	12.8%	8%
Biomass (lbs)							
Normal Operations	13	1,372	26	598	637	15	
Heat Treatment	734	677	567	520	432	181	
Number of Heat Treatment Surveys	1	6	4	5	4	4	
Total	747	2,049	593	1,118	1,069	196	
Normal Operation % of Total	1.7%	67.0%	4.4%	53.5%	59.6%	7.7%	32%

Results of macroinvertebrate impingement sampling at Units 1 & 2 and Units 3 & 4 by year are summarized in Tables 3-6 and 3-7, respectively. Dashes indicate no heat treatments were conducted during the year.

Table 3-6: ESGS Unit 1 & 2 Macroinvertebrate Impingement Monitoring (1999 – 2004)

Year	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**Average**
Abundance							
Normal Operations	366	230	14,957	245	538	1,143	
Heat Treatment	27	302	972	6	-	-	
Number of Heat Treatment Surveys	2	5	3	2	0	0	
Total	393	532	15,929	251	538	1,143	
Normal Operation % of Total	93.1%	43.2%	93.9%	97.6%	-	-	82%
Biomass (lbs)							
Normal Operations	144	921	316	24	306	686	
Heat Treatment	12	970	250	3	-	-	
Number of Heat Treatment Surveys	2	5	3	2	0	0	
Total	156	1,891	566	27	306	686	
Normal Operation % of Total	92.3%	48.7%	55.8%	88.9%	-	-	71%

Table 3-7: ESGS Unit 3 & 4 Macroinvertebrate Impingement Monitoring (1999 – 2004)

Year	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**Average**
Abundance							
Normal Operations	34,522	2,241	13,899	1,275	1,016	1,384	
Heat Treatment	1,198	9,229	2,591	3,071	680	813	
Number of Heat Treatment Surveys	1	6	4	5	4	4	
Total	35,720	11,470	16,490	4,346	1,696	2,197	
Normal Operation % of Total	96.6%	19.5%	84.3%	29.3%	59.9%	63.0%	59%
Biomass (lbs)							
Normal Operations	6,433	2,346	2,557	513	682	1,702	
Heat Treatment	111	3,778	337	258	55	64	
Number of Heat Treatment Surveys	1	6	4	5	4	4	
Total	6,544	6,124	2,894	771	737	1,766	
Normal Operation % of Total	98.3%	38.3%	88.4%	66.5%	92.5%	96.4%	80%

3.1.3 2001 ESPR Project I&E Impact Analysis

In December 2000, El Segundo Power II LLC submitted an Application for Certification (AFC) to the CEC for a proposed repowering project. The ESPR Project involves replacing Units 1 & 2 at the ESGS with a new combined cycle facility consisting of two combustion turbines (Units 5 and 7) and one steam turbine (Unit 6). ESPR was approved on February 2, 2005. The new units will use the existing Units 1 & 2 cooling water intake system. The AFC analyzed potential impacts to marine resources, including losses of organisms due to entrainment and impingement (ESP II 2000). As a result of subsequent discussions with CEC staff, an analysis of entrainment and impingement resulting from the proposed project was done using more recent data (ESP II 2001).

Losses due to entrainment at the ESGS were calculated from data collected within King Harbor, located approximately 4.7 miles downcoast from the ESGS. The Vantuna Research Group collected monthly ichthyoplankton samples at six stations in King Harbor from 1974 to 2001. Data from May 1997 to April 1998 were used to determine potential entrainment rates at the ESGS, since these were the most recent data available for analysis at the time. Densities of selected fish species at King Harbor (1997-1998) and at the SGS (1978-1979) were analyzed using correlation analyses. There were significant correlations detected between abundances at the two locations for most species. Larval fish densities were then converted to entrainment estimates using flow rates from Units 1 & 2 and Units 3 & 4, and further converted to equivalent adults using the Equivalent Adult Model (EAM). These equivalent adult estimates, combined with annual impingement estimates, are presented in Table 3-8.

Table 3-8: ESGS Annual Adult Equivalent Estimates for Total Impingement and Entrainment Losses (May 1997-April 1998)

		Units 1 & 2 Annual I&E	**Units 3 & 4 Annual I&E**
Target Fishes		**Abundance Estimates**	**Abundance Estimates**
queenfish	*Seriphus politus*	24	26,641
white croaker	*Genyonemus lineatus*	1,514	2,919
northern anchovy	*Engraulis mordax*	886	1,708
Pacific sardine	*Sardinops sagax*	461	1,398
walleye surfperch	*Hyperprosopon argenteum*	100	832
jacksmelt	*Atherinopsis californiensis*	334	644
topsmelt	*Atherinops affinis*	334	644
salema	*Xenistius californiensis*	29	493
sea basses	*Paralabrax* spp	42	267
yellowfin croaker	*Umbrina roncador*	8	102
blacksmith	*Chromis punctipinnis*	1	45
California halibut	*Paralichthys californicus*	2	4
white seabass	*Atractoscion nobilis*	0	6
Total		3,743	35,757

In summary, the adult equivalent loss (entrainment and impingement) was estimated at 10 fish per day at Units 1 & 2 and about 100 fish per day at Units 3 & 4. It was concluded that these losses were not significant.

3.1.4 2004 ESGS Larval Characterization

In preparation for potential 316(b) field studies, a preliminary larval sampling program was conducted to document the composition and density of larval fishes and target invertebrates in the vicinity of the ESGS (MBC 2005). Samples were collected during eight surveys from May

2004 to July 2004. A total of five stations were sampled off the Scattergood and El Segundo Generating Stations (Figure 3-1). Samples collected at the ESGS intakes were dominated by unidentified gobies (41%), combtooth blennies (22%), queenfish (7%), and northern anchovy (7%) (Table 3-9).

Table 3-9: Larval Fish Densities in the Nearshore Areas Around ESGS (May 2004 to July 2004)

		ESGS Intake Area	Total Study Area
Fishes		**Average Density (No. / 1,000 m^3)**	**Average Density (No. / 1,000 m^3)**
unidentified gobies	Gobiidae	119.2	254.0
combtooth blennies	*Hypsoblennius* spp.	63.7	48.7
queenfish	*Seriphus politus*	20.8	21.6
northern anchovy	*Engraulis mordax*	20.7	54.6
unid. yolk-sac larvae		14.1	5.1
white croaker	*Genyonemus lineatus*	10.4	9.2
black croaker	*Cheilotrema saturnum*	10.2	7.8
Invertebrates			
decapod megalops	Decapoda, unidentified	106.1	108.2
sand crab	*Emerita analoga*	37.1	55.7

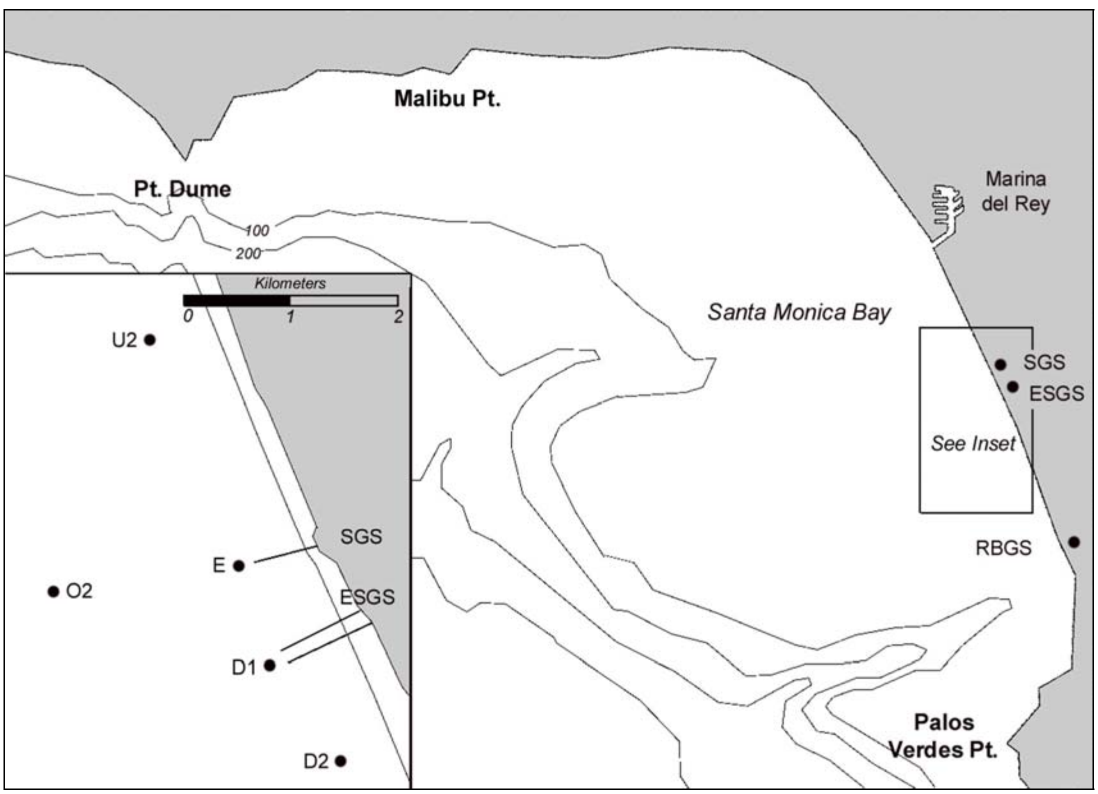

Figure 3-1: Location of Larval Fish and Invertebrate Sampling Stations, May-July 2004

The fish assemblage at the offshore station, located at the 69 ft isobath, differed markedly from that at the nearshore stations on the 33 ft isobath. The offshore larval fish community was more diverse, with 33 species collected at the offshore station and 25 species at the entrainment station. The offshore community consisted primarily of northern anchovy (41%), combtooth blennies (11%), sculpins (*Icelinus* spp.; 7%), California halibut (6%), and bay goby (5%). Only one of the three target invertebrate taxa was collected in entrainment samples: sand crab (*Emerita analoga*). Market squid paralarvae (*Loligo opalescens*) and California spiny lobster phyllosoma larvae (*Panulirus interruptus*) were collected infrequently at the offshore station and were not collected near the ESGS intakes.

The results from this preliminary study were used in the design of the entrainment sampling plan presented in this PIC as Attachment C.

3.2 SGS Impingement Mortality and Entrainment Characterization Studies

The following section summarizes some of the IM&E characterization studies performed at the SGS. Results of these studies are not intended for use in the ESGS 316(b) CDS but are presented here for informational purposes only.

3.2.1 1978-1979 SGS 316(b) Demonstration

In 1978-1979, the LADWP performed in-plant and source water studies at the SGS (IRC 1981). The single intake structure for the SGS is located approximately 0.6 mile upcoast from the ESGS intake structures. The single SGS intake structure is similar in design to the two intake structures at the ESGS and is capable of withdrawing slightly more water even though the combined capacity for the two ESGS CWIS is greater (495 mgd at SGS compared with 207 mgd at ESGS Units 1 & 2 and 398 mgd at ESGS Units 3 & 4). The SGS intake is located at a water depth of approximately 29.5 ft, and the intake riser extends approximately 10.5 ft above the seafloor. The vertical distance between the top of the riser and velocity cap is 5 ft. During the demonstration it was determined the "*waters most likely to be drawn into the Scattergood Generating Station are those which lie in the upper 15 m between the two submarine canyons found in Santa Monica Bay. Inshore of the canyon heads, the source water region may extend further longshore, especially to the northwest.*" Furthermore, the detectable zone of influence of the intake structure extended about 50 ft from the center of the intake velocity cap, which has a radius of 16.2 ft.

Plankton samples used to characterize entrainment and source water populations were collected at one station at the intake (near-field station) and at two stations in the source water located upcoast and offshore the intake (far-field stations). Studies were performed biweekly for one year, and most studies consisted of both day and night sampling. Similar to the SCE studies, target species were selected for analysis prior to the initiation of the study. The source water for the Scattergood study was restricted to the Santa Monica Bay and extended from shore out to the

90 ft depth contour. Impacts were assessed using a combination of approaches, including the Adult Equivalent Loss (AEL) model for fishes (Horst 1975, Goodyear 1978). AEL estimates for target fishes are presented in Table 3-10 for all of the fishes assessed in the study (IRC 1981). The projected adult losses of anchovies and croakers were equal in magnitude to routine otter trawl catches from nearby Los Angeles-Long Beach Harbor. Losses of silversides were far less than reported sportfishing landings from 1958–1961. Also calculated were the source water volumes necessary to induce a 5% cropping rate on each taxa. It was determined that these volumes represented only a fraction of the volume of Santa Monica Bay, leaving ample room for immigration from elsewhere within the Bay. Loss estimates were considered conservative since compensatory factors were not taken into consideration. Consequently, it was concluded that entrainment losses were insignificant.

Table 3-10: Estimates of SGS Adult Equivalent Loss Due to Entrainment (1978-1979)

		Adult Equivalent Loss Estimates	
Target Fishes		**from fish eggs**	**from fish larvae**
silversides	Atherinid species complex		84,600
anchovies	Engraulid species complex		9,880
northern anchovy	*Engraulis mordax*	13,300	
croakers	Scieaenid species complex	94,600	
white croaker	*Genyonemus lineatus*		23,200
queenfish	*Seriphus politus*		25,100
Total		107,900	142,780

Queenfish, white croaker, walleye surfperch, and white seaperch were the most abundant fish in impingement samples during the yearlong study. Total heat treatment impingement of target species was estimated at 9,580 lbs (Table 3-11), while total impingement biomass for the study year for all fishes was estimated at 14,656 lbs. The highest impingement rates were recorded in March 1978. Impingement estimates were compared to source population estimates, which for most species was considered to be the Santa Monica Bay between Redondo Beach and Point Dume, and extending offshore to the 230 ft or 70 m isobath (for queenfish, white croaker, and walleye surfperch). Source population estimates were derived from nearshore trawl data. To compute these estimates, the fish collected in the trawl surveys were multiplied by the ratio of the source water volume to the volume of water sampled by the trawls. Trawl catch efficiencies were estimated to be 12% to 30%. The source population for northern anchovy was considered to reside in the "Channel" area of the Southern California Bight, which extends between Dana Point and Santa Catalina Island to the south, and Santa Cruz Island and the city of Santa Barbara to the north. The effects of impingement mortality on these source populations during the study year ranged from 0.45% (queenfish) to 0.0004% (northern anchovy). Impingement losses for all fishes were also low when compared to recreational and commercial fishing losses.

Table 3-11: SGS Annual Impingement Estimate (1977-1978)

		Annual Impingement Estimates	
Target Fishes		**Abundance**	**Biomass (pounds)**
queenfish	*Seriphus politus*	89,230	5,507
white croaker	*Genyonemus lineatus*	19,437	2,340
walleye surfperch	*Hyperprosopon argenteum*	9,939	1,558
northern anchovy	*Engraulis mordax*	Not available	175
Total			**9,580**

The study concluded that there were no adverse environmental impacts due to CWIS impingement and entrainment at SGS, and based on 316(b) assessment guidelines, no intake technology review was necessary (IRC 1981).

3.2.2 1997 SGS 316(b) Update

In 1997 MBC Applied Environmental Sciences synthesized available information to update the original 316(b) assessment for the SGS (MBC 1997). No additional recent data on through-plant effects on zooplankton, fish eggs, or ichthyoplankton were included in the 316(b) update. Studies conducted during the original 316(b) assessment were carried out with the plant operating at full capacity. Cooling water flow at the SGS decreased substantially from the 1970's through the 1990's. Even though the cooling water flow has been substantially reduced, the loss estimates from the original 316(b) studies calculated under full operation and flow were used to present the most conservative case.

In the 316(b) update (MBC 1997), data from heat treatment samples conducted from 1989 through 1995 were used to determine effects of plant operations on adult fishes. Annual heat treatment loss estimates for the 10 most abundant fish species are presented in Table 3-12. Heat treatment data from SGS included fish species, abundance, biomass, and standard length. Critical fish taxa, chosen for the 316(b) update, included those most frequently entrained by the SGS, as well as those of high recreational or commercial value. Source population estimates for some fish species were updated using data from trawl surveys for the SGS, as well as for the nearby city of Los Angeles Hyperion Treatment Plant. Numbers of fish impinged at the SGS were compared with numbers of fish reported caught in the Santa Monica Bay catch blocks between 1989 and 1994 and fish reported caught from sportfishing landings known to target the Santa Monica Bay. For most species, annual impingement totals were less than 2% of catch block totals from the Santa Monica Bay. One exception was white croaker, where 9,063 individuals were impinged during the seven-year period, but only 1,894 individuals were reported from the Santa Monica Bay catch blocks. Similarly, annual impingement totals were less than 1% of annual sportfishing landing reported from the Santa Monica Bay, with the exception of white croaker. Sportfishers in the Santa Monica Bay caught an annual average 148 white croaker, compared with 1,053 in annual impingement totals. The most abundant fish in impingement samples from 1989 to 1995 were jack mackerel (32%), queenfish (18%), topsmelt (11%), jacksmelt (8%), and northern anchovy (7%).

Table 3-12: SGS Annual Impingement Estimates (1989-1995)

		Annual Impingement Estimates	
Target Fishes		**Abundance**	**Biomass (lb)**
jack mackerel	*Trachurus symmetricus*	11,862	853
queenfish	*Seriphus politus*	6,596	536
topsmelt	*Atherinops affinis*	4,119	392
jacksmelt	*Atherinopsis californiensis*	2,883	688
northern anchovy	*Engraulis mordax*	2,496	40
Pacific sardine	*Sardinops sagax*	1,800	205
white croaker	*Genyonemus lineatus*	1,554	90
salema	*Xenistius californiensis*	1,332	84
yellowfin croaker	*Umbrina roncador*	938	282
walleye surfperch	*Hyperprosopon argenteum*	569	73
Total		**34,149**	**3,244**

As with the original 316(b) documents, no alternative intake technologies were considered since entrainment and impingement losses were considered insignificant. Losses due to impingement represented less than 2% of fish taken locally by sportfishers, and less than 0.2% of estimated source populations in the Santa Monica Bay (from shore to the 100-m isobath) where such calculations were possible. Similar to the original 316(b) Demonstration, source population estimates were derived from trawl surveys performed for the SGS (1986 and 1988) and the Hyperion Treatment Plant (1990-1992, 1994-1995). To compute source population estimates, the fish collected in the trawl surveys were multiplied by the ratio of the source water area to the area sampled by the trawls. Trawl catch efficiencies were estimated to be 12% to 50%. Impingement abundance and biomass decreased substantially since the 1978-1979 316(b) demonstration (MBC 1997).

4.0 AGENCY CONSULTATIONS

The EPA 316(b) Phase II regulation [40 CFR 125.95 (b)(1)(iii)] requires that the PIC include a summary of any past and ongoing consultations with state and federal fish and wildlife agencies relevant to the development of the PIC for the facility. The following is a brief description of communications related to the ESGS IM&E impacts that have taken place since 2000 through the permitting process for the ESPR Project.

4.1 ESPR Agency Consultation

In December 2000, El Segundo Power II LLC submitted an AFC to the CEC for a proposed repowering project. The ESPR Project will replace Units 1 & 2 at the ESGS with new combined cycle units (Units 5–7) consisting of two combustion turbines and one steam turbine. The new units will use the existing Units 1 & 2 cooling water intake system. The AFC analyzed potential impacts to marine resources, including losses of organisms due to entrainment and impingement (ESP II 2000).

Throughout the course of the approval process, staff at several agencies commented on the proposed ESPR project. CEC staff and staff from the California Coastal Commission (CCC), the CDFG, and the National Marine Fisheries Service (NMFS) all commented that the study used to estimate entrainment and impingement impacts at the ESGS—the 1978–1980 316(b) demonstration—was not conducted at the ESGS, and had results that were over 20 years old. The agencies requested that the CEC require a one-year entrainment and impingement study at the ESGS to estimate the potential effects of the proposed project. Ultimately, the CEC disagreed with these recommendations and permitted the project in reliance of the existing studies and evidence. The CEC approved the project on February 2, 2005.

Documents related to the ESPR Project approval may be found at:
<http://www.energy.ca.gov/sitingcases/elsegundo/index.html>

4.2 LARWQCB 316(b) Meetings & Correspondence

On August 28, 2003, the LARWQCB began hosting periodic 316(b) Phase II working group meetings that were attended by LARWQCB staff, CEC staff, utility representatives, state and federal fish and wildlife agencies, U.S. EPA, and representatives of environmental groups and other stakeholders. The meetings were held to identify 316(b)-related areas of concern and discuss those topics. These meetings were not necessarily agency consultations, but provided a forum for interested parties to discuss the 316(b) compliance process. To date, six meetings have been held, and the discussion topics have included (1) regulatory requirements, (2) potential timelines for 316(b) compliance, (3) potential for a technical working group review of PICs, IM&E Sampling Plans, and IM&E Study reports, and (4) determination of calculation baseline.

This PIC has been developed taking into consideration the results of the discussions from these working group meetings.

On September 23, 2004 ESP submitted a letter to the LARWQCB requesting a schedule for submittal of information required to comply with the EPA 316(b) Phase II rule. The letter requests a schedule for submittal of the PIC on August 1, 2005, and for submittal of the CDS on January 7, 2008. A copy of that correspondence is included in Attachment B. To date, the LARWQCB has not responded to this request.

5.0 INTAKE TECHNOLOGY EVALUATION

The EPA 316(b) Phase II regulation [40 CFR 125.95(b)(1)(i)] requires that the PIC include a description of technologies which will be evaluated further to determine feasibility of implementation and effectiveness in meeting IM&E performance standards. Several technologies have been developed and have proven effective, in certain circumstances, in reducing IM&E at various CWIS. The feasibility of implementation and the performance of such technologies are highly site-specific. The design and capacity of the existing CWIS, as well as source waterbody physical and biological characteristics, will determine which technologies are practical for implementation and effective in reducing IM&E at the ESGS.

A preliminary screening of technologies has been conducted to determine which technologies offer the greatest potential for application at the ESGS facility and therefore warrant further evaluation. Technologies have been screened based upon feasibility for implementation, biological effectiveness (i.e. ability to achieve reductions in impingement mortality and/or entrainment), and cost of implementation (including capital, installation, and annual operations and maintenance costs). The following is a discussion of those technologies for which further study will be conducted to determine their potential for reducing IM&E at the ESGS CWIS. Also included is a description of technologies that have been determined to be infeasible for implementation and the rationale for that determination.

5.1 Technologies Selected For Further Evaluation

Based upon the results of the preliminary technology screen discussed above, the following is a description of those technologies selected for further evaluation for achieving performance standards, in whole or in part, for reduction in IM&E. The results of the evaluation of each technology will be utilized to develop the plan for implementation of technologies, operational and/or restoration measures that may be proposed to meet IM&E performance standards at ESGS. Upon selection of the most appropriate technology, engineering design calculations and drawings, as well as estimates of expected reductions in IM&E and a schedule for implementation will be developed. This information will become part of the Design & Construction Technology Plan (DCTP) (or Site-Specific Technology Plan in the event that the facility chooses to seek a site-specific determination of BTA) and Technology Installation & Operation Plan (TIOP) that will be included in the CDS to be submitted for the facility.

5.1.1 Velocity Cap Inlet

Velocity cap inlets are installed on the offshore cooling water intake conduits for the both Unit 1 & 2 and Unit 3 & 4 CWIS. A velocity cap is a device that is installed over a submerged offshore intake pipe. The cap limits the vertical extent of the offshore intake area of withdrawal. This technology reduces impingement of adult fish by stimulating a behavioral avoidance response. By redirecting the water withdrawal laterally from the intake (rather than vertically from an intake on the bottom), the water entering the intake is accelerated laterally and is more likely to provide horizontal velocity cues to fish and allow fish to respond and move away from the intake. When fish are better able to identify these changes in water velocity, fish can avoid the highest velocity areas near the mouth of the intake structure.

Studies conducted on the Unit 1 & 2 CWIS during the year before and after a velocity cap was installed on the entrance to the intake conduit in 1957 demonstrated a 95% reduction in the amount of fish (measured in biomass – abundance was not recorded) that enter the screenwell structure (Weight, 1958). EPA, in the TDD for the Final Section 316(b) Phase II Existing Facilities Rule, states that efficiencies of velocity caps on West Coast offshore intakes have exceeded 90% and cites a 1982 report by the American Society of Civil Engineers. Page 4-18 of the TDD specifically states that **“At the Huntington Beach and El Segundo stations in California, velocity caps have been found to provide 80 to 90 % reductions in fish entrapment.”**

The existing velocity cap inlets will be evaluated to determine the current reduction in IM&E occurring through operation of this technology at the ESGS CWIS. The evaluation will be used to determine the credit that may be obtained toward meeting the IM&E reduction performance standards and the additional reduction in IM&E (if any) that would be required in order to meet the standards. Evaluations of additional fish protection technologies will be based upon this determination.

5.1.2 Modified Traveling Screens w/ Fish Return

Traveling screens that are modified to enhance fish survival are designed with the latest fish removal features, including the Fletcher type buckets on the screen baskets, dual pressure spray systems (low pressure to remove fish, and high pressure to remove remaining debris), and separate sluicing systems for discarding trash and returning the impinged fish back to the water body. Screens of this type may be installed with either a fine-mesh or a conventional 3/8 inch screen mesh. Impingement survival may be improved with the use of continuously operating modified traveling water screens with a conventional 3/8 inch mesh. Fine mesh would be required to reduce entrainment (see discussion of fine mesh screens below).

Installation of modified “Ristroph” traveling screens at the ESGS would consist of replacing the existing traveling water screens at the two CWIS with the screens as described above. A fish return system would be installed to return fish collected on the traveling water screens to the Santa Monica Bay. The replacement screens would be equipped with the same 3/8 inch mesh size as the existing traveling screens.

The feasibility of replacing the existing traveling screens at the ESGS CWIS with modified Ristroph traveling screens with conventional 3/8 inch mesh, fish handling and fish return systems will be evaluated. The evaluation will include an assessment of the additional reduction in IM that may be expected through implementation of this technology.

5.1.3 *Fine Mesh Cylindrical Wedgewire Screens*

Wedgewire screens would operate as passive intakes attached to the existing submerged offshore velocity cap intake structure. Fine-mesh cylindrical wedgewire screens are designed to reduce both IM&E. The technology employs fluid dynamics and a small screen opening to prevent IM&E of aquatic species. Entrainment is prevented through physical exclusion of organisms that are larger than the slot width. Impingement is prevented by maintaining a low approach and through-screen velocity, allowing fish to swim away from the structure. Fine mesh screens typically have slot widths of 0.5 millimeter (mm) to 1.0 mm, and are designed to be placed in a water body where significant prevailing ambient cross flow current velocities (≥ 1 ft/s) exist. This cross flow is essential to the design and is required to minimize biofouling and clogging. Organisms that would otherwise be impinged on the wedgewire intake are swept away with the waterbody flow. An integral part of a typical wedgewire screen system is an air burst back flush system, which directs a charge of compressed air to each screen unit to blow off debris and impinged organisms back into the water body where they would be carried away from the screen unit by the ambient currents. This system consists of a compressor; compressed air tank, air piping, which connects the compressed air tank to a nozzle on each screen unit; control valves; and supporting electrical and control equipment.

Certain design, operational and maintenance problems are inherent with wedgewire screen systems, which may limit the applicability of this screening concept. General engineering criteria that will be considered in the evaluation of both coarse mesh and fine mesh wedgewire screens for possible application at ESGS include:

- Cross current flow - Cross flow water currents around the screens are necessary for good biological performance of the wedgewire screen design. Without this necessary cross flow on the wedgewire screens, any planktonic organism drawn to the face of the wedgewire screen would be permanently impinged on the new screen instead of being entrained though the cooling system.
- Clogging – To minimize clogging, the screen should be located in a location with an ambient water current of at least 1 ft/s to establish suitable hydraulic conditions for self-cleaning and the dispersal of back-flushed debris. An adequate backwash system, using compressed air, is also required for periodic cleaning of the screen units.
- Navigation / Recreation – The screens must be located such that they do not interfere with navigational and recreational uses of the waterbody.

- Large debris – In many areas, large debris (trees, kelp, etc) could damage or block the screens. Kelp beds are present upcoast and downcoast of the ESGS intakes and may present a significant potential clogging hazard for the wedgewire screen units. Clogging is especially a hazard for plant operations during and after storm events when kelp might be torn loose and distributed with the flows coming into the intake structure.

- Biofouling – The potential for biofouling of the screen media must be considered. Biofouling results in clogging of the screen media.

- Access – The screens must be readily accessible for maintenance and performance monitoring. The distance from shore and depth from water surface are factors that affect the accessibility of the screens.

- Design / Size Considerations – Due to the small slot sizes in the cylindrical screens, the flow rate through the screens is limited, and an array of multiple screens is required to accommodate the large once-through cooling water flow. The arrangement of the screens and the amount of space that the screens occupy in the waterbody must be considered to determine feasibility of implementation of the technology.

5.1.4 Aquatic Filter Barrier

An aquatic filter barrier system, such as the Gunderboom Marine Life Exclusion System (MLES)™, is a moored water permeable barrier with fine mesh openings that is designed to prevent both impingement and entrainment of ichthyoplankton and juvenile aquatic life. An integral part of the MLES is an air-burst back flush system similar in concept to the air burst system used with wedgewire screen systems to back flush impinged organisms and debris into the water body to be carried away by ambient cross currents.

A MLES has been installed and tested at the Lovett Station on the Hudson River. This test installation was applied to a cooling system of significantly smaller capacity than the ESGS intake systems. This test installation has had highly variable results and considerable reliability problems associated with maintaining barrier position in the tidal flows of the Hudson River.

An evaluation of an aquatic filter barrier system will be conducted to determine the feasibility of implementation at both the ESGS CWIS. Factors that will be considered in the evaluation include:

- Filter barrier size requirements - Based upon the maximum design loading rate for the MLES and the design flow rates for the two ESGS CWIS, the required filtering areas for the two intakes will be evaluated to determine the area of filter fabric that will be required for each intake;

- Configuration – Potential configurations and mooring systems will be evaluated to determine feasibility of installation in the open ocean at the two submerged intakes;

the system must also be designed to avoid or reduce the navigation hazard inherent with the conventional configuration with suspended foam floatation billets positioned on the ocean surface;

- Ability to withstand ambient conditions – Evaluation of the conditions in the open ocean at the ESGS, particularly during severe storms, will be conducted to determine the effects of such conditions on the aquatic filter; and
- Fouling – The potential for fouling of the filter barrier in the ocean will be evaluated, including the feasibility of installation of an air-burst back flush system to back flush impinged organisms and debris back into the water body to be carried away by ambient cross currents.

5.2 Technologies Considered Infeasible

The following is a discussion of the IM&E reduction technologies that have been evaluated and determined to be impractical for implementation at the facility. A rationale is provided for concluding that further evaluation of these technologies is not warranted.

5.2.1 Fine-Mesh Traveling Screens

Fine mesh traveling screens are screens with mesh openings of 1.0 mm or less. Fine mesh traveling water screens have been installed at a few large-scale steam electric cooling intakes and have been tested and found to significantly reduce entrainment, with results dependant upon screen mesh size and resident species. Results from field studies of fine-mesh traveling water screens have also indicated a reduction in impingement mortality, due in part to lower approach velocities and shorter impingement duration.

Fine mesh traveling screens require an approach velocity no greater than 0.5 ft/s to limit damage to fragile egg and larval stages that are in contact with the screen and to handle the higher potential clogging rate, which would be inherent with the finer mesh screening medium. This technology is not viable for the ESGS intake system due to high screen flow velocities of the existing system. The approach velocity to the existing screens is approximately 1 ft/s. Installation of fine mesh screens at ESGS would require construction of additional intake bays to both existing CWIS. The design requirements (0.5 ft/s approach or through-screen velocities) would necessitate two to four times the wetted screen surface area than is currently available in the existing traveling screen wells and would require major reconstruction or replacement of the existing screen structure. These new screening facilities would have to include transition structures to distribute the flow from the existing offshore intake pipes evenly to the new screens and then to distribute the screened flow to the existing on shore intake structures to provide acceptable flow conditions to the circulating water pumps. Space for such new structures is not available in the current footprint of the ESGS plant. Since a low approach velocity cannot be achieved, the system will not provide good survival of eggs and larvae. Thus, replacing existing screens at ESGS with fine mesh is infeasible and further evaluation of this technology is not warranted.

5.2.2 Fish Barrier Net

A fish net barrier is a mesh curtain installed in the waterbody in front of CWIS. All flow to the intake passes through the net so all aquatic life forms of a certain size are blocked from entering the intake. The net barrier is sized large enough to have very low approach and through net velocities of 0.1 ft/s or less to preclude impingement of juvenile fish with limited swimming ability. The mesh size must be large enough to preclude excessive fouling during normal station operation while at the same time small enough to effectively block passage of organisms into the intake. These conditions typically limit the mesh size such that adult and a percentage of juvenile fish can be blocked. However, the mesh is not fine enough to block most larvae and eggs. The fish net barrier could potentially meet the performance standards for reduction in IM, however it would not meet the performance requirements for reduction of entrainment of larvae and eggs.

Fish net barriers have been used successfully at large capacity power station once through cooling water intakes. The smaller the mesh size utilized, the lower the through-mesh velocity and the greater the net surface area required. A typical design loading rate for fish barrier nets is 20 gpm/ft^2. Therefore, a barrier net to handle the CWIS flow would require a net area of approximately 7,200 ft^2 for the Unit 1 & 2 CWIS (based upon existing facility design capacity) and 13,840 ft^2 for the Unit 3 & 4 CWIS. Maintaining such a fish barrier net in the open ocean moored around the existing intakes is not practical and would be a navigation hazard. In addition, this technology would not reduce entrainment and would not provide any reduction in IM over the existing velocity cap inlets. Therefore, further evaluation of this technology is not warranted.

5.2.3 Behavioral Barriers

A behavioral barrier relies on avoidance or attraction responses of the target aquatic organism to a specific stimulus to reduce the potential of entrainment or impingement. Most of the stimuli tested to date are intended to repulse the organism from the vicinity of the intake structure. Nearly all the behavioral barrier technologies are considered to be experimental or limited in effectiveness to a single target species. There are a large number of behavioral barriers that have been evaluated at other sites, and these are discussed separately below.

Air Bubble Curtain – Air bubble curtains have been tested alone and in combination with strobe lights to elicit an avoidance response in fish that might otherwise be drawn into the cooling water intake. Generally, results of testing the bubble curtain have been poor. Tests have been conducted with smelt, alewife, striped bass, white perch, menhaden, spot, gizzard shad, crappie, freshwater drum, carp, yellow perch, and walleye. Many species exhibited some avoidance response to the air bubble or the combination air bubble and light combination. This technology has some potential to enhance fish avoidance response in some species of fish. However, there are no reliable data for the species that may be susceptible to impingement at ESGS, and there is no way to estimate what type of reaction fish would have to the existing offshore intake with the addition of a bubble curtain. Therefore, there is no evidence to support that an air curtain would result in reduction of impingement or entrainment at the offshore cooling water intake. Further evaluation of this technology is not warranted.

Strobe Lights – There has been a great deal of research with this stimulus over the last 15 years to guide fish away from intake structures. The Electric Power Research Institute (EPRI) has co-funded a series of research projects and reviewed the results of other research in this field. In laboratory studies and field applications strobe lights were shown to effectively move selected species of fish away from the flashing lights. Most of the studies conducted to date have been with riverine fish species and for projects associated with hydroelectric generating facilities.

Laboratory testing was done for an application of strobe lights for the San Onofre Nuclear Generating Facility. Testing was conducted for white croaker, Pacific sardine and northern anchovy. Limited availability of test specimens and limited testing did not produce conclusive results and the CEC (2000) found this approach was not useful at this station. Few species similar to those collected in impingement sampling at ESGS have been tested for avoidance response either in the lab or in actual field studies. Based on studies of strobe lights conducted to date, it is likely that such studies conducted at ESGS would show differential effectiveness based on background light conditions (day vs. night), ambient seawater turbidity, and species composition. There is no evidence to suggest that strobe lights would reduce impingement or entrainment at the offshore cooling water intake. Further evaluation of this technology is not warranted.

Other Lighting – Incandescent and mercury vapor lights have also been tested as a behavioral stimulus to direct fish away from an intake structure. Mercury lights have generally been tested as a means of drawing fish to a safe bypass of the intake structure. Tests have not demonstrated a uniform and clearly repeatable pattern of attraction for all fish species. The mercury lights have been somewhat effective in attracting European eel, Atlantic salmon, and Pacific salmon. However, results with other species including American shad, blue back herring and alewife were more variable. One test with different life stages of Coho salmon shows both attraction to and repulsion from the mercury light. Testing with incandescent, sodium vapor and fluorescent lamps was more limited but also had variable and species specific results. Other lighting systems, as with most all the behavioral barrier alternatives, have not been tested with the species of fish common in the area of the ESGS. There is no evidence that these lights systems would reduce impingement or entrainment at the offshore cooling water intake. Further evaluation of this technology is not warranted.

Sound – Sound has also been extensively tested in the last 15 years as a method to alter fish impingement rates at water intake structures. Three basic groups of sound systems, including percussion devices (hammer, or poppers), transducers with a wide range of frequency output, and low frequency or infrasound generators, have all been tested on a variety of fish species. Of all the recently studied behavioral devices, the sound technology has demonstrated some clear success with at least one group of fish species. Clupeids, such as alewife, demonstrate a clear repulsion to a specific range of high frequency sound. Testing of this high frequency device on many other species, including weakfish, spot, Atlantic croaker, bay anchovy, American shad, blue back herring, alewife, white perch, and striped bass produced mixed results. Only the American shad and blue back herring demonstrated a similar and strong avoidance response. Although high frequency sound has potential for eliciting an avoidance response by the Alosid family (common name) of fish species, there is no data to demonstrate a clear avoidance response for the species of fish common to the ESGS cooling water intake. There is no evidence that a sound system would reduce impingement of fish at the ESGS intake. Further evaluation of this technology is not warranted.

6.0 OPERATIONS EVALUATION

The EPA 316(b) Phase II regulation [40 CFR 125.95(b)(1)(i)] requires that the PIC include a description of operational measures which will be evaluated further to determine feasibility of implementation and effectiveness in meeting IM&E performance standards at the facility. A preliminary screening of such measures has been conducted to determine those which offer the greatest potential for application at the facility and therefore warrant further evaluation. Operational measures have been screened based upon feasibility for implementation at the facility, biological effectiveness (i.e. ability to achieve reductions in IM&E), and cost of implementation (including additional power requirements and loss in generating capacity and unit availability).

Several operational measures have been proven effective in reducing IM&E at CWIS. Such measures include:

- CWIS flow reductions (e.g. capping capacity utilization rate)
- Variable speed drives for CWIS pumps
- Other cooling water efficiency improvements

The following is a discussion of operational measures for which further evaluation will be conducted to determine their potential for reducing IM&E at the ESGS CWIS. The results of the evaluation of such measures will be utilized to develop the plan for implementation of technologies, operational and/or restoration measures that will be proposed to achieve IM&E performance standards at the facility. Upon selection of the most appropriate operational measures, engineering design calculations and drawings, as well as estimates of expected reductions in IM and a schedule for implementation will be developed. This information will become part of the DCTP (or Site-Specific Technology Plan in the event that the facility chooses to seek a site-specific determination of BTA) and TIOP that will be included in the CDS to be submitted for the facility.

6.1 Circulating Water Flow Reduction / Caps

Circulating water flow caps are an operational control measure which would include administratively limiting the total withdrawal of cooling water from the Santa Monica Bay to an agreed upon value. The flow reductions may be scheduled for periods of the year when entrainment or impingement are highest to achieve a greater reduction to impingement and entrainment. Any reduction in flow reduces both entrainment and impingement effects associated with the operation of the plant. If flow reductions are concentrated during the seasons of the year that plankton life stages of species of concern are present, the overall seasonal reductions in fisheries impacts can greatly exceed the quantity of the flow reduction. Utilizing variable speed drive technology on the circulating water pumps could be an effective means of controlling total annual flow withdrawal.

6.2 Variable Speed Drives For Circulating Water Pumps

Variable-speed drives for circulating water pumps allow reduction in cooling water flow during periods when the unit is not operating at full-rated capacity, or during known periods of high entrainment. With this technology it would be possible to vary the speed of the motor from 10% to 100% and reduce the cooling water intake flow by up to 90%. Any reduction in flow reduces both entrainment and impingement effects associated with the operation of the plant. The lower pumping capacity allows for a lower approach velocity at the traveling screens and reduces the number of entrainable organisms drawn into the cooling water system. In addition, if flow reductions are concentrated during the seasons of the year that plankton life stages of species of concern are present, the overall seasonal reductions in fisheries impacts can greatly exceed the quantity of the flow reduction. The installation of variable speed drives will be evaluated further to determine the effectiveness in reducing IM&E at the ESGS cooling water intakes.

7.0 RESTORATION EVALUATION

The EPA 316(b) Phase II regulation [40 CFR 125.95(b)(1)(i)] allows the consideration of restoration measures as one of the options that may be implemented, either alone or in combination with technology and/or operational measures, to achieve performance standards for reduction in IM&E. Facilities may propose restoration measures that will result in an increase in the numbers of fish and shellfish in the waterbody that would be similar to those achieved with meeting performance standards through the implementation of technologies and/or operational measures. ESGS will conduct an evaluation of potential restoration measures that may be implemented in the event that it is determined that meeting performance standards through the implementation of technologies and/or operational measures alone is less feasible, less cost-effective, or less environmentally desirable than use of restoration measures.

7.1 Preliminary Selection Criteria

Habitat restoration projects that could potentially be used to offset impingement and entrainment losses at the ESGS, as determined by the results of studies proposed in Section 9.0, will be evaluated. The offsets calculated for each project will be based on a numerical comparison of the IM&E resulting from the operation of ESGS and the expected production of equivalent adults of the affected species resulting from the restoration efforts using various habitat models. The results of the restoration benefits analysis will be added to the ESGS's baseline credits to calculate the overall percent reduction in IM&E for comparison to the Phase II performance standard.

Any specific conservation, enhancement, or restoration project that is to be used for this purpose should have a nexus (i.e. relationship between the IM&E rates and the proposed restorartion project) to the IM&E effects of the power plant. The projects that will be evaluated to offset potential ESGS IM&E losses fall into three basic categories:

1. Projects that would directly restore or enhance coastal wetlands habitat in the vicinity of ESGS (Los Angeles and Orange Counties).
2. Projects that enhance habitat through watershed management, restoration, and enhancement.
3. Projects that enhance the nearshore coastal environment in the vicinity of the ESGS (Santa Monica Bay).

As an example, projects that result in the removal of accumulated sediment from coastal wetlands, would increase the coastal salt marsh habitat, which would, in turn, increase their biological productivity. Projects that restore the tidal flow between the ocean and the wetlands to historic levels would have a similar effect on productivity. Other projects that involve watershed management could reduce wetland sedimentation and thus preserve existing wetland habitat. Projects that enhance the biological productivity of the Bay could directly offset the loss of productivity in the same waterbody that occurs as a result of IM&E losses at the ESGS.

The "value" of the ecological services or benefits that will result from implementation of any of these restoration projects will be assessed using various habitat models to demonstrate that the ecological "credits" gained through restoration will outweigh the ecological "debits" caused by the IM&E losses.

7.2 Potential Restoration Measures

Using local environmental planning documents and resource agency recovery plans as references, projects that may be appropriate for inclusion as restoration alternatives to offset ESGS IM&E losses have been identified. These projects will create, restore and preserve habitat equivalent to the amount of habitat that produced the estimated numbers of impinged and entrained species of fishes and target invertebrates, as well as the other ecological and environmental effects of IM&E. Restoration projects that offset potential population effects of IM&E on specific species and at the same time contribute to the overall health of the Bay are presented.

The following is a list of potential restoration measures that will be evaluated to determine their feasibility of implementation, and potential efficacy in meeting IM&E performance standards at the ESGS:

- Restoration or Enhancement of Coastal Wetlands
    a. Re-establishment of tidal circulation
    b. Removal of concrete channels, weirs, and dams from historic wetlands
    c. Re-establishment of historic ocean/wetland channels
    d. Dredging to restore wetlands to historic depths
    e. Re-establishment of historic coastal lagoons
    f. Eradication of non-native/invasive plant species
    g. Restoration of the wetland ecosystems

- Restoration or Enhancement of Coastal Watershed
    a. Restoration of historic creek flows
    b. Eradication of non-native/invasive plant species
    c. Removal of manmade channels, weirs, and dams where necessary
    d. Sedimentation reduction
    e. Removal of fill and debris from historic channels
    f. Replanting of native vegetation

- Restoration or Enhancement of Nearshore Habitat
    a. Restoration of kelp beds
    b. Restoration of natural resources in intertidal habitats

c. Construction of artificial reefs
d. Fish hatchery and restocking programs

A preliminary screening of these potential restoration measures will be conducted to determine which projects warrant further evaluation. Selected projects will be evaluated further based upon the criteria described below.

7.3 Project Restoration Evaluation Criteria

Prospective habitat restoration projects will be evaluated based upon a number of criteria, which would include the following:

- Location
- Nexus to ESGS IM&E effects
- Basic need or justification for project
- Technical feasibility
- Stakeholder acceptance
- Ability to measure performance
- Nature and extent of ecological benefits
- Time before benefits accrue
- Duration of benefits
- Success of comparable restoration projects
- Consistency with ongoing resource agency work and environmental planning
- Implementation costs
- Cost / benefit

Depending upon the nature of a particular project, the relative importance and weighting of these criteria may vary. As a general proposition, however, projects will be selected so as to maximize the offset of ESGS IM&E effects for compliance with 316(b) and to optimize ecological benefits to the Bay or adjacent offshore areas within the Southern California Bight.

The evaluation results of each restoration measure will be utilized to develop an overall plan for implementation of technologies and operational and/or restoration measures that will be proposed to achieve IM&E performance standards at the facility. Upon selection of the most appropriate restoration measure(s), design calculations and drawings, estimates of expected increases in fishes and invertebrates that would offset IM&E losses and a schedule for implementation will be developed. This information will become part of the Restoration Plan (RP) that will be included in the CDS to be submitted for the ESGS.

8.0 OTHER COMPLIANCE OPTIONS FOR ESGS

Two additional compliance alternatives that ESGS may pursue in the course of developing the most appropriate CDS for the ESGS CWIS include a site-specific determination of BTA and a trading approach for cooperative restoration solutions. The site-specific determination option would be undertaken only in the event that implementation of some combination of an intake technology, operation change or restoration is significantly greater in cost than anticipated at this time. The trading program compliance alternative would involve ESGS teaming with other water users in the area to develop a more comprehensive solution to reduce or mitigate for IM&E with a cooperatively funded technology or restoration alternative. ESGS has no specific plans and has not developed potential teaming partners to pursue this compliance alternative at this time. However, ESGS will remain open to exploring this compliance alternative if the right opportunity is identified prior to submittal of the CDS.

8.1 Site-Specific Determination of BTA

The intent of the ESGS approach to compliance is to meet the entrainment and impingement performance standards established by the EPA when the new rule was promulgated. That is, ESGS hopes to demonstrate that the El Segundo intake has reduced the effects of entrainment by 60 to 90% and reduced the effects of station operation on impingement mortality by 80 to 95% from the calculation baseline. However, ESGS also recognizes that if the costs of reaching these goals cannot reasonably be achieved that the EPA 316(b) Phase II regulation allows a somewhat lower IM&E reduction standard. Specifically the new rule would allow ESGS to demonstrate that the ESGS facility is eligible for a site-specific determination of BTA to minimize IM&E and that ESGS has selected, installed, and is properly operating and maintaining, or will install and properly operate and maintain, design and construction technologies, operational measures, and/or restoration measures that the Director has determined to be the BTA to minimize adverse environmental impact of ESGS cooling water operations.

This compliance alternative allows the ESGS facility to request a site-specific determination of BTA for minimizing IM&E if ESGS can demonstrate that the costs for compliance with the new rule are significantly greater than those considered by EPA in the development of the rule (cost/cost test) or that the costs associated with compliance are significantly greater than the benefits (cost/benefit test) that would accrue to the environment.

8.1.1 Cost/Cost Test

If ESGS chooses to seek a site-specific determination of BTA, a cost/cost test will be performed to compare the cost of implementing options to achieve full compliance with the 316(b) Phase II standards to costs estimated by the EPA for the ESGS facility for achieving full compliance. In the 316 (b) Phase II rule, the EPA has assumed that the ESGS facility would already meet the performance standards based on existing technologies and measures already in place. Therefore EPA has projected zero compliance costs for the ESGS facility (Federal Register, Vol. 69 – 7/9/2004, page 41677 – see Facility ID# DNU2047). This determination was confirmed in a letter from EPA to ESGS dated February 17, 2005 (a copy of this letter has been included in Appendix B).

ESGS will only pursue this alternative if the costs of compliance for all possible alternatives that meet the performance standards are significant. ESGS will pursue this approach with a three-step method as follows:

1. Identification of feasible options for achieving full compliance (e.g. combinations of engineering, operational, and restoration actions);
2. Estimation of the dollar costs of implementing these actions (including capital, O&M, and lost generation revenue due to extended outages); and,
3. Comparison of the total estimated cost of compliance based upon the compliance options identified with EPA's estimated cost of compliance for the facility in question.

One thing that has not been fully resolved by EPA is what constitutes "significant" compared to the zero dollars that EPA projected for ESGS. ESGS will develop its perspective on what constitutes significant during the development of the CDS. It is likely that significance will be judged from the perspective of the capital and operating costs and revenues from the operation of ESGS, including the planned operation of the replacement combined cycle units.

8.1.2 Cost/Benefit Test

A cost/benefit test may also be performed for ESGS to compare the total costs of achieving compliance with the environmental benefits through implementation of the required technologies, operational, and/or restoration measures. Costs are the sum of direct costs and the indirect costs of any intake, operational or restoration mitigation actions. Direct costs include the costs of implementing compliance alternatives, including capital, O&M, and lost generation revenue due to extended outages. Indirect costs include any costs associated with impairment of navigation, higher energy prices, and negative ecological effects of the mitigation actions on the waterbody. An initial phase of the cost/benefit test will identify whether any of these indirect cost elements are relevant at ESGS. The cost/benefit test would specify the nature of the relevant direct and indirect cost components at the facility.

The benefits arise from reducing IM&E by the full amount of the 316(b) Phase II rule's performance standard relative to baseline conditions. The economic benefits of reductions in IM&E have been specified by the EPA in its evaluation of the national benefits of the rule. The classes of benefits identified by EPA in its assessment include direct use benefits (e.g. those from commercial and recreational fishing), indirect use benefits (e.g. increased forage organisms), and existence, or passive use benefits (e.g. improved biodiversity). These benefits are based on standard definitions of value used by economists in cost/benefit analysis. Methods for quantifying benefits to commercial and recreational fishing and other changes in natural resources have been widely employed by environmental and natural resource economists over the past several decades.

The exact nature of the data and methods required for a cost/benefit analysis will vary depending upon the magnitude of the potential IM&E effects on a local and regional scale, the availability of existing economic benefit studies that may be applied, as well as the comments of the regulators and natural resource agencies involved with reviewing this PIC. These can vary widely and will not really be well understood until the results of the IM&E study are complete. When the IM&E study is complete, the numbers of each species affected by operation of the intake can be quantified, and then a value for each species affected by IM&E at the ESGS CWIS can be developed.

The benefit studies would be undertaken using a phased approach. Following an initial scoping phase to determine the approach to conducting a cost/benefit analysis, an outline of a benefits assessment approach will be determined. ESGS will develop an approach to conducting a benefits valuation for use in supporting a site-specific determination of BTA if that becomes the selected approach for meeting compliance with the new rule The approach will address the following requirements for such a study as outlined in the Phase II rule:

1. Description of the methodologies to be used to value commercial, recreational, and other ecological benefits.
2. Documentation of the basis for any assumptions and quantitative estimates.
3. Analysis of the effects of significant sources of uncertainty.

If restoration is a component of the compliance approach, the ability of the restoration project(s) to generate benefits to offset impingement and/or entrainment effects must be demonstrated. This requires specification of a metric that can be used to quantify restoration benefits in a manner comparable to entrainment and impingement effects in the ecosystem.

Habitat assessment methods will be used for assessing the relative value of restoration actions. The approach taken will be to:

1. Identify the key species of concern affected by the facility;
2. Identify critical factors or habitat needs for those species;

3. Identify technically feasible and cost-effective restoration actions that address such critical factors and needs factors; and
4. Choose an appropriate ecological metric for scaling effects of mitigation and/or enhancing habitat needs within the adjacent ecosystem or area.

For example, if it is determined that the restoration project needs to compensate for entrainment of a species for which spawning habitat is a limiting factor, then creation of sufficient new spawning habitat to increase the population by the amount of entrainment would be required for full compliance with the Rule. This would then translate to acreage of created habitat with certain required structural characteristics.

If entrainment losses are of key concern, and the population of associated fish is of less concern, then biomass could also serve as the metric. The present value of the entrained biomass would be computed as the ecological debit. Then, a wetland or other habitat creation project could be scaled in size to produce the equivalent present value of biomass from the primary productivity of the wetland or new habitat.

8.1.3 Evaluation of a Site Specific BTA

The 316(b) Phase II Rule allows facilities to seek site-specific determinations of BTA if it can be demonstrated that the costs of achieving full compliance with the IM&E performance criteria at a facility are either:

1. Significantly greater than those considered by the EPA in development of the rule (cost/cost test), OR
2. Significantly greater than the net environmental benefits to be achieved (cost/benefit test).

If either of these methods is implemented, ESGS may propose this as the compliance approach if the costs are significantly higher than either the expected costs at the time the rule was promulgated or, for the amount of benefits that would be derived.

8.2 Trading For Cooperative Mitigation Solutions

In the preamble to the EPA 316(b) Phase II rule, as published in the Federal Register (Vol. 69, No. 131, pgs 41576 - 41693), there is a discussion of the role of trading under the rule (VII. F.2). The preamble describes how trading "…raises complex issues on how to establish appropriate units of trade and how to measure these units effectively given the dynamic nature of the populations of aquatic organisms subject to impingement mortality and entrainment." However, EPA suggests that delegated authorities responsible for implementing the 316(b) Phase II rule wishing to develop trading options "…would be best off focusing on programs based on metric of compatibility between fish and shellfish gains and losses among trading facilities.". This section of the rule also states that if the delegated NPDES authority can demonstrate to the EPA

Administrator that they have adopted a NPDES program within a watershed that provides for comparable reductions in IM&E, then the EPA Administrator must approve such alternative compliance alternative requirements.

ESGS may consider a watershed-approach trading program as a possible compliance alternative if the right combination of the coastal water users identify mutual goals for achieving compliance, either in whole or in part, with the new rule. ESGS has not developed any specific alliance of water dependent organizations to implement such a watershed-approach trading compliance alternative. However, ESGS expects that after field studies have characterized CWIS effects, that restoration may be the most feasible and cost-effective measure to meet the performance standards. This might be done alone, or in combination with other intake technologies or operational modifications. However, it might well be that different technologies implemented to achieve CWIS compliance at different electric generating facilities may result in mutual benefits for the regional ecosystem. If mutual benefits of mitigation are identified among different generating facilities, then ESGS would then consider establishing a trading program with other generating facilities to achieve the lowest cost, most comprehensive and effective method to comply with the new 316 b rule.

ESGS will remain open to seeking comprehensive solutions to the IM&E issues in the region and develop a plan for compliance with the possible cooperation of other water users such that the issue is addressed in the most comprehensive manner for the regional ecosystem.

9.0 IMPINGEMENT MORTALITY & ENTRAINMENT SAMPLING

An IM&E sampling program will be conducted to characterize the fishes and shellfish affected by impingement and entrainment by the CWIS at the ESGS. The data from the study will be used in calculating baseline levels of IM&E against which compliance with performance standards will be measured. A detailed IM&E sampling plan has been developed and is included as Attachment C.

As required in 40 CFR 125.95(b)(3), the results of the IM&E sampling program will be summarized in a report submitted as part of the CDS that will include the following:

- Taxonomic identifications of all life stages of fish, shellfish, and any threatened or endangered species that are collected in the vicinity of the CWIS and are susceptible to IM&E
- Characterization of all life stages of the target taxa in the vicinity of the CWIS and a description of the annual, seasonal, and diel variations in IM&E
- Documentation of the current level of IM&E of all life stages of the target taxa

The results of the IM&E study will be presented in an IM&E Characterization Study Report that will be included in the CDS submitted for the ESGS.

The goal of the proposed study is to characterize the fishes and shellfish affected by IM&E at the two CWIS at the ESGS. The EPA 316(b) Phase II rule allows “historical data that are representative of the current operation of your facility and of biological conditions at the site.” Impingement data at ESGS has been collected regularly since the early 1970s. Since 1998 impingement sampling has been collected monthly during normal plant operations and also during all heat treatment procedures. The long time series of existing impingement data provides an adequate data set for estimating baseline impingement levels. Therefore this plan proposes continuing impingement sampling during heat treatments and at the current monthly sampling interval and conducting a year-long study to characterize larval entrainment at the ESGS.

The proposed studies will examine losses at the ESGS resulting from impingement of juvenile and adult fishes and macroinvertebrates on traveling screens during normal operations and during heat treatment operations and entrainment of ichthyoplankton and invertebrates into the cooling water intake system. The proposed sampling methodologies and analysis techniques are derived from recent impingement and entrainment studies conducted for the AES Huntington Beach Generating Station (MBC and Tenera 2005), the Duke Energy South Bay Power Plant (Tenera 2004), and the Cabrillo Power I LLC, Encina Power Station. The studies at Huntington

Beach were performed as part of the CEC CEQA process for permitting power plant modernization projects, while the South Bay and Encina projects were for 316(b) compliance.

9.1 Assessment of Cooling Water Intake System Effects

Considerable effort among regulatory agencies and the scientific community has been expended on the evaluation of power plant intake effects over the past three decades. Power plant intake effects occur due to impingement of larger organisms onto the intake screens and entrainment of organisms into the CWIS that are smaller than the screen mesh on the intake screens. For the purposes of the proposed study we assume that both processes lead to mortality of all impinged and entrained organisms. The variety of approaches developed reflects the many differences in power plant locations and resource settings (MacCall et al. 1983). The various approaches have been divided into those that offer a judgment on the presence or absence of impact and those that describe the sensitivity of populations to varying operational conditions. These efforts have helped to establish the context for the modeling approaches proposed to estimate impingement and entrainment effects at the ESGS.

Impact assessment approaches that will be considered for this evaluation include:

- Adult-Equivalent Loss (*AEL*) (Horst, 1975; Goodyear, 1978),
- Fecundity Hindcasting (*FH*) proposed by Alec MacCall, NOAA/NMFS, and is related to the adult-equivalent loss approach, and
- Empirical Transport Model (*ETM*), which is similar to the approach described by MacCall et al. (1983), and used by Parker and DeMartini (1989).

The application of several models to estimate power plant effects is not unique (Murdoch et al. 1989; PSE&G 1993; Tenera 2000a; Tenera 2000b). Equivalent Adult Modeling (*AEL* and *FH*) is an accepted method that will be used at ESGS and has been applied in other 316(b) demonstrations (PSE&G 1993; Tenera 2000a; Tenera 2000b). The advantage of these demographic modeling approaches is that they translate losses into adult fishes that are familiar units to resource managers. The estimates from these demographic models can be combined with estimated losses to adult and juvenile organisms due to impingement to provide combined estimates of cooling water system effects. The *ETM* has been proposed by the USFWS to estimate mortality rates resulting from cooling water withdrawals at power plants (Boreman et al. 1978, 1981). The *ETM* estimates the conditional mortality due to entrainment while accounting for spatial and temporal variability in distribution and vulnerability of each life stage to power plant withdrawals. The *ETM* provides an estimate of power plant effects that may be less subject to inter-annual variation than demographic model estimates. It also provides an estimate of population-level effects not provided by demographic approaches. A description of each of these models and how they will be used to evaluate data collected in the IM&E study is included in the study plan.

The assessment approach used in the final report that will be submitted as part of the CDS for the ESGS will also depend upon the facility's baseline calculations and its method(s) of compliance with the 316(b) Phase II performance standards for reductions in IM&E. Compliance at ESGS may be achieved singly, or in combination, through technological or operational changes to the CWIS, restoration methods, and site-specific BTA standards. In order to demonstrate compliance it is only necessary to analyze IM&E data to determine baseline levels and assess the improvements achieved through the implementation of the technological or operational changes. In the case where restoration is limited to only commercially or recreationally important species, entrainment data may also be adequate to assess the levels of restoration necessary to offset IM&E losses, assuming that scientifically valid population models exist for the species providing the lost benefits. In assessing compliance with the performance standard in whole or in part through restoration of habitat to include non-use species in addition to the losses of recreational and commercial species it is necessary to assess the entrainment and impingement losses from the source water using a combination of assessment methods to determine the commensurate level of restoration. The same source water and entrainment data, and assessment methods would also be used to determine a site-specific BTA standard based on cost-benefit analysis of both use and non-use entrainment losses. Source water data would not be necessary for cost-benefit analysis based simply on the value of commercial and recreational species losses.

9.2 Target Species

Assessment of CWIS effects will be conducted on the most abundant organisms in the samples, and commercially or recreationally important species from entrainment and intake samples.

Impingement

Estimates of annual impingement will be calculated for all the target organisms, but assessment of CWIS impingement effects will only be conducted on the most abundant organisms in the samples. The assessment may also include other commercially or recreationally important taxa from the samples. All fishes and macroinvertebrates will be collected from impingement samples and identified, but the following groups of marine organisms will be enumerated, weighed, and measured.

Vertebrates:	**Invertebrates:**	
fishes	crabs	shrimp
	squid	octopus
	California spiny lobster	

Entrainment

Estimates of annual impingement will be calculated for all the target organisms, but assessment of CWIS entrainment effects will only be conducted on the most abundant organisms in the samples, and commercially or recreationally important taxa from entrainment and intake samples. The following groups of marine organisms will be sorted, identified and enumerated from entrainment intake and source water plankton samples:

Vertebrates:	**Invertebrates:**
fishes (all life stages beyond egg)	rock crab megalopal larvae (*Cancer* spp.)
	market squid hatchlings [larvae] (*Loligo opalescens*)
	California spiny lobster phyllosoma larvae (*Panulirus interruptus*)

These groups were also analyzed in most of the recent entrainment studies in southern California, including the AES Huntington Beach Generating Station (MBC and Tenera 2005). Fishes and rock crab larvae were selected because of their respective ecological roles or commercial and/or recreational fisheries importance. Market squid and California spiny lobster were selected because of their commercial and/or recreational importance in the area.

The organisms that will be analyzed will be limited to taxa that are sufficiently abundant to provide reasonable assessment of impacts. For the purposes of this study plan, we propose to limit the assessment to the most abundant taxa that comprise 90% of all larvae entrained and/or juveniles and adults impinged by the ESGS. The most abundant organisms are used in the assessment because they provide the most robust and reliable estimates of CWIS effects. Since the most abundant organisms may not necessarily be the organisms that experience the greatest effects on the population level, the data will be examined carefully before the final selection of target species to determine if additional species should be included in the assessment. This may include commercially or recreationally important species, and species with limited habitats.

Fish eggs will not be sorted or identified because a full assessment of their abundance would require different sampling techniques and they cannot be identified to the same taxonomic levels as fish larvae. Even if eggs are not quantified from the entrainment and source water samples, entrainment effects on fishes with planktonic eggs will be accounted for in the ETM model by adding the time period that eggs are planktonic to the estimate of the time period that larvae are at risk of entrainment. This approach assumes that the proportional mortality estimate used in the modeling of larval entrainment also applies to egg mortality.

9.3 Impingement

Impingement sampling at the ESGS has been conducted since the early 1970s and the data from these studies are summarized in Section 3.0. The existing NPDES permit for the plant requires regular sampling during periods of normal operation and during all heat treatment procedures. Since 1998 impingement sampling during normal operations has occurred monthly. The results from the two types of surveys are combined to obtain an estimate of the total impingement for the year. A normal operation survey is defined as a sample of all fish and macroinvertebrates entrained by water flow into the ESGS intake and subsequently impinged and removed by the traveling screens during a 24-hour period. Impingement abundance and biomass for the entire year is estimated by extrapolating the impingement rates measured during each survey using the total flow for the period between surveys and then combining the estimates for all of the surveys.

Impingement sampling at ESGS will occur over a 24-hour period one day per month for an entire year. The operating status of the circulating water pumps will be recorded on an hourly basis during the collection period. Each 24-hour sampling period at the traveling screens will be divided into four 6-hour cycles. The impinged material from the traveling screens will be rinsed into the collection baskets associated with each set of screens. A log containing hourly observations of the operating status (on or off) of the circulating water pumps for the entire study period will be obtained from the power plant operation staff. This will provide a record of the amount of cooling water pumped by the plant, which will then be used to calculate impingement rates. In addition to the regular monthly sampling that will conducted under normal plant operations, sampling will be conducted during any heat treatment procedures during the year that are conducted at the facility for the purposes of controlling biofouling of the intake conduit. During heat treatment surveys, all material impinged onto the traveling screens is removed from the forebay, identified, counted, and measured using the same procedures used for normal operations surveys. Six to eight heat treatments may occur during the one-year study period.

9.4 Entrainment

To determine composition and abundance of ichthyoplankton and target invertebrates entrained by the generating station, sampling in the immediate proximity of the cooling water intakes will be conducted once per month from January through December 2006.

Monthly sampling will be performed to determine composition and abundance of ichthyoplankton in the source water. The source water sampling design is being proposed because of the need to extrapolate densities offshore and alongshore to determine the appropriate source water area during each survey. Besides the entrainment stations, source water sampling is proposed at ten additional source water stations upcoast, downcoast, and offshore from the ESGS and SGS intake structures (see Figure 8-1 below). Two stations will be located 1.2 and 2.4 miles upcoast and downcoast from the midpoint between the ESGS and SGS intake structures along the 33 ft isobath. Six additional stations will be sampled offshore from the inshore line of stations, with three stations located along the 66 ft isobath and three stations along the 99 ft isobath (Figure 9-1).

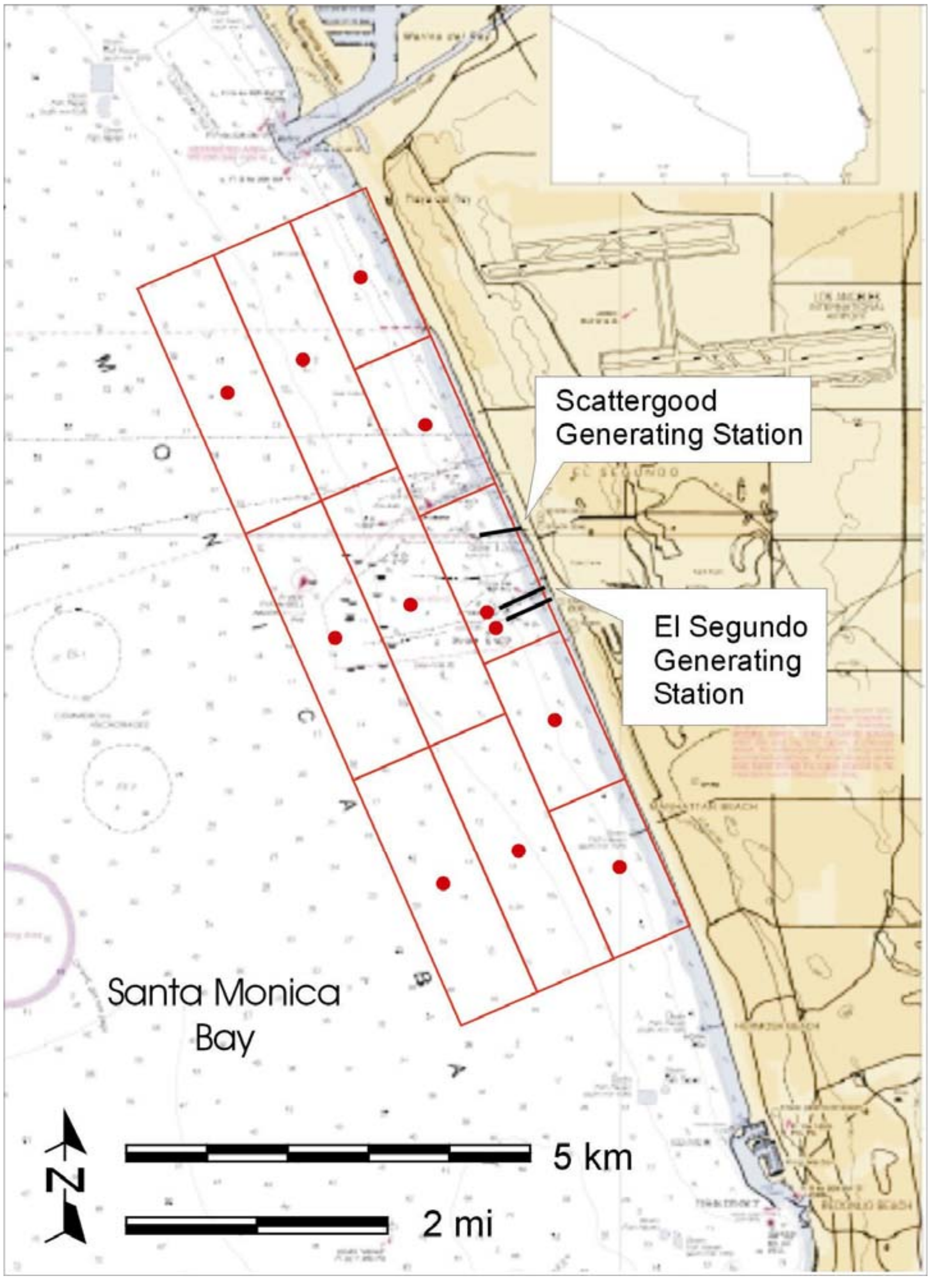

Figure 9.1: Location of Entrainment and Source Water Sampling Stations

This sampling grid is similar in design to the study of cooling water system effects at the AES Huntington Beach Generating Station (MBC and Tenera 2005), but was modified to allow for a more complete characterization of the distribution of organisms alongshore and offshore. This is necessary because the distribution of organisms within the sampling area is used to extrapolate densities alongshore using current displacement and offshore using a regression model of density and distance offshore. These extrapolations are used to estimate the population in the source water.

10.0 SUMMARY

This PIC has been prepared in accordance with 40 CFR 125.95(b)(1) and is being submitted to the LARWQCB prior to implementation of information collection activities. The following is a brief summary of the information collection activities described in this document that will be undertaken to support the development of the CDS, the plan for compliance with IM&E performance standards outlined in the EPA 316(b) Phase II rule.

10.1 Evaluation of IM&E Reduction Measures

ESGS has selected several intake technologies, operational measures, and restoration measures that will be evaluated to determine effectiveness and feasibility of implementation, either alone or in combination, to achieve the required reductions in IM&E. In summary, these include the following:

Intake Technologies:

1. Velocity Cap Inlet (existing intake technology)
2. Modified traveling screens with fish buckets and fish return
3. Cylindrical wedgewire screens
4. Aquatic filter barrier system

Operational Measures:

1. Circulating water flow reductions / caps
2. Variable speed drives for circulating water pumps

Restoration Measures:

1. Coastal wetland projects (various)
2. Coastal watershed projects (various)
3. Nearshore coastal projects (various)

Preliminary assessments of these IM&E reduction measures will be conducted to determine those which warrant further evaluation. A more detailed evaluation of those measures will be conducted and a combination of the most feasible measures proposed to meet IM&E performance standards will be presented in the CDS.

10.2 Impingement Mortality & Entrainment Sampling Plan

The proposed IM&E Characterization Study Plan is included in Attachment C. The study plan calls for collection of twelve months of impingement and entrainment sampling data at the ESGS to supplement recent impingement baseline studies and to measure entrainment at the ESGS.

The following are the main components of the sampling effort:

Impingement:

1. Monthly impingement sampling at each CWIS during normal plant operations
2. Impingement sampling at the Unit 3 & 4 CWIS during each heat treatment cycle

Entrainment:

1. Monthly entrainment sampling at each CWIS
2. Source waterbody sampling at several locations in the vicinity of the CWIS intakes

The characterization study plan also describes the sampling, quality assurance / quality control (QA/QC), and data management procedures that will be used in the study. Results of the study will be used to:

1. Determine the current level of IM&E occurring at each CWIS.
2. Compare the level of IM&E occurring due to the location, design, and operation of each existing CWIS with that which would occur if the CWIS were designed as a "calculation baseline" intake.
3. Determine the additional level of reduction in IM&E that would be required to meet performance standards.
4. Assist in the determination of the most feasible combination of intake technologies, operational measures, and/or restoration measures that may be implemented to reduce IM&E to vulnerable species.

10.3 Agency Review of PIC

As required by the EPA 316(b) Phase II regulation, this PIC is being submitted prior to information collection activities and in accordance with the schedule requested by ESP in a September 23, 2004 letter to the LARWQCB. The regulation requires that the LARWQCB *"provide their comments expeditiously (i.e. within 60 days) to allow facilities time to make response modifications in their information collection plans"* (Federal register, Vol. 69, No. 131, Pg. 41635). ESP anticipates that LARWQCB approval of the PIC will be received such that the IM&E sampling plan may be implemented in January 2006.

10.4 Implementation Schedule

ESGS plans to conduct sampling from January though December 2006. The results of the sampling program will be presented in a IM&E Characterization Study Report to be included as part of the CDS. The sampling schedule is subject to change if the LARWQB review and approval of the PIC is delayed.

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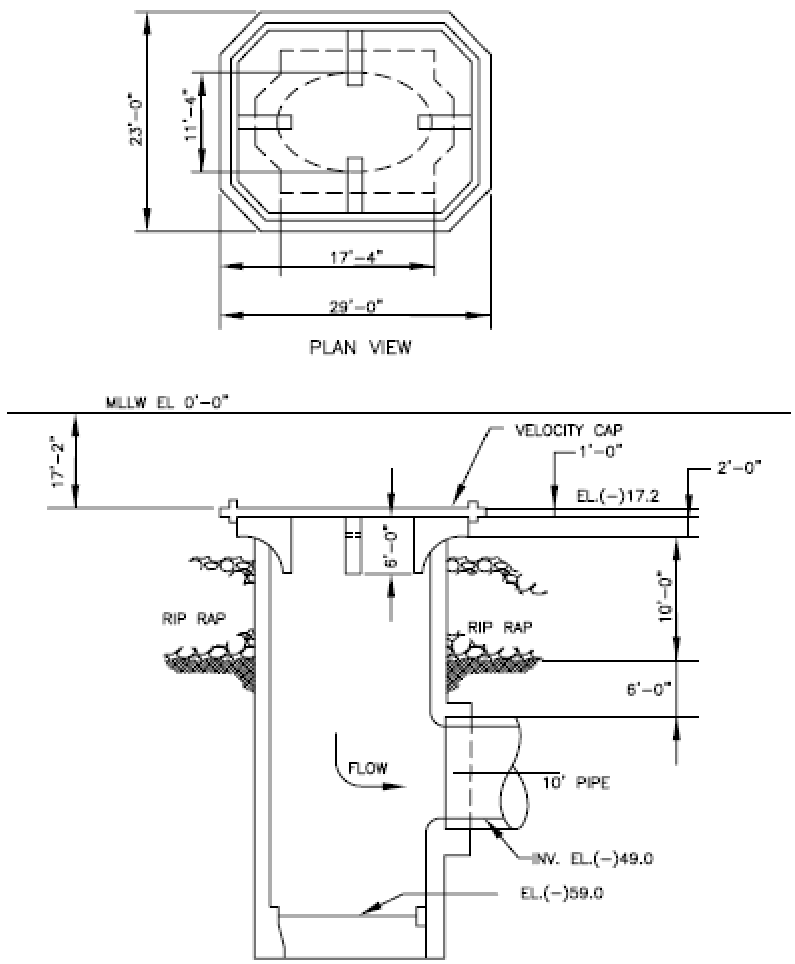
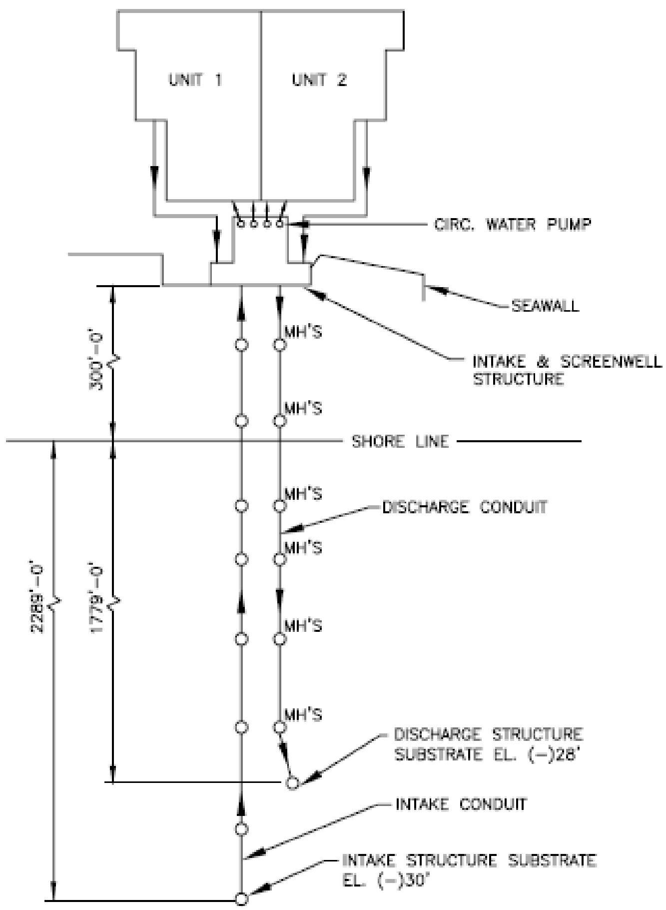
Attachment A
Structural Design Drawings



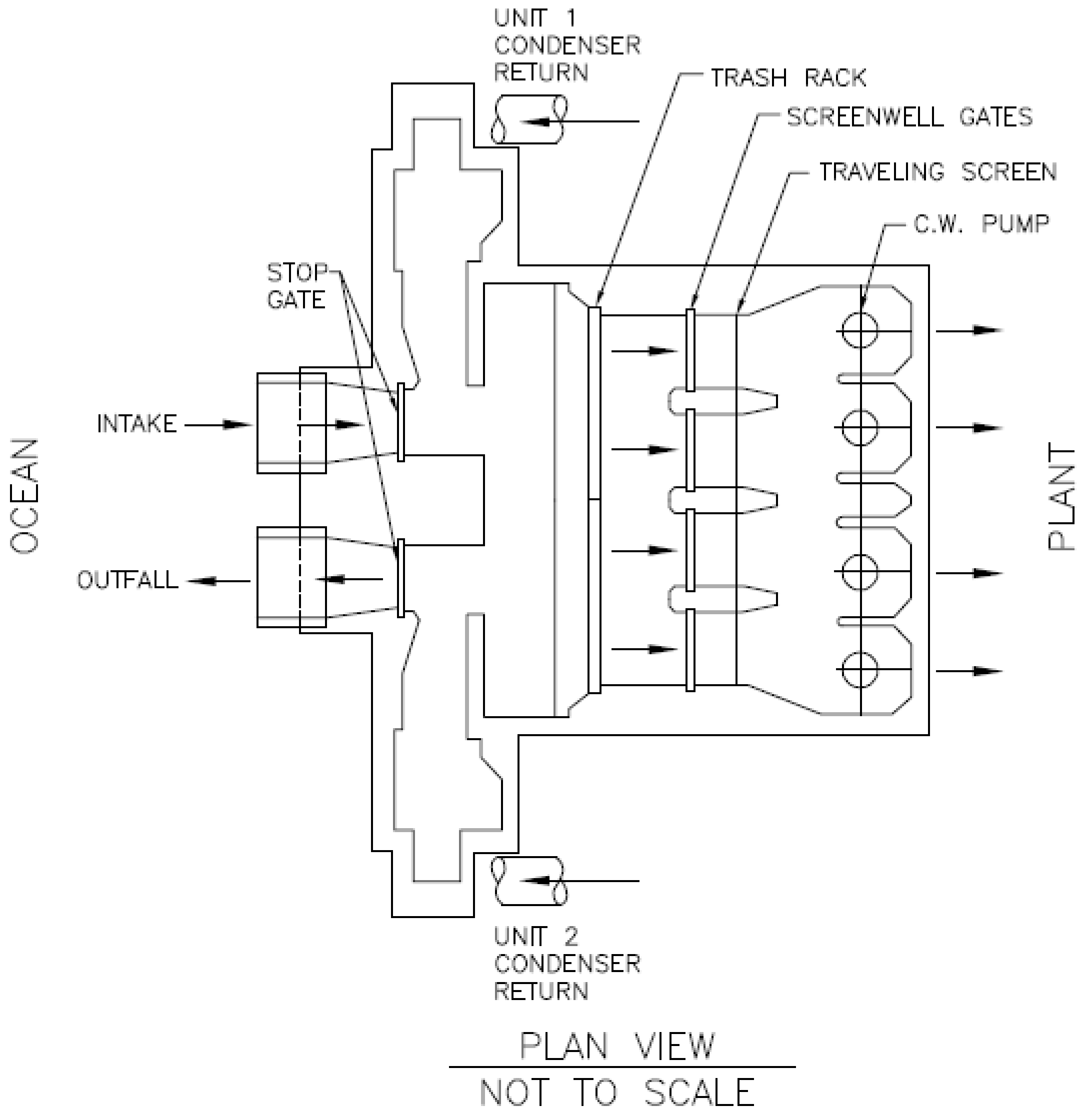
Shaw™ Shaw Environmental, Inc.

Figure A-1
Unit 1 & 2
Velocity Cap Inlet
Detail



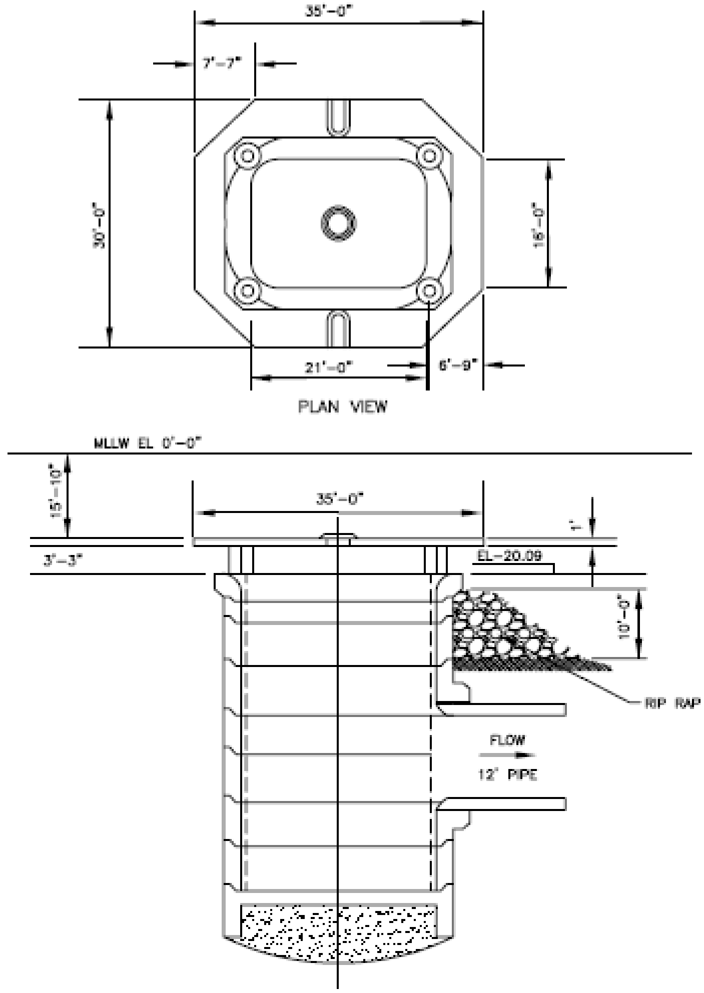
Shaw Environmental, Inc.

Figure A-2
Unit 1 & 2
Cooling Water Intake & Discharge
Piping Layout



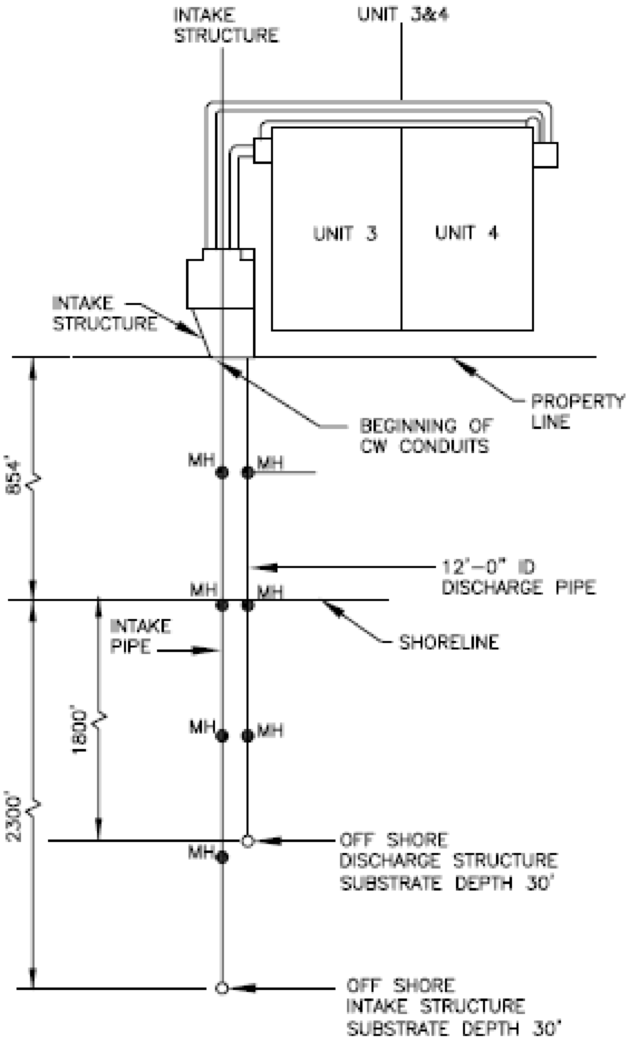
Shaw™ Shaw Environmental, Inc.

Figure A-3
Unit 1 & 2
Screenwell Structure



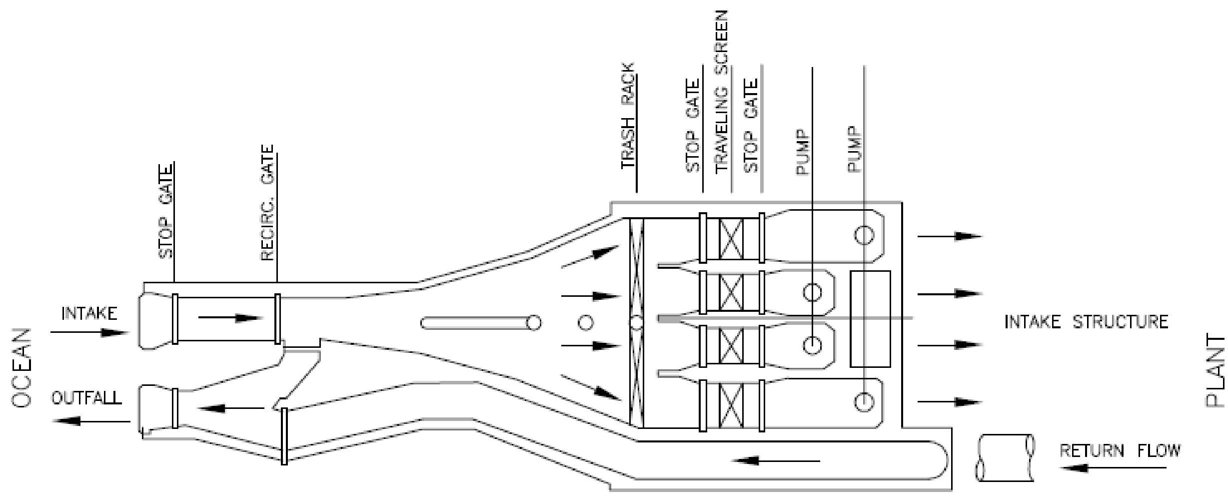
Shaw Environmental, Inc.

Figure A-4
Unit 3 & 4
Velocity Cap Inlet
Detail



Shaw™ Shaw Environmental, Inc.

Figure A-5
Unit 3 & 4
Cooling Water Intake & Discharge
Piping Layout



PLAN VIEW
NOT TO SCALE

Shaw™ Shaw Environmental, Inc.

Figure A-6
Unit 3 & 4
Screenwell Structure

Attachment B
Correspondence Related to 316(b) Issues

El Segundo Power, LLC
301 Vista Del Mar
El Segundo, CA 90245

Phone: 310.615.6387
FAX: 310.615.6060

September 23, 2004

John Bishop, P.E.
C/O California Regional Water Quality Control Board
Los Angeles Region
ATTN: Technical Support Unit
320 W 4th Street, Suite 200
Los Angeles, CA 90013

RE: <u>Request for Schedule to Submit Information to Comply with the Phase II 316(b) Rule (40 CFR Part 125 Subpart J)</u>

Dear Sir,

By this letter El Segundo Power, LLC (ESP) requests a schedule for submitting the information required by EPA's new Phase II 316(b) Rule for cooling water intake structures for the El Segundo Generating Station (ESGS). For the reasons to be presented in the following letter, ESP requests your approval to allow the information required by 40 CFR 125.95 to be submitted to you no later than January 7, 2008. In our circumstances, this date is as "expeditious as practicable." The basis for our request is explained below.

As you know, on July 9, 2004, EPA published its final rule prescribing how "existing facilities" may comply with Section 316(b) of the Clean Water Act. 69 Fed. Reg. 41575, 41683 (July 9, 2004). For most existing faculties, this rule will require a large amount of data to establish "best technology available" for the facility's intake structure and to demonstrate compliance with the rule.

ESGS is a "Phase II existing facility" within the meaning of 40 CFR 125.91. As such, it is required to comply with the Phase II rule, and in particular to submit the studies and information required by 40 CFR 125.95.

Section 125.95 of the new rule requires detailed studies and other information to establish what intake structure technology or other measures will be used to comply with the rule. Ordinarily this material is to be submitted with the facility's next application for renewal of its NPDES permit. See 40 CFR 125.95, 122.21(r)(1)(ii), 122.21(d)(2). For permits that expire less than four years after the rule was published on July 9, 2004 (that is, before July 9, 2008), the facility may have up to three and half years to submit the information, so long as it is submitted "as expeditiously as practicable." See 40 CFR

125.95(a)(2)(ii). The facility may have even longer, until the end of the permit term, under 40 CFR 122.21(d)(2)(i), if the permitting agency agrees.

The current NPDES permit for ESGS expires on May 10, 2005, well before July 9, 2008. Therefore, ESP hereby requests that you authorize the information called for by 125.95 to be submitted as expeditiously as practicable, which, as explained below, will require until January 7, 2008.

In order to satisfy the "expeditiously as practicable" requirement, it should be noted that ESP began the process of collecting the necessary information even before the final rule was published. ESP actually began as early as last year to begin collecting information and conducting internal evaluations on how the, at that time draft, requirements could be complied with at ESGS. Such information collection included preliminary technology assessments and research into existing data and information. ESP has also actively participated in the Los Angeles Regional Water Quality Control Board's (Board) initiation of 316(b) Working Group meetings, including the first meeting held on August 28, 2003, and also by hosting the most recent meeting at our ESGS site on July 12, 2004.

Despite our early efforts, we will still need until January 7, 2008, to complete the studies and collect the information required by 40 CFR 125.95. Our detailed explanation is presented below by first summarizing the significant number of informational requirements that must be submitted and then concludes by presenting the schedule by which the information would be submitted.

Cooling Water System Data

First, all facilities covered by the Phase II Rule must submit "cooling water system data" as required by 40 CFR 122.21(r)(5). This includes a narrative description of the operation of the cooling water system, its relationship to cooling water intake structures, the proportion of the design intake flow that is used in the system, the number of days of the year the cooling water system is in operation, and the seasonal changes in the operation of the system, if applicable. It also includes design and engineering calculations prepared by a qualified professional and supporting data to support the description of the operation of the cooling water system. See 40 CFR 122.21(R)(5)(i) and (ii). This information must be submitted at the same time as the Comprehensive Demonstration Study as discussed below. See 40 CFR 125.95(a)(2).

Proposal for Information Collection

Under 40 CFR 125.95(a)(1), ESP must also submit a Proposal for Information Collection (PIC). Preparing the PIC is a large undertaking. The PIC must contain the items listed in 40 CFR 125.95(b)(1), including a description of proposed and/or implemented technologies, operational measures, and/or restoration measures to be evaluated, a list and description of historical studies characterizing impingement mortality and entrainment and/or the physical and biological conditions in the vicinity of the cooling water intake structures and their relevance to the proposed study. For existing data, it must demonstrate the extent to which the data are representative of current conditions and that the data were collected using appropriate quality assurance/quality control procedures. The PIC must also include a summary of past or ongoing consultations with federal, state and tribal fish and wildlife agencies and a copy of their written comments, as well as a sampling plan for any new field studies describing all methods and quality assurance/quality control procedures for sampling and data analysis.

Because of the magnitude and specialized nature of the information to be submitted in the PIC, it is likely that ESP will have to contract with an outside consulting firm to obtain qualified personnel to perform the work and to handle the increased workload. ESP's contractor procurement process has precise steps that must be undertaken to conform to internal policies and procedures and applicable law. Including the time it takes to contract with a qualified consulting firm and to develop the PIC, ESP believes a comprehensive PIC could not be submitted for the Board's review and approval any earlier than August 1, 2005. ESP asks that the Board either approve it or advise us of any needed changes within 60 days as described in See 40 CFR 125.95(a)(1), 125.95(b)(1).

Comprehensive Demonstration Study

The Comprehensive Demonstration Study (CDS), as described in 40 CFR 125.95(b), includes many mandatory sections that require substantial effort and time to develop and submit. Many sections of the CDS require that the information collection process described in the PIC be completed prior to being able to initiate those sections of the CDS. Because the PIC data collection will not be completed until early 2007, as described below in the Impingement Mortality and/or Entrainment Characterization Study section, much of the CDS will have to be completed during calendar year 2007. This will most likely be a significant time constraint due to the level of work required by the Phase II 316(b) regulation. Below, ESP will describe each section of the CDS in detail, providing ample justification that ESP's proposed complete CDS submission schedule is "as expeditiously as practicable."

<u>Source Water Flow Information</u>

Because ESGS operates on the Pacific Ocean, no specific source waterbody flow information is required to be submitted. See 40 CFR 125.95(b)(2).

Impingement Mortality and/or Entrainment Characterization Study

ESP must provide, pursuant to 40 CFR 125.95(b)(3), an Impingement Mortality and/or Entrainment Characterization Study. This study must include (i) taxonomic identifications of all life stages of fish, shellfish, and any species protected under federal, state, or tribal law that are in the vicinity of the cooling water intake structures and are susceptible to impingement and entrainment; (ii) a characterization of all life stages of fish, shellfish, and any protected species, including a description of the abundance and temporal and spatial characteristics in the vicinity of the cooling water intake structures, based on sufficient data to characterize annual, seasonal, and diel variations in impingement mortality and entrainment (e.g., related to climate and weather differences, spawning, feedings, and water column migration). These may include historical data that are representative of current operation of the facility and of biological conditions at the site.

ESP must also document the current impingement mortality and entrainment of all life stages of fish, shellfish, and protected species and provide an estimate of impingement mortality and entrainment to be used as the "calculation baseline." See 40 CFR 125.95(b)(3)(iii). This may include historical data representative of the current operation of the facility and of biological conditions at the site. Impingement mortality and entrainment samples to support the calculations must be collected during periods of representative operational flows for the cooling water intake structure, and the flows associated with the samples must be documented.

ESP expects to submit, within the PIC document, justification for using the historical and representative impingement and entrainment data as well as new data to be collected. ESP is still evaluating how to most efficiently and reliably collect new representative data, but expects that new entrainment data will likely be collected for approximately one year. New data collected will not commence until the Board has approved ESP's PIC and new sampling plan (40 CFR 125.95(b)(1)(iv)), which, as explained above, is expected to be submitted by August 1, 2005. Therefore, because the Board has 60 days to respond to the PIC and may ask for more information or clarification, the earliest likely date the new entrainment data collection period could commence is approximately the beginning of calendar year 2006, and likely concluding in early 2007.

Design and Construction Technology Plan

Another analysis that must be provided is the Design and Construction Technology Plan. See 40 CFR 125.95(b)(4). If ESP decides to use design and construction technologies and/or operational measures to comply with the Phase II rule, a plan must be submitted that provides the capacity utilization rate for the two individual intake structures at ESGS and provide supporting data (including the average annual net generation of the facility in

MWh) measured over a five-year period (if available) of representative operating conditions and the total net capacity of the facility in MW, along with the underlying calculations. The plan must explain the technologies and/or operational measures that ESGS has in place and/or have selected to meet the requirements of the rule.

This Design and Construction Technology Plan must contain a large amount of information, as described in 40 CFR 125.95(b)(4)(A)-(D). This information includes (A) a narrative description of the design and operation of all design and construction technologies and/or operational measures, including fish handling and return systems, and information that demonstrates the efficacy of the technologies and/or operational measures; (B) a narrative description of the design and operation of all design and construction technologies and/or operational measures and information that demonstrates the efficacy of the technologies and/or operational measures for entrainment; (C) calculations of the reduction in impingement mortality and entrainment of all life stages of fish and shellfish that would be achieved by the technologies and/or operational measures we have selected; and (D) design and engineering calculations, drawings, and estimates prepared by a qualified professional to support the descriptions described above.

Technology Installation and Operation Plan (TIOP)

Assuming ESP decides that the best way to comply with the Phase II rule is to use design and construction technologies and/or operational measures, in whole or in part, we must submit to you the following information, in accordance with 40 CFR 125.95(b)(4)(ii): (A) A schedule for the installation and maintenance of any new design and construction technologies; (B) a list of operational and other parameters to be monitored and the location and frequency that we will monitor them; (C) a list of activities we will undertake to ensure to the degree practicable the efficacy of installed design and construction technologies and operational measures and our schedule for implementing them; (D) a schedule and methodology for assessing the efficacy of any installed design and construction technologies and operational measures in meeting applicable performance standards or site-specific requirements, including an "adaptive management plan" for revising design and construction technologies, operational measures, operation and maintenance requirements, and/or monitoring requirements in the event the assessment indicates that applicable performance or site-specific requirements are not being met; and (E) if ESP chooses the compliance alternative in 125.94(a)(4) (wedge-wire screens or a technology approved by the state), documentation that the appropriate site conditions described in 125.99(a) or (b) exist at our facility.

Restoration Plan

If ESP determines that restoration measures are the best method to comply with the new rule, in whole or in part, then a Restoration Plan must be submitted in the CDS. This plan must include the information described in 40 CFR 125.95(b)(5). It must include a plan using an adaptive management method for implementing, maintaining, and demonstrating the efficacy of the restoration measures that are selected and for determining the extent to which the restoration measures, or the restoration measures in combination with design and construction technologies and operational measures, have met the applicable performance standards.

Site-Specific Requirements

If ESP determines that site-specific requirements are appropriate because the cost of complying with the Phase II rule will be "significantly greater" than either the cost that EPA considered in its rulemaking or the benefits of complying with the rule, then ESP will have to submit the information described in 40 CFR 125.95(b)(6). This includes a Comprehensive Cost Evaluation Study and, for the cost-benefit analysis, a Benefits Evaluation Study. ESP must also include a Site-Specific Technology Plan describing and justifying the site-specific requirements.

Verification Monitoring Plan

Finally, ESP must prepare a Verification Monitoring Plan as part of a complete CDS. See 40 CFR 125.95(b)(7). This is a plan to conduct, at a minimum, two years of monitoring to verify the full-scale performance of the proposed or already implemented technologies and/or operational measures.

PIC and CDS Schedule

The first official submittal (besides this request for a schedule) that ESP will make to the Board in compliance with the Phase II 316(b) regulation will be the PIC. For the reasons explained above, ESP proposes to submit a comprehensive PIC for the Board's review and approval by August 1, 2005. ESP asks that the Board either approve the PIC or advise us of any needed changes within 60 days as described in See 40 CFR 125.95(a)(1), 125.95(b)(1).

Because ESP plans to collect substantial new information as part of the expected PIC, and since the new data collection is not likely to begin until after the Board approves the PIC (approximately early 2006), it is unlikely that the information needed to commence the majority of the sections of the CDS (including the Design and Construction Technology Plan, the Technology Installation and Operation Plan, the Restoration Plan (if applicable), the Site Specific Requirements (if applicable), and the Verification

Monitoring Plan) will be available until late 2006 or early 2007 when the data collection is complete or nearly complete.

Due to the step by step process by which the data must be collected, processed, evaluated, and then turned into a detailed plan of action to achieve the new Phase II 316(b) standards, ESP does not believe a comprehensive CDS can be submitted earlier than January 7, 2008. It is for these important reasons that ESP believes the most expeditious schedule possible for submittal of a comprehensive CDS is by January 7, 2008.

Conclusion

Collecting, generating, compiling, and analyzing the large amount of information required by the Phase II 316(b) rule will require a substantial effort. ESP will have to both collect and review already-existing data on the plant and the source waterbody, and we may have to generate significant new biological information.

Because the Phase II rule is new and untried, we foresee the need to coordinate closely with your department as we collect the necessary information, analyze it, and determine what combination of technology, operational measures, or restoration measures will best meet the Phase II rule for ESGS. ESP hopes your staff will be available to consult with us throughout this schedule as we complete these efforts.

For the above reasons, we request that we be allowed until January 7, 2008, to submit the information required for a permit application by the Phase II Rule, 40 CFR Part 125 Subpart J.

Sincerely,
El Segundo Power, LLC
By: NRG El Segundo Operations Inc.
It's Authorized Agent

By:____________________
Audun Aaberg
Regional Plant Manager

1 A 6 3
1 C 4 2

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

FEB 17 2005

OFFICE OF WATER

Mr. Tim Hemig
NRG Energy, Inc.
4600 Carlsbad Boulevard
Carlsbad, CA 92008

Re: Request for Phase II 316(b) Rule - Appendix A Cost Information

Dear Mr. Tim Hemig:

In a letter dated Janurary 17, 2005, El Segundo Power requested the Environmental Protection Agency (EPA) provide Phase II 316(b) Rule - Appendix A Cost Information and associated data for the El Segundo Generating Station. This information may be used to support a request for a site-specific determination of best technology available in accordance with the Clean Water Act Section 316(b) final Phase II regulations. Additional guidance on how to use these costs can be found in Section IX (Implementation) of the preamble to the final regulations in the Federal Register notice at 69 FR 41630.

El Segundo Power, LLC, has waived claims of Confidential Business Information (CBI) associated with design intake flow data. In accordance with our security procedures, we are still handling the remainder of the requested information as CBI, therefore we can not email or fax you with the requested information. In response to your complete request, please see the table enclosed with this cover letter. You may contact Ms. Martha Segall of my staff at 202-566-1041, if you have any further questions.

Sincerely,

Mary T. Smith, Director
Engineering and Analysis Division 4303T

Enclosures: 1 (Appendix A Cost Information)

cc: Paul Shriner
Martha Segall
Ahmar Siddiqui, Document Control Officer

Section 316(b) Phase II Regulations
Facility Cost Rationale For Phase II Facilities

Facility Name	Rule Requirements	Rationale For Costs Assigned In The Regulation
El Segundo	Based upon the facility's responses to EPA's industry questionnaire (administered in 2000), the facility is located on an ocean. As such, it is subject to impingement mortality and entrainment requirements under 195.94(b)(3).	In its industry questionnaire, the facility indicated that it employed a fish diversion technology on its submerged offshore cooling water intake structure. In developing the regulation, data available to EPA indicated that this class of technology, in concert with the intake location and depth, would consistently meet the performance range for the impingement mortality and entrainment performance standards. Therefore, for the purposes of assigning costs for the regulation, the facility was not assigned any additional technologies or costs.

Attachment C
Impingement Mortality & Entrainment Characterization Study Sampling Plan

EL SEGUNDO GENERATING STATION

IMPINGEMENT MORTALITY AND ENTRAINMENT CHARACTERIZATION STUDY

SAMPLING PLAN

July 29, 2005

Prepared for:

El Segundo Power L.L.C.
El Segundo, California

Prepared by:

Tenera Environmental
San Luis Obispo, California

MBC *Applied Environmental Sciences*
Costa Mesa, California

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FIGURES AND TABLES

1.0 INTRODUCTION

On 9 July 2004, the U.S. Environmental Protection Agency (EPA) published Final Regulations to Establish Requirements for Cooling Water Intake Structures at Phase II Existing Facilities. Those §316(b) requirements went into effect in September 2004, and apply to existing generating stations with cooling water intake structures that withdraw at least 50 million gallons per day (mgd) from rivers, streams, lakes, reservoirs, oceans, estuaries, or other waters of the United States. The El Segundo Generating Station (ESGS) has four generating units with two separate submerged offshore intakes equipped with velocity caps. One of the intake supplies cooling water for Units 1 and 2, which withdraws a maximum of 207.4 million gallons per day (mgd), and the other intake supplies cooling water for Units 3 and 4, which withdraws a maximum of 398.6 mgd. Both intakes are located approximately 2,600 ft (790 m) from a seawall located onshore and withdraw water from Santa Monica Bay.

As part of the §316(b) Comprehensive Demonstration Study required under the new regulations, a facility may be required to submit an Impingement Mortality and Entrainment Characterization Study depending on the chosen compliance pathway. The Impingement Mortality component is not required if a facility's through-screen intake velocity is less than or equal to 0.5 ft/s (15 cm/s). Based on previously collected intake velocity measurements, both intakes at the El Segundo Generating Station exceed this value. The Entrainment Characterization component is not required if a facility: (a) has a capacity utilization rate of less than 15 percent; (b) withdraws cooling water from a lake or reservoir, excluding the Great Lakes; or (c) withdraws less than five percent of the mean annual flow of a freshwater river or stream. Therefore, both the Impingement Mortality and Entrainment components of the Study apply at the ESGS.

According to the §316(b) Phase II Regulations, the Impingement Mortality and Entrainment Characterization Study must include the following (for all applicable components):

- Taxonomic identifications of all life stages of fish, shellfish, and any species protected under Federal, State, or Tribal Law (including threatened or endangered species) that are in the vicinity of the cooling water intake structure(s) and are susceptible to impingement and entrainment;
- A characterization of all life stages of fish, shellfish, and any species protected under Federal, State, or Tribal Law (including threatened or endangered species) identified in the taxonomic identification noted previously, including a description of the abundance and temporal and spatial characteristics in the vicinity of the cooling water intake structure(s), based on sufficient data to characterize the annual, seasonal, and diel variations in the impingement mortality and entrainment; and
- Documentation of current impingement mortality and entrainment of all life stages of fish, shellfish, and any protected species identified previously and an estimate of impingement mortality and entrainment to be used as the calculation baseline.

The goal of the proposed study is to characterize the fishes and shellfish affected by impingement and entrainment by the two cooling water intake structures (CWIS) at the ESGS. The §316(b) final regulations allow "historical data that are representative of the current operation of your facility and of biological conditions at the site" to be used to characterize impingement and entrainment. Impingement data at ESGS has been collected regularly since the early 1970s. Since 1998 impingement sampling has been collected monthly during normal plant operations and also during all heat treatment procedures. The long time series of existing impingement data provides an adequate data set for estimating baseline impingement levels. Therefore this plan proposes continuing impingement sampling during heat treatments and at the current monthly sampling interval and conducting a year-long study to characterize larval entrainment at the ESGS. Concurrent with entrainment sampling, the study plan also proposes sampling of the source water to characterize the populations potentially affected by entrainment. The source water sampling would be used to help evaluate population level impacts to entrained species and to assist in designing appropriate restoration projects that might be used to help offset estimated entrainment losses due to the ESGS CWIS. The use of restoration in offsetting IM&E losses under the new 316(b) rules is currently being challenged in the courts. If the use of restoration is not allowed as a result of the court decision, the source water sampling may be curtailed. Even if the court decision does not provide for restoration, the source water sampling may continue to meet other regulatory requirements and help to evaluate impacts to populations of aquatic organisms.

The proposed studies will examine losses at the ESGS resulting from impingement of juvenile and adult fish and macroinvertebrates on traveling screens during normal operations and during heat treatment operations and entrainment of ichthyoplankton and larval shellfish into the cooling water intake system. Proposed sampling methodologies and analysis techniques are derived from recent impingement and entrainment studies conducted for the AES Huntington Beach Generating Station (MBC and Tenera 2005), the Duke Energy South Bay Power Plant (Tenera 2004), and the Cabrillo Power I LLC, Encina Power Station. The studies at Huntington Beach were performed as part of the California Energy Commission CEQA process for permitting power plant modernization projects, while the South Bay and Encina projects were for §316(b) compliance.

The sampling efforts conducted for this study may be coordinated with similar studies at the AES Redondo Beach Generating Station (RBGS) and the Los Angeles Department of Water and Power Scattergood Generating Station (SGS). The intake for the SGS is located approximately 0.6 mi (0.9 km) upcoast from the ESGS intakes, while the RBGS intakes are located approximately 5 mi (8 km) downcoast. Coordinating the entrainment and source water sampling will allow for a more comprehensive characterization of the source water and the organisms potentially affected by the CWISs at the three facilities. Although the same data may be shared for the IM&E studies conducted at all three facilities, the data may not necessarily be used or presented in the same way. The final CDS report for each facility will be unique, since the specific issues and compliance approaches may differ.

1.1 Environmental Setting

The ESGS (33° 54.4' N, 118°26' W) is located in the city of El Segundo on the shore of Santa Monica Bay. Santa Monica Bay is an open embayment approximately 27 mi (43 km) across and delineated by Point Dume, which is located approximately 23 mi (37 km) to the northwest of the ESGS and Palos Verdes Point, which is located approximately 9 mi (15 km) miles to the south (**Figure 1-1**). The surface area of the Bay is approximately 266 square miles (689 square km) (MBC 1988). The Bay is characterized by a gently sloping continental shelf which extends seaward to the shelf break at water depths of approximately 265 ft (80 m) (Terry et al. 1956). Natural rocky outcrops are confined to the northern and southern portions of the bay from Point Dume to the Malibu coast area to the north, and the Palos Verdes point area to the south.

The prevailing current direction in the shallow, nearshore areas of Santa Monica Bay is downcoast (equatorward) suggesting an eddy-type circulation pattern resulting from the upcoast (poleward) currents outside of the bay (Hendricks 1980). This description is supported by more extensive studies by Hickey (1992) that also showed downcoast currents on the shelf within the bay and prevailing upcoast (poleward) currents at the edge of the shelf at the outer boundary of Santa Monica Bay. The circulation pattern within the bay results from the presence of the Southern California Countercurrent in the outer coastal waters of the Southern California Bight.

Sediments off the ESGS are primarily composed of sand, with lesser amounts of silt and clay (Allen et al. 1998, MBC 2003). The infaunal community is typical for the sandy nearshore habitat, primarily composed of annelid worms, arthropods, small mollusks, and nemertean worms

Figure 1-1. Location of the ESGS in Santa Monica Bay.

(MBC 2003). The nearshore demersal soft-bottom fish community, as sampled by otter trawl, is largely composed of flatfishes, including speckled sanddab (*Citharichthys stigmaeus*), English sole (*Parophrys vetulus*), hornyhead turbot (*Pleuronichthys verticalis*), and California halibut (*Paralichthys californicus*) (Allen et al. 1998, MBC 2003). Other species present further offshore include Pacific sanddab (*Citharichthys sordidus*), longfin sanddab (*C. xanthostigma*), yellowchin sculpin (*Icelinus quadriseriatus*), pink surfperch (*Zalembius rosaceous*), plainfin midshipman (*Porichthys notatus*), and California scorpionfish (*Scorpaena guttata*) (CLA-EMD 1999, 2001). Fish assemblages commonly associated with hard substrate in southern California are often comprised of both conspicuous fishes, such as kelp bass (*Paralabrax clathratus*), black surfperch (*Embiotoca jacksoni*), garibaldi (*Hypsypops rubicundus*), California sheephead (*Semicossyphus pulcher*), etc. (Allen 1985, Stephens and Pondella 2002), as well as cryptic reef fishes such as the reef finspot (*Paraclinus integrippinnis*), bluebanded goby (*Lythrypnus dalli*), and combtooth blennies (*Hypsoblennius* spp.) (Allen et al. 1992, Stephens and Pondella 2002).

Impingement surveys at the ESGS indicate demersal schooling and/or aggregating species are primarily affected by the operation of the intake structure, including queenfish (*Seriphus politus*), jacksmelt (*Atherinopsis californiensis*), northern anchovy (*Engraulis mordax*), salema (*Xenistius californiensis*), and Pacific sardine (*Sardinops sagax*) (Allen 1985, MBC 2003).

All croakers (including queenfish and white croaker) release pelagic eggs when fertilized, which remain planktonic for the duration of the larval period (Tucker 1998). Queenfish peak spawning occurs from April to August, while white croaker spawning peaks primarily occur from October through April (Goldberg 1976). Love et al. (1984) observed year round spawning in white croaker, based on presence of larvae in ichthyoplankton samples, with distinct peaks from January to April.

Jacksmelt range from Yaquina Bay, Oregon to Santa Maria Bay, Baja California, typically forming large dense schools nearshore within the upper reaches of the water column (Gregory 2001). Spawning in jacksmelt, as well as topsmelt (*Atherinops affinis*), occurs from fall to spring

(October–April) in southern California (Gregory 2001). Large, pink eggs are attached to substrate, typically eelgrass or similar aquatic vegetation (Gregory 2001). Resulting larvae are planktonic, commonly encountered in surface waters prior to transformation and subsequent recruitment into adult populations (Moser 1996, Gregory 2001).

Northern anchovy release pelagic eggs throughout the year, with peaks from February to April (Bergen and Jacobson 2001). Eggs typically hatch within two to four days, based on water temperatures (Bergen and Jacobson 2001). Pacific sardines typically spawn year round, with peaks from April to August south of Point Conception to Magdalena Bay, Baja California in the upper portions of the water column (less than 180 ft [55 m] depth) (Wolf and Smith 2001). Northern anchovy and Pacific sardine abundances exhibit inverse correlations to one another, with decadal sea surface temperature fluctuations believed to influence species-specific population trends, and Pacific sardine spawning production declining in cooler waters (Wolf and Smith 2001).

Trawl-caught macroinvertebrates common off the ESGS in 2003 included spiny sand star (*Astropecten armatus*), the jellyfish *Scrippsia pacifica*, California sand star (*Astropecten verrilli*), tuberculate pear crab (*Pyromaia tuberculata*), and blackspotted bay shrimp (*Crangon nigromaculata*) (MBC 2003). The most abundant macroinvertebrates further offshore to depths of 60 m include the white urchin (*Lytechinus pictus*) and spiny sand star (CLA-EMD 1999, 2001). The most abundant macroinvertebrates in impingement samples at the ESGS in 2003 included yellow rock crab (*Cancer anthonyi*), red rock shrimp (*Lysmata californica*), intertidal coastal shrimp (*Heptacarpus palpator*), and California spiny lobster (*Panulirus interruptus*).

2.0 POWER PLANT COOLING WATER SYSTEM ASSESSMENT

Power plant intake effects occur due to impingement of larger organisms onto the intake screens and entrainment of organisms into the cooling water intake system (CWIS) that are smaller than the screen mesh on the intake screens. For the purposes of our study we assume that both processes lead to mortality of all impinged and entrained organisms. Considerable effort among regulatory agencies and the scientific community has been expended on the evaluation of power plant intake effects over the past three decades. The variety of approaches developed reflects the many differences in power plant locations and resource settings. MacCall et al. (1983), in their review of the various approaches, divided them into those that offer a judgment on the presence or absence of impact and those that describe the sensitivity of populations to varying operational conditions. These efforts have helped to establish the context for the modeling approaches proposed to estimate impingement and entrainment effects at the ESGS.

Impact assessment approaches considered in this evaluation include:

- adult-equivalent loss (*AEL*) (Horst, 1975; Goodyear, 1978),
- fecundity hindcasting (*FH*) proposed by Alec MacCall, NOAA/NMFS, which is related to the adult-equivalent loss approach, and
- empirical transport model (*ETM*), which is similar to the approach described by MacCall et al. (1983), and used by Parker and DeMartini (1989).

These approaches can be placed under the umbrella of two general approaches: demographic models that rely on species life history information such as the equivalent adult model (*EAM*; Horst 1975; Goodyear 1978) which includes adult equivalent loss (*AEL*) and fecundity-hindcasting (*FH*); and models that estimate the conditional mortality on a population resulting from power plant CWIS operations such as the empirical transport model (*ETM*; Boreman et al. 1978).

The application of several models to estimate power plant effects is not unique (Murdoch et al. 1989; PSE&G 1993; Tenera 2000a; Tenera 2000b). Equivalent adult modeling (*AEL* and *FH*) is an accepted method that will be used at ESGS and has been applied in other 316(b) demonstrations (PSE&G 1993; Tenera 2000a; Tenera 2000b). The advantage of these demographic modeling approaches is that they translate losses into adult fishes that are familiar units to resource managers. These estimates can be also combined with estimated losses to adult and juvenile organisms due to impingement to provide combined estimates of cooling water system effects.

The empirical transport model (*ETM*) has been proposed by the U.S. Fish and Wildlife Service to estimate mortality rates resulting from cooling water withdrawals at power plants (Boreman et al. 1978, 1981). Variations of this model have been discussed in MacCall et al. (1983) and used to assess impacts at the San Onofre Nuclear Generating Station (Parker and DeMartini 1989). The *ETM* has also been used to assess impacts at the Diablo Canyon Power Plant and Huntington Beach Generating Station in California (Tenera 2000a, MBC and Tenera 2005), and at the Salem Nuclear Generating Station in Delaware Bay, New Jersey (PSE&G 1993), as well as other power stations along the East Coast. Empirical transport modeling permits the estimation of conditional mortality due to entrainment while accounting for the spatial and temporal variability in distribution and vulnerability of each life stage to power plant withdrawals. The *ETM* provides an estimate of power plant effects that may be less subject to inter-annual variation than demographic model estimates. It also provides an estimate of population-level effects not provided by demographic approaches.

The results of the *ETM* modeling provide the best and most direct estimates of the effects of entrainment on source water populations since the effects are estimated on the larval populations being affected. The *ETM* estimates can be used to appropriately scale restoration projects that might be used to help offset entrainment losses. The estimates can also be used to provide a context for demographic model estimates that are based solely on entrainment estimates. For example, especially in estuarine systems, entrainment estimates may show large losses of fish larvae that are sometimes difficult to interpret and put in context without estimates of the adult or larval source water populations. The *ETM* provides a context for these estimates and if the results show that the effects on the source populations are relatively low can account for some of the uncertainty associated with determining an appropriate level of entrainment reduction.

The following sections provide details on our approaches for estimating cooling water system effects on marine organisms in the vicinity of the ESGS. Impingement effects will be assessed using data from intake sampling. Entrainment effects will be assessed using data from cooling-water intake and source water sampling using all three modeling approaches where appropriate for a taxon. The results of the *FH* and *AEL* impingement and entrainment assessments will be combined for taxa when possible.

2.1 Selection of Target Taxa

Impingement

Estimates of annual impingement will be calculated for all the target organisms, but assessment of CWIS impingement effects will only be conducted on the most abundant organisms in the samples. The assessment may also include other commercially or recreationally important taxa from the samples. All fishes and macro invertebrates will be collected from impingement samples and identified, but the following groups of marine organisms will be enumerated, weighed, and measured.

Vertebrates:
- fishes

Invertebrates:
- crabs
- squid
- shrimp
- octopus
- California spiny lobster

Entrainment

Estimates of annual impingement will be calculated for all the target organisms, but assessment of CWIS entrainment effects will only be conducted on the most abundant organisms in the samples, and commercially or recreationally important taxa from entrainment and intake samples. The following groups of marine organisms will be sorted, identified and enumerated from entrainment intake and source water plankton samples:

Vertebrates:
- fishes (all life stages beyond egg)

Invertebrates:
- rock crab megalopal larvae (*Cancer* spp.)
- market squid hatchlings [larvae] (*Loligo opalescens*)
- California spiny lobster phyllosoma larvae (*Panulirus interruptus*)

This same group of organisms were also analyzed in most of the recent entrainment studies in southern California, including the AES Huntington Beach Generating Station (MBC and

Tenera 2005). Fishes and rock crab larvae were selected because of their respective ecological roles or commercial and/or recreational fisheries importance. Market squid and California spiny lobster were selected because of their commercial and/or recreational importance in the area. All the target organism groups (fishes, rock crabs, squid, and lobster) will be counted and identified to the lowest taxonomic level possible.

The specific taxa (species or group of species) that will be analyzed in the assessment will be limited to the taxa that are sufficiently abundant to provide reasonable assessment of impacts. For the purposes of this study plan, the target taxa analyzed in the assessment will be limited to the most abundant taxa that together comprise 90-95 percent of all larvae entrained and/or juveniles and adults impinged by the generating station. The most abundant taxa are used in the assessment because they provide the most robust and reliable estimates of CWIS effects. Since the most abundant organisms may not necessarily be the organisms that experience the greatest effects on the population level, the data will be examined carefully before the final selection of target taxa to determine if additional taxa should be included in the assessment. This may include commercially or recreationally important taxa, and taxa with limited habitats.

The power plant also entrains numerous other non-target planktonic and larval life forms that will not be specifically included in the study. These other non-target groups, including the larvae of other shellfish (crabs, clams, abalone, crabs, etc.), are not included because they are smaller than the larvae from the target organism groups and would require separate sampling efforts and equipment to collect. In addition, the identification of many of these other non-target larvae to the species level is problematic and would likely lead to uncertainty in the estimates of their abundance. The *ETM* model provides a means of examining the potential effects on these other non-target organisms by assuming that they are uniformly distributed in the source water area and are withdrawn at a rate equal to the volumetric ratio of the cooling water flow to the source water volume. The effect of entrainment on these organisms also depends on their larval duration or the time period they are exposed to entrainment. The relationship between larval duration and currents that determine the volume of the source water will be used to estimate effects at various larval durations.

Fish eggs will not be sorted or identified because a full assessment of their abundance would also require different sampling techniques and, as with the non-target species, they also cannot be identified to the same taxonomic levels as fish larvae. Even though egg life stages will not be quantified from the entrainment and source water samples, entrainment effects on fishes with planktonic egg stages will be accounted for in the ETM model by adding the time period that eggs are planktonic to the estimate of the time period that larvae of that species are at risk of entrainment. This approach assumes that the proportional mortality estimate used in the modeling of larval entrainment also applies to egg mortality and that for both egg and larval stages, mortality on passage through the cooling system is 100%.

3.0 IMPINGEMENT STUDY

Impingement sampling at the ESGS has been conducted since the early 1970s. The existing NPDES permit for the plant requires regular sampling during periods of normal operation and during all heat treatment procedures. Since 1999 impingement sampling during normal operations has occurred monthly. The results from the two types of surveys are combined to obtain an estimate of the total impingement for the year. A normal operation survey is defined as a sample of all fish and macroinvertebrates entrained by water flow into the generating station intake and subsequently impinged and removed by the traveling screens during a 24-hr period. Fish and macroinvertebrates are separated from incidental debris, identified, and counted. Up to 200 individuals of each species are measured, and examined for external parasites, and any anatomical or other abnormalities. Aggregate weights were taken by species. The plant usually does not operate 365 days per year due to plant maintenance and seasonal fluctuations in power demand, resulting in decreased cooling water flow during these periods. Therefore, normal operation abundance and biomass for each sampling period were estimated by extrapolating the impingement rates measured during the survey using the total flow for the period between surveys.

Heat treatments are operational procedures designed to eliminate mussels, barnacles, and other fouling organisms growing in the cooling water conduit system. During a heat treatment, heated effluent water from the discharge is redirected to the intake conduit via cross-connecting tunnels until the water temperature rises to approximately 105°F (40.5°C) in the screenwell area. This temperature is maintained for at least one hour, during which time all biofouling organisms, as well as fish and invertebrates living within the cooling water system, succumb to the heated water. During heat treatment surveys, all material impinged onto the traveling screens is removed from the forebay, identified, counted, and measured using the same procedures used for normal operations surveys.

The estimates from the normal operations and heat treatment surveys were combined to estimate total impingement for a year. Data for heat treatment surveys date back to 1979, while normal operation data are available from weekly surveys done from October 1978 to September 1980, and from monthly surveys done from 1999 to the present. The data from the 1999 through 2004 NPDES annual reporting periods (October 1998 through September 2004) were analyzed to determine if the existing long-term data were adequate for calculating baseline impingement for the ESGS.

A comparison of total annual estimated impingement shows very low levels of impingement during normal operations relative to heat treatment surveys, with the numbers of impinged fishes during normal operations averaging less than 10% of heat treatment impingement (**Table 3-1**). The very low levels of impingement during normal operations indicate that measuring impingement during only heat treatments would result in annual estimates of approximately 90% of the total estimated impingement on average.

The monthly normal operations data from Units 3&4 for the 1999 through 2004 NPDES annual reporting periods were also used to determine the effects of more frequent sampling on the estimate of impingement rates. Only the data from Units 3&4 were used in the analysis because of the similarity of the results for normal operations for the two intakes and the larger numbers of years for Units 3&4 with both heat treatment and normal operations surveys. The analysis was done by resampling the 1999-2004 data with replacement to generate 1000 estimates of annual impingement based on monthly (n=12), biweekly (n=24) and weekly (n=52) sampling frequencies. The mean impingement rates (# per 10^6 gal) from the 1000 sets of samples were used to calculate a 95% confidence interval for the mean for each sampling frequency. The resampling approach was taken because the large numbers of zero values in the data did not allow the use of standard statistical probability distributions in calculating confidence intervals. As expected, the average impingement rates for the different sampling frequencies are approximately equal since the samples were drawn from the same set of data (**Table 3-2**). The decrease in sampling frequency from weekly to biweekly to monthly resulted in increases in the confidence interval around the mean of 31 and 108 percent, respectively. Given the low levels of impingement during normal operations relative to heat treatment impingement, these potential differences in the precision of our estimate of average normal operations impingement do not justify increasing the sampling frequency during the study. Increased sampling frequency also isn't justified because the same resampling techniques used in this analysis could be used with the long-term data set and data collected during the characterization study to provide estimates of impingement that are representative of current and long-term conditions. The estimates from these data will be superior to estimates obtained from a one-year study with more frequent sampling because they represent impingement under a range of environmental conditions.

Table 3.1: Comparison of total annual estimated numbers (top) and biomass (lbs; bottom) of fishes impinged at a) Units 1&2 and b) Units 3&4 during normal operations and heat treatments (number of heat treatments shown in parentheses) from the 1999 through 2004 NPDES reporting periods (October through September). The single fish collected in normal operations at Units 1&2 in 2002 was a bat ray (*Myliobatis californica*) that was subsequently released. However, it's final disposition was unknown so it was included in the impingement total. Dashes for Units 1&2 indicate no heat treatments were conducted during the year.

a) Units 1 & 2

Year	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**Average**
Abundance							
Normal Operations	31	0	205	1	52	0	
Heat Treatment	135	271	1,732	5	-	-	
Number of Heat Treatment Surveys	2	5	3	2	0	0	
Total	166	271	1,937	6	52	0	
Normal Operation % of Total	19%	0%	11%	17%	-	-	12%
Biomass (lbs)							
Normal Operations	4	0	287	49.6	410	0	
Heat Treatment	87	84	525	0.4	-	-	
Number of Heat Treatment Surveys	2	5	3	2	0	0	
Total	91	84	812	50.4	410	0	
Normal Operation % of Total	5%	0%	35%	98%	-	-	35%

b) Units 3 & 4

Year	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**Average**
Abundance							
Normal Operations	110	420	124	116	35	152	
Heat Treatment	1,054	4,574	2,673	1,301	1,669	1,037	
Number of Heat Treatment Surveys	1	6	4	5	4	4	
Total	1,164	4,994	2,797	1,417	1,704	1,189	
Normal Operation % of Total	9.5%	8.4%	4.4%	8.2%	2.1%	12.8%	8%
Biomass (lbs)							
Normal Operations	13	1,372	26	598	637	15	
Heat Treatment	734	677	567	520	432	181	
Number of Heat Treatment Surveys	1	6	4	5	4	4	
Total	747	2,049	593	1,118	1,069	196	
Normal Operation % of Total	1.7%	67.0%	4.4%	53.5%	59.6%	7.7%	32%

Table 3-2. Comparison of monthly, biweekly, and weekly sampling frequency on confidence intervals for the mean impingement rate (# organisms per 10^6 gallons) based on 1000 estimates of annual impingement from samples randomly drawn with replacement from monthly normal operations impingement data for Units 3&4 for the 1999 through 2004 NPDES sampling periods. Mean number of organisms collected during impingement surveys also presented without confidence intervals.

Sampling Frequency	Mean Rate per 10^6 gal	Low Value for 95% Interval	High Value for 95% Interval	Range for 95% Interval	% Increase in Confidence Interval from Weekly Sampling	Mean Count per 10^6 gal
Monthly	0.145	0.000	0.376	0.376	107.7%	0.466
Biweekly	0.143	0.031	0.293	0.262	30.8%	0.462
Weekly	0.144	0.063	0.244	0.181		0.464

3.1 Impingement Sampling

The purpose of the proposed 316(b) impingement study will be to characterize the juvenile and adult fishes and selected macroinvertebrates (e.g.,rock crabs, lobsters, and squid) impinged by the power plant's CWIS. The sampling program is designed to provide current estimates of the abundance, biomass, taxonomic composition, diel periodicity, and seasonality of organisms impinged at ESGS. In particular, the study will focus on the rates (i.e., number and biomass of organisms per water volume flowing per time into the plant) at which various species of fishes and macroinvertebrates are impinged. The impingement rate is subject to tidal and seasonal influences that vary on several temporal scales (e.g., hourly, daily, and monthly) while the rate of cooling water flow varies with power plant operations and can change at any time.

In accordance with procedures employed in similar studies, impingement sampling will occur over a 24-hour period one day per month. Before each sampling effort, the traveling screens will be rotated and washed clean of all impinged debris and organisms. The sluiceways and collection baskets will also be cleaned before the start of each sampling effort. The operating status of the circulating water pumps on an hourly basis will be recorded during the collection period. Each 24-hour sampling period at the traveling screens will be divided into four 6-hour cycles. The traveling screens will remain stationary for a period of 5.5 hours then they will be rotated and washed for 30 minutes. The impinged material from the traveling screens will be rinsed into the collection baskets associated with each set of screens. If during the 24-hour sampling an extreme event occurs resulting in the impingement of a large number of fishes, we may continue sampling an additional day or two to obtain a more representative estimate of the impingement rate for the sampling period.

If the traveling screens are operating in the continuous mode, then sampling will be coordinated with the intake crew so samples can be collected safely. A log containing hourly observations of the operating status (on or off) of the circulating water pumps for the entire study period will be obtained from the power plant operation staff. This will provide a record of the amount of cooling water pumped by the plant, which will then be used to calculate impingement rates.

Impingement sampling will also be conducted during heat treatment operations. Procedures for heat treatment will involve clearing and rinsing the traveling screens prior to the start of the heat treatment procedure. At the end of the heat treatment procedure normal pump operation is resumed and the traveling screens rinsed until no more dead fish are collected on the screens. Processing of the samples will occur using the same procedures used for normal impingement sampling. Six to eight heat treatments may occur during the one-year study period.

Depending on the number of individuals of a given target species present in the sample, one of two specific procedures is used, as described below. Each of these procedures involves the following measurements and observations:

1. The appropriate linear measurement for individual fishes and motile invertebrates is determined and recorded. These measurements are recorded to the nearest 1 mm. The following standard linear measurements are used for the animal groups indicated:

   Fishes - Total body length for sharks and rays and standard lengths (or fork length) for bony fishes.

   Crabs - Maximum carapace width.

   Shrimps & Lobsters - Carapace length, measured from the anterior margin of carapace between the eyes to the posterior margin of the carapace.

   Octopus - Maximum “tentacle” spread, measured from the tip of one tentacle to the tip of the opposite tentacle.

   Squid – Dorsal mantle length, measured from the edge of the mantle to the posterior end of the body.

2. The wet body weight of individual animals is determined after shaking loose water from the body. Total weight of all individuals combined is determined in the same manner. All weights are recorded to the nearest 0.035 ounce (1 g).

3. The qualitative body condition of individual fishes and macroinvertebrates is determined and recorded, using codes for decomposition and physical damage.

4. Other non-target, sessile macroinvertebrates are identified to species and their presence recorded, but they are not measured or weighed. Rare occurrences of other impinged animals, such as dead marine birds, are recorded.

5. The amount and type of debris (e.g., *Mytilus* shell fragments, wood fragments, etc.) and any unusual operating conditions in the screen well system are noted by writing specific comments in the “Notes” section of the data sheet.

The following specific procedures are used for processing fishes and motile invertebrates when the number of individuals per species in the sample or subsample is < 30:

- For each individual of a given species the linear measurement, weight, and body condition codes are determined and recorded on separate lines.

The following specific subsampling procedures are used for fishes and motile invertebrates when the number of individuals per species is >30:

- The linear measurement, individual weight, and body condition codes for a subsample of 30 individuals are recorded individually on the data sheet. The individuals selected for measurement are selected after spreading out all of the individuals in a sorting container, making sure that they are well mixed and not segregated into size groups. Individuals with missing heads or other major body parts are eliminated from consideration, since their linear measurements are not representative.
- The total number and total weight of all the remaining individuals combined are

determined and recorded separately.

3.2 Quality Control Program

A quality control (QC) program will be implemented to ensure that all of the organisms are removed from the debris and that the correct identification, enumeration, length and weight measurements of the organisms are recorded on the data sheet. Random cycles will be chosen for QC re-sorting to verify that all the collected organisms were removed from the impinged material. Quality control surveys will be done on a quarterly or more frequent basis if necessary during the study.

4.0 ENTRAINMENT STUDY

The proposed entrainment study consists of 1) cooling water intake system sampling and 2) source water sampling. Analytical approaches for estimating entrainment effects are also presented.

4.1 Cooling-Water Intake System Entrainment Sampling

The cooling water intake structure for Units 1&2 at the ESGS is located approximately 700 m offshore from the generating station at an approximate depth of 30 ft (9.1 m) Mean Lower Low Water (MLLW). The top of the intake velocity cap is approximately 17 ft (5.2 m) below the water surface (13 ft [3.9 m] above bottom). Cooling water is directed horizontally through the opening between the top of the intake riser and the velocity cap (a distance of approximately 2 ft [0.6 m] at approximately 2.4 ft/s (0.7 m/s) (McGroddy et al. 1981). Maximum flow rate at Units 1&2 is 144,000 gallons per minute (gpm), or 207.4 million gallons per day (mgd).

The cooling water intake structure for Units 3&4 at the ESGS is located approximately 295 ft (90 m) downcoast from the Units 1&2 intake structure, about 2300 ft (700 m) offshore and an additional 850 feet (260 m) from the generating station forebay at an approximate depth of 32 ft (9.8 m) MLLW. The top of the intake velocity cap is approximately 15.7 ft (4.8 m) below the water surface (16.4 ft [5.0 m] above bottom). Cooling water is directed horizontally through the opening between the top of the intake riser and the velocity cap (a distance of approximately 3 ft [1.0 m]) (McGroddy et al. 1981). Maximum flow rate at Units 3&4 is 276,800 gpm, or 398.6 mgd.

To determine composition and abundance of ichthyoplankton and target invertebrates entrained by the generating station, sampling in the immediate proximity of the two cooling water intakes is proposed to be conducted once per month from January through December 2006. The ESGS intake structures are located in the lower one-half of the water column, and therefore, it is reasonable to assume that the intake draws water from just above the bottom to the middle of the water column. At the AES Redondo Beach L.L.C. generating station, water is drawn into the intake structure from the lower 2/3 of the water column (KLI 1979). However, since no supporting data are available for El Segundo, we propose to sample within 164-328 ft (50-100 m) of the intake structures using an oblique tow that will sample the water column from the surface down to approximately 6 inches (13 cm) off the bottom, and back to the surface (**Figure 4-1**). Two replicate tows will be taken at each intake with a target sample volume of 7,900 to 10,570 gal (30 to 40 m^3) for each net on the bongo frame. The net will be redeployed if the target volume is not collected during the initial tow. Sampling will be conducted four times per 24-hr period--once every six hours.

The wheeled bongo frame proposed for sampling has 2 ft (60 cm) diameter net rings with plankton nets constructed of 333-*u*m Nitex® nylon mesh, similar to the nets used by the California Cooperative Oceanic Fisheries Investigations (CalCOFI). Each net will be fitted with a Dacron sleeve and a plastic cod-end container to retain the organisms. Each net will be equipped with a calibrated General Oceanics flowmeter, allowing the calculation of the amount of water filtered. If the target volume (7,900 to 10,570 gal [30 to 40 m^3] per net) is not met with one oblique tow, subsequent tows will be performed at the station until the target volume is collected. Coordinates of each sampling station will be determined using a differential Global Positioning System (DGPS). At the end of each tow, nets will be retrieved and the contents of the net gently rinsed into the cod-end with seawater. Contents will be washed down from the outside of the net to avoid the introduction of plankton from the wash-down water. Samples will then be carefully transferred to prelabeled jars with preprinted internal labels. Samples from one of the two nets will be preserved in 4 percent buffered formalin-seawater, while contents of the other net will be

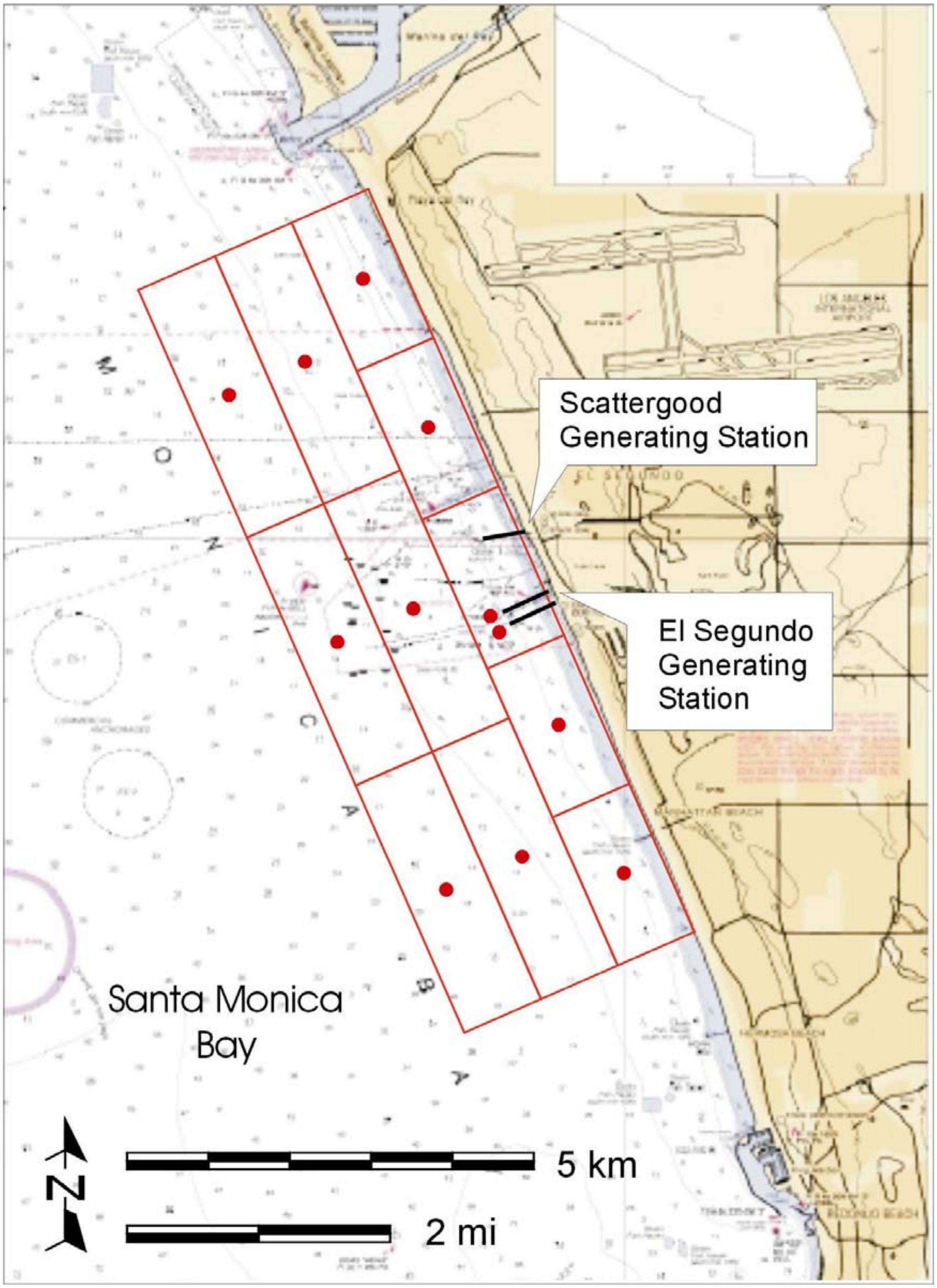

Figure 4-1. Map showing locations of ESGS and SGS intakes and entrainment and source water sampling stations.

preserved in 70 to 80 percent ethanol. Larvae preserved in ethanol can be made available for genetic and/or otolith analysis, if required. Genetic analyses have been performed in recent studies in attempts to validate the identity of certain species. Normally the data from the two subsamples will be combined for analysis, but if the quantity of material in the two samples is very large only one of the two subsamples will be processed and analyzed.

4.2 Source Water Sampling

The source water study area is designed to 1) characterize the larvae of target species potentially entrained by the ESGS cooling water intakes, and 2) represent a variety of nearshore habitats.

To determine composition and abundance of ichthyoplankton in the source water, sampling will be done monthly at the same time that the entrainment stations are sampled. The source water sampling design is being proposed because of the need to extrapolate densities offshore to determine the appropriate source water area during each survey. Besides the entrainment stations, we propose that source water sampling occur at ten additional source water stations upcoast, downcoast, and offshore from the ESGS and SGS intake structures (**Figure 4-1**). Stations will be located 1.2 and 2.4 miles (2 and 4 km) upcoast and downcoast from the midpoint between the ESGS and SGS intake structures along the 33 ft (10 m) isobath. The spacing of the samples upcoast and downcoast was based on a review of water current data available from the area. Data from Hickey (1992) showed that nearshore alongshelf water currents in Santa Monica Bay averaged 0.15 ft/sec (4.5 cm/sec) with a monthly maximum average speed of 0.29 ft/sec (8.8 cm/sec). Based on these water current speeds, the distances that larvae could be transported alongshore during a day ranged from 2.4 to 4.7 miles (3.9 to 7.6 km). The average value was used to determine the alongshore extent of the source water sampling locations upcoast and downcoast since the proportional entrainment estimate used in the Empirical Transport Model is an estimate of the daily entrainment mortality on the available source water population. The length of the sampling area alongshore is also approximately equal to the daily distance larvae travel based on the maximum monthly average water current speed thus ensuring that even at higher water current speeds an adequate source water area is sampled.

Six additional stations will be sampled offshore from the inshore line of stations, with three stations located along the 66 ft (20 m) isobath and three stations along the 98 ft (30 m) isobath (**Figure 4-1**). This sampling grid is similar in design to the study of cooling water system effects at the AES Huntington Beach Generating Station (MBC and Tenera 2005), but was modified to allow for a more complete characterization of the distribution of organisms alongshore and offshore. This is necessary because the distribution of organisms within the sampling area is used to extrapolate densities alongshore using water current displacement and offshore using a regression model of density and distance offshore. These extrapolations are used to estimate the plankton populations in the source water. The prevailing alongshore currents in Santa Monica Bay (Hickey 1992) indicate that there may be less mixing of waters across the shelf close to shore. As a result the data from the stations closest to shore may be poor predictors of the abundance and composition further offshore. The proposed sampling grid provides for at least three stations at each depth contour alongshore that can be used in extrapolating the sampled source water data over a larger area.

All stations will be sampled using a wheeled bongo plankton net using the same oblique tows described for the entrainment sampling (See Section 4.1). During each source water survey, the additional 10 source water stations (plus the entrainment stations) will be sampled four times per 24-hr period--once every six hours. This allows adequate time to conduct all source water and entrainment sampling. During each sample cycle the order that the stations are sampled will be varied to avoid introducing a systematic bias into the data.

4.3 Laboratory Processing

Ichthyoplankton samples will be returned to the laboratory; after approximately 72 hours the samples preserved in 4 percent buffered formalin-seawater will be transferred to 70–80 percent ethanol. All entrainment and source water samples will be processed. Samples will be examined under dissecting microscopes and fish larvae and targeted invertebrate larvae will be removed from debris and other zooplankton and placed and placed in labeled vials. Larvae will be identified to the lowest practical taxonomic level (species for most larvae) and enumerated. Fish eggs will not be sorted or identified because a full assessment of their abundance would require different sampling techniques and they cannot be identified to the same taxonomic levels as fish larvae.

If any of the proposed target invertebrate taxa are in very high abundances in the samples we will process only one of the paired nets from the bongo frame for invertebrates after thorough analysis is performed to determine the effect of this reduction in sample volume on the estimates.

The first ten samples sorted by an individual will be resorted by a designated quality control (QC) sorter. A sorter is allowed to miss one target organism when the total number of target organisms in the sample is less than 20. For samples with 20 or greater target organisms the sorter must maintain a sorting accuracy of 90 percent. After a sorter has ten consecutive samples with greater than 90 percent accuracy, the sorter will have one of their next ten samples randomly selected for a QC check. If the sorter fails to achieve an accuracy level of 90 percent their next ten samples will be resorted by the QC sorter until they meet the required level of accuracy. If the sorter maintains the required level of accuracy one of their next ten samples will be resorted by QC personnel.

A similar QC program will be conducted for the taxonomists identifying the samples. The first ten samples of fish or invertebrates identified by an individual taxonomist will be completely re-identified by a designated QC taxonomist. A total of at least 50 individual fish larvae from at least five taxa must be present in these first ten samples; if not, additional samples will be reidentified until this criterion is met. Taxonomists are required to maintain a 95 percent identification accuracy level in these first ten samples. After the taxonomist has identified ten consecutive samples with greater than 95 percent accuracy, they will have one of their next ten samples checked by a QC taxonomist. If the taxonomist maintains an accuracy level of 95 percent then they will continue to have one of each ten samples checked by a QC taxonomist. If they fall below this level then ten consecutive samples they have identified will be checked for accuracy. Samples will be re-identified until ten consecutive samples meet the 95 percent criterion.

Identifications will be cross-checked against taxonomic voucher collections maintained by MBC and Tenera Environmental.

A maximum of 200 representative fish larvae from each of the target taxa will be measured using a dissecting microscope and image analysis system. Larvae will be measured to the nearest 0.02 inch (0.5 mm).

4.4 Data Management

Field and laboratory data will be recorded on preprinted data sheets formatted for entry into a computer database for analysis and archiving. On a monthly basis these data will be transmitted to Tenera Environmental for entry into the project database and eventual analysis. Density of ichthyoplankton by species will be reported as number per 1,000 cubic meters (#/1,000 m^3).

4.5 Estimating Entrainment Effects

Estimates of daily and annual larval entrainment at ESGS will be calculated from data collected at the entrainment station. Estimates of entrainment loss, in conjunction with demographic data collected from the fisheries literature, will permit modeling of adult equivalent loss (*AEL*) and fecundity hindcasting (*FH*). Data from sampling of the potential source populations of larvae will be used to calculate estimates of proportional entrainment (*PE*) that are used to estimate the probability of mortality due to entrainment using the Empirical Transport Model (*ETM*). In the ESGS entrainment and impingement studies we will use each approach (i.e., *AEL*, *FH*, and *ETM*) as appropriate for each target taxon to assess effects of power plant losses.

The assessment approach used in the final report that will be submitted as part of the Comprehensive Demonstration Study (CDS) for the ESGS will also depend upon the facility's baseline calculations and its method(s) of compliance with the new §316(b) rule's performance standards for reductions in impingement mortality and entrainment. Compliance at ESGS may be achieved singly, or in combination, by technological or operational changes to the CWIS (TIOP), restoration methods, and site-specific BTA standards. In order to demonstrate compliance through the TIOP it is only necessary to analyze entrainment data to determine baseline entrainment levels and assess those levels against the improvements achieved through the implementation of the TIOP. In the case where restoration is limited to only commercially or recreationally important species, entrainment data may also be adequate to assess the levels of restoration necessary to offset entrainment and impingement losses, assuming that scientifically valid population models exist for the species providing the lost benefits. In assessing compliance with the performance standard in whole or in part through restoration of habitat to include non-use species in addition to the losses of recreational and commercial species it is necessary to assess the entrainment and impingement losses from the source water using a combination of assessment methods to determine the commensurate level of restoration. The same source water and entrainment data, and assessment methods would also be used to determine a site-specific BTA standard based on cost-benefit analysis of both use and non-use entrainment losses. Source water data would not be necessary for cost-benefit analysis based simply on the value of commercial and recreational species losses.

4.5.1 Demographic Approaches

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

Demographic approaches, exemplified by the *EAM*, produce an absolute measure of loss beginning with simple numerical inventories of entrained or impinged individuals and increasing in complexity when the inventory results are extrapolated to estimate numbers of adult fishes or biomass. We will use two different but related demographic approaches in assessing entrainment effects at ESGS: *AEL*, which expresses effects as absolute losses of numbers of adults, and *FH*, which estimates the number of adult females whose reproductive output has been effectively eliminated by entrainment of larvae. Both estimates require an estimate of the age at entrainment. These estimates will be obtained by measuring a random sample of up to 200 larvae of each of the target taxa from the entrainment samples and using published larval growth rates to estimate the age at entrainment. The age at entrainment will be calculated by dividing the difference between the size at hatching and the average size of the larvae from entrainment by a growth rate obtained from the literature.

Age-specific survival and fecundity rates are required for *AEL* and *FH*. Adult-equivalent loss estimates require survivorship estimates from the age at entrainment to adult recruitment; *FH* requires egg and larval survivorship until entrainment. Furthermore, to make estimation practical, the affected population is assumed to be stable and stationary, and age-specific survival and fecundity rates are assumed to be constant over time. Each of these approaches provides estimates of adult fish loss, which will still need to be placed into context regarding standing stocks of adult fishes.

Species-specific survivorship information (e.g., age-specific mortality) from egg or larvae to adulthood is limited for many of the taxa likely to be considered in this assessment. Thus, in many cases, these rates must be inferred from the literature along with their measures of uncertainty. Uncertainty surrounding published demographic parameters is seldom known and rarely reported, but the likelihood that it is very large should be considered when interpreting results from the demographic approaches for estimating entrainment effects. For some well-studied species (e.g., northern anchovy, *Engraulis mordax*), portions of early mortality schedules and fecundity have been reported (e.g., Parker 1980; Zweifel and Smith 1981; Hewitt 1982; Hewitt and Methot 1982; Hewitt and Brewer 1983; Lo 1983, 1985, and 1986; McGurk 1986). Because the accuracy of the estimated entrainment effects from *AEL* and *FH* will depend on the accuracy of age-specific mortality and fecundity estimates, lack of demographic information may limit the utility of these approaches.

The precursor to the *AEL* and *FH* calculations is an estimate of total annual larval entrainment. Estimates of larval entrainment at ESGS will be based on the monthly sampling where $\hat{E}_T$ is the estimate of total entrainment and $\hat{E}_i$ is the monthly entrainment estimate. Estimates of total entrainment are based on two-stage sampling designs, with days within each sampling period and cycles within days. The within-day sampling is based on a stratified random sampling scheme with four temporal cycles and two replicates per cycle.

4.5.1.1 Adult Equivalent Loss *(AEL)*

The *AEL* approach uses estimates of the abundance of the entrained or impinged organisms to project the loss of equivalent numbers of adults based on mortality schedules and age-at-recruitment. The primary advantage of this approach is that it translates power plant-induced early life-stage mortality into numbers of adult fishes that are familiar units to resource managers. Adult equivalent loss does not require source water estimates of larval abundance in assessing effects. This latter advantage may be offset by the need to gather age-specific mortality rates to predict adult losses and the need for information on the adult population of interest for estimating population-level effects (i.e., fractional losses).

Starting with the number of age class j larvae entrained, $\hat{E}_j$, it is conceptually easy to convert these numbers to an equivalent number of adults lost $\widehat{AEL}$ at some specified age class from the formula:

$$\widehat{AEL} = \sum_{j=1}^{n} \hat{E}_j S_j \qquad (1)$$

where

n = number of age classes;

$\hat{E}_j$ = estimated number of larvae lost in age class j; and

S_j = survival probability for the jth class to adulthood (Goodyear 1978).

Age-specific survival rates from larval stage to recruitment into the fishery must be included in this assessment method. For some commercial species, natural survival rates are known after the fish recruit into the commercial fishery. For the earlier years of development, this information is not well known and may not exist for non-commercial species.

An alternative expression of adult-equivalent loss would be to standardize $\hat{AEL}$ by the size of the adult population of interest to estimate the relative magnitude of the equivalent adult loss such that,

$$\hat{R}AEL = \frac{\hat{AEL}}{\hat{P}1}, \tag{2}$$

where $\hat{P}1$ = estimated size of the adult population of interest. Information on adult source populations will be limited for many species and thereby limit the utility of Equation (2), although the same approach will be used to place the estimated losses into context for taxa with published commercial or recreational fishery catch data.

4.5.1.2 Fecundity Hindcasting (FH)

The *FH* approach compares larval entrainment losses with adult fecundity to estimate the amount of adult female reproductive output eliminated by entrainment, hindcasting the numbers of adult females effectively removed from the reproductively active population. The accuracy of *FH* estimates, as with those of the *AEL* above, is dependent upon accurate estimates of age-specific mortality from the egg and early larval stages to entrainment and accurate estimates of the total lifetime female fecundity. If it can be assumed that the adult population has been stable at some current level of exploitation and that the male:female ratio is constant and 50:50, then fecundity and mortality are integrated into an estimate of loss by converting entrained larvae back into females (i.e., hindcasting).

A potential advantage of *FH* is that survivorship need only be estimated for a relatively short period of the larval stage (i.e., egg to larval entrainment). The method requires age-specific mortality rates and fecundities to estimate entrainment effects and some knowledge of the abundance of adults to assess the fractional losses these effects represent. This method assumes that the loss of a single female's reproductive potential is equivalent to the loss of an adult fish.

In the FH approach, the total of larval entrainment for a species $\hat{E}_T$ will be projected backward to estimate the number of breeding females required to provide the numbers of larvae seen in the entrainment samples. The estimated number of breeding females $\hat{FH}$ whose fecundity is equal to the total loss of entrained larvae would be calculated as follows:

$$\hat{F}H = \frac{\hat{E}_T}{\hat{T}LF \cdot \prod_{j=1}^{n} S_j} \tag{3}$$

where

$\hat{E}_T$ = total entrainment estimate;

S_j = survival rate from eggs to entrained larvae of the j th stage ;

$\hat{TLF}$ = average total lifetime fecundity for females, equivalent to the average number of eggs spawned per female over their reproductive years.

The two key input parameters in Equation (3) are total lifetime fecundity $\hat{TLF}$ and very early survival rates S_j from spawning to entrainment. Descriptions of these parameters may be limited for many species and are a possible limitation of the method.

An alternative interpretation of FH is possible by expressing the estimate in terms of the relative size of the adult fish stock in the source populations where

$$\hat{RFH} = \frac{\hat{FH}}{\hat{P}} \qquad (4)$$

where $\hat{P}$ = estimated size of the adult population of interest. Information on adult source populations will be limited for many species and thereby limit the utility of Equation (4), although the same approach can be used to place the estimated losses into context for taxa with published commercial or recreational fishery catch data where $\hat{RFH}$ is the proportion of the breeding females whose fecundity was lost due to entrainment by the ESGS.

4.5.1.3 Empirical Transport Model (ETM)

The ETM calculations provide an estimate of the probability of mortality due to power plant entrainment. The calculations require not only the abundance of larvae entrained but also the abundance of the larval populations at risk of entrainment. Sampling at the cooling water intakes is used to estimate the total number of larvae entrainment for a given time period, while sampling in the coastal waters around the ESGS intakes is used to estimate the source population for the same period.

On any one sampling day, the conditional entrainment mortality can be expressed as

$$PE_i = \frac{\hat{E}_i}{\hat{R}_i} \qquad (5)$$

where

E_i = total numbers of larvae entrained during the *i* th survey; and

R_i = numbers of larvae at risk of entrainment, i.e., abundance of larvae in source water.

The values used in calculating *PE* are population estimates based on the respective densities and volumes of the cooling water system flow and source water areas. The abundance of larvae at risk in the source water during the *i* th survey can be directly expressed as

$$\hat{R}_i = V_S \cdot \hat{\bar{\rho}}_{S_i} \qquad (6)$$

where V_S denotes the static volume of the source water (S_i), and $\hat{\bar{\rho}}$ denotes an estimate of the average density in the source water.

Regardless of whether the species has a single spawning period per year or multiple overlapping spawnings the estimate of total larval entrainment mortality can be expressed by

$$\hat{P}_M = 1 - \sum_{i=1}^{N} \hat{f}_i \left(1 - \hat{P}E_i\right)^q \tag{7}$$

where

q = number of days that the eggs and larvae are susceptible to entrainment, and

$\hat{f}_i$ = estimated annual fraction of total larvae hatched during the i th survey period.

To establish independent survey estimates, it is assumed that during each survey a new and distinct cohort of larvae is subject to entrainment. Each of the monthly surveys is weighted by $\hat{f}_i$ and estimated as the proportion of the total source population present during the i th survey period.

As shown in Equations 5 and 6 the estimates of *PE* are based on population estimates of specific volumes of water. While a reasonably accurate estimate of the volume of the cooling water intake flow can be obtained, estimating the volume of the source water is more difficult and will vary depending upon oceanographic conditions and target taxon. Source water volumes will be estimated separately for each taxon during each survey. Onshore and alongshore current vectors measured during each survey period will be used to determine the maximum distance a larvae could travel based on the estimated maximum larval duration for each taxon. The maximum age at entrainment will be calculated using the lengths of a random sample of up to 200 larvae from the entrainment samples for each target taxon. The maximum age will be calculated based on the upper 95th percentile value of the lengths measured from the samples. The maximum age at entrainment will be calculated by dividing the difference between the upper 95th percentile value of the lengths measured from the samples minus the hatch length by the growth rate.

Alongshore and onshore current velocities will be measured using current meters positioned offshore from the ESGS intake. The final position and depth of the current meters will be chosen to ensure that they are outside the influence of the intake flow. The direction in degrees true from north and speed in cm per second will be estimated for each hour of the source water survey periods. The hourly current meter data will be analyzed by rotating the current vectors so that they are orthogonal to the coast and then tracking the movement of water during each survey period. A total alongshore length or displacement in kilometers will be calculated from these data using the range of both upcoast and downcoast movement over the larval duration period prior to each survey period. The maximum upcoast and downcoast displacement measured prior to each survey period will be added together to obtain an estimate of total alongshore movement. Onshore movement, excluding periods of offshore movement, will be similarly calculated for the egg and larval larval duration periods for each species.

Data from the source water sampling will be used to extrapolate densities onshore and offshore using the following approaches:

1. For species where the regression of density versus offshore distance has a negative slope, the offshore distance predicted where density is zero (i.e., integral of zero) will be calculated. The alongshore distance will be calculated from the cumulative current data vectors for the duration based on the maximum larval length.

2. For species where the regression of density versus offshore distance has a slope of ≥ 0, either the offshore distance from the water current data or an average distance based on

literature values on the depth distribution of the adults offshore will be used. Literature values (e.g., CalCOFI) will be used to place a ceiling on both the distance and density values used in the offshore extrapolation.

3. The offshore distance of the source water study area will be used when the onshore water current displacement is less than the width of the study area unless the limits of the regression or the depth distribution for the taxa is less than the distance offshore.

These three approaches will use the same regression coefficients to extrapolate source water densities to the shoreline. Survey specific regression coefficients will be calculated by fitting either a linear, quadratic, or other model to the density data. For example, a linear model would be fit as follows:

$$\rho_{ij} = \alpha + \beta w_i + \varepsilon_{ij}$$

where

$\rho_{ij} =$ larval density for the *j* th observation in the *i* th survey,
$w_i =$ distance for the *i* th survey, and
$\alpha, \beta =$ regression coefficients.

The regression analysis will treat the four six-hour cycles during each source water survey as sampling strata according to Cochran (1977). The data collected during the surveys will be converted to counts per m^3 using the sample volumes from the flow meters in the bongo nets. Depths at each station will be recorded and used to convert, by multiplication, these data on larval concentration to densities in counts per m^2. The larval densities (ρ_{ij}) will be analyzed using a model to define density as a function of distance from shore ($\rho_{ij} = f(w_i)$). This function will then be used to extrapolate density as a function of distance from shore by integrating from the offshore margin of the sampling area to a point estimated by the maximum current vector, or where the extrapolated larval density is zero or biologically limited. This point may occur beyond the offshore extent of the study area. A similar integration of the function will occur from the inshore edge of the study area towards the shoreline. This integration will result in units of counts per m. When multiplied by the alongshore distance from the cumulative current vectors we obtain our final estimate for the source water (R_i). This is used in Equation 5 to obtain an estimate of *PE* for the survey. Alternatively, the sampling locations within the source water study area could be treated as spatial strata and an estimate of counts per m obtained.

5.0 REPORTING

Tenera Environmental and MBC Applied Environmental Sciences will produce a final report on the findings from the entrainment and impingement studies. Results from field surveys will be presented, and loss estimates derived from one or more of the assessment methods will be presented for each of the selected target taxa. The report will be submitted as part of the Comprehensive Demonstration Study for the ESGS.

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