CARLSBAD SEAWATER DESALINATION PROJECT

SAN DIEGO REGIONAL WATER QUALITY CONTROL BOARD

REGION 9, SAN DIEGO REGION

ORDER NO. R-9-2006-0065

NPDES NO. CA0109223

FLOW, ENTRAINMENT AND IMPINGEMENT MINIMIZATION PLAN

ATTACHMENT 5 - ESTIMATION OF THE POTENTIAL FOR IMPINGEMENT SHOULD THE CDP OPERATE IN STAND-ALONE MODE

March 9, 2009

ESTIMATION OF THE POTENTIAL FOR IMPINGEMENT SHOULD THE CDP OPERATE IN STAND-ALONE MODE

The San Diego Regional Water Quality Control Board ("Regional Board") will consider the Flow, Entrainment and Impingement Minimization Plan ("the Plan") for the Carlsbad Desalination Project (the "CDP" or "Project") at its April 8, 2009 meeting. The Plan was required as a Special Provision of the Project's NPDES permit[1] in order to assure compliance with the Porter-Cologne Water Quality Control Act, Water Code Section 13142.5(b), which requires that the intake and mortality of marine life be minimized. Relevant to that evaluation is the potential for impingement should the CDP operate in stand-alone mode.

This memorandum evaluates potential approaches that could be used to estimate the potential for impingement when the CDP is operated in stand-alone mode. Based on the relevant facts, data, and literature, this memorandum concludes that a sound and reasonable approach is a flow-proportioned approach. Accordingly, the Regional Board reasonably may rely on this approach in making findings about projected impingement.

I. BACKGROUND

The CDP will be co-located with the Encina Power Station ("EPS"), and will receive its feedstock water from Agua Hedionda Lagoon through the EPS's existing seawater intake system.

From June 2004 to June 2005, Tenera Environmental ("Tenera") conducted a field program during which impingement at the EPS intake structure was measured. Since the Project's feedwater will come from the EPS's intake system, the Project's projected impingement was estimated based on the impingement data collected during this program, in which biological samples were collected one day each week from June 24, 2004 through June 15, 2005. Table 1 presents the results from the weekly sampling events. It reflects the number and weight of marine organisms collected from the intake screens for each 24-hour sampling event along with the corresponding intake flow.

Table 2

Number and weight of fishes (bony fishes, sharks and rays) and invertebrates impinged during normal operations at EPS from June 2004 to June 2005 on the sample days

	Daily Volume (MGD)	**Fishes (Bony Fishes & Sharks + Rays)**		**Invertebrates**	
		Number	Weight (g)	Number	Weight (g)
6/24/2004	632	287	4,355.6	7	66.1
6/30/2004	620	419	4,666.3	6	106.4
7/7/2004	671	209	3,590.1	6	54.0
7/14/2004	856	842	12,377.4	4	272.1
7/21/2004	817	263	7,264.0	3	21.1
7/28/2004	751	255	6,479.3	2	32.5
8/4/2004	676	70	3,951.0	2	7.4
8/11/2004	857	679	11,898.7	7	45.1

[1] Order No. R9-2006-0065, NPDES No. CA0109223, § VI.C.2.e.

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Table 2

Number and weight of fishes (bony fishes, sharks and rays) and invertebrates impinged during normal operations at EPS from June 2004 to June 2005 on the sample days

	Daily Volume (MGD)	**Fishes (Bony Fishes & Sharks + Rays)**		**Invertebrates**	
		Number	Weight (g)	Number	Weight (g)
8/18/2004	857	86	3,999.7	3	24.9
8/25/2004	626	100	3,809.5	5	26.4
9/1/2004	735	34	1,489.8	2	4.7
9/8/2004	857	250	4,010.0	1	2.5
9/15/2004	771	96	1,348.4	8	62.6
9/22/2004	793	167	2,092.4	6	50.1
9/29/2004	840	122	1,581.4	15	115.9
10/6/2004	823	218	2,908.8	28	116.5
10/13/2004	550	17	323.6	21	118.8
10/20/2004	419	258	2,942.3	16	70.2
10/27/2004	477	206	4,724.5	37	254.0
11/3/2004	477	99	488.5	12	100.1
11/10/2004	550	21	129.0	29	196.6
11/17/2004	544	61	965.6	12	117.9
11/22/2004	550	43	1,350.5	37	156.2
12/1/2004	813	1,947	9,782.8	21	142.5
12/8/2004	784	324	2,899.0	22	335.0
12/15/2004	710	207	2,570.5	20	161.3
12/20/2004	710	66	678.9	20	197.7
12/29/2004	710	1,146	10,427.0	45	189.8
1/5/2005	566	528	7,280.2	40	385.6
1/12/2005	560	5,001	109,526.0	95	2,583.5
1/19/2005	599	600	6,914.1	49	444.0
1/26/2005	632	306	8,330.4	39	414.0
2/2/2005	560	246	3,196.5	26	678.4
2/9/2005	632	227	5,696.6	19	133.5
2/16/2005	497	23	1,186.0	714	2,153.6
2/23/2005	307	1,274	29,531.0	42	4,199.8
3/2/2005	497	48	3,638.2	20	424.6
3/9/2005	497	132	6,586.5	74	629.9
3/16/2005	497	30	887.6	16	62.0
3/23/2005	673	282	7,722.8	65	295.8
3/30/2005	674	240	9,163.4	37	162.5
4/6/2005	673	109	7,150.5	49	343.0
4/13/2005	673	220	11,137.4	184	631.4
4/20/2005	745	96	2,734.5	23	288.1
4/27/2005	745	102	3,891.5	8	24.4
5/4/2005	706	280	4,241.8	7	28.6
5/11/2005	576	200	6,343.4	11	328.4
5/18/2005	706	312	7,347.4	20	96.6
5/25/2005	632	195	4,444.6	20	107.0
6/1/2005	700	228	5,925.4	19	52.9
6/8/2005	778	234	4,626.6	5	13.0
6/15/2005	563	37	1,912.7	8	24.5

Table 2

Number and weight of fishes (bony fishes, sharks and rays) and invertebrates impinged during normal operations at EPS from June 2004 to June 2005 on the sample days

	Daily Volume (MGD)	Fishes (Bony Fishes & Sharks + Rays)		Invertebrates	
		Number	Weight (g)	Number	Weight (g)
EPS Totals (52 days)	**34,167**	**19,442**	**372,520**	**1,987**	**17,554**
EPS Daily Averages	**657**	**374**	**7,163.8**	**38**	**337.6**

The EPS has the capacity to withdraw 863.5 million gallons per day ("MGD").[2] During the 2004-2005 sampling period, the EPS's average flow volume was approximately 657 MGD for the 52 sample days. In contrast, the water demand for the Project is 304 MGD. Unlike the EPS, the cooling water requirements of which are driven by variable demand for electricity, the CDP's feedstock demand will remain relatively constant.

II. IMPINGEMENT IS RELATED TO INTAKE VELOCITY, FLOW VOLUME, AND FISH SWIM SPEED

Impingement is defined as the entrapment of all life stages of fish and shellfish on the outer part of an intake structure or against a screening device during periods of intake water withdrawal.[3] It long has been recognized that impingement is related to water velocities in the vicinity of the intake structure[4]. In particular, it is well-established that fish can escape intake structures if their ability to swim away from the structure is not overwhelmed by the velocities at the structure[5]. The fish also must be able to detect the structure, and the flow field at and near the structure must be uniform enough so that the fish's ability to navigate is not compromised. All other things being equal, when intake flow at an intake structure is relatively low compared to the design capacity of the structure, intake velocities correspondingly will be relatively low. Thus, reducing flow at a given intake structure is an effective means by which to reduce velocities and the potential for impingement.

These principles are reported in the scientific literature, and have supported national standards proposed by the United States Environmental Protection Agency ("EPA"). EPA explains that the impingement of organisms is governed by the combination of three primary factors—flow, intake velocity, and fish swim speed.[6] Consistent with EPA's guidance, each of these factors is relevant in estimating the Project's projected impingement. California agencies also recognize the relationship between intake velocity and flow, on the one hand, and the potential for impingement, on the other.

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[2] EPS's NPDES Permit, Order No. R9-2006-0043, NPDES No. CA0001350, at 5.

[3] Criteria and Standards for the National Pollutant Discharge Elimination System, 40 C.F.R. 125(93) (2009).

[4] General Fish Screen Criteria, Interagency Ecological Program's CALFED Fish Facility Technical Team (p. 18).

[5] *Id.*

[6] National Pollutant Discharge Elimination System—Final Regulations to Establish Requirements for Cooling Water Intake Structures at Phase II Existing Facilities; Final Rule, 69 Fed. Reg. 41612 (July 9, 2004) (to be codified at 40 C.F.R. pt. 9, 122 et al).

A. The Scientific Literature Documents the Generally Accepted Relationship Between Velocity and Flow, on the One Hand, and Impingement, on the Other

"Rates of entrainment and impingement of aquatic resources are directly related to intake velocities at and around the intake structure, and also to numerous other physical and biological phenomena."[7] "Naturally, the best technique is to minimize the number of fish which enter the intake area. This can be accomplished by locating the intake in an area of low fish population, reducing the velocity of the intake water, and eliminating areas where fish can be trapped."[8] "'[A]pproach velocity and screen face velocity are the principal design criteria for controlling the impingement of larger organisms, principally fish, on intake screens."[9]

A gross cross-sectional area can be calculated if the width of the intake bay and the depth of the water in that opening are known values. From this gross cross-sectional area, the net open area that flow can pass through is determined by subtracting the area of the rack bars and supports that block the passage of water through the opening. Once the net area has been calculated, the equation $Q = AV$ provides the relationship between flow and velocity (i.e., $V = Q/A$).[10] Since the area of an existing intake is fixed, velocity is exclusively a function of flow.

Turnpenny (1988) reported that the "three vital elements to fish exclusion" from intake structures are as follows:

> (1) the fish must be able to detect its approach to an intake before it can attempt to escape; (2) the direction of water flow must be horizontal, since fish are ill-equipped to react to vertical flow components; (3) the water velocity must be within the fish's swimming performance range. All three requirements must be met simultaneously; it is futile, for example, to reduce intake current velocities where waters are perpetually turbid, since fish would be unlikely to detect their approach to the intake.[11]

Turnpenny also points out the common sense fact that fish are not influenced by currents when they are very low. "At low current speeds ($<$1-3 cm s^{-1}), the current has no effect on the direction in which the fish swims."[12] In other words, there is some minimum threshold below which intake velocities and corresponding flows do not place the fish at risk of impingement. He concludes that, "it is possible to predict how fish will respond to man-made

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[7] Boreman, J. 1977. Impacts of power plant intake velocities on fish. Power Plant Team (p. 2), U.S. Fish and Wildlife Service.

[8] *Id*. at 14.

[9] U.S. Nuclear Regulatory Comm'n, Office of Nuclear Regulatory Research, Regulatory Guide 4.7, General Site Suitability Criteria for Nuclear Power Stations, n. 4, at B-3 (April 1998).

[10] Q = the flow in cubic feet per second being provided by the pumps (where 448.8 gallons per minute = 1 cubic foot per second); A = the net area (in square feet) available for flow to pass through the racks; and V= the velocity in feet per second of the water passing through the racks.

[11] Turnpenny, A.W. H. The Behavioral Basis of Fish Exclusion from Coastal Power Station Cooling Water Intakes (p. 1) Central Electricity Generating Board Research Report, RD/L/3301/R88, 1988.

[12] *Id*. at 5.

currents at CW [cooling water] intakes."[13] "The main consideration for fish escape is therefore that the approach velocity at that point," referring to the coarse screens, "is kept within the swimming ranges of the fish…."[14]

B. EPA and California State Regulators Have Recognized the Relationship between Velocity and Flow, on the One Hand, and Impingement, on the Other

1. The Agencies Recognize that Reducing Flow Reduces Impingement

Since the 1970s, EPA has recognized the relationship between flow and impingement.[15] EPA notes that "flow reduction serves the purpose of reducing both impingement and entrainment."[16] According to EPA, this explains why "[e]nvironmental commentators [have] advocated for flow reduction technologies as the most direct means of reducing fish kills from power plant intakes."[17]

In accord with these well-recognized principles, EPA's Phase I, II and III regulations use flow as a criterion when determining which set of rules will apply to a particular intake system. The regulations reflect that the rate of impingement is related to the flow (i.e., volume) of water drawn through an intake structure. As a facility increases its flow by pumping more water from the source water body, the amount of impingement can be expected to increase correspondingly when other factors remain constant. Conversely, as a facility decreases its flow by pumping less water from the source water body, the amount of impingement can be expected to decrease.

For example, in the Preamble to its Phase II regulations, EPA explains that it established 50 MGD as the threshold level for applying its regulations, "because the regulation of existing facilities with flows of 50 MGD or greater in Phase II will address those existing power generating facilities with the greatest potential to cause or contribute to adverse environmental impact."[18]

Similarly, the State Water Resources Control Board ("SWRCB") recognizes the relationship between reduced flow and reduced impingement. In its March 2008 Scoping Document, Water Quality Control Policy on the Use of Coastal and Estuarine Water for Power Plant Cooling, the SWRCB reiterated EPA's conclusion and observed that "[f]low reduction will

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[13] *Id*.

[14] *Id*. at 15.

[15] Development Document for Best Technology Available for the Location, Design, Construction and Capacity of Cooling Water Intake Structures for Minimizing Adverse Environmental Impact. EPA 440/1-76/015-a. USEPA April 1976. Washington, DC.

[16] U.S. Environmental Protection Agency, Phase II, Final Rule Technical Development Document, Chapter 4 (Efficacy of Cooling Water Intake Structure Technologies), at Section 1.5, p. 4-4, *available at* http://www.swrcb.ca.gov/rwqcb3/water_issues/programs/duke_energy/docs/usepa_efficacy_of_intake_technologies.pdf.

[17] 69 Fed. Reg. 41612

[18] *Id*.

reliably reduce both impingement and entrainment impacts of OTC [once through cooling]."[19] The EPS intake structure is an OTC intake, although the structure will be used for feedstock water – not cooling[20] – when the CDP operates in stand-alone mode.

2. The Agencies Recognize that Reducing Velocity Reduces Impingement

When EPA established "best technology available" under Section 316(b) of the federal Clean Water Act for purposes of new facilities utilizing cooling water intake structures (Phase I Rule), the agency determined that a maximum intake velocity of 0.5 fps (feet per second) or less minimizes impingement to acceptable levels.[21]

In developing the Phase I Rule, EPA drew from federal agency reports that recommend a velocity of 0.5 fps to protect fish species from impingement previously.[22] These reports were based in part on a study of fish swimming speeds and endurance performed by Sonnichsen et al. (1973).[23] EPA concluded that "thresholds should be based on the fishes' swimming speeds (which are related to the length of the fish) and endurance (which varies seasonally and is related to water quality)."[24] This analysis demonstrated that "the species and life stages evaluated could endure a velocity of 1.0 ft/s."[25] However, in order to "develop a threshold that could be applied nationally and is effective at preventing impingement of most species of fish at their different life stages, EPA applied a safety factor of two to the 1.0 ft/s threshold to derive a lower threshold of 0.5 ft/s. This safety factor, in part, was meant to ensure protection when screens become partly occluded by debris during operation and velocity increases through portions of the screen that remain open."[26] "EPA compiled the data from three

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[19] SWRCB, Scoping Document: Water Quality Control Policy on the Use of Coastal and Estuarine Waters For Power Plant Cooling (March 2008), at 45, *available at* http://www.energy.ca.gov/2008publications/SWRCB-1000-2008-001/SWRCB-1000-2008-001.PDF.

[20] This is why the CDP's operations will not involve heat treatment.

[21] *See* 66 Fed. Reg. 65274; *see also* 40 C.F.R. 125.84(b)(2), 125.84(c)(1) (*cited in* Comment Letter of January 26, 2009 at Section V, Footnote 49).

[22] 66 Fed. Reg. 65274 (citing Boreman, J. 1977. Impacts of power plant intake velocities on fish. Power Plant Team, U.S. Fish and Wildlife Service; 33 Christianson, A. G., F. H. Rainwater, M.A. Shirazi, and B.A. Tichenor. 1973. Reviewing environmental impact statements: power plant cooling systems, engineering aspects, U.S. Environmental Protection Agency (EPA), Pacific Northwest Environmental Research Laboratory, Corvallis, Oregon, Technical Series Report EPA–660/2–73–016; King, W. Instructional Memorandum RB–44: Review of NPDES (National Pollutant Discharge Elimination System) permit applications processed by the EPA (Environmental Protection Agency) or by the State with EPA oversight.'' In: U.S. Fish and Wildlife Service Navigable Waters Handbook.) (*cited in* Comment Letter of January 26, 2009 at Section V, Footnote 51).

[23] Sonnichsen, J.C., Bentley, G.F. Bailey, and R.E. Nakatani. 1973. A review of thermal power plant intake structure designs and related environmental considerations. Hanford Engineering Development Laboratory, Richland, Washington, HEDL–TME 73– 24, UC–12. (*cited in* Comment Letter of January 26, 2009 at Section V, Footnote 52).

[24] 66 Fed. Reg. 65274 (*cited in* Comment Letter of January 26, 2009 at Section V, Footnote 53).

[25] *Id* (*cited in* Comment Letter of January 26, 2009 at Section V, Footnote 54).

[26] *Id* (*cited in* Comment Letter of January 26, 2009 at Section V, Footnote 55).

studies[27] on fish swim speeds …[which] suggest that a 0.5 ft/s velocity would protect 96 percent of the tested fish[28]."

III. <u>DATA SET INCLUDES TWO EVENTS WHERE FACTORS OTHER THAN FLOW APPEAR TO BE PRIMARY DRIVERS OF IMPINGEMENT</u>

Inspection of the data set indicated that the vast majority of the data clustered around a range of flows and corresponding values of impingement. On two of the 52 sampling days, however, there seemed to be more impingement than could be accounted for on the basis of flow. These two events were given particular consideration as they suggest that, from time to time, the EPS's impingement primarily is influenced by factors other than flow at the intake. In essence, the data set appears to consist of two populations. For the vast majority of the time, perhaps fifty weeks per year, impingement is within a range where flow appears to be a meaningful influence.

Based on the data set, about two weeks out of the year, factors other than flow may be primary. This section focuses on that smaller population. Please note that the analysis presented in this section assumes that each of the two non-flow-related events will occur seven days each year. If in fact these events are associated with storm events, it will be important to examine the nature of these storms in order to get a better picture of the frequency of such events. If it is true that the non-flow-related events correspond to infrequent storm events, it may be warranted to assume that these events will repeat seven times per year. Doing so may be very conservative. Poseidon's experts continue to assess this matter.

1. <u>January 12 and February 23, 2005 Data May be Outliers</u>.

EPA defines the term "outliers" to include "measurements that are extremely large or small relative to the rest of the data set and…suspected of misinterpreting the population from which they were collected."[29] The impingement totals on January 12 and February 23, 2005 were "extremely large" relative to the mean values of the other collection samples. As such they may qualify as outliers per EPA's definition.

On January 12 and February 23 of 2005, impingement was relatively high. During the 50 more typical sampling events, Tenera collected an average of 263 fish, with a daily biomass of 4.67 kg. Table 2 compares these mean values with the impingement totals collected on January 12 and February 23 and demonstrates the differing nature of these two days. On January 12, Tenera collected 5,001 fish weighing 109,526 grams. The number and weight of

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[27] *Id*. (*citing* <u>University of Washington study</u> [Smith, L.S., L.T. Carpenter. Salmonid Fry Swimming Stamina Data for Diversion Screen Criteria. Prepared by Fisheries Research Institute, University of Washington, Seattle, WA for Washington State Department of Fisheries and Washington State Department of Wildlife, 1987], <u>Turnpenny</u> [Turnpenny, A.W. H. The Behavioral Basis of Fish Exclusion from Coastal Power Station Cooling Water Intakes. Central Electricity Generating Board Research Report, RD/L/3301/R88, 1988], and <u>EPRI</u> [EPRI. Technical Evaluation of the Utility of Intake Approach Velocity as an Indicator of Potential Adverse Environmental Impact Under Clean Water Act Section 316(b). Technical Report. 1000731, 2001]) (*cited in* Comment Letter of January 26, 2009 at Section V, Footnote 56).

[28] 69 Fed. Reg. 41601.

[29] EPA (2006) Qa/G-9S Report Data Quality Assessment: Statistical Methods for Practitioners.

fish collected on that day were, respectively, 19 and 23.5 times greater than the other 50 days. On February 23, Tenera collected 1,274 fish weighing 29,531 grams. The number and weight of fish collected on February 23 were, respectively, 4.8 and 6.3 times greater than the other 50 days.

Table 2: comparison of flow-related and non-flow-related days				
	Number Fishes		**Weight**	
Average for the 50 normal sampling events	263		4.67 kg/day	
January 12, 2005	5,001	19 times greater than the average	109,526 (grams)	23.5 times greater than the average
February 23, 2005	1,274	4.8 times greater than the average	29,531 (grams)	6.3 times greater than the average

2. Non-flow-related Factors Contribute to Impingement.

A number of non-flow-related factors also cause impingement. For instance, water quality, temperature, salinity, urban runoff, herding behavior by predators (e.g., sea lions), attractants like light, and other factors each can affect impingement.[30] In 1977 the U.S. Fish and Wildlife Service reported that, "impingement rates of fishes are strongly influenced by temperature and salinity conditions in the vicinities of estuarine power plant intakes."[31]

An examination of the data for January 12 and February 23 suggests that some combination of these and/or other non-flow-related factors may have contributed to the relatively higher impingement totals observed on these days. On February 23, for instance, the EPS's flow was only 307 million gallons—the lowest flow volume recorded for the entire sampling period. Nevertheless, approximately 30 kg of fish biomass were collected on that day. Similarly, on January 12 the flow volume was 560 million gallons—about 15 percent less than the average 657 MGD amount recorded over the entire sampling period. Despite this below-average flow, Tenera collected nearly 110 kg of fish biomass.

While non-flow-related factors may have contributed significantly to the impingement recorded on January 12 and February 23, the exact nature of these factors is not clear. One theory is that heavy rains preceding the sampling events somehow caused the added

[30] It is unclear whether or to what extent these factors contributed to the two outlier sampling events. However, because only two of the 52 sampling events exhibited relatively high values (i.e., extreme events occurred only 3.85 % of the time of the study – 2/52 = 3.85 %), the analysis of the collected data indicates that a relationship between flow and impingement weight was observed more for more than 96% of the time. Since trends that persist over 95% of the time are usually considered significant, the exclusion of the two outliers establishes a correlation between impingement weight and flow that reflects commonly accepted scientific principles.

[31] Boreman, J. 1977. Impacts of power plant intake velocities on fish. Power Plant Team (p. 5), U.S. Fish and Wildlife Service.

impingement, e.g., by affecting water quality and/or salinity levels at or near the intake. Fish killed by urban runoff from these rains may have drifted to the mouth of the lagoon and eventually settled against the intake screens. This theory is supported by the large number of freshwater fishes that were collected on these two days.[32] For instance, 40 freshwater catfish were collected on these two days (2 on January 12th and 38 on February 23rd) while catfish were never collected on any other day. These catfish and other freshwater fishes[33] may have been flushed from Agua Hedionda Creek into the saltwater lagoon where they may have died before settling against the intake screens.

Given that the data are not available to control for all of the potential non-flow-related variables, we were not able to conduct a statistical analysis to account for these factors. Rather than hypothesizing as to why these events were outside the remainder of the data set, this memorandum identifies and evaluates different approaches that could be used to account for these data.

3. Outliers Are Typically Treated in One of Three Ways.

Outliers may be suspect and warrant careful examination. In the realm of statistical analysis, the appropriateness of their treatment depends on the nature of the observations. First, the outliers may simply be unusual values that have occurred by chance. In this case they should be retained without modifying the model. Second, they may represent erroneous data; if so, the data should be corrected or disregarded. Third, they may signal a violation of model assumptions; if so, another model should be considered.[34]

Three facts weigh against the application of the first option to the EPS data. First, as described above, the impingement values on the outlier days were significantly higher than the number and weight averages for the 50 other days. Second, the number of outlier events (2) was small relative to the number of other events (50)—in other words, only 4% of the samples were outside the remainder of the population. Third, these events followed heavy rains, which may have contributed to the increased impingement. These facts suggest that the outliers are not typical, but also not random, and, consequently, should either be declared erroneous and removed from the data set per the second option or treated specially under a modified model per the third.

IV. APPROACHES TO ESTIMATING THE POTENTIAL FOR IMPINGEMENT DURING STAND-ALONE OPERATIONS

This Section describes five different approaches to estimating the Project's impingement: (1) a correlation approach that excludes non-flow-related events altogether; (2) a correlation that then adds back the non-flow-related events; (3) an equivalence approach that

[32] See Attachment 3, "IMPINGEMENT RESULTS, G1 - TRAVELING SCREEN AND BAR RACK WEEKLY SURVEYS, G2 - HEAT TREATMENT SURVEYS", pages G1-18, G1-23.

[33] In addition to the catfish that it collected on January 12 and February 23, Tenera also collected the following freshwater species: chubs (95), bluegill (16), green sunfish (15), sunfishes (1), and smallmouth bass (1). *See* Id.

[34] DAVID RAY ANDERSON ET AL., STATISTICS FOR BUSINESS AND ECONOMICS 588 (8th ed. 2002).

includes non-flow-related events; (4) a standard flow-proportioned approach that includes non-flow-related events; and (5) a flow-proportioned approach that adds back non-flow-related events. Each approach is evaluated by considering (a) the manner by which it accounts for the non-flow-related events, and (b) the extent to which it draws upon the well-recognized relationships between flow, velocity, and impingement.

The utility of the first approach, the regression analysis approach, is lessened because it treats the non-flow-related events as outliers without accounting for them. The second approach, the weighted average regression analysis, is deemed reasonable because it accounts for non-flow-related events while also reflecting the well-established relationship between flow and impingement. The utility of the third approach, the equivalence approach, is limited because it treats the data from both the flow-related and the non-flow-related populations the same, and does not account for the reduced flows and velocities relative to the sampling period. The fourth approach, the standard flow-proportioned approach, is deemed reasonable because it accounts for the non-flow-related events, and reflects the relationship between flow and impingement while providing a conservative estimate by not adjusting for the Project's reduced velocities. The fifth approach, the weighted average flow-proportioned approach, is recommended because it (a) accounts for non-flow-related events by treating them as a separate, but relevant and important, population, (b) reflects the relationship between flow and impingement, and (c) provides a conservative estimate by not adjusting for the Project's reduced velocities.

Table 3 summarizes the results of the five impingement estimation approaches. Results are presented in terms of number and weight (in grams) of fish impinged. The table indicates whether the results includes outlier values.

Table 3: estimates of CDP's stand-alone impingement based on five possible approaches

Approaches	**Treatment of Non-Flow-Related Events**	**Number of Fishes**	**Weight (kg/day)**
1. Regression (1-A)	Excluded	N/A	1.57
2. Regression (1-B)	Weighted Average	N/A	4.18
3. Equivalence (2)	Included	374	7.16
4. Proportional (3-A)	Included	188	3.74
5. Proportional (3-B)	Weighted Average	232	4.70

A. Approaches 1-A and 1-B: Regression Analyses

1. Explanation of the Approaches.

Both of the regression approaches employ statistical principles in order to characterize the potential for impingement from the Project's stand-alone operations. Both seek to develop a site-specific relationship between flow volume and impingement by plotting each of the 2004/2005 sampling events on a graph (Figure 1) where the X axis represents the EPS's flow and the Y axis represents the amount of impingement (in terms of kg/day). Each point on this graph represents data obtained from one sampling event—i.e., the total weight of fishes impinged and the total flow drawn through the EPS's intake structure over a 24-hour period. Figure 1 contains 50 plotted points—one for each of the 52 days of the year, excluding two samples considered for this particular analysis to be outliers.

The regression approaches are different to the extent that they treat the outliers differently. Regression Approach 1-A excludes the outliers from the analysis altogether. It operates on the assumption that the outliers represent erroneous data that should be disregarded.

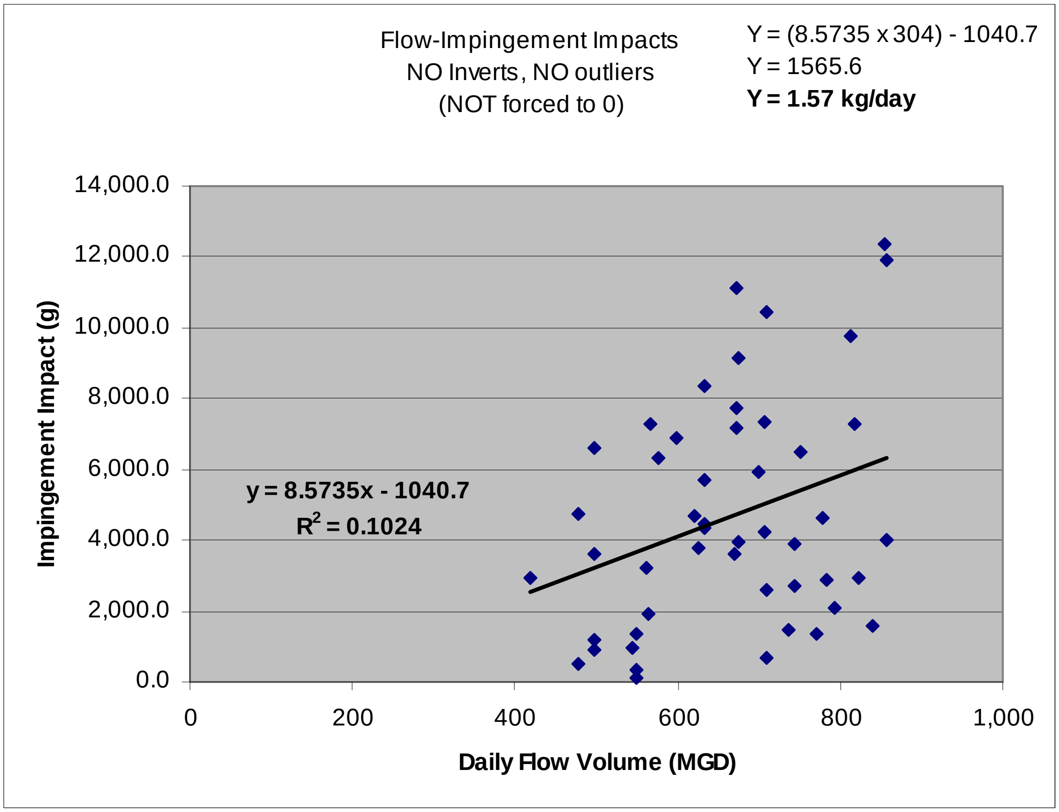
Regression Approach 1-B, on the other hand, accounts for the outliers by treating them as a population separate and distinct from the other 50 events. This approach makes a distinction between flow-related events—i.e., the 50 more typical data points—and non-flow-related events—i.e., the two other days with higher relative impingement. Regression Approach 1-B calculates a weighted average between (a) the regression result for the 50 more typical events and (b) the average of the non-flow-related events as follows:

$$\text{Daily Impingement} = {}^{(\text{regression value for normal events x }50) + (\text{outlier average x }2)}\!\big/_{52}$$

2. Results of the Regression Approaches:

The regression approaches use the least-squares methods to calculate a line through the data points that is described by the following equation: y = (8.5735 x 304) – 1040.7. Based upon the Project's flow of 304 MGD, this approach calculates a straight-line extrapolation value of 1.57 kg/day (i.e., (8.5735 x 304 – 1040.7) x 304/1000).

Figure 1: Regression Analysis



a. Approach 1-A: 1.57 kg/day

b. Approach 1-B: 4.18 kg/day

$$\text{Daily impingement result} = \frac{((1{,}566 \times 50) + (((109{,}526 + 29{,}531)/2) \times 2))}{52}$$

$$\frac{(78{,}300 + 69{,}528.5 \times 2)}{52}$$

$$\frac{(78{,}300 + 139{,}057)}{52}$$

$$\frac{(217{,}357)}{52}$$

4,180 grams/day

3. Evaluation of the Approaches. The regression approaches provide methods by which to attempt to account for the generally recognized relationship between flow and impingement. The results of the regression generally are consistent with the proposition that impingement declines as flow decreases, but there are weaknesses in the statistics.

The regression yields a y-intercept that is less than zero.[35] While impingement should be about zero when there are no flows, it will not be less than zero, as the regression suggests. This outcome is not physically possible. In addition, the regression requires an extrapolation beyond the data set, since flows as low as 304 MGD were not observed during the 2004-2005 sampling events.

a. Regression Approach 1-A. By excluding outliers altogether, this approach does not account for the fact that the data show that on certain occasions (i.e., 4% of the time), non-flow-related factors may result in relatively higher impingement. While these data points may reflect errors that occurred in the sampling process and would hence be justifiably excluded, without further information, there is an insufficient basis upon which to draw such a conclusion at this juncture.

b. Regression Approach 1-B. This approach is reasonable to the extent that it accounts for the non-flow-related events and results in a higher impingement estimate in doing so. The weaknesses inherent in the statistics, however, remain present.

B. Approach 2: Equivalence

1. Explanation of the Approach. The equivalence approach assumes that there is no difference between the EPS's impingement and the CDP's projected impingement, even though the CDP will be operating at substantially lower flows than those recorded during the EPS sampling period. For each discrete sampling event that resulted in the collection of a given number and weight of impinged fishes, the approach assumes that the Project's stand-alone impingement would have been the same. For instance, the data show that on June 24, 2004, the EPS withdrew 632 million gallons of seawater, which resulted in the impingement of 287 fish that weighed 0.436 kg in total. The assumed equivalence approach estimates that the Project would impinge the same number and weight of fish (i.e., 287 and 0.436 kg, respectively) as the EPS, notwithstanding its significantly lower flow of 304 MGD.

2. Result of the Approach.

a. 374 fish weighing 7.16 kg/day (including non-flow-related events)

b. 263 fish weighing 4.67 kg/day (excluding non-flow-related events)

[35] The main reason for the deviation from the linear relationship, however is that impingement is reduced abruptly when the screen velocity falls below 0.5 fps, which is the basis upon which EPS established BTA as 0.5 fps. *See e.g.,* 66 Fed. Reg. 65274.

3. Evaluation of the Approach. It may make sense to use the EPS's impingement at higher flow rates to make a first-order assessment as to whether the CDP might bear a minimization obligation with respect to impingement. Based on general principles, it can be reasonably anticipated that impingement during stand-alone operations at 304 MGD will be less than the impingement that actually occurred during the 2004-2005 sampling period at an average of 657 MGD. Thus, if the EPS impingement were such that it required no minimization, or plainly was offset by planned mitigation measures, one could stop there. In the event that the EPS impingement implies a need for minimization or mitigation, one would want to obtain a value of projected impingement for the CDP itself, which this approach does not provide.

The equivalence approach is easy to apply, and incorporates non-flow-related events, but is limited in utility as described above, and uses the impingement from one project, the EPS, to characterize the impingement for another project, the CDP, without taking into account any of the important differences between these two projects. The equivalence approach also suffers from the fact that it fails to make any distinction whatsoever between two populations that plainly are distinct. In so doing, the equivalence approach allows the non-flow-related events to skew the impingement estimate. Finally, the equivalence approach ignores relationships between flow and impingement that are well-recognized in the scientific literature. In addition to not accounting for flow reduction, the equivalence approach does not account for velocity reduction associated with the reduced flows.

Two hypothetical scenarios illustrate the equivalence approach's inherent limitations. In the first scenario, assume that the EPS had withdrawn 1.26 billion gallons of water on June 24, 2004—an amount that (a) is twice the 632 million gallons amount that the facility actually withdrew on that day (b) and approximates the factor by which the EPS's flow will actually exceed the CDP's. The equivalence approach would ignore this extreme flow differential and assume that the EPS's operations would have resulted in the impingement of only 287 fish. In the second scenario, assume that the EPS's steam-generating units had been shut down on June 24, 2004. In the event of an outage, the facility will probably turn off its cooling water pumps but it will continue to pump approximately 60 MGD via its smaller saltwater service pumps.[36] Even if the EPS had withdrawn 60 million gallons on June 24, 2004 instead of its actual flow of 632 million gallons, the equivalence approach would ignore the extreme flow differential and assume that the Project's operations would still have resulted in the impingement of 287 fish.

C. Approaches 3-A and 3-B: Flow-Proportioned Approaches

1. Explanation of the Approaches.

The two flow-proportioned approaches assume that the Project's stand-alone impingement will be related to the EPS's impingement based on its proportional flow. Both approaches estimate the Project's impingement by adjusting the EPS's impingement by its reduced flow percentage. The manner by which they each do so, however, is somewhat different.

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[36] Saltwater service pumps (SWSP) supply water for a variety of purposes, e.g., cooling of small capacity heat exchangers, lubrication of rotating equipment, etc.

a. Standard Flow-Proportioned Approach 3-A.

Approach 3-A simply adjusts the EPS's impingement by the Project's reduced flow percentage. For instance, on June 24, 2004, the Project's flow volume would have been 48.1% that of the EPS (304/632). The standard flow-proportioned approach would adjust the impingement resulting from the EPS's operations on that day by 48.1%. This calculation estimates that the Project's stand-alone operations would result in the impingement of 138 fish (48.1% x 287) weighing 0.209 kg (48% of 0.436 kg).

b. Weighted Average Flow-Proportioned Approach 3-B.

Approach 3-B is similar to Regression Analysis Approach 1-B in that both approaches account for the non-flow-related events by treating them as a population distinct from the other 50 events. Approach 3-B makes a distinction between flow-related events—i.e., the 50 data points—and non-flow-related events—i.e., the 2 days with relatively higher impingement. Whereas Regression Approach 1-B calculates a weighted average on the basis of the regression result, however, the flow-proportioned approach prorates the 50 more typical events and uses this value along with the average of the non-flow-related events to estimate a weighted average. The model operates as follows:

$$\text{Daily Impingement} = {}^{\text{(prorated value for normal events x 50)} + \text{(outlier average x 2)}}\!/_{52}$$

$$\text{Daily impingement result} = {}^{((2{,}111\text{ grams} \times 50\text{ days}) + (((109{,}526\text{ grams} + 29{,}531\text{ grams})/2) \times 2))}\!/_{52}$$

$$(105{,}550 + 69{,}528.5 \times 2)/_{52}$$

$$(105{,}550 + 139{,}057)/_{52}$$

$$(244{,}607)/_{52}$$

$$4{,}704\text{ grams/day}$$

$$\text{Daily impingement result} = {}^{((116\ \text{fishes} \times 50\text{ days}) + (((5{,}001\text{ fishes} + 1{,}274\text{ fishes})/2) \times 2))}\!/_{52}$$

$$(5{,}800 + 3137.5 \times 2)/_{52}$$

$$(5{,}800 + 6{,}275)/_{52}$$

$$(12{,}075)/_{52}$$

$$232\text{ fishes/day}$$

2. Results of the Approaches.

a. Approach 3-A: 188 fish weighing 3.74 kg/day

b. Approach 3-B: 232 fish weighing 4.70 kg/day

3. Evaluation of the Approaches. The flow-proportioned approaches provide methods by which to account for the relationship between flow and impingement. The approaches show that impingement declines as flow decreases, which appropriately reflects EPA's understanding that impingement is in fact related to flow.

The approaches are conservative and similar to the others to the extent that they include the non-flow-related events, and do not fully account for the impingement reductions that may arise when the Project reduces flow velocities. Since velocity is a function of flow, the fact that the Project will evenly distribute its flow over the longest possible time periods means that the Project will reduce its intake velocity meaningfully below that of the EPS. In addition, by using the EPS's 2004/2005 impingement data—data that reflect the impingement associated with the EPS's variable flow and higher velocities—the flow-proportioned approaches are based on a data set which would appear to be conservative for the purpose of estimating the Project's potential impingement.

a. Standard Flow-Proportioned Approach 3-A.

The standard flow-proportioned approach does not distinguish between the 50 more typical, flow-related events and the two non-flow-related events. Rather, it is used to estimate a daily average based on the inclusion of all of these values. Because it appears that the two non-flow-related events represent days during which various factors other than flow resulted in relatively higher impingement, it may be more reasonable to exclude these values from the overall prorated calculation. In other words, it may not make sense to rely on the flow-impingement relationship for those days when flow was not a principal driver of impingement.

b. Weighted Average Flow-Proportioned Approach 3-B.

The weighted average-flow proportioned approach does not include flow-independent days in the prorated calculation. This modified model responds to the two-population issue by assuming that on 2/50 days—i.e., 4% of the time—factors other than flow will drive impingement, and may result in relatively higher impingement.

The proportional approach is limited somewhat, however, because it assumes that the relationship between flow and impingement is always directly proportional. Even on more typical days, we cannot be certain that a 50% reduction in flow will result in an exactly proportional reduction in impingement. Nevertheless, the weighted average, flow-proportioned approach reasonably approximates the potential for impingement from the Project by accounting for the important relationship between flow and impingement. Its reasonableness is supported by the conservative manner by which it discounts the benefits of reduced flow velocities.

V. CONCLUSION

The relevant facts, data, and scientific principles and literature indicate that the weighted average, flow-proportioned approach provides a reasonable, conservative estimate of the potential for impingement from the Project. By treating the non-flow-related events separately and accounting for the relationship between flow and impingement while discounting the fact that the intake flow velocities during stand-alone operations will be lower than the

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velocities that occurred during the sampling period, this approach provides a reasonable basis for estimating that impingement during such operations will be approximately 4.70 kg/day of fish biomass. Employing calculations that are consistent with generally accepted scientific principles, this method provides the Regional Board a rational basis upon which to base its Section 13142.5(b) analysis.