CHAPTER 9
COSTING METHODOLOGY

9.1 INTRODUCTION

EPA identified several potential regulatory options for the concentrated aquatic animal production (CAAP) industry. This chapter describes the methodology used to estimate engineering compliance costs associated with installing and operating the treatment technologies and management practices considered for the regulatory options.

9.1.1 Regulatory Option Summary

EPA developed three regulatory options for CAAP facilities:

- Option 1—solids removal through treatment technologies and best management practices (BMPs).
- Option 2—BMP plan for pathogen control, prevention of nonnative species escapement, and minimization of drugs and chemicals.
- Option 3—additional solids control through treatment technologies.

Table 9.1-1 illustrates the treatment technologies and BMPs for each proposed option by subcategory. All three options were evaluated for Best Practicable Control Technology Currently Available (BPT)/Best Available Technology Economically Achievable (BAT) regulatory options. To determine the cost for complying with each option, EPA developed combinations of technologies and management practices that form the basis of the cost estimate for each type of CAAP facility production system under the BPT/BAT options. The combinations of treatment technologies and management practices are based primarily on the type of production system used at a facility. (See Chapter 5, Subcategorization of the Technical Development Document, for more information.) The type of production system determines the relative volume and strength of wastewater produced at a particular facility and the treatability of the wastewater using cost-efficient treatment technologies and management practices. The size of a facility (e.g., production level) determines the overall volume of water discharged and associated pollutant load. EPA used the type of production system and facility size in combination to determine the BMPs and treatment technologies that formed each proposed regulatory option.

Table 9.1-1. Treatment Technologies and BMPs for Proposed Regulatory Options, by Subcategory

Regulatory Option	*Required BMPs and Technologies*	*Subcategory*			
		Flow-through		*Recirculating*	*Net Pen*
		Medium[a]	*Large*[a]		
Option 1	Sedimentation basin	X	X	X	
	Quiescent zones	X	X		
	BMP plan	X	X	X	
	Compliance monitoring	X	X	X	
Option 2	Drug & chemical BMP plan		X	X	X
Option 3	Solids polishing		X	X	
	Compliance monitoring		X	X	
	Active feed monitoring				X

Note: “X” represents a required treatment technology or BMP component for an option.
[a]See section 9.3.1 for description of medium and large flow-through systems.

EPA proposed alternate compliance provisions for meeting the solids removal requirements for flow-through and recirculating systems. The first alternative requires specific numeric TSS limits (Table 9.1-2). These limits were determined for different discharge scenarios and levels of treatment options. The cost analysis included weekly monitoring and monthly reporting to show that a facility is meeting the requirements (see section 9.4 for more details on the cost assumptions) for monitoring and reporting. The second alternative allows facilities to develop and implement a BMP plan that will achieve the numeric limits. The BMP plan and its implementation would then be used as the measure of compliance, in lieu of the weekly monitoring and monthly reporting. EPA

Table 9.1-2. Summary of TSS Numeric Limits for Flow-through and Recirculating Systems

System/Discharge Type	*Maximum Daily (mg/L)*	*Maximum Monthly Average (mg/L)*
Flow-through; more than 475,000 lb annual production; full flow and single discharge	10	6
Flow-through; more than 475,000 lb annual production; offline settling, separate discharge	69	55
Flow-through; more than 100,000 lb, but less than or equal to 475,000 lb annual production; full flow and single discharge	11	6
Flow-through; more than 100,000 lb, but less than or equal to 475,000 lb annual production; offline settling, separate discharge	87	67
Recirculating; more than 100,000 lb annual production	50	30

believes that the alternate BMP plan approach could cost less than the monitoring and reporting approach. EPA does not believe that the BMP compliance alternative will cost any more than the estimated costs associated with the technology options described in this report. EPA did not perform any additional cost analysis for the BMP plan alternative.

9.1.2 Approach for Estimating Compliance Costs

EPA traditionally develops either *facility-specific* or *model facility* compliance costs and pollutant loading reduction estimates. Facility-specific compliance costs and pollutant loading reduction estimates require detailed process and geographic information about many, if not all, facilities in an industry. These data typically include production, capacity, water use, wastewater generation, waste management operations (including design and cost data), monitoring data, geographic location, financial conditions, and any other industry-specific data that might be required for the analyses. EPA then uses each facility's information to estimate the cost of installing new pollution controls and the expected pollutant removals from these controls.

When facility-specific data are not available, EPA develops model facilities to provide a reasonable representation of the industry. For the CAAP industry, EPA chose a model-facility approach to estimate compliance costs because detailed information about the scope of the CAAP industry was not available. EPA expects to obtain more detailed facility-level information, although not on every facility, through the detailed AAP survey (USEPA, 2002a).

EPA developed model facilities to reflect CAAP facilities with a specific production system, type of ownership, and (in many cases) species. The model facilities represented these facilities across a specific size range and were based on the average production value for all facilities represented within this range. These model facilities were based on data gathered during site visits, information provided by industry members and their associations, and other publicly available information. EPA estimated the number of facilities represented by each model using data from the Aquatic Animal Production (AAP) screener survey (Westat, 2002), in conjunction with information from the U.S. Department of Agriculture (USDA) 1998 Census of Aquaculture (USDA, 2000b). Costs and pollutant loading reductions were estimated for each model facility, and then industry-level costs were calculated by multiplying model facility costs by the estimated number of facilities required to implement the treatment technology or management practice in each model category.

EPA designed the model facility approach to capture the key characteristics (model facility configuration) of individual facilities, based on the Census of Aquaculture and the AAP screener survey, by averaging these key characteristics and then representing the averages as a model facility. Using this approach, every facility was characterized according to specific attributes, which included production system type, species, and dollar level of production. EPA estimated or calculated other key attributes for each of the model facilities, including system inputs (e.g., feed), estimated pollutant loads, discharge flow characteristics, and geographic data. All of these attributes and characteristics were then linked into option modules using Microsoft Excel as a computing platform to enable ease of changes to model facility assumptions and characteristics, as well as ease of calculation.

Control technology options and BMPs used to prevent the discharge of pollutants into the environment were linked with the unit cost modules, which calculated an estimated cost of the component based on estimates of capital expenses (which included elements such as engineering design, equipment, installation, one-time costs, and land) and annual operation and maintenance (O&M) expenses. For each model facility, EPA applied combinations of technologies and BMPs, given the model facility configuration characteristics (e.g., system type, size, and species). EPA adjusted the total cost of the component with a frequency factor that accounts for CAAP facilities that already have that technology or management practice in place. This adjusted cost, which reflects the number of facilities that would incur the costs associated with the technologies or management practices, is used to determine the estimated national capital and O&M costs for each model facility type.

9.1.3 Basic Model Assumptions

EPA based the compliance cost models on several primary assumptions:

- Feed offered to the cultured species contributes to pollutant discharges in two ways. First, metabolic wastes and unmetabolized feed consumed by the cultured species are contained in the feces and urine. Second, uneaten feed settles and increases the pollutant load in the culture water. Thus, feed inputs to the systems are the drivers of the quality of effluents from CAAP facilities.
- Feed conversion ratios (FCRs), although they vary among species and production systems, geographically, and by size or age of the animal, determine the amount of feed put into CAAP production systems. To determine the annual amount of feed used at a CAAP facility, EPA multiplied the annual production for a model facility by the FCR. EPA evaluated the technical literature for information about FCRs (Hochheimer and Westers, 2002a) and found the reported values to vary, especially by system type and species. EPA assumed that using average values for predominant species (e.g., catfish, trout, hybrid striped bass, and salmon), which are also the FCRs reported in the literature, in estimating pollutant loads and costs was a reasonable approach. The averages reflect some of the variation that occurs among species and within a system type. EPA used average FCRs for each production system to estimate the feed inputs, which translate into pollutant loads to a model facility (Table 9.1-3).

Table 9.1-3. Feed Conversion Ratios

System Type	*Initial FCR*	*Treatment/BMP*	*New FCR*
Ponds	2.2	—	—
Flow-through	1.4	—	—
Recirculating	1.6	—	—
Net pen	1.2	Active feed monitoring	1.0

Source: Hochheimer and Westers, 2002a.

- EPA received several comments from industry representatives regarding FCRs. The comments ranged from "FCRs are species- and site-specific" (Rice, 2002) to "FCRs are constantly changing" (Rheault, 2002). Several commenters thought the FCRs were too low (Engle, 2002; Pierce, 2002), and some thought EPA had estimated too high (Plemmons, 2002). As a result of these comments, EPA verified the assumed FCRs with other industry sources (Hinshaw, 2002, personal communication; MacMillan, 2002, personal communication). EPA will continue to evaluate the impact of different FCR assumptions.
- Technology options and BMPs have typical, definable, and steady-state efficiency rates of removing specific pollutants from water.
- Certain technologies are more applicable to some system types and flows than to others.

9.1.4 Organization of the Cost Chapter

The following costing information is discussed in detail in this chapter:

- *Section 9.2* presents the structure of the cost model. EPA's cost model for the CAAP industry uses the model facility approach to develop costs associated with each regulatory option.
- *Section 9.3* discusses the model facility configuration. This section also describes input data, including wastewater generation, pollutant inputs, and cost factors, for the model facilities for flow-through, recirculating, and net pen systems. EPA's cost model relies on specific information about the species raised, culture system, pollutant inputs, and wastewater generation rates to accurately predict the costs associated with each regulatory option.
- *Section 9.4* discusses unit cost modules, which are components of the treatment technologies and BMPs that compose the regulatory options. Each treatment technology or BMP cost module contains formulas by which to calculate the costs associated with each regulatory option based on the facility characteristics.
- *Section 9.5* describes the current frequency of existing BMPs and treatment technologies at CAAP facilities. EPA used this occurrence frequency, or frequency factor, to estimate the portion of the operations that would not incur costs to comply with the new regulation.
- *Section 9.6* provides output data.
- *Section 9.7* describes the evolution and changes EPA made to the costing methodology.

9.2 COST MODEL STRUCTURE

EPA estimated the costs associated with regulatory compliance for each of the regulatory options under consideration. The estimated costs of compliance to achieve the proposed requirements include initial capital costs, in some cases, as well as annual O&M and monitoring costs. EPA estimated compliance costs based on the cost of implementing the BMPs or control technologies that have been shown to meet particular requirements, as demonstrated by facilities in the CAAP facility industry.

To generate industry compliance cost estimates associated with each regulatory option for AAP facilities, EPA developed a computer-based model made up of several individual cost modules. Figure 9.2-1 illustrates the cost model by showing that it consists of several components, which can be grouped into four major categories:

- Model facility configuration
- Unit cost of treatment technology or BMP
- Frequency factors
- Output data

Each module calculates costs and loading data for a specific wastewater treatment technology or BMP (e.g., a primary settling basin) based on model facility characteristics. Frequency factors are then applied to the component costs to weight the costs by the estimated percentage of operations that already have that treatment technology or practice in place. These weighted facility costs are then summed for each regulatory option and model facility. All costs are in year 2000 dollars.

9.2.1 Model Facility Configuration

The model facility configuration part of the cost model sets up the characteristics of each unique model facility, based primarily on system type, species, the combination of existing and proposed management practices and technologies, capital costs (e.g., land costs, regional differences in technology implementation costs), annual production, and feed inputs.

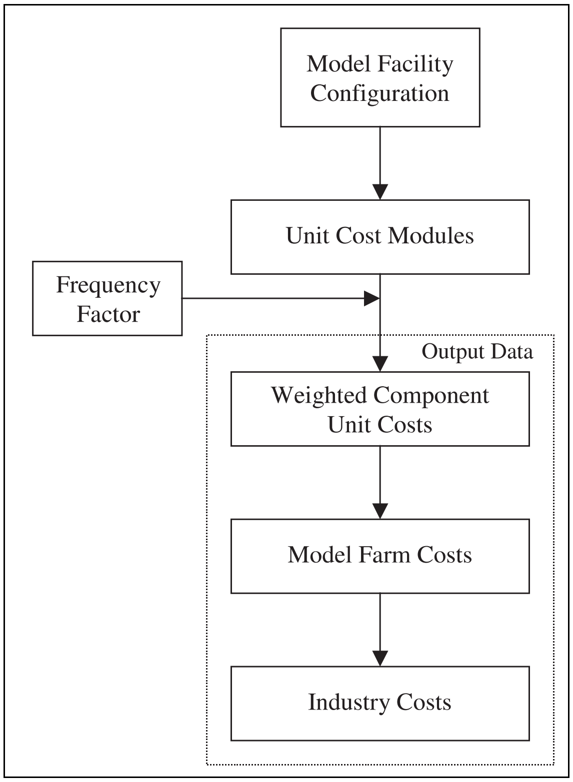

Figure 9.2-1. Schematic of Cost Model Structure

Input data to the model facilities include the following:

- Number of facilities for a combination of system types, sizes, culture species, facility types, and locations.
- Technologies and BMPs.
- National average capital cost, land requirements of technology options, and BMPs.
- Average flow (daily).
- Estimates of annual production and price per pound.
- Data associated with feeding practices, including feeding in pounds per day and pollutant concentrations associated with feed.

9.2.2 Unit Cost of Treatment Technologies or BMPs

9.2.2.1 Unit Cost Components

The unit cost component of treatment technologies or BMPs (unit cost modules) contains the cost information for each component (BMP or treatment technology) contained in the regulatory options. The cost modules calculate the various capital and O&M costs for the model facilities, based on culture species and production system, using various cost factors for labor, electricity, and land values for each of the regulatory options. Section 9.3 describes the various cost factors. The unit cost modules are used in conjunction with the frequency factors (see Section 9.5) to determine the costs for each segment of the industry.

9.2.2.2 General Cost Assumptions

Most of the input data for each model facility are specific to the species cultured and the production system, such as facility size, annual production, or unit sizes. Some cost input, however, is independent of the species and culture system. EPA assumed a management labor rate of $13.46/h, based on government labor statistics for full-time employees in the agricultural industry (Department of Labor, 2001). EPA assumed a general labor rate of $7.69/h, based on government labor statistics for full-time employees in the agricultural industry (Department of Labor, 2001). For cost estimates, EPA assumed average land values of $1,050/ac (USDA, 2000a). The value is the average U.S. farm real estate value, including all land and buildings for the continental United States in the year 2000 (USDA, 2000a). For cost estimates EPA assumed an electricity cost of $0.0722/kWh (EIA, 2002). The value is the average retail revenue per kilowatt-hour in the continental United States in the year 2000 (EIA, 2002). Additional costing impacts are species- or system-specific and are described in Sections 9.3.1 through 9.3.4.

9.2.3 Frequency Factors

EPA recognized that some individual facilities have already implemented some of the treatment technologies or BMPs included as part of the proposed options. When estimating costs and pollutant loadings for implementing the proposed options across the entire subcategory nationwide, EPA did not include costs or pollutant removals for BMPs or treatment technologies already in place.

EPA determined the current frequency of existing BMPs and treatment technologies at CAAP facilities based on existing NPDES permit requirements, screener survey responses, site visits, and sampling visits and information provided by the industry. This occurrence frequency was used to estimate the portion of the operations that would not incur costs to comply with the new regulation. Frequency factors are discussed in greater detail in Section 9.5.

9.2.4 Output Data

Output data from the cost model provide economic estimates for incremental pollution control in the CAAP industry. Capital and one-time costs, annual O&M costs, and pre-tax annualized costs were calculated for each subcategory and, more specifically, by option and facility size. From the cost model EPA also estimated the pre-tax annualized cost of the proposed options, based on the screener survey facility counts, and summed the pre-tax annualized costs for all of the proposed options to estimate the national pre-tax annualized cost of the proposed options. The national pre-tax annualized costs, which were used to evaluate the economic affordability of the regulation, are estimates of the annual costs that an individual facility would incur as a result of the proposed regulation.

9.3 MODEL FACILITY CONFIGURATION

EPA defined model facilities for flow-through, recirculating, and net pen systems based on species, ownership (e.g., commercial, federal, state), and facility production size.

9.3.1 Flow-through Systems

Flow-through systems are located where water is abundant, which allows farmers to produce fish that require continuous supplies of high-quality water. Discharges from flow-through systems can be low in concentrations of pollutants, primarily because of the high flow rates. Flow-through systems require a high volume of water to flush wastes from the production area and make oxygen available to the aquatic animals. Most flow-through systems are designed and operated with water flows that exchange or replace water in the system tanks or raceways 3 to 6 times per hour (Hinshaw and Fornshell, 2002), which translates into a system flow rate of 100 gal/min per pound of annual production (Hochheimer and Westers, 2002b).

For flow-through systems, EPA developed model facilities for two production groups. EPA determined the production levels based on an initial analysis of cost and economic impacts. EPA based this initial cost estimate on model facilities derived from revenue categories (Hochheimer and Moore, 2002) using the Census of Aquaculture (USDA, 2000b). EPA used the results of this initial analysis to arrive at the production thresholds for medium and large facilities. Data from the AAP screener survey (Westat, 2002) representing a species, lifestage (e.g., food-size or stockers), and facility type (e.g., commercial, federal, state) were sorted into two production groups, facilities that produce 100,000 lb up to 475,000 lb (medium) and facilities producing 475,000 lb or more (large) annually. All of the facilities from the AAP screener survey that fell within a species-lifestage-facility type combination for medium and large facility size classes were then averaged to produce the model facility. For example, all seven of the federal (facility type) facilities that produce trout (species) stockers (lifestage) in flow-through systems that annually produce 100,000 lb up to 475,000 lb were grouped as medium facilities.

EPA used average production values for the facilities grouped within a specific model facility to reflect the distribution of facilities reported in the AAP screener results. An example of how EPA calculated average model facility size, using trout-stockers-federal, is provided in Table 9.3-1. In this example, the range of facility sizes is 106,788 to 309,885 lb, with an average of 208,296 lb.

Table 9.3-1. Model Facility Production Calculation: Trout-Stockers-Federal

Facility Number	*Facility Production (lb/yr)*
Facility 1	106,788
Facility 2	121,600
Facility 3	198,400
Facility 4	214,400
Facility 5	230,850
Facility 6	276,152
Facility 7	309,885
Average model facility size	208,296

Based on industry input (Hinshaw, 2002, personal communication; Plemmons, 2002), EPA assumed a loading density of 3 lb/ft^3 for sizing of facilities (determining the estimated number of raceways for a given facility size). EPA assumed the raceway size for medium facilities to be 150 ft long by 14 ft wide by 3 ft deep (volume = 6,300 ft^3). The raceway size for large facilities was assumed to be 175 ft long by 18 ft wide by 3 ft deep (volume = 9,450 ft^3). The number of raceways is a factor in many of the cost estimates. EPA believes the sizes and loading densities are reasonable for medium and large flow-through systems. To estimate the number of raceways at a flow-through facility, EPA used the following calculation:

> Number of raceways = annual production/(loading density * volume per raceway)

Where:

- Number of raceways is the number for a model facility type (rounded up to the nearest integer)
- Annual production is the average production for the model facility type in pounds
- Loading density is 3 lb/ft^3 (Hinshaw, 2002, personal communication; Plemmons, 2002)
- Volume per raceway is 6,300 ft^3 for medium facilities and 9,450 ft^3 for large facilities

EPA developed raceway configurations from information obtained during site visits and conversations with AAP industry representatives (Hinshaw, 2002, personal communication; Tetra Tech, 2002d; Tetra Tech, 2002f; Tetra Tech, 2002g; Tetra Tech, 2002h; Tetra Tech, 2002i; Tetra Tech, 2002j; Tetra Tech, 2002k; Tetra Tech, 2002l; Tetra Tech, 2002m; Tetra Tech, 2002n;). For the purpose of costing, EPA developed models for flow-through systems assuming raceways would be concrete. Site visits and screener data indicated smaller flow-through facilities also operate circular tanks, earthen raceways, and flow-through concrete or earthen ponds (Tetra Tech, 2002d; Tetra Tech, 2002e; Tetra Tech, 2002f; Tetra Tech, 2002g; Tetra Tech, 2002h; Tetra Tech, 2002i; Tetra Tech, 2002j; Tetra Tech, 2002k; Tetra Tech, 2002l; Tetra Tech, 2002m; Tetra Tech, 2002n). EPA assumed that raceways are the predominant systems used in flow-through facilities at the sizes being considered for this proposed regulation.

For the purpose of costing, EPA also assumed costs for non-raceway flow-through systems to be comparable to those for concrete raceway systems. For flow-through system facilities that do not use raceways, there are a variety of alternatives for collecting solids to remove them from the discharge. Circular tank systems often use dual drains to take advantage of the settling and concentrating of solids around a bottom center drain. In a dual drain system, overflow water is typically drained at a location above the tank bottom to control water levels in the tank. This primary drain discharges most of the flow and typically has low concentrations of solids. The second drain, at the bottom center of the tank, discharges the higher concentrated solids portion of the effluent. The bottom drain can be constructed to continually discharge a small volume of water with the concentrated solids or to be manually opened to discharge the concentrated solids. Summerfelt and others (2000) provides additional information on drains for circular tanks.

The number of facilities represented by each flow-through model facility group is indicated in Table 9.3-2. EPA found nothing to indicate that the wide range of facility sizes represented by the average production values used as input for the model facilities grouped as “large” would misrepresent the range of facilities that made up the class. Although the larger facilities can realize economies of scale in production costs, EPA did not find any differences in waste treatment or effluent quality characteristics at the larger systems in the range. Thus, EPA assumed the average facility sizes could accurately represent the range of facilities in the size class. (This observation holds for the ranges in facility sizes for recirculating and net pen systems as well.)

Table 9.3-2. Model Facility Information

Model Facility	***Size***	***Number of Facilities***[a]	***Production Range (lb/yr)***[b]	***Average Production (lb/yr)***[b]
Trout-Commercial-Flow-through	Medium	22	100,000-370,000	208,986
	Large	8	592,900-8,260,815	2,499,170
Trout-State-Flow-through	Medium	< 5	—	—
	Large	< 5	—	—
Trout-Stockers-Commercial-Flow-through	Medium	5	128,000-317,000	192,137
Trout-Stockers-Federal-Flow-through	Medium	7	106,788-309,885	208,296
	Large	< 5	—	—

Model Facility	***Size***	***Number of Facilities***[a]	***Production Range (lb/yr)***[b]	***Average Production (lb/yr)***[b]
Trout-Stockers-State-Flow-through	Medium	44	100,800-433,915	224,193
	Large	< 5	—	—
Trout-Stockers-Other-Flow-through	Medium	< 5	—	—
	Large	< 5	—	—
Tilapia Commercial-Flow -through	Medium	< 5	—	—
	Large	< 5	—	—
Striped Bass Commercial-Flow-through	Medium	< 5	—	—
Salmon-Other-Flow-through	Large	< 5	—	—

a < 5 indicates a group with fewer than five facilities and is reported in this manner to protect the confidentiality of the individual facilities.
b Model facility groups with fewer than five facilities are not reported.

Common industry BMPs and treatment technologies observed at flow-through production facilities include:

- Feed management
- Solids management BMP plan
- Raceway cleaning[1]
- Mortality removal
- Quiescent zones
- Quiescent zone cleaning
- Primary settling
- Vegetated ditches
- Land application of collected solids

9.3.2 Alaska Flow-through Systems

Alaska's salmon producers refer to production operations as "ocean ranching" in which hatchery fish are released into coastal areas to supplement the natural populations. Government and nonprofit organizations operate these facilities, which commercial and recreational fishermen support through fees.

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[1] Raceway cleaning removes accumulated solids (biofouling and adhering feces or uneaten feed) from the raceways. The frequency of cleaning depends on factors such as temperature, sunlight, feed type, and size of the cultured species and can range from once every 2 to 3 weeks to once per growing cycle. Operators typically brush the walls and bottom of the raceway and port the solids-laden water to a sedimentation basin.

Alaska's salmon production systems represent a slight departure from traditional flow-through culture systems. Because of the high costs associated with the disposal of solids and tidal flushing in the waters adjacent to the facilities, most facilities do not operate wastewater treatment units for the collection of solids. Otherwise, the facilities operate much like all other flow-through systems.

Because facility-specific data were available for the Alaskan facilities, EPA analyzed each facility separately to determine compliance costs. EPA estimated production data for each facility using 2000 hatchery production data reported in Alaska Fish and Game's *Alaska Salmon Enhancement Program 2000 Annual Report* (McNair, 2001). EPA estimated hatchery releases by facilities using a conversion of 0.4 g per fish for pink and chum salmon and 20 g per fish for coho, chinook, sockeye, and other salmon species, based on industry-provided information (Tetra Tech, 2002a).

Only the facilities producing 100,000 lb/yr or more were modeled. Table 9.3-3 shows production estimates for the Alaska salmon facilities producing more than 100,000 lb/yr.

Table 9.3-3. Alaskan Salmon Producers

Facility	***Production (lb/yr)***	***Facility***	***Production (lb/yr)***
Facility 1	104,738	Facility 10	207,649
Facility 2	201,052	Facility 11	985,194
Facility 3	204,139	Facility 12	116,636
Facility 4	144,436	Facility 13	366,030
Facility 5	135,510	Facility 14	244,543
Facility 6	403,515	Facility 15	571,095
Facility 7	150,822	Facility 16	145,089
Facility 8	125,720	Facility 17	222,290
Facility 9	153,371	Facility 18	250,047

EPA used Alaska-specific data for the general cost (electricity rates, land values, and labor rates). The Energy Information Association (EIA, 2002) reports average electricity rates in 2000 for Alaska as \$0.093/kWh. Land costs were estimated from a report on habitat and restoration of stream bank property, which valued land at an average of \$12,024 (\$12,697 in 2000 dollars) per acre (Alaska Department of Fish and Game, 2002). In 2000, Alaska's labor rates for managers were \$21.38/h and for general labor were \$15.03/h (Alaska Department of Labor and Workforce Development, 2002).

EPA used the following assumptions to estimate compliance costs at Alaska facilities:

- Loading densities are estimated at 3 lb/ft^3.
- Raceway size is 150 ft long by 14 ft wide by 3 ft deep, which is the same size as medium-sized flow-through facilities in other states.

- Flow rate is 100 gal/min per pound of production, which is the same rate as that of medium-sized flow-through facilities in other states.

Common Alaska salmon industry BMPs and treatment technologies include:

- Feed management
- Raceway cleaning

9.3.3 Recirculating Systems

Recirculating systems typically require inputs of relatively small volumes of water because water in these systems is continuously filtered and reused. Internal biological filtration processes remove ammonia, mechanical filters remove solids, and other life-support equipment adds oxygen and alkalinity to the system water. The production water treatment process is designed to minimize water requirements, which results in a small-volume, concentrated waste stream that is discharged daily. Many recirculating systems are operated with a 10% makeup volume of water added daily to dilute the production water and replace water lost to evaporation and backwashing of the solids filters (Chen et al., 2002). Thus, recirculating systems have a continuous discharge consisting of the backwash from the solids filter and overflows resulting from the added makeup water.

The loading density was indicated by the average stocking density of the culture species within the production system at maximum production levels. Information from site visits conducted at facilities operating recirculating production systems indicated loading densities of about 1 lb per gallon of culture water (Tetra Tech, 2002b; Tetra Tech, 2002o; Tetra Tech, 2002p; USEPA, 2002d).

EPA calculated the production system volume for recirculating systems using the model facility's annual production and loading density. The formula used to calculate production system volume is as follows:

Production system volume = facility annual production/loading density

where production system volume is reported in gallons, loading density is 1.0 lb/gal (Tetra Tech, 2002b; Tetra Tech, 2002o; Tetra Tech, 2002p), and facility annual production is the average annual model facility production in pounds. Since many recirculating system operators add about 10% of the system volume per day, EPA assumed that recirculating systems would generate a daily discharge volume of about 10% of the system volume. For systems that add less make-up water, then this assumption is a conservative estimate of the volume of effluent requiring treatment on a daily basis.

For recirculating systems EPA developed one model facility to represent all facilities having a production level equal to or greater than 100,000 lb/yr. EPA grouped data from the AAP screener survey (Westat, 2002) representing a species, lifestage (e.g., food-size or stockers), and facility type (e.g., commercial, federal, state) combination into model facility groups representing facilities annually producing 100,000 lb or more (large). All of the species-lifestage-facility type combinations for the large facility size class were then averaged to produce the model facility. Table 9.3-4 provides an example of how

EPA calculated production for a model facility, using tilapia-food-size-commercial. Table 9.3-5 shows the number of facilities represented by each recirculating model.

Table 9.3-4. Model Facility Production Calculation: Tilapia-Food-size-Commercial

Facility Number	*Facility Production (lb/yr)*
Facility 1	Range: 300,000 to 525,000
Facility 2	
Facility 3	
Facility 4	
Facility 5	
Average model facility size	351,634

Table 9.3-5. Model Facility Information

Model Facility	*Size*	*Facilities Represented*
Tilapia-Recirculating	Large	5
Striped Bass-Recirculating	Large	< 5[a]

[a] < 5 indicates a group with fewer than five facilities and is reported in this manner to protect the confidentiality of the individual facilities.

Common industry BMPs and treatment technologies at recirculating production facilities include:

- Feed management
- Solids management BMP plan
- Mortality removal
- Primary settling
- Microscreen filtration
- Biological treatment

9.3.4 Net Pen Systems

Net pen systems are suspended or floating holding cages or nets used for the growout of the culture species. The systems may be located along a shore or pier or may be anchored and floating offshore. Net pens rely on tides and currents to provide a continual supply of high-quality water to the cultured animals. For most locations the structural design of net pens must consider the potential high-energy environment in open waters, especially during storms. Net pens are designed to withstand such high-energy environments and are anchored to keep them in place during extreme weather events. Net pen systems are located in coastal bays or estuaries where tidal or river flow is abundant.

For net pen systems EPA developed one model facility to represent all facilities having a production level equal to or greater than 100,000 lb. EPA sorted data from the AAP screener survey representing a species, lifestage (e.g., food-size), and facility type (e.g., commercial, federal, state) into facilities producing 100,000 lb or more (large) annually. All of the species-lifestage-facility type combinations for the large facility size class were then averaged to produce the model facility. Table 9.3-6 provides an example of how EPA calculated production for a model facility.

Table 9.3-6. Model Facility Production Calculation: Salmon-Food-size-Commercial

Facility Number	*Facility Production (lb/yr)*
Facility 1	Range: 342,380 – 6,352,715
Facility 2	
Facility 3	
Facility 4	
Facility 5	
Facility 6	
Facility 7	
Facility 8	
Average model facility size	2,387,086

EPA estimated that a loading density of 0.8 lb/ft^3 was applicable to the industry (Hochheimer and Westers, 2002c). The volume of individual nets was assumed to be 250,000 ft^3, based on site visit information (Tetra Tech, 2002c; Tetra Tech, 2002s). To estimate the number of net pens at a facility, EPA used the following calculation:

Number of net pens = annual production/(loading density * volume per net pen)

Where:

- Number of net pens is the number for a model facility type (rounded up to the nearest integer)
- Annual production is the average production for the model facility type in pounds
- Loading density is 0.8 lb/ft^3
- Volume per net pen is 250,000 ft^3 for all facilities

Common industry BMPs and treatment technologies at net pen production facilities include:

- Feed management
- Solids management BMP plan
- Mortality removal
- Active feed monitoring

- Double netting
- Net maintenance (removal of fouling organisms)

9.4 UNIT COST OF TREATMENT TECHNOLOGIES AND BMPS

Cost modules calculate the direct capital and annual costs for installing, operating, and maintaining a particular technology or practice for an AAP facility. Each cost module determines an appropriate design of the system component based on the characteristics of the model facility and the specific regulatory option. Waste volumes generated by the model facility spreadsheets were used to size equipment and properly estimate the direct capital costs for purchasing and installing equipment and annual O&M costs.

Estimates of capital and annual cost components are based on information collected from the USDA 1998 Census of Aquaculture (USDA, 2000b), screener surveys, literary references, technical reports, EPA site and sampling visits, and estimates based on standard engineering methods of cost estimation (Hydromantis, 2001; Metcalf and Eddy, 1991). The following subsections describe each technology or BMP cost module used as a basis for the regulatory options and specifically discuss the following:

- Description of technology or practice
- Design
- Cost

9.4.1 Quiescent Zones

Quiescent zones are a technology control considered in Option 1 for all flow-through CAAP facilities as a part of primary solids removal.

9.4.1.1 Description of Technology or Practice

Quiescent zones are a practice used in raceway flow-through systems in which the last approximately 10% of the raceway serves as a settling area for solids. It is important to note that flow-through system raceways are typically sized according to loading densities (e.g., 3 to 5 lb of fish per cubic foot), but the flow rate of water through the system drives the production levels in a particular raceway. Thus, EPA evaluated the impacts of placing quiescent zones in the lower 10% of raceways and found no adverse impacts on the production capacity of a facility (Hochheimer and Westers, 2002b). The goal of quiescent zones and other in-system solids collection practices is to reduce the total suspended solids (TSS) and associated pollutants in the effluent. Estimates of quiescent zone pollutant reductions were based on information supplied by AAP industry representatives (Hinshaw, 2002, personal communication; MacMillan, 2002, personal communication).

Quiescent zones usually are constructed with a wire mesh screen that extends from the bottom of the raceway to above the maximum water height to prohibit the cultured species from entering the quiescent zone. The reduction in the turbulence usually caused by the swimming action of the cultured species allows the solids to settle in the quiescent zone. The collected solids are then available to be efficiently removed from the system. Quiescent zones are usually cleaned on a regular schedule, typically once per week in medium to large systems (Hinshaw, 2002, personal communication; MacMillan, 2002, personal communication), to remove the settled solids. The Idaho BMP manual (IDEQ, n.d.) recommends a minimal quiescent zone cleaning frequency of once per month in upper raceways and twice per month in lower units. The settled solids must be removed regularly to prevent breakdown of particles and leaching of pollutants such as nutrients and biochemical oxygen demand (BOD).

Quiescent zones placed at the bottom or end of each rearing unit or raceway allow for the settling of pollutants before they are discharged to other production units (when water is serially reused in several rearing units) or receiving waters.

Operational factors associated with operating quiescent zones include the following:

- The necessity to clean the screens to prevent fouling and damming of water in the raceway.
- The regular removal of collected solids from the quiescent zones. Timely cleaning involves the dedication of the needed resources to regularly clean the quiescent zones. Facilities must also have the equipment needed to clean the quiescent zones regularly.

Quiescent zones increase labor inputs because of the need to remove collected solids regularly and maintain the screens that exclude the culture species. Cleaning of the quiescent zones also creates a highly concentrated waste stream that should be treated before it is discharged into a receiving water body.

9.4.1.2 Design

Quiescent zones are designed to exclude fish from the lower portion of the raceway. The influent side of the quiescent zone usually has a wire mesh screen that extends from the bottom of the raceway to above the maximum water height to prohibit the cultured species from entering the quiescent zone and disturbing the settled solids. Most designs use channels cut into the concrete sides of a raceway to retain the screen and might also require a center column to support the screen frame in wider raceways. Water leaving the effluent end of the quiescent zone is controlled with dam boards installed across the width of the raceway. The dam boards are stacked to regulate the height of water in the raceway. Water flows slowly from the entire width of the raceway at the top of the water column so that the settled solids are not disturbed. A drain is installed in the bottom of the quiescent zone for cleaning the accumulated solids. A standpipe, which is higher than the height of the dam boards, prevents water from entering the drain under normal operation. When cleaning is desired, the standpipe is pulled and a vacuum hose is attached to the drain. The solids are then vacuumed into the drain for additional treatment.

9.4.1.3 Capital Costs

For the purpose of estimating capital costs, EPA assumed that the costs for quiescent zones in both medium and large systems are based on construction that rebuilds approximately 100 ft^2 of surface area in the lower portion of the raceway to install a drain and to cut channels for the screens and dam boards. Even though raceway widths vary among facilities, EPA assumed a constant construction disturbed area of 100 ft^2 because the installation of drains should require disturbing about the same size area independent of the actual width of the raceway. This construction could result in excavation to a depth of 3.5 ft. The rebuilding of the lower portion of the raceway includes the installation of channels to hold the fish exclusion screen and dam boards, as well as reconstruction of the drain structure to allow for water level management and drains for cleaning the solids.

EPA assumed that, in the worst case, a facility would have raceways with the bottom of the slab 3.5 ft below grade. This would necessitate the following excavation volume:

$$\text{Excavation volume} = \frac{100\ \text{ft}^2 \times 3.5\ \text{ft}}{27\ \text{ft}^3/\text{yd}^3} = 13\ \text{yd}^3$$

where the excavation volume is in cubic yards.

The excavation cost would then be:

$$\text{Excavation cost} = 13\ \text{yd}^3 \times \$5.70/\text{yd}^3 = \$74.10$$

where excavation cost is in dollars and the cost per cubic yard ($\$5.70/\text{yd}^3$) is from RS Means (2000).

The quiescent zone walls and floor were considered to be constructed with concrete and have an 8-in. thickness. Concrete used in the wall and floor construction was estimated to cost $73.50 per cubic yard installed (RS Means, 2000). EPA observed several different drain and quiescent zone configurations during the site visits at flow-through system facilities. The design that required the most concrete included a concrete dam (across the width of the raceway and lower than the outside wall height) that acts as a water level control. For the purpose of estimating costs, EPA assumed this quiescent zone design would require the addition of the equivalent of four walls (the two sides, the end, and the dam) at the tail end of a raceway. The volume of concrete required for the concrete walls and floor was computed using the following two equations:

Concrete required = (wall length * wall height * wall thickness * 4) + (floor surface area * floor thickness)

Concrete costs = concrete required * concrete costs ($\$/\text{yd}^3$)

Where:

Wall length = the length of one wall of the quiescent zone

Wall height = the height of the quiescent zone

Wall thickness = the thickness of the concrete wall

Floor thickness = the thickness of the concrete floor

EPA assumed that the concrete would be reinforced with reinforcing steel bar (Rebar), which would add 10% to the concrete costs (Swanson, 2002). The rebar costs were computed as follows:

Rebar costs = concrete costs * 10%

EPA assumed that facilities installing quiescent zones would also install offline settling basins and that the costs for additional piping were part of the estimates for the settling basins (see Section 9.4.2). Water and solids in the quiescent zone are suctioned into the drain (assuming gravity flow) and conveyed under the raceway to the feeder pipe leading to the sedimentation basin. Screens are cleaned as part of the quiescent zone cleaning at intervals of no more than 2 weeks.

9.4.1.4 Operation and Maintenance Costs

Facilities using quiescent zones must clean the accumulated solids at least every 2 weeks to prevent breakdown of the solids and resuspension in the effluent. Most facilities can use gravity flow to pull a vacuum, which can be used to suction out accumulated solids in quiescent zones and transport them to the offline settling basin. EPA assumed quiescent zones could be cleaned with gravity flows and the cleaning would not require pumps or electrical costs. Vacuums connect to the drain line of the raceway that runs to the sedimentation basin and are made from PVC plastic pipe fittings and PVC flexible hoses. To vacuum a raceway, the standpipe normally in the drain is pulled and one end of the vacuum inserted. Solids are then vacuumed from the quiescent zone by the water flowing into the flexible hose. The cost for materials to construct a vacuum is assumed to be $500 per year. The vacuum component costs are an annual cost because of the normal wear on the vacuum. For the purpose of estimating O&M costs, EPA used information collected during the sampling program for the CAAP industry that indicated facility personnel spend about 20 to 30 minutes per week per raceway cleaning and maintaining quiescent zones (Tetra Tech, 2002d). EPA estimated this cost using general labor at a rate of 5 minutes per raceway 6 d/wk (312 d/yr). EPA found 6-d workweeks to be the prevalent practice among the facilities visited during the site visits, so 312 d was used as the standard number of working days for general labor for O&M activities. The equation for all quiescent zone O&M, including cleaning, is as follows:

> Raceway O&M labor costs = number of raceways * 5 minutes per day * 312 days/year * general labor rate

where the raceway O&M costs are in dollars per year, the number of raceways is estimated in the model configuration, and the general labor rate is $7.69/h.

The cost for screens is assumed to be $100 per raceway per year. Screens are constructed with a metal or wood frame to hold the screen and can be made of metal or plastic mesh. One screen that spans the width of the raceway and is about 6 inches higher than the water depth is required for each raceway. Adding wooden dam boards after the screen can also enhance settling. The cost for the dam boards is assumed to be $20 per raceway per year (Hochheimer, 2002).

9.4.2 Sedimentation Basins (Gravity Separation)

Sedimentation basins are a technology control considered in Option 1 for all flow-through and recirculating CAAP facilities as a part of primary solids removal. Sedimentation basins at flow-through facilities can be in the form of offline or full-flow basins. Offline settling treats a portion of the flow-through effluent volume in which solids have been concentrated. When offline settling is used, treatment technologies to concentrate solids (e.g., quiescent zones) are also used. Full-flow settling treats the entire flow-through effluent volume. For recirculating systems, sedimentation basins are used to treat the waste stream discharged from the recirculating system.

9.4.2.1 Description of Technology or Practice

Sedimentation, also known as settling, separates solids from water using gravity settling of the heavier solid particles (Metcalf and Eddy, 1991). In the simplest form of sedimentation, particles that are heavier than water settle to the bottom of a tank or basin. Sedimentation basins (also called settling basins, settling ponds, sedimentation ponds, or sedimentation lagoons) are used extensively in the wastewater treatment industry (Metcalf and Eddy, 1991) and are commonly found in many flow-through and recirculating CAAP facilities (Westat, 2002). Most sedimentation basins are used to produce a clarified effluent (for solids removal), but some sedimentation basins remove water from solids to produce a more concentrated sludge. Both of these applications of sedimentation basins are used and are important in CAAP systems.

Periodically, when accumulating solids exceed the designed storage capacity of the basin, the basin is cleaned of the accumulated solids. EPA found that the cleaning frequencies of sedimentation basins used at CAAP facilities ranged from 2 to 12 times per year depending on the size of the facility (Jackoviac, 2002, personal communication; MacMillan, 2002, personal communication). For estimating costs EPA used a cleaning frequency of nine times per year to capture some of the variation in cleaning frequencies used by the industry. By sizing sedimentation basins for a cleaning frequency of 9 times per year, the basin volume is larger than that for a cleaning frequency of 12 times per year. The extra storage also provides a safety factor to accommodate facilities that cannot use a solids disposal method such as land application, which requires year-round access to application sites.

The primary advantages of sedimentation basins for removing suspended solids in effluents from CAAP systems are the relative low cost of designing, constructing, and operating sedimentation basins; the low technology requirements for the operators; and the demonstrated effectiveness of their use in treating similar effluents. In many aquatic animal production systems, most of the solids from feces and uneaten feed are of sufficient size to settle efficiently in most moderately sized (37 ft^3 to 741 ft^3) sedimentation basins, without adding chemicals. Many of the pollutants of concern in CAAP system effluents can be partly or wholly removed with the solids captured in a sedimentation basin. Much of the phosphorus tends to bind with the solids; BOD and organic nitrogen are in the form of organic particles in the fish feces and uneaten feed; and some other compounds, such as oxytetracycline, were found in the sediments captured in sedimentation basins in EPA's sampling data.

Disadvantages of sedimentation basins include the need to clean out accumulated solids, the potential odor emitted from the basin under normal operating conditions, and the inability of the basins to remove small-sized particles without chemical addition. Accumulated solids must be periodically removed and properly disposed of through land application or other sludge disposal methods. For the purpose of costing, EPA assumed no cost associated with the disposal of collected solids in flow-through and recirculating systems. EPA based this assumption on the observation that disposal alternatives are available to CAAP facilities that have a no cost impact. For example, collected solids can be used as a valuable fertilizer by the facility on other facility-owned land or taken for free by local farmers and gardeners. System operators should maintain or increase the efficiency of sedimentation basins by cleaning quiescent zones as frequently as possible and attempt to minimize the breakdown of particles (into smaller sizes) by avoiding cleaning methods that tend to grind up the particles. Industry representatives report that existing CAAP systems might have limited available space for the installation of properly sized sedimentation basins. Therefore, included in the cost for sedimentation basins is a cost for the purchase of land.

9.4.2.2 Design

Settling in sedimentation basins occurs when the horizontal velocity of a particle entering the basin is less than the vertical (settling) velocity in the tank. The settling properties of an effluent, particularly the settling velocities, are determined, and sedimentation basins are sized to accommodate the expected flow through the basin. From Metcalf and Eddy (1991), the length of the sedimentation basin and the detention time can be calculated so that particles with a particular settling velocity (V_c) will settle to the bottom of the basin. The relationship of the settling velocity to the detention time and basin depth is

$$V_c = \text{depth/detention time}$$

Other design factors include the effects of inlet and outlet turbulence, short-circuiting of flows within the basin, solids accumulation in the basin, and velocity gradients caused by disturbances within the basin (such as those from solids removal equipment).

A sedimentation basin does not function if it is frozen. Proper design, construction, and operation of the sedimentation basin are essential for the efficient removal of solids. Collected solids must be removed when they reach the design accumulation depth to ensure the designed removal efficiencies of the sedimentation basin. Otherwise, particles entering the sedimentation basin will not have sufficient depth in which to settle.

For the purpose of cost analysis, EPA assumed the use of quiescent zones (see Section 9.4.1) and offline settling in flow-through systems, which should be less expensive to install and operate than full-flow settling in the larger systems for which requirements are being considered. Large production facilities are not expected to effectively operate full-flow settling basins because of the surface area that would be required to settle the entire volume of water. Offline settling basins in flow-through systems were assumed to treat about 1% of the flow rate in flow-through systems. Thus, full-flow settling would require 100 times more settling capacity than offline settling. In small systems, full flow might be cost-effective in lieu of installing and maintaining quiescent zones (also see IDEQ, n.d.).

EPA used the Computer–Assisted Procedure for the Design and Evaluation of Wastewater Treatment (CAPDET) model (Hydromantis, 2001) to aid in determining capital costs associated with the construction of sedimentation basins. CAPDET is intended to provide planning-level cost estimates to analyze alternative design technologies for wastewater treatment systems (Hydromantis, 2001). CAPDET estimates costs and design parameters based on settling velocity, influent wastewater parameters (TSS in this case), and flow rate. EPA used CAPDET to estimate construction and design (engineering) costs associated with sedimentation basins for both recirculating and flow-through systems. The estimated settling velocity for particles in a CAAP wastewater stream, regardless of system type, ranges from 0.0015 to 0.0030 ft/s, so a mid-range value of 0.0023 ft/s was used (Chen et al., 1994). Chen et al. (1994) provides the most comprehensive review of solids settling for CAAP facilities.

EPA used an average TSS value of 689 mg/L (range of 4 mg/L to 1,040 mg/L from flow-through system sampling data) (Tetra Tech, 2002q, Tetra Tech, 2002r) as the solids input for CAPDET to design the sedimentation basin. For initial costs estimates, EPA used a flow rate of 93.8 gpm, which represented a medium to large flow-through facility. CAPDET cost output was not very sensitive over the range of flow rates from the different model facilities. EPA chose the mid-range value of 93.8 gpm to estimate costs on a dollar per gallon basis to provide more sensitivity in the cost estimates because the flow rates from the model facilities were from a narrow range at the lower end of the input flows used in CAPDET. The value of 93.8 gpm was at about the middle of the range of flows for medium and large flow-through facilities (and at the upper end of the range for recirculating systems). For the range of model facility flows, CAPDET produces a linear relationship between sedimentation basin inflows and cost. Thus, EPA chose the midpoint value of 93.8 gpm to estimate dollars per gallon per minute values to calculate sedimentation basin costs. At 93.8 gpm, CAPDET generates an engineering design cost of $10,300, which is about $109.8/gpm. CAPDET estimates the construction costs at $68,400, or about $729.2/gpm. The construction costs include cost elements for earthwork and concrete work. To determine the design costs for all settling basins, EPA multiplied the flow rate to the settling basin by $109.8; for the construction costs, EPA multiplied the flow rate by $729.2.

EPA estimated land costs by using the settling area calculated by CAPDET and adding 10%. These values were similar to those reported in the Idaho BMP Manual (IDEQ, n.d.) and by Chen et al. (1994). For ease of calculation, land costs were rounded up to the nearest 1%, 10%, 25%, 50%, 75%, or 100% of an acre. EPA used land values of $1,050/ac (USDA, 2000a) and $12,024/ac in Alaska (Alaska Department of Fish and Game, 2002), and the land cost was negligible in the overall cost of implementing settling basins (for large facilities, less than 1% of the total capital cost).

9.4.2.3 Capital Costs: Flow-through Systems

The cost calculation for the design and construction of a sedimentation basin based on the outputs from the CAPDET model are provided below:

Design costs = facility flow rate * 0.01 * $109.8/gpm
Construction costs = facility flow rate * 0.01 * $729.20/gpm

Where:

Facility flow rate = the discharge rate from the facility

EPA included costs for a gravity-fed conveyance system constructed of PVC pipe to carry effluent from each raceway to the sedimentation basin. EPA assumed a quiescent zone configuration similar to that shown in Figure 9.4-1. Quiescent zones have a bottom (floor) drain that connects to a feeder pipe leading to the offline sedimentation basin. EPA assumed that, in the worst case, a series of raceways two wide are placed end to end at a facility. This approach estimates the longest possible length of pipe. The connection from the stand pipe/drain to the feeder pipe is an elbow for all of the raceways in a series. The connection at the feeder pipe is an elbow for the uppermost raceway in a series and a “T” for all other downstream raceways.

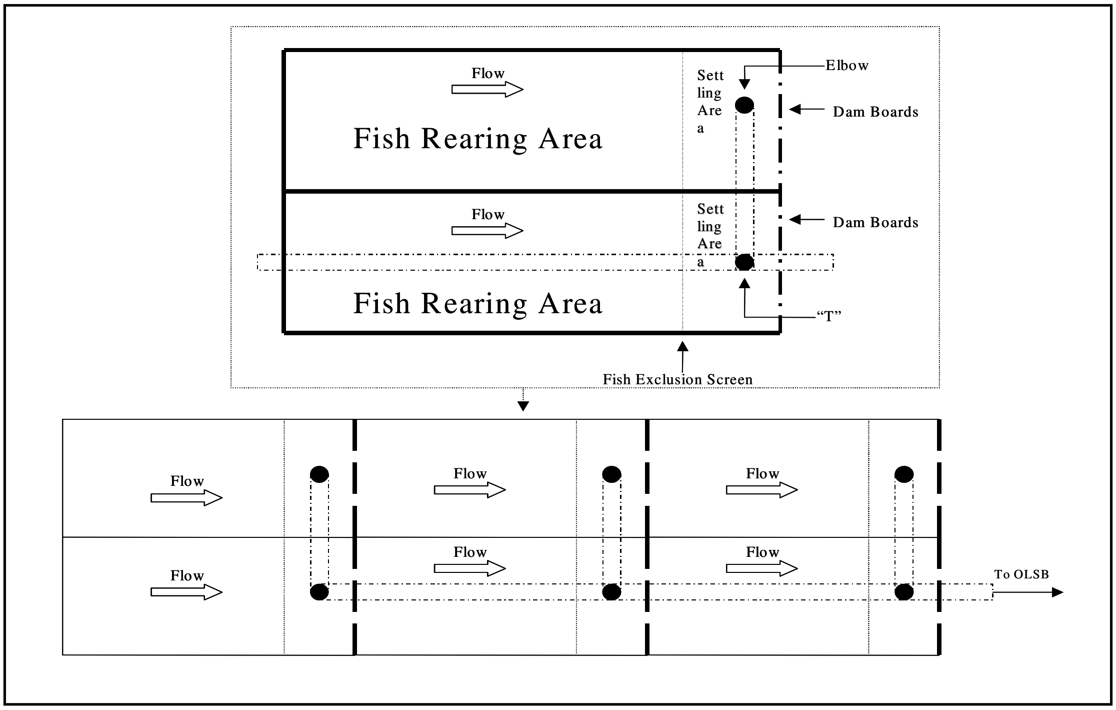

Figure 9.4-1. Model Facility Quiescent Zone Configuration and Drain Layout

EPA assumed 8-in. diameter PVC pipe could be used for all conveyance systems (Hochheimer, 2002). The cost for 8-in. installed PVC pipe was estimated to be $4.25 per linear foot installed underground (VA AG, 2000). The cost for PVC pipe was obtained by multiplying the length of each raceway by the number of raceways (see Section 9.3.1). The costs for 8-in. 90° elbows and "T's" were estimated to be $50.65 and $78.39 each (Hochheimer, 2002). The cost calculation for installation of the conveyance system is as follows:

PVC pipe cost = no. of raceways * raceway length * installed pipe cost

Where:

No. of raceways = the number of production raceways at the model facility
Raceway length = the length of the production raceways at the facility
Installed pipe cost = the price per foot for 8-in. PVC pipe installed

Total cost of "T's" = ((no. of raceways ÷ 2) − 1) * cost per "T"

Where:

No. of raceways = the number of production raceways at the model facility
Cost per "T" = the cost per unit for an 8-in. PVC "T"

Total 90° elbow costs = ((no. of raceways ÷ 2) + 1) * cost per elbow

Where:

No. of raceways = the number of production raceways at the model facility
Cost per elbow = the cost per unit for an 8-in. PVC elbow

Total conveyance system cost = PVC pipe costs + total “T” costs + total elbow costs

After each component was computed, the components were summed to indicate the total capital costs for the sedimentation basin. The calculation for total capital costs is as follows:

Sedimentation basin cost = design cost + construction cost + land cost + conveyance system cost

9.4.2.4 Capital Costs: Recirculating Systems

The construction and design costs for a sedimentation basin at a recirculating facility were also estimated using the CAPDET model. Recirculating systems are expected to generate a maximum of about 10% of the system volume per day, which is about 125,000 gpd in large recirculating systems. The cost calculation for the design and construction of a sedimentation basin is as follows:

Daily discharge rate = total system volume * 0.10

Where:

Total system volume = the total volume of water used for the production of the cultured species

Design costs = daily discharge rate * $109.8/gpm
Construction costs = daily discharge rate * $729.20/gpm

9.4.2.5 Operation and Maintenance Costs: Flow-through and Recirculating Systems

The O&M costs include the labor to maintain and clean the basins. For O&M costs, EPA assumed that no electricity costs would be necessary because the basins operate using gravity flow. CAPDET estimated the time required for general maintenance at 82.7 h/yr for the 93.8-gpm sedimentation basin. This equates to 0.88 h/yr/gpm of flow. EPA used the 0.88 h/yr/gpm, multiplied by the total system flow, to estimate labor requirements. General labor was required for this O&M task, which, as specified by CAPDET, includes checking for proper operation of the sedimentation basin, performing minor repairs, and observing and correcting for short-circuiting of flows.

The O&M costs also include equipment and labor to clean the basin nine times per year. The estimated cleaning frequency was based on information supplied by AAP industry representatives and information obtained during site and sampling visits. EPA assumed that cleaning a settling basin with a front-end loader and a two-person cleaning crew takes 1 day and occurs nine times per year. The cost for renting a front-end loader (tractor) was estimated to be $293.00 per day (RS Means, 2000). For estimating costs, EPA assumed facilities that currently collect solids (facilities with quiescent zones and/or sedimentation basins in place) currently incur the cost of cleaning the sedimentation basins. For those facilities that are not currently collecting solids (those facilities that need to install quiescent zones and sedimentation basins), a front-end loader is not available onsite and one would be rented. The cleaning labor cost associated with cleaning was estimated using the following equation:

Cleaning labor cost = 16 h (2 people, 1 day) * general labor rate

Where:

General labor rate = the hourly wage rate for general labor employees

The total cleaning cost for a sedimentation basin includes the cleaning labor cost plus the cost for the tractor rental. The total cleaning cost was computed as follows:

Total cleaning cost = (tractor rental + cleaning labor costs) * 9 cleanings per year

Where:

Tractor rental = the cost for a 1-day rental of a tractor equipped with a front-end loader

9.4.3 Solids Control BMP Plan

Solids control BMP plans are considered as a management practice for all CAAP facilities under Option 1. All requirements and costs associated with the solids control BMP plans are assumed to be equal for all species and culture systems.

9.4.3.1 Description of Technology or Practice

Evaluating and planning site-specific activities to control the release of solids from CAAP facilities is a practice currently required in several EPA regions as part of individual and general National Pollutant Discharge Elimination System (NPDES) permits (e.g., shrimp pond facilities in Texas, net pens in Maine, and flow-through facilities in Washington and Idaho). BMP plans in these permits require the facility operators to develop a management plan for preventing excess feed from entering the system and removing solids from the effluent. The BMP plan also ensures planning for proper O&M of equipment, especially treatment control technologies. Implementation of the BMP plan results in a series of pollution prevention activities, such as ensuring that employees do not waste feed and planning for the implementation of other O&M activities, which are costed under each technology control or BMP.

9.4.3.2 Capital Costs: All System Types

The capital costs for the BMP plan are based on the amount of managerial time required to develop a plan. The following components should be included in the plan:

- Operational components such as a description of pollution control equipment, feeding methods, preventative maintenance, and the layout and design of the facility.
- Integrated loss control plan to describe precautions taken by the facility to prevent the loss of nonnative species.

- Description of cleaning of culture tanks/raceways and other equipment including how accumulated solids are removed and methods of disposal.
- Description of training for facility personnel to assure they understand the goals and objectives of BMPs and their role in complying with the goals and objectives of the BMP plan.
- Description of records maintenance for feed records, water quality monitoring and final disposition of collected solids.
- The BMP plan should also include a statement that the plan has been reviewed and endorsed by the facility manager and the individuals responsible for the implementation of the plan.

AAP industry representatives (Fromm and Hill, 2002; MacMillan, 2002, personal communication) indicated that development of a solids management BMP plan would take from about 4 hours for smaller facilities to at least 40 hours for larger facilities. Because the proposed requirements for the solids control BMP plan affect medium and large facilities, EPA has assumed that about 40 hours would be required to develop a solids control BMP plan. EPA assumed that the plan would be developed by the facility manager and would be revised or updated as needed or at least every 5 years upon permit renewal. The cost equation for plan development was as follows:

BMP plan costs = 40 h * managerial labor rate

where BMP plan costs are in dollars and the managerial labor rate is $13.46/h ($21.38/h in Alaska).

9.4.3.3 Operation and Maintenance Costs: All System Types

The O&M costs associated with the BMP plan included monthly plan review of 1 h each for the farm manager and one general labor employee. EPA used the following formula to calculate costs associated with this monthly plan review:

BMP O&M costs = [(1 * general labor rate) + (1 * managerial labor rate)]* 12 mo/yr

where O&M costs are in dollars, the general labor rate is $7.69/h ($15.03/h in Alaska), and the managerial labor rate is $13.46/h (21.38/h in Alaska). Other implementation costs are included in the cost of specific unit technologies, such as the costs associated with maintaining quiescent zones.

9.4.4 Compliance Monitoring

For the purpose of estimating costs, EPA assumed compliance monitoring for CAAP facilities was a function of the production level or the production system used at the facility.

9.4.4.1 Flow-through Facilities

EPA estimated the cost of monitoring for flow-through facilities based on the production level (medium or large) at the facility. EPA assumed that all costs related to compliance monitoring would be included under O&M costs. The O&M costs for monitoring consist of two components: (1) the labor associated with sampling (e.g., collecting the sample and preparing it for transport) and transport of the sample to the lab and (2) sampling materials (e.g., bottles) and analysis. EPA estimated for costing purposes that medium facilities, those producing between 100,000 lb and 474,999 lb, monitor weekly for TSS.

EPA estimated costs for the sampling and the transport of the samples to the analysis laboratory at 4 h of general labor, which includes time to collect an 8-h composite sample at 15 min/h to grab one sample per hour and 2 h to prepare the samples and transport them to a lab. Sampling materials and sample analysis were estimated to cost $40.00 per sample, which includes sample bottles (two needed at $2 each), the analysis (at $30/sample), and a cooler with ice (at $6/sample). The total monthly cost for sampling once per month (which includes all the materials, labor for collecting the samples, and the analysis) is estimated to be $283.04 per month, which is added to O&M costs.

EPA estimated monitoring requirements for flow-through facilities producing 475,000 lb or more per year to include both TSS and total phosphorus monitoring at a frequency of once per month. Regulatory Option 1 for the large facilities estimates weekly monitoring for TSS (see costs listed previously).

Regulatory Option 3 also estimates weekly monitoring for total phosphorus, which requires additional weekly sampling materials and an analysis cost of $40 per sample. The cost breakdown is the same as that for TSS. The total monthly cost for sampling (which includes all materials, labor for collecting the sample, and the analysis) was estimated to be $443.04.

9.4.4.2 Recirculating Systems

The monitoring estimates for recirculating CAAP systems are the same as those for flow-through facilities producing 475,000 lb or more per year. EPA assumed that no capital costs would be associated with compliance monitoring for recirculating systems.

9.4.4.3 Operation and Maintenance Costs: Recirculating Systems

The O&M costs for monitoring consist of two components: (1) the labor associated with sampling (e.g., collecting the sample and preparing it for transport) and transport of the sample to the lab and (2) sampling materials (e.g., bottles) and analysis. Monitoring cost estimates are specific to the size of the facility. Recirculating facilities were estimated to monitor weekly for TSS and total phosphorus.

EPA based the monitoring estimates for recirculating systems on the regulatory option chosen. Regulatory Option 1 requires weekly monitoring for TSS (see costs listed previously for flow-through facilities).

Regulatory Option 3 also estimates weekly monitoring for total phosphorus, which requires additional weekly sampling materials and an analysis cost of $40 per sample. The cost breakdown is the same as that for TSS. The total monthly cost for sampling (which includes all materials, labor for collecting the samples, and the analysis) was estimated to be $443.04.

9.4.5 Feed Management

Feed management is a management practice that was considered as part of Option 1 for all net pen operations, but was not required in the proposed regulation.

9.4.5.1 Description of Technology or Practice

Feed management recognizes the importance of effective, environmentally sound use of feed. Net pen operators should continually evaluate their feeding practices to ensure that feed placed in the production system is consumed at the highest rate possible. Observing feeding behavior and noting the presence of excess feed can be used to adjust feeding rates to ensure minimal excess (USEPA, 2002b).

An advantage of this practice is that proper feed management decreases the costs associated with the use of excess feed that is never consumed by the cultured species. Excess feed distributed to net pens breaks down, and some of the resulting products remain dissolved in the receiving water. More important, solids from the excess feed usually settle and are naturally processed along with feces from the aquatic animals. Excess feed and feces accumulate under net pens, and if there is inadequate flushing this accumulation can overwhelm the natural benthic processes, resulting in increased benthic degradation.

The primary operational factors associated with proper feed management are development of precise feeding regimes based on the weight of the cultured species and constant observation of feeding activities to ensure that the feed offered is consumed. Other feed management practices include use of high-quality feeds, proper storage and handling (which includes keeping feed in cool, dry places; protecting feed from rodents and mold conditions; and handling feed gently to prevent breakage of the pellets), and feeding pellets of proper size. Feed management is a practice required in net pen facility permits issued by EPA Regions 1 and 10 (USEPA, 2002b; USEPA, 2002c).

9.4.5.2 Capital Costs: Net Pens

Because feed management does not require any capital improvements or additions to implement the practice, EPA assumed that no capital costs would be associated with the implementation of feed management for net pen systems.

9.4.5.3 Operation and Maintenance Costs: Net Pens

Observing feeding and keeping records helps net pen system operators to minimize wasted feed and adjust feeding rates as necessary. EPA estimated that implementing a feed management program at a net pen facility would require an extra 10 minutes per net pen for each day of feeding. The extra time required would be used to observe feeding behavior and perform additional record keeping (amount of feed added to each net pen, along with records tracking the number and size of fish in the pen). The record-keeping duties involve filling in a logbook. EPA assumed that feeding occurred once per day, 312 days per year, based on information collected during site visits (Tetra Tech 2002c; Tetra Tech 2002s). EPA assumed that the feed management (observing feeding behavior and record keeping) would be performed by the person feeding and thus included labor costs for a general laborer. EPA also assumed that the farm manager already estimates the amount of feed needed for each daily feeding and performs other management duties related to feeding. The practice considered would have explicitly required written records to document that the person feeding actually carries out the prescribed daily plan.

The equation used to calculate the labor costs is as follows:

Feed management costs = number of net pens * (10 min/d ÷60 min/h) * general labor rate

where feed management costs are in dollars, the number of net pens is derived based on model facility production (see Section 9.3.4), and the general labor rate is $7.69/h.

9.4.6 Drug and Chemical Management

The drug and chemical BMP plan proposed under Option 2 is for large flow-through systems (producing 475,000 lb or more annually), net pens, and recirculating systems. All requirements and costs associated with the drug and chemical BMP plan are estimated to be equal for all species and culture systems.

9.4.6.1 Description of Technology or Practice

The purpose of the proposed drug and chemical BMP plan is to document the use of specific classes of drugs and chemicals, the release of nonnative species, and specific aquatic animal pathogens in the production facility. The plan would also address practices that minimize the inadvertent spillage or release of drugs and chemicals. Additionally, the intentional release of nonnative aquatic animals would be prohibited. Facilities would need to develop an integrated loss control plan before moving or transferring nonnative animals to the facility. The loss control plan should have a schedule for maintenance and inspection of a containment system (screens over inlet and outlet pipes or double nets on net pens). Components of the plan should also include:

- Methods of predator determent
- Escape recovery protocols
- Storm preparedness measures
- Fish transfer procedures

9.4.6.2 Capital Costs: All Systems

The capital costs for the drug and chemical BMP plan include the managerial time required to develop a plan. EPA assumed the facility manager would develop the plan. For estimating costs, EPA assumed the development of the drug and chemical BMP plan would require the same amount of effort as the solids control BMP plan. Development of both plans requires the manager to assess activities at the facility and to develop a written management plan. The plan would require 40 h to complete and would be reviewed, and revised if necessary, every 5 years upon permit renewal. The cost equation for plan development was as follows:

Drug and chemical BMP plan costs = 40 h * managerial labor rate

where drug and chemical BMP plan costs are in dollars and managerial labor rates are $13.46/h ($21.38/h in Alaska).

9.4.6.3 Operation and Maintenance Costs: All Systems

The O&M costs for the drug and chemical BMP plan include managerial and general labor for meeting and updating the plan.

The O&M costs associated with the drugs and chemical BMP plan include monthly plan review for the farm manager and one general labor employee. EPA used the following formula to calculate costs associated with this monthly plan review:

> Drug and chemical BMP O&M costs = (1 * general labor rate) + (1 * managerial labor rate) * 12 mo/yr

where O&M costs are in dollars, the general labor rate is $7.69/h ($15.03/h in Alaska), and the managerial labor rate is $13.46/h ($21.38/h in Alaska).

9.4.7 Additional Solids Removal (Solids Polishing)

Additional solids removal is considered under Option 3 for flow-through systems and recirculating systems.

9.4.7.1 Description of Technology or Practice

“Solids polishing” refers to the use of a wastewater treatment technology to further reduce solids discharged from sedimentation basins used to treat flow-through and recirculating systems. Several technologies are available, including microscreen filters and polishing ponds. For the purpose of cost analysis, EPA assumed that polishing ponds could be used, especially if particle sizes remain larger than 100 μm. However, for particles 75 to 100 μm, technologies such as microscreens might perform better (Chen et al., 1994). Also, microscreen filters, sized to polish effluents, are available at a much lower cost than that for large solids retention ponds. For example, the cost of a second sedimentation basin for a large salmon flow-through system is up to 100 times the cost of a microscreen filter.

Microscreen filters consist of fine mesh filters that are usually fitted to a rotating drum. The wastewater stream is pumped into the drum, and solids are removed from the effluent as the water passes through the screen. The screen size usually varies from 60 to 90 microns. The filters are equipped with automatic backwash systems that remove collected solids from the screen and direct them to further treatment or solids storage (Chen et al., 1994).

9.4.7.2 Design

EPA assumed that a rotary microscreen filter would be used so that clogging problems were minimized. A small motor rotates the screen to enhance performance, and automatic backwash jets are activated when the pressure drop across the screen reaches a set level (Chen et al., 1994). The backwash solids and water are usually conveyed to a solids storage tank or basin to await proper disposal. Commercial units are readily available for the flow rates and TSS concentrations expected from sedimentation basins at CAAP facilities.

9.4.7.3 Capital Costs: Flow-through and Recirculating Systems

The capital costs for a microscreen filter are based on treating the effluent flow from the settling basin or 1% of the total facility flow. The sizing of the microscreen filter is based on a single unit with the capacity to treat up to 150 gpm. For flows in excess of 150 gpm, EPA costed a larger unit that can treat up to 300 gpm. EPA obtained quotes from vendors of microscreen filters that market to CAAP facilities. The vendors quoted estimated costs of $7,527.50 for the smaller unit and $8,049.45 for the larger unit. The costs for shipping and delivery were estimated to be $200 (Chen et al., 1994).

Microscreen filters are relatively small (with a footprint of about 25 ft^2) and can be installed adjacent to the sedimentation basin. EPA observed that most of the larger facilities had electrical service readily available around the facility. For the purpose of estimating costs, EPA assumed the filter would be installed within 40 feet of the previous treatment technology at the facility and within 100 feet of the closest electrical connection. The filters contain electrical motors that can be powered by a standard GFI electrical outlet. The costs for each component of the electrical installation are included in Table 9.4-1.

Table 9.4-1. Installation Costs

Component	*Unit Costs*	*Total Costs*
# 8 Stranded copper wire	$15.60/100 ft	$46.80
Wire installation	$50.90/100 ft	$50.90
Wire conduit	$7.30/100 ft	$7.30
Trencher	$19.91/h	$19.91
GFI receptacle (installed)	$74.50	$74.50
6-inch PVC pipe (installed)	$3.15/ft	$126.00

Source: RS Means, 2000.

9.4.7.4 Operation and Maintenance Costs: Flow-Through and Recirculating Systems

For the purpose of estimating costs, EPA assumed O&M for the microscreen filter would take 5 min/d of general labor on 312 d/yr for general maintenance and to ensure the filter was functioning properly (Chen et al., 1994). EPA assumed most flow-through facilities operate minimal crews 1 d/wk, but the filter operates 24 h/d, 365 d/yr. The cost calculation for general labor was as follows:

$$\text{General labor costs} = 5 \text{ min/d} \div 60 \text{ min/h} * 312 \text{ d/yr} * \text{general labor rate}$$

where the general labor costs were in dollars and the general labor rate was $7.69/h ($15.03/h in Alaska).

EPA assumed the electricity requirements for the microscreen filter would be 12,900 kWh/yr (Chen et al., 1994). The national average electricity costs were found to be $ 0.07/kWh (EIA, 2002), or $0.08/kWh in Alaska. The total electricity costs for the microscreen filter were computed using the following equation:

$$\text{Electricity costs} = \text{electricity requirement (kWh)} * \text{electricity costs per kWh}$$

AAP industry representatives indicated that the microscreen should be replaced approximately every 2 yr under normal conditions (Chen et al., 1994). The cost for a new microscreen was estimated at $500 (Chen et al., 1994). The cost for a new screen was divided over 2 yr of O&M costs, resulting in a yearly cost of $250.

9.4.8 Active Feed Monitoring

Active feed monitoring is considered as a management practice in Option 3 for all net pen facilities. Active feed monitoring is a relatively new but proven technology used by some facility operators in the salmon industry. Some type of remote monitoring equipment, such as an underwater video camera, is lowered from the surface to the bottom of a net pen during feeding to monitor for uneaten feed pellets as they pass by the video camera.

9.4.8.1 Description of Technology or Practice

The goal of active feed monitoring is to further reduce pollutant loads associated with feeding activities. A variety of technologies have been reported, including video cameras with human or computer interfaces to detect passing feed pellets. A new NPDES permit issued in Maine (USEPA, 2002b) also suggests that ultrasonic equipment might be available. Most facilities that use this technology use a video monitor at the surface that is connected to the video camera. An employee watches the monitor for feed pellets passing by the video camera and then stops feeding activity when a predetermined number of pellets (typically only two or three) pass the camera.

9.4.8.2 Capital Costs

The camera equipment includes a single portable underwater video camera and a monitor for a facility, estimated to cost about $10,000, with a life span of greater than 10 years (Tetra Tech, 2002c; Tetra Tech, 2002s). EPA observed the use of portable feed monitoring equipment, which consists of the monitor mounted on a wheeled cart that is pushed from pen to pen along the floating walkway and the camera mounted on a long cable that is dropped into the pen being monitored. The camera and monitor was easily moved from pen to pen (Tetra Tech, 2002c; Tetra Tech, 2002s).

9.4.8.3 Operation and Maintenance Costs

For O&M costs, EPA assumed that an active feed monitoring system would require an additional 10 min of general labor per net per feeding day. EPA assumed that feeding would take place 6 d/wk or 312 d/yr. The equation used to calculate the additional general labor cost is as follows:

$$\text{General labor cost} = (10 \text{ min} \div 60 \text{ min/h}) * \text{no. of net pens} * 312 \text{ d/yr} * \text{labor rate}$$

Where:

- General labor cost is the labor cost in dollars
- Number of net pens is calculated in Section 9.3.4
- 312 d/yr assumes feeding takes place 6 d/wk
- The general labor rate is $7.69/hr

9.5 FREQUENCY FACTORS

Applying the frequency factors to the unit component costs reduces the effective cost of that component for the model facility. Essentially, EPA adjusts the component cost to account for those facilities that already have the component in place. Facilities that already have the component in place would not have to install and operate a new component as a result of the proposed regulation. If a cost component has a frequency factor value of zero, the cost for that component is incurred by all facilities. If a cost component has a frequency factor of 1, the cost for that component is incurred by none of the facilities.

EPA estimated frequency factors based on sources such as those listed below. (Each source was considered along with its limitations.)

- EPA site visit information was used to assess general practices of CAAP facility operations and how they vary among regions and size classes.
- The screener survey was used to assess general treatment practices, determine specific frequency factors of CAAP facility operations, and evaluate variation of treatments among regions and size classes.
- EPA used observations on CAAP operations by industry experts, who were contacted to provide insight into operations and practices, especially where data were limited or not publicly available.
- The data currently available from the NASS 1998 CAAP Census were used to determine the distribution of CAAP facility operations across the USDA Regional Aquaculture Center regions by size class.
- *State Compendium: Programs and Regulatory Activities Related to Aquatic Animal Production* (Hochheimer and Mosso, 2002) was used to estimate frequency factors, based on current requirements for treatment technologies and BMPs that already apply to CAAP facilities in various states. For example, BMP plans are required for all facilities with permits in Idaho and Washington, so the facilities in these states were assumed to have solids control BMP plans in place.

9.5.1 Quiescent Zones

Quiescent zones are commonly used by flow-through CAAP facilities to remove solids. EPA developed frequency factors for quiescent zones in flow-through CAAP facilities from the AAP screener survey (Westat, 2002), and they are presented in Table 9.5-1.

Table 9.5-1. Quiescent Zone Frequency Factors

Species	*Model*	*Frequency Factor*
Trout-Food-size-Commercial-Flow-through	Medium	0.91
	Large	1.00
Trout-Food-size-State-Flow-through	Medium	1.00
	Large	1.00
Trout-Stockers-Commercial-Flow-through	Medium	1.00
Trout-Stockers-Federal-Flow-through	Medium	0.57

Species	*Model*	*Frequency Factor*
	Large	0.50
Trout-Stockers-State-Flow-through	Medium	0.91
	Large	1.00
Trout-Stockers-Other-Flow-through	Medium	1.00
	Large	1.00
Tilapia-Commercial-Flow-through	Medium	0.67
	Large	1.00
Tilapia-Commercial-Recirculating	Large	—
Striped Bass-Commercial-Flow-through	Medium	1.00
Striped Bass-Commercial-Recirculating	Large	—
Salmon-Other-Flow-through	Large	1.00

9.5.2 Sedimentation Basin

Sedimentation basins are the most common solids separation technique used to treat effluents in the United States. EPA based frequency factors for sedimentation basins used in the cost model for flow-through and recirculating CAAP facilities on the AAP screener survey (Westat, 2002), and they are presented in Table 9.5-2.

Table 9.5-2. Sedimentation Basin Frequency Factors

Species	*Model*	*Frequency Factor*
Trout-Food-size-Commercial-Flow-through	Medium	0.91
	Large	1.00
Trout-Food-size-State-Flow-through	Medium	1.00
	Large	1.00
Trout-Stockers-Commercial-Flow-through	Medium	1.00
Trout-Stockers-Federal-Flow-through	Medium	0.57
	Large	0.50
Trout-Stockers-State-Flow-through	Medium	0.91
	Large	1.00
Trout-Stockers-Other-Flow-through	Medium	1.00
	Large	1.00
Tilapia-Commercial-Flow-through	Medium	0.67
	Large	1.00
Tilapia-Commercial-Recirculating	Large	1.00
Striped Bass-Commercial-Flow-through	Medium	1.00
Striped Bass-Commercial-Recirculating	Large	1.00
Salmon-Other-Flow-through	Large	1.00

9.5.3 BMP Plans

Solids management BMP plans are currently required of CAAP facilities operating in EPA's Region 10 (e.g., Idaho, Oregon, and Washington). EPA developed frequency factors for solids management BMP plans in flow-through, net pen, and recirculating CAAP facilities from the AAP screener survey (Westat, 2002), and they are presented in Table 9.5-3.

Table 9.5-3. BMP Plan Frequency Factors

Species	*Model*	*Frequency Factor*
Trout-Food-size-Commercial-Flow-through	Medium	0.32
	Large	1.00
Trout-Food-size-State-Flow-through	Medium	0.00
	Large	0.00
Trout-Stockers-Commercial-Flow-through	Medium	0.60
Trout-Stockers-Federal-Flow-through	Medium	0.14
	Large	0.50
Trout-Stockers-State-Flow-through	Medium	0.02
	Large	0.00
Trout-Stockers-Other-Flow-through	Medium	1.00
	Large	1.00
Tilapia-Commercial-Flow-through	Medium	0.00
	Large	0.00
Tilapia-Commercial-Recirculating	Large	0.40
Striped Bass-Commercial-Flow-through	Medium	0.00
Striped Bass-Commercial-Recirculating	Large	0.00
Salmon-Other-Flow-through	Large	0.00
Salmon-Commercial-Net Pen	Large	0.13

9.5.4 Feed Management

Feed management is a commonly used practice in the CAAP facility industry because its benefits include both a costs savings for farms and reductions to pollutant loads. Feed management is specified as a management practice for net pen operations. Frequency factors used in the cost model are based on the AAP screener survey (Westat, 2002) and are listed in Table 9.5-4.

Table 9.5-4. Feed Management Frequency Factor

Species	*Model*	*Frequency Factor*
Salmon-Net Pen	Large	0.88

9.5.5 Drug and Chemical BMP Plan

EPA does not currently know of any facilities that have developed a drug and chemical BMP plan. Therefore, for the purpose of estimating costs, EPA assumed the frequency factors for a drug and chemical BMP plan in flow-through, net pen, and recirculating CAAP facilities were all zero.

9.5.6 Solids Polishing

Approximately 5% of all facilities responding to EPA's AAP screener survey (Westat, 2002) reported using several different treatment technologies, including microscreen filters, for additional solids removal. EPA developed frequency factors for additional solids removal in flow-through and recirculating CAAP facilities from the AAP screener survey (Westat, 2002). They are presented in Table 9.5-5.

Table 9.5-5. Solids Polishing Frequency Factors

Species	*Model*	*Frequency Factor*
Trout-Food-size-Commercial-Flow-through	Medium	0.09
	Large	0.00
Trout-Food-size-State-Flow-through	Medium	0.00
	Large	0.00
Trout-Stockers-Commercial-Flow-through	Medium	0.00
Trout-Stockers-Federal-Flow-through	Medium	0.00
	Large	0.00
Trout-Stockers-State-Flow-through	Medium	0.05
	Large	0.00
Trout-Stockers-Other-Flow-through	Medium	0.00
	Large	0.00
Tilapia-Commercial-Flow-through	Medium	0.00
	Large	0.00
Tilapia-Commercial-Recirculating	Large	0.40
Striped Bass-Commercial-Flow-through	Medium	1.00
Striped Bass-Commercial-Recirculating	Large	0.67
Salmon-Other-Flow-through	Large	0.00

9.5.7 Compliance Monitoring

The frequency factor for compliance monitoring was estimated at zero in the absence of any data readily available to EPA linking facilities used to estimate costs in the model facility analysis.

9.5.8 Net Pen Active Feed Monitoring

EPA developed frequency factors for active feed monitoring in net pen CAAP facilities from the AAP screener survey (Westat, 2002). They are presented in Table 9.5-6.

Table 9.5-6. Active Feed Monitoring Frequency Factors

Species	*Model*	*Frequency Factor*
Salmon-Net Pen	Large	0.38

9.6 OUTPUT DATA

EPA combined results from the unit cost modules (Section 9.4) and the frequency factors (Section 9.5) to form the inputs to industry estimated costs. Appendix B provides results for all of the model facilities that EPA analyzed for flow-through, recirculating, and net pen systems. Appendix B includes the analysis for Alaska salmon flow-through facilities. EPA used these results to develop weighted component unit costs and combined the unit costs to form the costs for each model facility. EPA then summed the model facility costs to estimate the total industry costs. This section provides a detailed explanation of the process EPA used to estimate these costs.

9.7 CHANGES TO COSTING METHODOLOGY

9.7.1 Background

While the proposed regulatory options were under development, EPA performed several analyses and reviews to evaluate the options, including sharing drafts with stakeholders, small entity representatives (SERs), and technical experts. As specific elements of the proposed options were defined, EPA researched technical literature and studies and contacted technical experts to better quantify the compliance costs and the pollutant load removal efficiencies of the options. Throughout the option development process, EPA continued to modify the options to reflect new information as it became available. EPA developed and presented (to the Small Business Regulatory Enforcement Fairness Act (SBREFA) panel) a range of control technology and BMP options and estimated their compliance costs as part of the small business panel process.

EPA considered several technology options in its initial analysis. Some of these options were estimated to require a high cost in relation to revenues, and therefore EPA did not pursue those technologies further. For example, one option EPA considered, but did not pursue, was disinfection. EPA considered disinfection as an option to control pathogens present in effluents from solids collection and storage units at AAP facilities, which might adversely affect human health. The economic impact of the estimated costs for disinfection was found to be high in proportion to revenues and could impose a severe adverse economic impact on facilities required to implement disinfection.

Initially, EPA also considered a feed management BMP plan for all subcategories. Based on input from industry representatives, EPA removed this option component for all subcategories except net pen systems. SERs indicated that good feed management practices are site-specific for individual facilities and are already a common practice throughout the AAP industry. Industry input also indicated that facilities apply good feed management practices as an effective animal husbandry measure, as well as a means of keeping facility costs down. Although EPA is still applying feed conversion ratio data in the cost and loadings models to estimate pollutant loadings in the raw waste, the Agency is not assigning a specific FCR as a goal to represent optimum feed management.

EPA performed several analyses, including economic and technical analyses, to evaluate the impacts of the proposed regulation on various sectors of the CAAP industry. As a result of the economic analyses, consultation with industry experts, and the deliberation of the Small Business Advisory Review Panel, production of aquatic animals in pond systems, lobster pounds, and aquariums, as well as the production of crawfish, molluscan shellfish in open waters, and alligators were no longer considered within the scope of the proposed regulation. This section will summarize the analysis of these system types and the development of options and their costs, but does not provide the same level of detail as prescribed earlier for systems subject to the proposed requirements.

9.7.1.1 Pond Systems

EPA considered numerous management practices for pond operations, such as discharge management technologies. After extensive discussions with industry experts, the Agency concluded that discharge management technologies would provide limited benefits in reducing wastewater pollutants discharged during pond drainage for most aquatic animals species grown in pond systems.

9.7.1.2 Lobster Pounds

Intertidal "pounds" are used for live storage of marine crustaceans (e.g., lobsters, crabs) to keep caught wild animals alive pending sale. EPA is not proposing nationally applicable effluent limitations guidelines for lobster pounds at this time because the Agency has not found any applicable pollutant control technologies to reduce discharges. EPA continues to evaluate BMPs that might apply for these types of facilities.

9.7.1.3 Crawfish

Crawfish are typically raised in conjunction with plant crops, such as rice or soybeans, because crawfish maintain aeration of the growing medium. EPA is not proposing nationally applicable effluent limitations guidelines for discharges associated with crawfish operations because crawfish producers do not add feed, drugs, or chemicals to manage the crawfish operations and because any associated pollutants tend to be assimilated into the soils used to grow plant crops.

9.7.1.4 Molluscan Shellfish Production in Open Waters

For large-scale production of molluscs for food, operators typically use bottom culture, bottom- anchored racks, or floating rafts tethered to the bottom in open waters. Because such operations do not typically add materials to waters of the United States, and because EPA has not found any generally applicable pollutant control technologies to reduce any discharge, the Agency is not proposing effluent limitations guidelines and standards for discharges from open-water mollusc culture. EPA notes that molluscs are filter feeders that in some cases are recommended not only as a food source but also as a pollution control technology. Molluscs remove pollutants from ambient waters by filtration. EPA also is aware that molluscs have been incorporated into polyculture AAP operations to minimize discharges of pollutants.

9.7.1.5 Aquariums

Public aquariums are AAP facilities that display a variety of aquatic animals to the public and conduct research on many different threatened and endangered aquatic species. EPA has determined, through the AAP screener survey, that most aquariums are indirect dischargers. If these facilities discharge directly into waters of the United States, it is done only in emergency situations requiring rapid tank dewatering. These systems maintain low stocking densities and very clean, clear water to enhance the visual display of the animals. Discharges from aquariums are likely to be low in TSS and nutrients because of the low stocking densities. Because most of the drugs used to treat stressed or ill animals are injected directly into the animal, EPA believes that discharges of drugs would be minimal. The few chemicals used include pH buffers and chemicals used to make artificial sea salt.

9.7.1.6 Alligators

Alligator production systems are unique because they produce discharges from production units in "batches" when pens or huts are drained and cleaned. EPA found that effluents from alligator production systems are typically treated and stored on-site in lagoons. After consultation with industry representatives, EPA also discovered that alligator production facilities do not discharge from treatment lagoons. Excess volume in lagoons is applied to cropland.

9.7.2 Modifications to Model Facility Methodology

EPA developed model facilities to reflect CAAP facilities with a specific production system, type of ownership, and often species. These model facilities were based on data gathered during site visits, information provided by industry members and their associations, and other publicly available information. EPA estimated the number of facilities represented by each model using data from the AAP screener survey (Westat, 2002), in conjunction with information from the USDA 1998 Census of Aquaculture (USDA, 2000b). EPA estimated costs for each model facility and then calculated industry-level costs by multiplying model facility costs by the estimated number of facilities required to implement the treatment technology or management practice in each model category.

Initially, EPA developed the production rate thresholds based on data from the 1998 Census of Aquaculture (USDA, 2000b). To group the facility production data reported in the screener surveys (Westat, 2002), EPA used six production size categories, based on revenue classifications in the 1998 Census of Agriculture: $1,000 to $24,999; $25,000 to $49,999; $50,000 to $99,999; $100,000 to $499,999; $500,000 to $1,000,000; and >$1,000,000. EPA used national average product prices, taken from the 1998 Census, to estimate the production (in pounds) for the dominant species that were reported grown in ponds (e.g., catfish, hybrid striped bass, shrimp), flow-through (e.g., trout salmon, tilapia), recirculating (e.g., tilapia, hybrid striped bass), and net pen (e.g., salmon) systems. For alligator systems reported in the screener survey, EPA used data from industry reports to estimate production value and create groupings of the facilities. EPA used this size classification grouping to more accurately estimate costs of the proposed limitations and standards for each of the size classifications within the various species (or aquatic animal types) cultured in this industry. That is, instead of assuming one model facility for each of the three regulatory subcategories, EPA used a minimum of six model facilities for each facility type (e.g., commercial, government, research, tribal) and species size combination (e.g., fingerlings, stockers, food-size) for better accuracy in its analyses. EPA applied these size classifications to the screener survey data to derive the model facility characteristics that have been used to support the proposed regulation. Final cost estimations for the proposed options are based on screener survey data. Commercial facilities are adjusted by a scaling factor, which is the ratio of commercial facilities in the 1998 Census of Aquaculture to the number of commercial facilities responding to the AAP screener survey.

Several SERs (Engle, 2002; Hart, 2002; Pierce, 2002; Vaught, 2002) questioned the ability of a model facility to capture the diversity of production sizes and operational differences among AAP facilities. EPA used average production data and average values to estimate loadings to account for some of the variation among facilities. EPA recognizes the diversity in the AAP industry; however, the Agency does not have site-specific data on each AAP facility. EPA used the best available data to make its estimates for the cost models, including AAP screener survey results, USDA Census of Aquaculture data, and technical input from producers and industry leaders. These data sources will be supplemented with the results of EPA's detailed survey in the final rule.

9.7.3 Pond Systems

Based on additional input from industry representatives regarding in-pond processes, pond systems were evaluated for their unique ability to serve as treatment systems, and this treatment capacity was incorporated into the assessment of various options for ponds (Hargreaves, 2002a, personal communication; Hargreaves, 2002b). EPA considered several factors related to pond systems in this initial option evaluation, including the relationship of draining frequency to pollutants discharged, water management strategies in ponds, and species-specific operational factors. The culture of aquatic animals in ponds requires pond owners to maintain high-quality water at all times to sustain and grow the aquatic animal crop. Most pond owners drain or actively discharge water only when necessary to completely harvest a crop or to maintain the pond. The frequency of draining is usually once per year and associated with harvesting the crop, but it can be less than once per 10 or more years. For many aquatic animals raised in ponds, the pond itself serves as a natural biological treatment system to reduce wastes generated by the animals in the pond (including excess feed, manure, and dead aquatic animals). The only other time a pond might discharge is when excess runoff occurs (usually during periods of heavy precipitation). Most ponds have overflow pipes that drain passively from the top surface of the pond. The water quality of this overflow discharge is comparatively high (Tucker et al., 2002).

Shrimp are produced in ponds, but the operation of shrimp ponds is somewhat different from that of ponds in which other aquatic animals are raised. To harvest shrimp, the pond is drained, and the shrimp are removed from the pond along with the water. Shrimp are captured external to the pond in a harvest box. The water must be drained rapidly from the pond to prevent the shrimp from burrowing into the pond bottom. Because of the need to drain the ponds so rapidly, there is a greater potential for the discharge of pollutants resulting from the disturbance of the pond bottom. Therefore, EPA evaluated shrimp culture in ponds and found ponds to have adequate controls and BMPs in place. Shrimp pond effluents potentially contain higher TSS and BOD loadings than other pond drainage. State requirements for existing shrimp farms include the capture of discharge water in sedimentation basins or constructed wetlands to minimize the release of TSS so that facilities can meet effluent limits set by the state. Some shrimp farmers reuse the water discharged from draining ponds to fill other ponds or to grow other aquatic animal crops (e.g., oysters or clams) over the winter. Most of the shrimp grown in the United States is considered nonnative, which leads to concern regarding escapement of the shrimp and discharge of exotic pathogens when disease outbreaks occur. Strict state requirements are in place to minimize the risk of shrimp escapement and release of pathogens. These requirements include use of certified disease-free seed stock, testing of animals before harvest or draining, BMP plans, and mandatory escapement controls.

9.7.4 Flow-through and Recirculating Systems

EPA initially considered an approach to manage the use of drugs and chemicals, minimize the escape of nonnative species, and maintain animal health similar to the Hazardous Analysis at Critical Control Points (HACCP) paradigm used in the food processing industry. Input from industry representatives indicated that an HACCP-based plan, with its extensive training and record-keeping requirements, would be expensive to implement. The requirement would also depend on the creation of an infrastructure to provide the training necessary to develop and implement these plans. Industry input also indicated that the plan did not have clearly identified targets. Therefore, EPA modified the approach and developed a drug and chemical BMP plan. Under the drug and chemical BMP plan, facilities would develop a plan to prevent spills or accidental discharges.

EPA also proposes to require facilities to develop and implement a BMP plan that addresses the discharge of solids from recirculating and flow-through systems. This plan would include cleaning and maintaining quiescent zones. EPA revised its labor cost estimates for quiescent zone maintenance to reflect input from industry representatives. Input from the industry indicated that most facilities spend approximately 15 to 30 min/wk cleaning quiescent zones. Using the high end of this range (30 min/wk) and the number of days per week for normal facility operations (6 d/wk), EPA reduced its estimate of the time needed to clean quiescent zones from 30 minutes to 5 minutes per raceway per day. EPA considers quiescent zone cleanings part of normal facility operations, and input from industry representatives (Hinshaw, 2002, personal communication; MacMillan, 2002, personal communication) indicates that most facilities conduct normal operations 6 d/wk. EPA also based quiescent zone cleaning on 312 d/yr, which more accurately reflects the 6 d/wk schedule of facilities.

EPA estimated construction and O&M costs on a per gallon treated basis to enable ease of calculations for the different sizes of facilities encountered in the cost modeling. Using this approach, EPA initially estimated costs over a wide range of facilities, including many in the 20,000 to 50,000-pound size range. Certain fixed costs, such as design and equipment mobilization costs, are relatively constant for construction of sedimentation basins at facilities of any size. EPA used an average treatment volume, which was strongly influenced by the large number of smaller facilities that use flow-through systems, to estimate the initial design volume for scaling costs among all model facilities. For example, construction costs for sedimentation basins were reduced from $0.014 per gallon treated to $0.0014 per gallon treated by increasing the average sedimentation basin size up to 93.8 gpm. This cost reduction reflects EPA's reevaluation of sizing and costs for larger-sized sedimentation basins that would be needed at the medium- and large-sized flow-through and recirculating facilities. EPA analyzed the CAPDET (Hydromantis, 2001) capital and O&M cost estimates for facilities in the medium and large size range and found the costs to be linear over this range of system sizes. When looking at smaller sizes, however, the costs were not linear. Design costs for sedimentation basins were also reduced from $0.0021 per gallon treated to $0.000209 per gallon treated. Values for O&M labor for sedimentation basins has been reduced from

$0.000008 per gallon treated to $0.0000017 per gallon treated. (See Section 9.4 for additional information on sizing of sedimentation basins.)

Although EPA initially considered disinfection treatment as a regulatory option, it is not being considered for the proposed regulation. After reviewing existing NPDES permits and consulting with industry experts and EPA regional NPDES coordinators, EPA believed that practices like disinfection would not be affordable and that the supporting data were too inconclusive to warrant disinfection as a treatment option. (An analysis of the microbiological indicator data collected at the sampled facilities did not clearly indicate the presence of human health pathogens.)

Another modification to the cost model includes the cost components for compliance monitoring in Options 1 and 3 to reflect the monitoring that would be necessary to comply with the numeric limits for TSS.

9.7.5 Net Pen Systems

Net pen systems are unique because their placement directly in the receiving water allows little opportunity for the treatment of effluents. Initially EPA targeted management practices that reduce feed inputs and uneaten feed in the development of options for net pen systems. After consulting with industry representatives and evaluating AAP screener survey data and existing NPDES permits, EPA found some net pen facilities currently using feed management practices. Thus, EPA determined the estimated cost of implementing feed management to be affordable.

Initially EPA also considered an option requiring net pen facilities to develop HACCP plans. Input from industry representatives indicated that an HACCP-based plan, with its extensive training requirements, would not be affordable to implement. Comments from industry representatives indicated that EPA's estimates of costs associated with training and hours needed for developing the HACCP-based plan were too low. Industry input also indicated that the plan did not have clearly identified targets. EPA evaluated current industry practices and found that some of the facilities with NPDES permits are required to have loss control plans and implement practices (such as double netting and inventory reporting) to prevent escapes. The original BMP plan, now the drug and chemical BMP plan, requires only BMPs for pathogen control, prevention of nonnative species escapement, and reporting requirements for drugs and chemicals.

EPA evaluated the labor costs for mortality removal in the cost calculations and found that mortality removal is an integral part of daily net pen system management. Input from site visits confirmed that facilities already routinely remove mortalities and take them to land-based disposal sites.

EPA changed the feed management BMP plan to a broader solids management plan, which requires the facility to develop and implement a plan to reduce treatment of solids discharged. EPA found this required in several states and regional NPDES permits. EPA used a lower FCR as a means to measure the removal efficiency of each pollutant based on the effectiveness of the solids management BMP plan.

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