DRAFT
INITIAL COST ESTIMATES

Prepared for the May 23, 2001 Public Meeting of Technical Experts to Review EPA's Preliminary Data on Cooling Water Intake Structure Technologies in Place at Existing Facilities and Their Costs

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USEPA Office of Science and Technology
Engineering and Analysis Division

A. PURPOSE OF THIS DRAFT REPORT

The U.S. Environmental Protection Agency (EPA) will conduct a public meeting of technical experts on May 23, 2001, to review the Agency's preliminary data on cooling water intake structure technologies that are in place at existing facilities and the costs associated with the use of available technologies for reducing impingement and entrainment. The purpose of this meeting is to elicit individual comments from the technical experts. The topics for discussion are as follows: there may be occasions when a facility needs to reduce impingement or entrainment of aquatic organisms, on those occasions, what are the technologies that might be used and what are the costs and advantages or limitations associated with their use?

This draft report contains the results of preliminary analyses to estimate the cost of cooling water intake structure and cooling system technologies in place at existing facilities. In a separate report, EPA will provide information on what cooling water intake structure and cooling system technologies are in place at existing facilities based on the Agency's preliminary data analyses using responses from the Detailed Industry Questionnaire: Phase II Cooling Water Intake Structures (January 2000).

B. DRAFT MODEL PLANT COOLING WATER INTAKE STRUCTURE COSTS

Table 1 – Summary of Draft Model Plant Cooling Water Intake Structure Costs

Description: The table below presents the capital and net increase in annual operation and maintenance (O&M) and annual costs for selected cooling system technologies installed at facilities with existing once-through cooling systems with low, medium, and high cooling water flows.

Cooling System	CWIS Improvements	Cooling Flow[a] (gpm)	Intake Flow (gpm)	Capital Cost	Net O&M Cost[b] Net / Baseline	Net Annual Cost[bc] Net / Baseline
Once-through	**None Baseline Scenario**	17,400	17,400	$0	$0 / $147,000	$0 / $147,000
		104,000	104,000	$0	$0 / $880,000	$0 / $880,000
		347,000	347,000	$0	$0 / $2,935,000	$0 / $2,935,000
Once-through	**Passive Screens** Intake Velocity = 0.5 fps.	17,400	17,400	$160,000	$0	$13,000
		104,000	104,000	$808,000	$0	$65,000
		347,000	347,000	$2,745,000	$0	$221,000
Once-through	**Traveling Screens with Fish Baskets** Intake Velocity = 0.5 fps	17,400	17,400	$442,000	$19,000	$55,000
		104,000	104,000	$1,740,000	$56,000	$196,000
		347,000	347,000	$5,759,000	$193,000	$657,000
Wet Tower	**None**	17,400	1,740	$1,230,000	$173,000	$272,000
		104,000	10,400	$6,790,000	$842,000	$1,390,000
		347,000	34,700	$21,400,000	$2,540,000	$4,270,000

Cooling System	CWIS Improvements	Cooling Flow[a] (gpm)	Intake Flow (gpm)	Capital Cost	Net O&M Cost[b] Net / Baseline	Net Annual Cost[bc] Net / Baseline
Wet Tower	**Passive Screens**	17,400	1,740	$1,270,000	$173,000	$275,000
	Intake Velocity = 0.5 fps	104,000	10,400	$6,916,000	$842,000	$1,400,000
		347,000	34,700	$21,740,000	$2,540,000	$4,300,000
Wet Tower	**Traveling Screens with Fish Baskets**	17,400	1,740	$1,340,000	$179,000	$389,000
		104,000	10,400	$7,070,000	$858,000	$1420,000
	Intake Velocity = 0.5 fps	347,000	34,700	$22,100,000	$2,570,000	$4,350,000
Dry Tower	**None**	17,400 Equivalent	348	$4,130,000	$863,000	$1,190,000
		104,000 Equivalent	2,080	$21,500,000	$4,230,000	$5,970,000
		347,000 Equivalent	6,940	$72,600,000	$9,700,000	$15,500,000

[a] Equipment was sized for the cooling water flow shown. These flows represent the once-through or recirculating flow or, in the case of dry towers they represent the equivalent cooling water flow rate for a similarly sized steam turbine power plant. These flows are equivalent to 25 million gallons per day (MGD), 150 MGD and 500 MGD.
[b] All costs are net values in which the O&M costs of the baseline technology have been subtracted. For the baseline facility, the baseline costs for the existing cooling system are also shown after the "/" .
[C] Annual costs are the sum of annual O&M costs and the annualized capital cost assuming a 30 year amortization period and a discount rate of 7%.

Basis for Cost Estimates

Table 1 provides EPA's draft initial estimate of the costs that would be incurred by a facility with an existing once-through cooling system if it were required to modify or replace the existing cooling system with one of the selected technology scenarios. Within each technology scenario, costs are presented for cooling systems with three different cooling water flows (or equivalent measures) representing small, medium, and large facilities. The data presented in the table includes the net increase in capital, annual O&M, and total annual cost for the selected technology scenarios as compared to the costs for an existing once-through cooling system. Net costs are derived by subtracting the estimated costs for the baseline once-through cooling system that has the same cooling flow or equivalent. Annual costs are the sum of annual O&M costs and the annualized capital cost. The annualized capital costs (not shown separately) were derived from the capital costs using an amortization period of 30 years and a discount rate of 7%. The salvage value of the existing once-through cooling system was assumed to offset capital costs for the resized water intake system, and therefore, the capital costs did not require adjustment on a net basis. The technologies are presented in the order of increasing costs. Note that for power plants these comparative costs do not include consideration of the energy penalty associated with changes in the turbine exhaust pressure that may occur when different types of cooling systems are used. In general, this penalty varies for different regions and times of year.

Three cooling water flow rates were selected to represent low, medium, and high cooling water flow values. The values are roughly equivalent to the 25th, 50th, and 75th percentile of intake flows from utilities and non-utilities, as indicated by data from the preliminary Detailed Technical Questionnaire database. For this initial analysis, no attempt was made to stratify these flow data according to once-through versus recirculating systems. The flow values picked are 25 MGD, 150 MGD, and 500 MGD, which are equivalent to 17,400 gpm, 104,000 gpm, and 347,000 gpm, respectively. It was assumed that the cooling water flow rate through the condenser would be equal for both once-through systems and recirculating wet towers. Additionally, the dry cooling costs correspond to systems that would have equivalent power generating capacity to wet systems using the selected cooling water flows.

With the exceptions described below (*e.g.*, retrofit cost assumptions), EPA developed all of these draft initial cost estimates using the cost data presented in the Economic and Engineering Analysis of Proposed 316(b) New Facility Rule, August 2000 (EEA).

Technology Selection

The technologies selected for these draft initial cost estimates represent the spectrum of costs associated with varying degrees of cooling system modification and varying degrees of cooling water intake structure (CWIS) modifications, where applicable. The costs represent an estimate of the financial impact of applying the different technology scenarios to an existing once-through cooling system. The technologies selected are limited to only those for which EPA has already generated cost estimates.

The alternative cooling system technologies include:

- None (once-through as baseline)
- Wet towers
- Dry towers

The CWIS improvements include:

- None
- Passive/wedge wire screens
- Traveling screens with fish baskets

Draft initial cost estimates for these CWIS improvements are included for both the once-through systems and for the intake structure for the reduced intake flow needed for wet towers. These technologies were selected to represent varying degrees of costs representing low, medium, and high values. These CWIS technologies, however, do not represent the only technologies EPA is evaluating. Additional technologies being considered but not shown in these estimates include:

- Gunderbooms
- Barrier nets
- Light/sound barriers
- Fish return systems
- Variable speed pumps

Cost estimates for these additional CWIS technologies are still under development.

Technology Summary Description

The following assumptions were used in the development of these draft initial cost estimates.

Baseline Scenario - Once-through Cooling

This scenario represents the baseline existing facility to which the draft costs of all technology modifications were compared. The draft costs for the baseline system are estimated with the impact on net costs in mind. Since the technology is already in-place, no capital costs were estimated. Any salvage value of equipment no longer needed in the alternative cooling system scenarios, such as large volume pumps, was assumed to offset the cost for new smaller volume pumps and piping.

Once-through O&M costs are based on the cooling water pumping energy requirement, since the surface water pumping requirement would be greatly reduced with installation of cooling towers. Note that the cooling tower O&M cost estimates include the recirculation pumping costs. The once-through pumping costs are based on the selected cooling water flows and the following assumptions:

- pumping head = 50 ft.
- energy cost = $0.08/KWh
- pump efficiency = 70%
- operating time = 7860 hrs/yr.

These annual O&M pumping costs are deducted from the annual costs for alternative technologies to obtain net costs for the alternative technologies. For wet cooling towers, only 90% of this cost is deducted, since, as described below, an estimated 10% of the original withdrawal is still pumped as make-up water.

Once-through with Passive Screens

The addition of passive screens represents a medium cost with respect to CWIS improvements for which EPA has developed draft cost estimates. The screens are sized for an intake velocity of 0.5 fps. The capital cost estimates used are based on new facilities and therefore an additional cost equal to 30% of the capital cost was added to account for modifications to the existing structure associated with retrofitting. Since the screens are cleaned using an air backwash system, there is no appreciable increase in O&M costs over the baseline system. Since backwash debris must be swept away naturally, these screens may not be appropriate for locations with low water velocities. Since the low cooling flow value was within the cost curve range for the largest unit costed, 10 ft wide traveling screens were used for all three flow volumes. For the two higher flows >26,000 gpm (high end of the cost curve), costs were developed for four and 13 parallel 10 ft wide units. The cost data in Chart 30 of the EEA was used.

Once-through with Traveling Screens with Fish Baskets

The addition of traveling screens with fish handling features (a.k.a. fish baskets) represents a high cost with respect to CWIS improvements for which EPA has developed draft cost estimates. The traveling screens with fish baskets are sized for an intake velocity of 0.5 fps. The capital costs are based on new facilities and, therefore, an additional cost equal to 30% of the capital cost was added to account for modifications to the existing structure associated with retrofitting. Since the low cooling flow value was within the cost curve range, 14 ft wide traveling screens were used for all three flow volumes. For the high flow >104,000 gpm (high end of the cost curve), costs were developed for two parallel 14 ft wide units. The cost data in Chart 36 and 41 of the EEA were used.

Wet Towers without CWIS Improvements

The use of wet towers results in substantial reduction in, but not the elimination of, cooling water requirements and therefore represents a medium level of improvement to the cooling system itself for which EPA has developed draft cost estimates. The cooling system technology selected consists of a recirculating wet tower constructed of redwood with an approach of 10 ^{o}F. Redwood construction was selected because it corresponds to the median capital cost for cooling towers made from different building materials (see Chart 8 of EEA). EPA recognizes that redwood is not commonly used as a tower construction material and chose redwood towers simply because they represent the median cost.

Wet towers still need make-up water to account for evaporation, drift and blowdown. The make-up flow volume is assumed to be equal to 10% of the recirculating flow, resulting in intake flows of 1,740 gpm, 10,400 gpm, and 34,700 gpm for the small, medium, and large facilities, respectively. An intake flow factor of 10% instead of the estimated average value of 5% was chosen to account for overall variations. Thus, a 10% factor is considered a conservative estimate (i.e., the estimated intake volumes and CWIS costs for wet towers are close to the high end of what would be expected). The new intake system will require modification to accommodate the reduced flow. It is assumed that the salvage value of the existing intake equipment such as pumps (currently sized for 10 times the reduced intake volume) will offset the capital cost for the much smaller equipment required for the modified intake system. The cost estimates include the treatment and discharge of cooling tower blowdown (Scenario 1 from EEA). This technology scenario does not include any CWIS improvements to the surface water intake and therefore there are no CWIS costs. Note that the estimated O&M costs include the recirculating cooling water pumping, which is sized for the cooling needs of the plant, not the intake/makeup water requirements. The costs for the wet towers were derived from data in Charts 10 and 19 of the EEA.

Wet Towers with Passive Screens

The addition of passive screens represents a medium cost with respect to CWIS improvements for the intake system for wet towers. Wet towers with passive screens consist of the same recirculating redwood wet tower as described above. This scenario uses the same passive screen technology (as described for the once-through system above) as part of the make-up water intake structure. The capital costs are based on new facilities and therefore an additional cost equal to 30% of the capital cost was added to account for modifications to the existing structure associated with retrofitting. The costs for the systems with low, medium, and high intake flows were based on 2-ft wide, 10-ft wide, and 10-ft wide screens, respectively. The cost for the large facility was based on two parallel 10-ft wide screens.

Wet Towers with Traveling Screens with Fish Baskets

The addition of traveling screens with fish baskets represents the high cost with respect to CWIS improvements for the intake system for wet towers. Wet towers with traveling screens with fish baskets consist of the same recirculating redwood wet tower as described above. This scenario uses the same traveling screen with fish baskets technology (as described for the once-through system above) as part of the make-up water intake structure. The capital costs are based on new facilities and therefore an additional cost equal to 30% of the capital cost was added to account for modifications to the existing structure associated with retrofitting. The costs for the system with low, medium, and high intake flows were based on 2-ft wide, 10-ft wide, and 14-ft wide screens, respectively.

Dry Cooling

A dry system nearly eliminates the need to withdraw surface water and, therefore, represents the highest level of improvements to the cooling system itself. Dry cooling involves the replacement of the existing surface condenser with an air cooled condenser. The draft costs presented are for cooling systems sized for power plants that would otherwise use comparable volumes of cooling water as the three flow rates used to estimate costs for the water-based cooling systems. The conversion factor used is for a steam turbine power plant using a cooling factor of 12,000 BTUs/ton and 3 gpm cooling water/ton for wet systems and 15,000 BTUs/ton for dry systems.

The make-up water requirements are very low (EPA estimates 2% of equivalent flow) and, therefore, EPA assumes the pumping and CWIS cost (if any is needed) will be insignificant compared to the total cost and that the salvage value of the once-through pumping equipment will more than offset any costs for equipment needed to supply this water. As a result, only one dry cooling technology scenario is evaluated.

One cost not addressed for dry cooling installation at existing facilities that previously utilized once-through or recirculating cooling towers is the potential need for replacement turbines. EPA is developing and gathering data to address steam turbine retrofitting costs and needs. This potential cost is not included in the estimates presented above and could represent a significant capital cost incurrence.

C. DRAFT RESTORATION COST ESTIMATES

The following draft initial cost estimates for restoration are drawn from materials EPA prepared prior to proposal of regulations for cooling water intake structures at new facilities (65 Fed.Reg. 49060).

Historically, restoration measures, as used in the context of section 316(b) determinations, include practices that seek to compensate for the fish or aquatic organisms killed, or enhance the aquatic habitat in the waterbody in which a cooling water intake structure operates. Examples of restoration measures that have been included as conditions of permits include creating, enhancing, or restoring wetlands; developing or operating fish hatcheries or fish stocking programs; removing impediments to fish migration; enhancing natural resources in an impacted watershed; and other projects designed to replace fish or restore habitat. Such projects have proven useful in permitting certain cooling water intake structures because they provide a substantial degree of flexibility to the permit writer to address the adverse environmental impact caused by a cooling water intake structure.

According to the National Oceanic and Atmospheric Administration, there are three components to a restoration measure being used for mitigation purposes:

- restoration of the injured habitat or species to baseline (primary restoration);
- compensation for the interim loss of resources from the time of injury until the resources recover to baseline (compensatory restoration); and
- performance of the damage assessment (NOAA, 1999).

EPA developed draft initial cost estimates for two primary restoration approaches. The first approach is the restoration or creation of habitat. The purpose of habitat restoration is to restore all or some ecological functions, such as increased forage or protective cover, to a currently degraded habitat. This is typically accomplished through reseeding, replanting, removal of invasive species, physical modification of the site, or some combination of these efforts. Habitat creation, rather than restoring an existing habitat, involves the direct modification of a site to establish new habitat. This process is similar to site restoration, however, it can involve extensive modification of the site substrate, alteration of site hydrology, and excavation work to modify site topography.

Due to the more extensive reliance on site modification, habitat creation tends to be more costly than the restoration of existing but degraded habitat.

For freshwater rivers, lakes and reservoirs, the most common type of habitat restored is wetlands. For tidal rivers, estuaries, and oceans, there is a greater variety of habitats restored, ranging from salt marshes to oyster reefs.

The second approach to restoration does not restore habitat for the species impacted due to cooling water intake but, instead, mitigates the loss of organisms through restocking. For this analysis, EPA made the conservative assumption that a facility implementing restoration measures would do both habitat restoration and fish restocking.

Habitat Restoration Costs

The cost of a habitat restoration project depends on numerous site-specific factors including the type of habitat being restored, the size of the project, the cost of suitable land, the extent of site preparation needed, and the anticipated survival rate of the restored biota. As a result, habitat restoration project costs are highly site-specific and can vary greatly from project to project. Furthermore, such site-specific conditions and extreme cases cannot be accurately accounted for when developing cost estimates at the national level.

For purposes of costing a habitat restoration project, habitat type (e.g. wetlands, sea grass, reef) and project size are the two key factors that predominately determine costs. Therefore to develop cost estimates for a habitat restoration project, an estimate of the size of the project and habitat is needed.

A habitat equivalency analysis would need to be performed to determine both the type and extent of habitat to be restored. In this type of analysis the first step is to calculate the extent of damage typically in terms of reduced biomass, species diversity and population levels, or loss of benefits derived from the impacted area. Then the per hectare increase in biota that is anticipated from various habitat restoration measures is estimated. Using this information the scope of the restoration project could then be derived.

For purposes of this initial costing exercise, EPA made assumptions as to the required size or type of habitat restoration project that each facility would be likely to undertake. EPA assumed salt marsh, sea grass, and oyster reef restoration are the types of projects used for estuaries, tidal river, and oceans. EPA derived cost estimates for each of these habitats from a literature review of restoration project costs published in the National Oceanic and Atmospheric Administration's *Primary Restoration Guidance Document for Natural Resource Damage Assessment Under the Oil Pollution Act of 1990*. The document reported cost information for salt marsh restoration, seagrass restoration, and oyster reef restoration in 1992 dollars on a per hectare basis.

EPA assumed the type of habitat restoration project that would most likely be available for streams, nontidal rivers, lakes, and reservoirs, is wetlands restoration and creation. Given that tidal rivers, estuaries, and coastal water bodies are typically larger in size and more biologically diverse than freshwater rivers, streams, lakes, and reservoirs, EPA assumed that there would be a greater abundance of potential restoration projects available for facilities to consider. Therefore, it was assumed that facilities would choose projects where restoration could be achieved primarily through replanting and reseeding that required little to no construction costs in order to minimize the cost of the restoration measure. The costs for habitat restoration in the salt water habitats are based primarily on replanting or reseeding costs with minimal construction work necessary. The literature reviewed for wetlands creation (NOAA,1996) did include both project size and site preparation cost information.

When developing costs for a potential requirement for restoration at new facilities, EPA anticipated that the average size of most facility restoration projects would be considerably smaller than that of a typical restoration project, which is assumed to be approximately 200 hectares.[1] The reason for this was an assumption that new facilities subject to the requirements of the proposed Section 316(b) New Facility regulations would meet the various proposed limitations for capacity, proportional flow, velocity and use of additional technologies such as fish diversion or return systems. Therefore, to represent the expected small, median, and large project sizes, EPA chose size estimates of 5, 10, and 30 hectares, which are approximations of the lowest, median, and largest project sizes that fall into the first 25th percentile of project sizes in the literature review of wetland restoration projects (NOAA,1996). For an existing facility with much larger intake capacity, the draft costs presented below at Worst Case Scenario for Restoration, below, may be more appropriate.

Furthermore, EPA assumed that on average facilities with larger flows would impinge and entrain a greater number of fish and other aquatic fauna. Therefore, EPA assumed that the lowest, median, and highest flow facilities would require project sizes of 5, 10, and 30 respectively. Table 1 provides these flow rates and the corresponding restoration project size. From this assumed corresponding relationship between flow and project size, EPA developed an equation which could be used for estimating the project size for the rest of the facilities conducting habitat restoration.

[1] Based on a literature review of wetland restoration/creation case studies (NOAA, 1996), a typical project size was estimated to be 200 hectares.

Table 1. Estimated Relationship Between Facility Flow and Restoration Project Size		
	Facility Flow Rates (gpm)	**Corresponding Project Size**
Smallest	1,700	5 hectares
Median	9,000	10 hectares
Largest	53,000	30 hectares

Equation for relationship between flow (gpm) and project size (ha).

$$-4E\text{-}09 * \text{flow}^{2} + 0.0007 * \text{flow} + 3.766 = \text{project size}$$

EPA used these assumptions and the unit habitat restoration costs reported in the National Oceanic and Atmospheric Administration's *Primary Restoration Guidance Document for Natural Resource Damage Assessment Under the Oil Pollution Act of 1990* to develop the habitat restoration costs reported in Tables 2 and 3.

Table 2. Draft Estimated Restoration Project Costs for Estuaries, Tidal Rivers and Oceans (1992 $)

1992 dollars	mean$/ha	5 ha	10 ha	30 ha
Salt Marsh Restoration[1]	$25,559	$127,794	$255,588	$766,763
Sea Grass Restoration[2]	$96,804	$484,019	$968,037	$2,904,112
Oyster Reef Restoration[3]	$6,038	$30,188	$60,376	$181,128
Assuming Equal Probability	$42,800	$214,000	$428,000	$1,284,001
Assuming Equal Probability in 1999$[4]	**$51,000**	**$256,000**	**$512,000**	**$1,537,000**

1. Median cost based upon eight salt marsh replanting and reseeding studies (NOAA, 1996).
2. Sea Grass restoration costs assume an equal probability for both temperate and subtropical sea grass restoration. The median per hectare cost for temperate sea grass is $24,620, based upon five restoration studies. The median cost for (NOAA, 1996).
3. Median cost based upon 15 oyster reef restoration studies (NOAA, 1996).
4. Cost figures were adjusted to 1999 dollars using a 19.7% inflation factor, using the Consumer Price Index.

Table 3. Draft Habitat Restoration Costs (1999$)

Restoration Project Size	5 ha	10 ha	30 ha
Fresh Water Wetland Restoration	$229,000	$388,000	$893,000

Equation for relationship between wetlands restoration/creation project size(ha) and project cost($).[1]

$$56{,}475 * \text{size}^{-0.241} = \text{project cost}$$

1. Equation derived from 15 case studies reported

Project size estimates were based upon the anticipated cooling water intake flow for each facility under consideration as EPA developed proposed regulations for cooling water intake structures at new facilities.

Fish Restocking Costs

Fish restocking can be used as either the primary means of restoration or compensatory restoration purposes during the recovery period for the habitat restoration measure. Facilities may decide to use restocking for primary restoration purposes when a suitable restoration site is not available to them, and when the impingement and entrainment losses primarily affect fish species that can be obtained from fish hatcheries. When habitat restoration is employed facilities will need to restock fish during the initial years following the implementation of the habitat restoration project, while flora and fauna become reestablished at the restoration site.

EPA chose three commonly restocked species: salmon, trout, and bass, to represent the estimated per fish cost for restocking, and assumed that they would be restocked with equal probability on a national scale (i.e. the species specific costs were averaged).

Fish are typically sold on a per-inch basis. Larger fish have a higher survival rate, but are also generally more expensive. As a result, a mixture of juvenile and mature fish are usually used for restocking purposes. EPA chose a restocking mix of 50 percent five inch fish, 30 percent seven inch fish, and 20 percent of the fish at 10 inches. Using national hatchery cost averages for the three representative species, and the assumed stocking mixture, the estimated cost per fish is $1.42 (1999 dollars) (NOAA, 1996).

Typically when fish are restocked, it is for mitigation purposes. Fish are usually restocked on an annual basis (NOAA, 2000), so the total annual number of fish restocked is based on the estimated losses per year. As with habitat restoration, determining the scope of the restocking effort is made difficult by the lack of information concerning new facilities. As a result, EPA took the same approach as with habitat restoration and based the restocking rate on the expected flow for each facility. The range of restocking rates EPA chose is between 25,000 and100,000 fish per year. EPA also selected a travel distance for restocking of 500 miles per trip, and that the number of fish transported per trip was 25,000.[4] Table 4 provides the estimated restocking costs for the representative species and for various restocking rates.

Table 4. Draft Annual Fish Restocking Costs for Restoration Measures (1999$)

Type of Cost	Number of Fish Restocked		
	25k	50k	100k
Transportation Cost	$700	$1,400	$2,900
Fish Cost*	$35,500	$70,900	$141,900
Total Cost**	**$36,200**	**$72,000**	**$145,000**

*Cost is based on the $1.42 per fish cost.

** Total cost figures have been rounded to the nearest thousand.

When restocking is being used as the only means of restoration, EPA assumed that facilities will continue to restock at the same annual rate. However, when restocking is used for compensatory restoration during the interim recovery period for the habitat, EPA assumed that the rate of restocking will decrease as flora and fauna become established at the site.

Based upon a series of case studies that document the establishment of flora and fauna at the restored site, EPA determined that three to fifteen years was a reasonable recovery period for wetland projects and one to five years for estuary/tidal river projects (NOAA, 1996). Using the documented recovery rate from a restoration project on the Salmon River, EPA developed a habitat recovery equation. Table 5 provides the information from the case study and the resulting equation. This equation was then used to approximate the recovery rate for fish species using the habitat. EPA estimated that facilities could reduce the restocking at an inversely proportionate rate to the recovery of the fish. Because of the more rapid recovery rate of estuarine habitats, EPA assumed that by the second year, the restocking level could be reduced by 40% , by 70% in year three, 90% in year four, and would not be necessary by year five.

Table 5. Recovery Rate Based Upon the Salmon River Restoration Project

Years after project	% recovery of vegetation at site
0	0%
2	31%
10	91%
15*	100%

Equation for the Percentage Recovery forWetland Restoration Projects

$$((-0.0051*(Year^2))+(0.1416*Year)+0.0193)=\%Recovery$$

* The recovery of the site was monitored for 10 years, so the recovery rate for year 15 was assumed based upon information from other case studies.

Draft Worst-Case Scenario for Restoration

EPA decided to cost a worst-case scenario for a large coal-fired or nuclear power plant with high cooling water flow based on a restoration case study from a large nuclear plant with a large cooling water intake flow. EPA correlated flow, size of restoration project (per hectare), and the unit cost of restoration measures to develop a reasonable estimate of costs for a restoration project on a dollar per gallon per minute ($/gpm) of cooling water flow. EPA used a worst-case cost estimate for fish restocking of 1 million fish per year. Table 6 shows the resulting draft, initial worst-case estimates.

Table 6. Draft Capital and O&M Costs for Restoration Worst-Case Scenarios (1999$)

	Restoration Capital Cost	O&M Cost for Restoration During First Year
Coal-fired- Max flow for recirc	$68,000,000	$1,448,000
Coal-fired - Avg flow for Top 1/3 of once through systems	$6,000,000	$1,448,000
Nuclear - Max flow for recirc	$143,000,000	$1,448,000
Nuclear - Avg flow for Top 1/3 of once through systems	$16,000,000	$1,448,000

Restoration References

National Oceanic and Atmospheric Administration, April 1999, *Habitat Equivalency Analysis: An Overview*, Damage Assessment and Restoration Program, NOAA, Silver Spring, Maryland.

National Oceanic and Atmospheric Administration, August 1996, *Primary Restoration Guidance Document for Natural Resource Damage Assessment Under the Oil Pollution Act of 1990*, Prepared for NOAA's Damage Assessment and Restoration Program. Silver Spring, Maryland. Prepared by EG&G Washington Analytical Services Center, Inc.

Personal communication between Todd Doley of SAIC and Russell Bellmer of NOAA, May 18, 2000.

Personal Communication between Todd Doley of SAIC and the fish restocking service (Fish Wagon 1-800-643-8439) on May 22, 2000.

D. DRAFT BIOLOGICAL MONITORING COSTS

The following draft initial cost estimates for biological monitoring were not derived from cost modeling exercises, but rather represented cost estimates provided by contractors with experience in impingement/entrainment monitoring. A consensus of these experts formed the basis for these draft cost estimates. The draft cost estimates differ depending on the type of waterbody being sampled (with the exception of impingement monitoring). For example, the equipment, effort and expertise needed to sample an ocean facility would be more costly than that needed to monitor a facility located on a stream or small river.

SOURCEWATER BASELINE CHARACTERIZATION (as described at proposed 40 CFR 125.86 (65 Fed. Reg. 49119)

Freshwater stream/river -- $8,000 to 25,000
Lake/reservoir -- $8,000 to 35,000
Estuary/tidal river -- $8,000 to 50,000
Ocean -- $8,000 to 70,000

BIOLOGICAL MONITORING - ENTRAINMENT (as described at proposed 40 CFR 125.87 (65 Fed. Reg. 49121)

Freshwater stream/river -- $15,000 to 40,000
Lake/reservoir -- $15,000 to 40,000
Estuary/tidal river -- $20,000 to 50,000
Ocean -- $20,000 to 50,000

BIOLOGICAL MONITORING - IMPINGEMENT (as described at proposed 40 CFR 125.87 (65 Fed. Reg. 49121)

Freshwater stream/river -- $10,000 to 25,000
Lake/reservoir -- $10,000 to 25,000

Estuary/tidal river -- $10,000 to 25,000
Ocean -- $10,000 to 25,000