CHAPTER 10
POLLUTANT LOADING METHODOLOGY

10.1 INTRODUCTION

EPA identified several potential regulatory options for the concentrated aquatic animal production (CAAP) industry. To develop and evaluate these options, EPA used a computer spreadsheet model that estimates compliance costs and pollutant loadings for different combinations of the regulatory options considered. Chapter 9 presents the costing methodology. This chapter describes the methodology used to estimate the pollutant loading reductions associated with installing and operating the pollutant control technologies and best management practices (BMPs) considered for the regulatory options.

The following pollutant loading/removal information is discussed in detail in this chapter:

- *Section 10.2* presents the structure of EPA's loading model for the CAAP industry. The model uses the model facility approach to develop estimated loading removal efficiencies associated with each regulatory option.
- *Section 10.3* discusses the model facility configuration. This section also describes input data, including wastewater generation and pollutant inputs, for the model facilities for flow-through, recirculating, and net pen systems. EPA's loading model relies on specific information about the species raised, culture system, pollutant inputs, and wastewater generation rates to accurately predict the pollutant removals associated with each regulatory option.
- *Section 10.4* discusses the effectiveness of the treatment technology units that compose the regulatory options. Each technology/BMP unit contains equations by which to calculate the reduction of the loadings associated with each regulatory option based on the facility characteristics.
- *Section 10.5* describes the current frequency of existing BMPs and treatment technologies at CAAP facilities.
- *Section 10.6* discusses the loading model structure and provides an example calculation.
- *Section 10.7* provides pollutant removals by model facility for the proposed options.

10.1.1 Regulatory Options

EPA developed three regulatory options for CAAP facilities:

- Option 1—solids removal through treatment technologies and 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 10.1-1 presents the treatment technologies and BMPs for each proposed option by subcategory. EPA describes the development of this set of options in more detail in Section 9.1 of this document. EPA used the combination of pollutant control technologies and BMPs shown in Table 10.1-1 as the basis for pollutant reductions in the pollutant loading models. These combinations of control technologies and BMPs reflect the pollutant reduction strategies that EPA found effective for removing the types of pollutants found in CAAP effluents, including total suspended solids (TSS), biochemical oxygen demand (BOD), total nitrogen (TN), and total phosphorus (TP).

Table 10.1-1. 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**	**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.

10.1.2 Approach for Estimating Loadings

EPA typically uses one of two approaches, a *facility-specific* approach or a *model facility* approach, to estimate pollutant loading reductions for an industry. In both cases, EPA evaluated combinations of regulatory options that are applied to subcategories, or groups, of facilities to determine estimates of pollutant removals. Facility-specific pollutant loading reduction estimates require detailed process and geographic information about individual facilities in an industry. These data typically include facility characteristics such as the amount of aquatic animals produced (e.g., pounds of aquatic animals), size or production capacity of the facility, water use, quantity and quality of wastewater generated, waste management operations currently in place (including design, pollutant loadings, and removal effectiveness data), monitoring data, geographic location, financial conditions, and any other industry-specific data (e.g., species of the aquatic animals, life stages produced, types of feed used, amount of feed used, and drugs and chemicals used) that might be required for the analyses. EPA uses each facility's information to estimate the expected pollutant removals at that facility, based on the regulatory options applied to the subcategory for which the facility is classified.

When sufficient facility-specific data are not available, EPA uses model facilities to provide a reasonable representation of the industry. A model facility is created to characterize a group of actual facilities for which EPA has some key facility-specific information it can use to approximate the process and effluent. Thus, a model facility represents a reasonable approximation of facility-specific characteristics for a group of similar real facilities. EPA makes a series of assumptions about the model facility characteristics to create the reasonable assumptions. For the pollutant loading model facilities, EPA averaged a range of characteristics to account for some of the variation among facilities within a model facility grouping.

EPA developed model facilities to reflect CAAP facilities with specific production system, ownership, and species combinations. EPA uses the average production value to represent all facilities within the group of facilities characterized by a model facility. For example, the model facility representing 44 medium (defined as facilities that produce 100,000 lb/yr to 475,000 lb/yr) flow-through facilities, which are state-owned and produce trout stockers, have an annual average production of 224,193 lb (the production actually ranges from 100,800 lb/yr to 433,915 lb/yr). The facility size and configuration, water use, wastewater generation, and other facility characteristics for the *state–flow-through–trout–stockers–medium* model facility are based on this annual average production of 224,193 lb.

EPA based these model facilities 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, 2000). EPA estimated pollutant loading reductions for each model facility and then calculated industry-level loading reductions by multiplying model facility reductions by the estimated number of facilities required to implement the treatment technology or management practice in each model category. For the CAAP industry, EPA chose a model facility approach to estimate the pollutant reductions because detailed information about the scope of the industry was not available. EPA expects to obtain more detailed facility-level information, although not on every facility, through the detailed survey (USEPA, 2002a).

EPA designed the model facility approach to capture the key characteristics (model facility configuration) of individual facilities, based on the Census of Aquaculture (USDA, 2000) and the AAP screener survey (Westat, 2002), by averaging these key characteristics and then representing the averages as a model facility. Using this approach, EPA characterized every facility 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 loadings, discharge flow characteristics, and geographic data. EPA then linked all of these attributes and characteristics 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 in the unit loading modules, which calculated an estimated loading removal efficiency of the component based on estimates of pollutant reductions. EPA used sampling data, industry experts, and technical literature as sources of pollutant removal efficiencies for the components making up each regulatory option. 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 loading removal efficiency of the component with a frequency factor that accounts for CAAP facilities that already have that technology or management practice in place. EPA used this adjusted loading estimate, which reflects the number of facilities that are subject to the proposed regulations, to determine the estimated national pollutant loading reductions associated with the proposed pollutant control technologies or management practices for each of the model facility types.

10.1.3 Basic Model Assumptions

EPA used annual facility production rates in the pollutant loading models to estimate the amount of feed added to a facility. The feed input drives the pollutant output from a facility. EPA used annual pollutant loadings, based on average annual production at a facility, as a basis for decision-making to account for the impacts of production variability on the model facility outputs. One source of this variation is the natural growing cycle of the aquatic animals; that is, small fish grow fast, but they add little biomass to a system, whereas larger fish grow more slowly, but add larger biomass to a system. Many CAAP facilities have multiple production units with different sizes and cohorts of animals in production at a given time. These multiple production units often combine effluent streams into one or two discrete conveyances. Although commercial CAAP facilities attempt to maintain maximum biomass in the culture facilities at all times to maximize production, there is often month-to-month variation within a facility. In a multiple-cohort practice, where different sizes of fish are in a system at one time, the biomass can have a narrower range at any given time. Many noncommercial facilities have a goal of producing a single cohort (generational group of animals) for natural resources enhancement. In a single cropping (a single cohort of animals from start to finish in a production unit, such as a pond or tank) management practice, the biomass in a production unit increases throughout the growing cycle. For both cases (single- and multiple-cohort production systems), the discharge varies in pollutant loadings over time, depending on the biomass of animals in the production units at a given time.

Availability of seed stock or fingerlings is another factor that strongly influences the size distribution of animals at a facility. Trout eggs, particularly those species and strains used for commercial production of foodfish, are usually available all year. The eggs of other species, such as hybrid striped bass, are typically available only when naturally spawning broodstock are available (in the spring). Another factor affecting growth and feed inputs is temperature, which influences growth of the cold-blooded animals grown in most CAAP facilities. Most aquatic animals grow in a defined range of water temperatures; for example, trout grow best at temperatures of 52 to 67 ºF and remain relatively dormant at temperatures below 41 ºF.

EPA based the pollutant loading model 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. Second, uneaten feed settles and increases the pollutant loading in the culture water. Thus, feed inputs to the systems drive 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 facility 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 loadings 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 loadings to a model facility (Table 10.1-2).

Table 10.1-2. Feed Conversion Ratios

System Type	*Initial FCR*	*Treatment/BMP*	*New FCR*
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.
- Although EPA found TSS, BOD, nitrogen, phosphorus, some metals (e.g., aluminum, barium, boron, copper, iron, manganese, selenium, and zinc), and a few organic compounds (e.g., bis (2-ethylhexyl) phthalate, hexanoic acid, P-cresol, phenol) present in effluents from CAAP facilities during sampling events, EPA focused its modeling efforts on TSS, BOD, TN, and TP. Most of the metals and organic compounds found in the sampled effluents were associated with the solids fraction in the effluent, so removing the solids would remove substantial portions of the metals and organic compounds as well.

- 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.
- EPA developed the pollutant loadings models for estimating the fate of TSS, BOD, TN, and TP in CAAP facilities. EPA had insufficient data to determine the pollutant removal efficiencies for drugs and chemicals used at CAAP facilities. Other special pollutants, such as escaping animals and aquatic animal pathogens, do not have pollutant removal efficiencies available for EPA to use in modeling.

10.1.3.1 Feed Inputs

EPA assumed the sources of pollutant loadings in CAAP facility production systems are the feed input and resulting metabolic wastes generated by the aquatic animals. The pollutant loadings calculated in the loading model were based on the feed input to the system and the feed-to-pollutant calculation, as described in the following discussion. The feed input to the model facility system was obtained by multiplying the model facility production, which was determined by analysis of the AAP screener results (see Section 10.3 for more details), by the initial FCR (listed in Table 10.1-2) for the CAAP facility.

EPA obtained the amount of feed input to each system using the following equation:

Feed input = model facility production * FCR

Where:

Model facility production = the average yearly production at the model facility (pounds)

FCR = the initial feed conversion ratio for the production system (pounds of feed per pound of fish produced).

10.1.3.2 Feed-to-Pollutant Conversion Factors

EPA only modeled pollutant generation as a function of feed inputs, which are the feed and associated metabolic wastes. The Agency used values for the feed-to-pollutant conversion factors (Table 10.1-3) in the loading model to represent the range of values found in literature reviews (Hochheimer and Westers, 2002a).

Table 10.1-3. Feed-to-Pollutant Conversion Factors

Pollutant	*Conversion Factor*
BOD	0.35
TN	0.03
TP	0.005
TSS	0.3

Source: Hochheimer and Westers, 2002a.

EPA found studies that determine the pollutants associated with feeding fish are often done in controlled laboratory situations using tanks with static water. The feed-to-pollutant conversion factors vary somewhat by species and the constituents in the feed, so EPA used typical values found in the literature to represent some of this variability. For the purpose of estimating pollutant loadings, EPA assumed that all feed added to a production system is consumed and undergoes some metabolic conversion by the aquatic animals. The resulting pollutants were estimated using the conversion factors in Table 10.1-3. Although feed conversion ratios greater than 1 indicate potentially uneaten feed, the amount of uneaten feed could vary considerably on a daily basis in a given production unit. Some of the factors that contribute to this variation are stress to the animals (e.g., changes in dissolved oxygen, spikes in production unit ammonia, unusual activity at the production facility, or a recent storm), water temperature, age of the aquatic animal, and the presence of disease. The mass of pollutants associated with unmetabolized feed are greater than those that are consumed and undergo the metabolic processes of the aquatic animals, so EPA used the more conservative value in the loading models. EPA used this assumption in all cases except active feed monitoring in net pens.

EPA used the feed-to-pollutant conversion factors to estimate an untreated or "raw loading," which was used as the input to pollutant control technologies and BMPs. EPA calculated raw pollutant loadings by using the following equations:

Raw pollutant loading = annual feed input * feed-to-pollutant conversion factor

Where:

Annual feed input is the amount of feed distributed to the production system (pounds per year).

Feed-to-pollutant conversion factor converts feed inputs into pollutant loadings.

10.1.3.3 Production System Treatment Trains

EPA's loading model consists of combinations of regulatory options, which are combinations of pollutant control technologies and BMPs that are added to achieve increasing levels of pollutant loading reduction. EPA uses specific combinations of pollutant control technologies and BMPs (or treatment trains) for a model facility in estimating pollutant reductions. The loading model first estimates a raw wastewater pollutant loading based on feed conversion ratios and feed inputs. As the wastewater flows through different components of the treatment train, pollutants are removed. The loading model calculates pollutant loadings, not concentrations.

Figure 10.1-1 illustrates the treatment train for flow-through systems. Option 1 for flow-through systems consist of a quiescent zone coupled with a sedimentation basin and a BMP plan for solids removal. For the purpose of analysis, EPA assumed that all pollutant removals from the quiescent zone are conveyed to the sedimentation basin. The drug and chemical BMP plan is the only additional component of Option 2. Because this plan is targeted at only special pollutants (drugs and chemicals) for which EPA has no BMP efficiency removals/rates, the Agency could not include any pollutant removals for TSS, BOD, TN, and TP under Option 2. Solids polishing is the only additional component of Option 3 in flow-through systems.

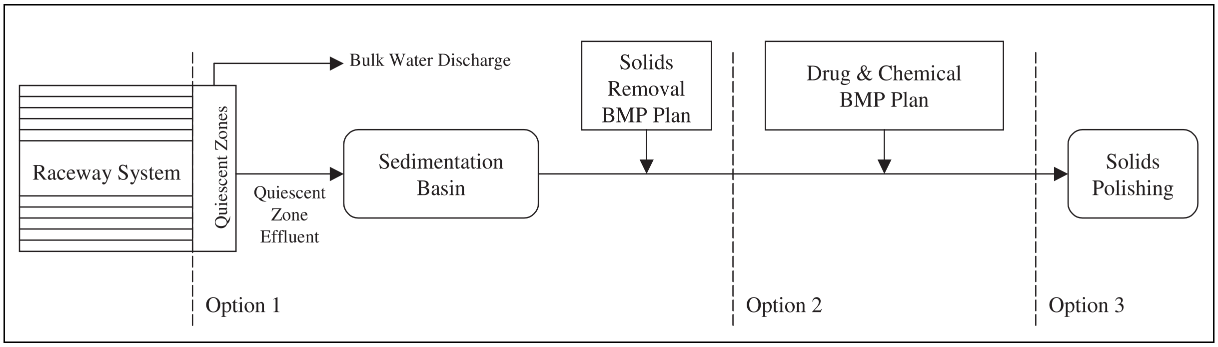

Figure 10.1-1. Flow-through Systems

For recirculating systems, Option 1 consists of the sedimentation basin and solids removal BMP plan. EPA assumed that all of the daily discharge would be conveyed to the sedimentation basin for treatment. The drug and chemical BMP plan is the only additional component of Option 2. Similar to flow-through systems, EPA targeted the drug and chemical BMP plan specifically for special pollutants (drugs and chemicals), for which EPA has no BMP efficiency removals. EPA did not include any pollutant removals for TSS, BOD, TN, and TP at Option 2. In recirculating systems, solids polishing is the only additional component of Option 3. Figure 10.1-2 illustrates the treatment train for recirculating systems. The treatment train includes only treatment practices for the wastewater discharge component of the recirculating system. Treatment components in the recirculating systems used for the process culture water, such as biological filters for ammonia removal, oxygenators, or internal solids collection devices, were not included in the treatment options. Also, treatment practices, such as biological treatment, to reduce BOD in the effluent were not evaluated.

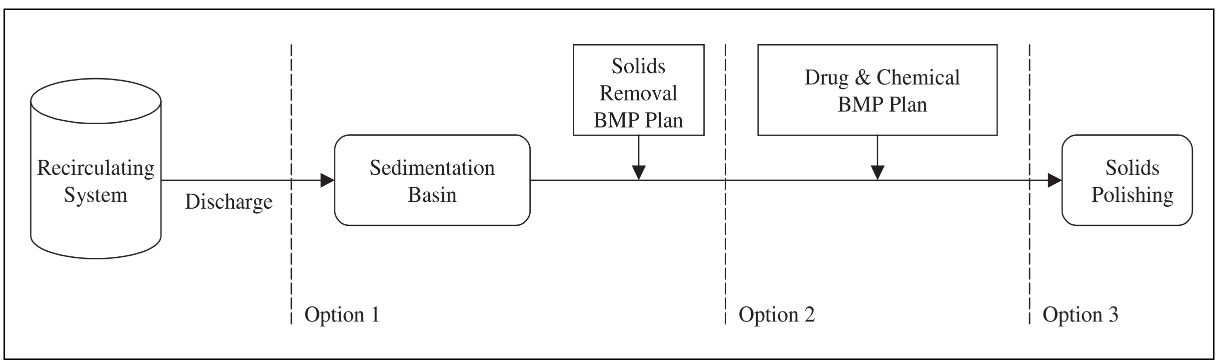

Figure 10.1-2. Recirculating System

Figure 10.1-3 illustrates the treatment train for net pen systems. Option 1 includes pollutant removals with feed management and the solids removal BMP plan. The pollutant reductions estimated for Option 1 are based on decreasing the FCR of the production system. 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. The drug and chemical BMP plan is the only additional component of Option 2. Similar to flow-through and recirculating systems, EPA could not include any pollutant removals for TSS, BOD, TN, and TP. Active feed monitoring is the only additional component of Option 3.

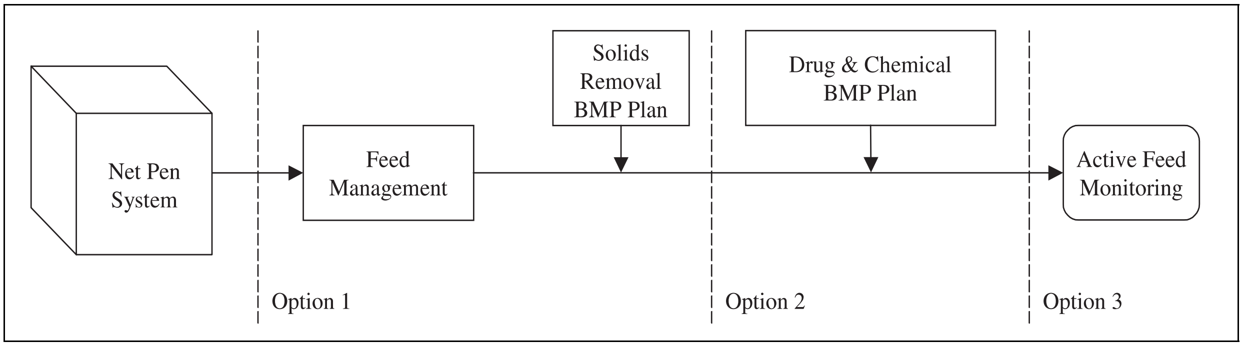

Figure 10.1-3. Net Pen System

10.2 LOADING MODEL STRUCTURE

EPA estimated the loading reduction associated with each of the regulatory options under consideration. EPA estimated loading reductions based on the implementation of BMPs and control technologies that have known pollutant removal efficiencies, as demonstrated by facilities in the CAAP facility industry.

To generate industry loading removals associated with each regulatory option for AAP facilities, EPA developed a computer-based model made up of several individual treatment technology/BMP modules. Figure 10.2-1 illustrates the loading model by showing that it consists of several components, which can be grouped into four major categories:

- Model facility configuration
- Treatment/BMP modules
- Frequency factors
- Output data

Each module calculates loading reductions for a specific wastewater treatment technology or BMP (e.g., a primary settling basin) based on loading reductions for the specific model facility characteristics. Frequency factors are then applied to the loading reductions to weight the reductions by the estimated percentage of operations that already have that treatment technology or practice in place. EPA summed these weighted facility reductions for each regulatory option and model facility for those facilities without treatment.

10.2.1 Model Facility Configuration

The model facility configuration part of the loading 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, annual production, and feed inputs.

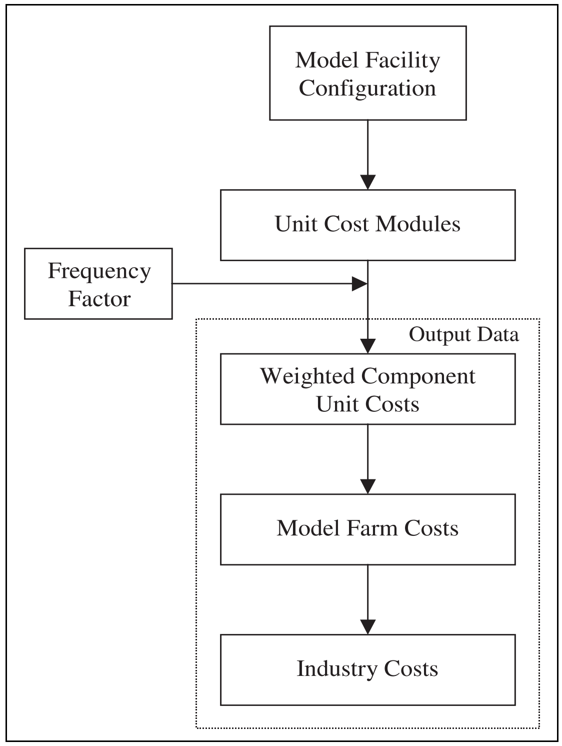

Figure 10.2-1. Schematic of Loading Model Structure

Input data to the model facilities includes the following:

- Number of facilities for a combination of system types, sizes, culture species, facility types, and locations.
- Technologies and BMPs by system type and facility size.
- Pollutant removals of technology options and BMPs.
- Average daily flow by system type and facility size.
- 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.

10.2.2 Unit Loading Modules

The unit loading modules contain the loading information for each component, BMP, or treatment technology contained in the regulatory options. The loading modules calculate the pollutant removals for the model facilities, based on culture species and production system, using pollutant-specific removals for each of the regulatory options. The various loading factors are discussed in Section 10.3. The unit loading modules are used in conjunction with the frequency factors (see Section 10.5) to determine the pollutant loading for each segment of the industry.

10.2.3 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 pollutant loadings for implementing the proposed options across the entire subcategory nationwide, EPA did not include 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. EPA used this occurrence frequency to estimate the pollutant removals resulting from wastewater treatment technologies and BMPs already in use at CAAP facilities. Frequency factors are discussed in greater detail in Section 10.5.

10.2.4 Output Data

Output data from the loading model provide estimates of baseline pollutant loadings discharged and incremental pollutant removals associated with each regulatory option. Section 10.7 discusses the output data in more detail.

10.3 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.

10.3.1 Flow-through Systems

The basic flow-through system model facility consists of a series of raceways and a treatment train of pollutant control technologies, including a quiescent zone, an offline settling basin, and a microscreen filter. Site visits (Tetra Tech, 2002d; Tetra Tech, 2002e; Tetra Tech, 2002f) and screener data (Westat, 2002) indicated that smaller flow-through facilities also operate circular tanks, earthen raceways, and flow-through concrete or earthen ponds. EPA assumed that raceways are the predominant systems used in flow-through facilities at the sizes being considered by the proposed regulation.

EPA developed raceway configurations from information obtained during site visits and conversations with AAP aquaculture industry representatives (Hinshaw, 2002, personal communication; Tetra Tech, 2002d; Tetra Tech, 2002e; Tetra Tech, 2002f). For flow-through systems, EPA developed the following physical attributes:

- Annual production (pounds of aquatic animals)
- Number of facilities
- Total facility flow rate (gallons per minute of water flowing through the facility)
- Feed conversion ratio (pounds of feed per pound of animal produced)
- Loading density (pounds of fish per cubic foot of raceway)
- Raceway dimensions
    - – Length of individual raceways (feet)

  – Width of individual raceways (feet)

  – Depth of individual raceways (feet)

  – Volume of individual raceway (cubic feet)

- Number of raceways at a facility
- Loadings from raceways (pounds of pollutants in the raw effluent)

10.3.1.1 Annual Production

For flow-through systems EPA developed model facilities for facilities producing 100,000 lb/yr up to 475,000 lb/yr and facilities producing 475,000 lb/yr or more. EPA sorted 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) into two production groups, facilities producing 100,000 lb/yr up to 475,000 lb/yr (medium) and facilities producing 475,000 lb/yr or more (large). EPA then averaged 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 to develop the model facility. For example, EPA grouped all seven of the federal (facility type) facilities that produce trout (species) stockers (lifestage) in flow-through systems producing 100,000 lb/yr up to 475,000 lb/yr as medium facilities. Table 10.3.1 provides details on the annual production ranges and average annual production used in the flow-through system calculations. Section 9.3 describes EPA's development of model facility size classifications in more detail.

EPA evaluated the limited available data, including the AAP screener survey data (Westat, 2002) and site visit information (see Chapter 3), and found nothing to indicate that the wide range of facility sizes represented by the average production values used as input for the model facilities in the large size class would misrepresent the range of facilities that made up the class. Although larger facilities can realize economies of scale in production costs, EPA was not able to find any differences in waste treatment or effluent quality characteristics for 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.) EPA will evaluate the detailed survey data to verify this assumption.

10.3.1.2 Number of Facilities

Table 10.3-1 presents the number of facilities represented by each flow-through model facility group. EPA used the AAP screener survey results (Westat, 2002) for the counts of facilities in each model facility group.

10.3.1.3 Total Flow Rate

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 1 gallon per minute per 100 lb of annual production (Hochheimer and Westers, 2002b).

Table 10.3-1. 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	—	—
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 5 facilities and is reported in this manner to protect the confidentiality of individual facilities.
[b] Model facility groups with fewer than 5 facilities are not reported.

10.3.1.4 Feed Conversion Ratio

EPA used an FCR of 1.4 for all flow-through systems. (See Section 10.1.3 for additional information on FCR values and assumptions.)

10.3.1.5 Loading Density

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).

10.3.1.6 Raceway Dimensions

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).

10.3.1.7 Number of Raceways

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

10.3.1.8 Loadings from Raceways

To estimate the pollutant loadings from each raceway, EPA used the pollutant loading values presented in Table 10.1-3 and the methodology described in Section 10.1.3 to estimate values for BOD, TN, TP, and TSS. Table 10.3-2 provides the estimated raw pollutant loadings for flow-through facilities.

Table 10.3-2. Raw Loading Estimates (per Facility) for Flow-through Facilities

Model Facility	*BOD (lb/yr)*	*TN (lb/yr)*	*TP (lb/yr)*	*TSS (lb/yr)*
Trout-Food-size-State-Medium-Flow-through	119,959	10,282	1,714	102,822
Trout-Food-size-State-Large-Flow-through	269,500	23,100	3,850	231,000
Trout-Food-size-Commercial-Medium-Flow-through	102,403	8,777	1,463	87,774
Trout-Food-size-Commercial-Large-Flow-through	1,224,593	104,965	17,494	1,049,651
Trout-Stockers-Federal-Medium-Flow-through	102,065	8,748	1,458	87,484
Trout-Stockers-Federal-Large-Flow-through	671,300	57,540	9,590	575,400
Trout-Stockers-Commercial-Medium-Flow-through	94,147	8,070	1,345	80,698
Trout-Stockers-Other-Medium-Flow-through	186,830	16,014	2,669	160,140
Trout-Stockers-Other-Large-Flow-through	235,200	20,160	3,360	201,600
Trout-Stockers-State-Medium-Flow-through	109,855	9,416	1,569	94,161
Trout-Stockers-State-Large-Flow-through	242,963	20,825	3,471	208,254
Tilapia-Food-size-Commercial-Medium-Flow-through	120,867	10,360	1,727	103,600
Tilapia-Food-size-Commercial-Large-Flow-through	490,000	42,000	7,000	420,000
Striped Bass-Food-size-Commercial-Medium-Flow-through	60,409	5,178	863	51,779
Salmon-Food-size-Other-Large-Flow-through	1,160,871	99,503	16,584	995,033

10.3.2 Alaska Flow-through Systems

Alaskan salmon producers refer to their production operations as "ocean ranching" in which hatchery fish are released into coastal areas to supplement the natural populations. Alaska 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 good tidal flushing in the waters adjacent to the facilities, most facilities do not operate wastewater treatment units for the collection of solids. Otherwise, facilities operate much like all other flow-through systems.

Because EPA received facility-specific data from the Alaska facilities, the Agency modeled each facility separately to determine pollutant removals.

10.3.2.1 Annual Production

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, 2002i). EPA modeled only the facilities producing more than 100,000 lb/yr. Table 10.3-3 presents production estimates for each Alaska salmon facility producing more than 100,000 lb/yr.

Table 10.3-3. Alaska 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

10.3.2.2 Number of Facilities

EPA estimated the number of facilities based on 2000 hatchery production data reported in Alaska Fish and Game’s *Alaska Salmon Enhancement Program 2000 Annual Report* (McNair, 2001). Table 10.3-3 shows the 18 Alaska facilities that EPA used to estimate loadings.

10.3.2.3 Total Flow Rate

EPA used a system flow rate of 1 gallon per minute per 100 pounds of annual production, which is the same flow rate used for other flow-through systems (Hochheimer and Westers, 2002b).

10.3.2.4 Feed Conversion Ratio

EPA used a feed conversion ratio of 1.4 for all flow-through systems. (See Section 10.1.3 for additional information on FCR values and assumptions.)

10.3.2.5 Loading Density

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).

10.3.2.6 Raceway Dimensions

EPA used the raceway size of 150 ft long by 14 ft wide by 3 ft deep, which is the same size as the medium-sized flow-through facilities in other states.

10.3.2.7 Number of Raceways

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

10.3.2.8 Loadings from Raceways

To estimate the pollutant loadings from each raceway, EPA used the pollutant loading values presented in Table 10.1-3 and the methodology described in Section 10.1.3 to estimate values for BOD, TN, TP, and TSS. Table 10.3-4 provides the estimated raw pollutant loadings for Alaska flow-through facilities.

Table 10.3-4. Raw Loading Estimates (per Facility) for Alaska Flow-through Facilities

Model Facility	*BOD (lb/yr)*	*TN (lb/yr)*	*TP (lb/yr)*	*TSS (lb/yr)*
Facility 1	51,322	4,399	733	43,990
Facility 2	98,515	8,444	1,407	84,442
Facility 3	100,028	8,574	1,429	85,738
Facility 4	70,774	6,066	1,011	60,663
Facility 5	66,400	5,691	949	56,914
Facility 6	75,152	6,442	1,074	64,416

Model Facility	*BOD (lb/yr)*	*TN (lb/yr)*	*TP (lb/yr)*	*TSS (lb/yr)*
Facility 7	197,722	16,948	2,825	169,476
Facility 8	73,903	6,335	1,056	63,345
Facility 9	61,603	5,280	880	52,802
Facility 10	101,748	8,721	1,454	87,213
Facility 11	482,745	41,378	6,896	413,781
Facility 12	57,152	4,899	816	48,987
Facility 13	179,355	15,373	2,562	153,733
Facility 14	119,826	10,271	1,712	102,708
Facility 15	571,095	14,169	2,362	141,693
Facility 16	71,094	6,094	1,016	60,937
Facility 17	108,922	9,336	1,556	93,362
Facility 18	122,523	10,502	1,750	105,020

10.3.3 Recirculating Systems

Recirculating systems typically require inputs of relatively small volumes of water because water in these systems is continuously filtered and reused. The production water treatment process is designed to minimize water requirements, which results in a small-volume, concentrated waste stream that is discharged daily. For the loading modeling, EPA used a basic recirculating system configuration for the production system and support equipment (with no predefined internal process configuration) that produces a concentrated effluent. The effluent waste stream is treated with a sedimentation basin and microscreen.

EPA developed recirculating system configurations from information obtained during site visits (Tetra Tech, 2002a; Tetra Tech, 2002g; Tetra Tech, 2002h; USEPA, 2002d) and from AAP industry representatives (AES, 2001). For recirculating systems, EPA developed the following characteristics:

- Annual production (pounds of aquatic animals)
- Number of facilities
- Feed conversion ratio (pounds of feed per pound of animal produced)
- Loading density (pounds of fish per cubic foot of production system volume)
- Volume of the system (cubic feet)
- Daily discharge rate (gallons per minute of water flowing from the facility)
- Loadings in effluent (pounds of pollutants in the raw effluent)

10.3.3.1 Annual Production

For recirculating systems EPA developed one model facility to represent all facilities producing 100,000 lb/yr or more. EPA sorted 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) into facilities producing greater than 100,000 lb/yr (large). EPA then averaged all of the species-lifestage-facility type combinations for the large facility size class to develop the model facility. Section 9.3 provides additional details on the development of production size ranges. Table 10.3-5 shows the production ranges and average production for recirculating facilities.

Table 10.3-5. Model Facility Information

Model Facility	*Size*	*Production Range (lb/yr)*	*Average Production (lb/yr)*	*Facilities Represented*
Tilapia-Recirculating	Large	200,000-525,000	351,643	5
Striped Bass-Recirculating	Large	–	–	< 5[a]

[a] <5 and "–" indicate a group with fewer than five facilities, reported in this, to protect the confidentiality of the individual facilities.

10.3.3.2 Number of Facilities

Table 10.3-5 presents the number of facilities represented by each recirculating system model facility group. EPA used the AAP screener survey results (Westat, 2002) for the counts of facilities in each model facility group.

10.3.3.3 Feed Conversion Ratio

EPA used a feed conversion ratio of 1.6 for all recirculating systems. (See Section 10.1.3 for additional information on FCR values and assumptions.)

10.3.3.4 Loading Density

EPA used the average stocking density of the culture species within the production system at maximum production levels for estimating the loading density. 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, 2002a; Tetra Tech, 2002g; Tetra Tech, 2002h) are common in the United States.

10.3.3.5 System Volume

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, and facility annual production is the average annual model facility production in pounds.

10.3.3.6 Daily Discharge Rate

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. EPA calculated the daily discharge rate as

Daily discharge rate = production system volume * daily makeup factor

Where the daily discharge rate is in gallons per day, the production system volume is in gallons, and the daily makeup factor is 10% of the system volume per day.

10.3.3.7 Loadings from Recirculating Systems

To estimate the pollutant loadings from each recirculating system, EPA used the pollutant loading values presented in Table 10.1-3 and the methodology described in Section 10.1.3 to estimate values for BOD, TN, TP, and TSS. Table 10.3-6 provides the estimated raw pollutant loadings for recirculating system facilities.

Table 10.3-6. Raw Loading Estimates (per Facility) for Recirculating System Facilities

Model Facility	*BOD (lb/yr)*	*TN (lb/yr)*	*TP (lb/yr)*	*TSS (lb/yr)*
Striped Bass-Food-size-Commercial-Large-Recirculating	688,800	59,040	9,840	590,400
Tilapia-Food-size-Commercial-Large-Recirculating	196,915	16,878	2,813	168,784

10.3.4 Net Pen Systems

Net pen systems are suspended or floating holding cages or nets used for the growout of the culture species. Net pen systems are located directly in the receiving water, and wastes are directly deposited from the net pen into the water. For the loading modeling, EPA used a net pen system physical configuration consisting of only the production system with no pollutant control technologies in place. EPA had observed at the site visits that some of the net pen facilities already have some of the BMPs in place (e.g., feed management, escapement plans, or active feed monitoring) and accounted for these in-place management practices with frequency factors.

EPA developed net pen system configurations from information obtained during site visits and conversations with AAP industry representatives (Tetra Tech, 2002b; Tetra Tech, 2002c) For net pen systems EPA developed the following characteristic:

- Annual production (pounds of aquatic animals)
- Number of facilities
- Feed conversion ratio (pounds of feed per pound of animal produced)
- Loading density (pounds of fish per cubic foot of net pen)
- Volume of the system (cubic feet)
- Number of net pens
- Loadings from net pens (pounds of pollutants in the raw effluent)

10.3.4.1 Annual Production

For net pen systems EPA developed one model facility to represent all facilities producing 100,000 lb/yr or more. EPA sorted data from the AAP screener survey (Westat, 2002) representing a species, lifestage (e.g., food-size), and facility type (e.g., commercial, federal, state) into facilities producing 100,000 lb (large) or more annually. All of the species-lifestage-facility type combinations for the large facility size class were then averaged to produce the model facility. Additional information on production system sizes for net pens is provided in Section 9.3. Table 10.3-7 provides production information for net pen facilities.

Table 10.3-7. Model Facility Information

Model Facility	*Size*	*Production Range (lb/yr)*	*Average Production (lb/yr)*	*Facilities Represented*
Salmon-Net Pens	Large	342,380–6,352,715	2,387,086	8

10.3.4.2 Number of Facilities

Table 10.3-7 presents the number of facilities represented by the net pen system model facility group. EPA used the AAP screener survey results (Westat, 2002) for the counts of facilities in each model facility group.

10.3.4.3 Feed Conversion Ratio

EPA used an initial feed conversion ratio of 1.2 for all net pen systems. (See Section 10.1.3 for additional information on FCR values and assumptions.)

10.3.4.4 Loading Density

EPA estimated that a loading density of 0.8 lb/ft^3 was applicable to the industry (Hochheimer and Westers, 2002c).

10.3.4.5 System Volume

The volume of individual nets was assumed to be 250,000 ft^3, based on site visit information (Tetra Tech, 2002b; Tetra Tech, 2002c).

10.3.4.6 Number of Net Pens

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

10.3.4.7 Loadings from Net Pen Systems

To estimate the loadings of pollutants from the net pen system model, EPA used the pollutant loading values presented in Table 10.1-3 and the methodology described in Section 10.1.3 to estimate values for BOD, TN, TP, and TSS. Table 10.3-8 provides the estimated raw pollutant loadings for net pen facilities.

Table 10.3-8. Raw Loading Estimates (per Facility) for Net Pen Facilities

Model Facility	*BOD (lb/yr)*	*TN (lb/yr)*	*TP (lb/yr)*	*TSS (lb/yr)*
Salmon-Food-size-Commercial-Large-Net Pen	1,002,576	85,935	14,323	858,351

10.4 UNIT LOADING MODULES

Loading modules calculate the pollutant removal associated with a particular technology or practice for an AAP facility. Each loading module contains the pollutant-specific removal efficiencies of the system component.

- Description of technology or practice
- Pollutant removal efficiencies

10.4.1 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.

10.4.1.1 Description of Technology or Practice

Quiescent zones are a practice used in raceway flow-through systems that use the last approximately 10% of the raceway as a settling area for solids. 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. Because quiescent zones settle and store solids in the production system, the solids must be removed and further treated. EPA observed facilities treating these solids (and any water removed from the quiescent zone during cleaning) by concentrated, direct land application, or dewatering and composting. For most medium and large facilities, quiescent zones are coupled with an offline settling basin to concentrate the solids and water mixture vacuumed from the quiescent zone. Solids are stored in the basin and removed before exceeding the storage capacity of the basin (typically about once per month at large facilities). Treated water is decanted from the offline basin and discharged directly or combined with the bulk discharge stream. For estimating pollutant loadings, EPA assumed that quiescent zones are coupled with offline settling basins. Thus, treatment efficiencies and pollutant removals were estimated for the combination of a quiescent zone and settling basin, not each practice individually. EPA also assumed a single frequency factor for the quiescent zone–offline settling basin combination.

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 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, personal communication, 2002; MacMillan, personal communication, 2002), 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 BOD.

10.4.1.2 Pollutant Removal Efficiencies: Flow-Through Systems

EPA used pollutant removals specific to each pollutant to calculate the removal by the quiescent zones. EPA obtained pollutant removal efficiencies for quiescent zones from the technical literature (Hinshaw and Fornshell, 2002). Table 10.4-1 presents the removal efficiency for each pollutant modeled. The calculation used in the loading model to obtain the loading discharged from the quiescent zone is as follows:

Effluent pollutant loading = influent pollutant loading * (1 - removal efficiency)

Where:

Influent pollutant loading = the pollutant removal from the quiescent zone

Removal efficiency = the specific removal efficiency for the treatment unit

Table 10.4-1. Quiescent Zone Removal Efficiencies

Pollutant	*Removal Efficiency (%)*
BOD	94.0
TN	8.5
TP	17.7
TSS	51.2

10.4.2 Sedimentation Basins

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. Offline settling treats a portion of the flow-through effluent volume in which solids have been concentrated. Full-flow sedimentation basins treat all of the flow from flow-through systems and are sized to accommodate settling of solids prior to discharge. Full-flow settling requires large areas to accommodate the higher flow rates encountered in medium and large flow-through systems. EPA found only a few full-flow settling basins in medium-sized facilities and none in larger systems. When offline settling is used, treatment technologies to concentrate solids (e.g., quiescent zones) are also used. For recirculating systems sedimentation basins are used to treat the concentrated waste stream that is discharged from the recirculating system.

10.4.2.1 Description of Technology or Practice

Sedimentation basins (also called settling basins, settling ponds, sedimentation ponds, or sedimentation lagoons) are used extensively in the wastewater treatment industry (Metcalf and Eddy, 1991a) and are commonly found in many flow-through and recirculating CAAP facilities (Westat, 2002). Sedimentation basins are used to collect and store the solids captured in quiescent zones or other in-system pollutant removal practices. EPA assumed that all solids captured in the quiescent zone are vacuumed and conveyed to the offline sedimentation basin. 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.

Sedimentation basins are sized according to the settling time for the particles in the effluent and the desired final effluent quality. EPA based its estimated sedimentation basin pollutant reductions on information supplied by AAP industry representatives (Hinshaw, 2002, personal communication; MacMillan, 2002, personal communication). EPA also used pollutant reductions in the model that were specific to each pollutant. Based on information obtained during site visits, EPA expects recirculating systems to generate a maximum of about 10% of the system volume per day.

10.4.2.2 Pollutant Removal Efficiencies: Flow-through Systems and Recirculating Systems

EPA's loading model used pollutant removals specific to each pollutant to calculate the removal by the sedimentation basin. EPA obtained the removal for each pollutant from the technical literature (Hinshaw and Fornshell, 2002). These values used in the model are similar to those obtained in EPA sampling trips and are comparable to those reported in AAP industry publications (e.g., Boyd and Tucker, 1995). Table 10.4-2 presents the removal efficiency for each pollutant modeled.

Table 10.4-2. Sedimentation Basin Removal Efficiencies

Pollutant	*Removal Efficiency (%)*
BOD	79.0
TN	7.1
TP	29.1
TSS	84.1

Influent loadings to the sedimentation basin were derived differently for flow-through and recirculating systems. For flow-through systems, EPA assumed that the total loading removed by the quiescent zone would be conveyed to the sedimentation basin for treatment. For recirculating systems, the entire raw pollutant loading was conveyed to the sedimentation basin.

The loading model calculates the pollutant removal by using two calculations. First the influent loading is multiplied by (1 – removal efficiency) to obtain the loading discharged from the sedimentation basin. The loading removed is the influent loading multiplied by the removal efficiency. The calculations used for pollutant removals is as follows:

Effluent pollutant loading = influent pollutant loading * (1 - removal efficiency)
Loading removed = influent pollutant loading * removal efficiency

Where:

Influent pollutant loading = the pollutant loading entering the sedimentation basin
Removal efficiency = the specific removal efficiency for the treatment unit
Loading removed = the pollutant removal by the sedimentation basin

10.4.3 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.

10.4.3.1 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 added 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 the production system increases the oxygen demand of the culture water and increases the solids loading to the treatment system. 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. Feed management is a practice required in net pen facility permits issued by EPA Regions 1 and 10 (USEPA, 2002b; USEPA, 2002c).

10.4.3.2 Pollutant Removal Efficiencies: Net Pen Systems

The pollutant removals for feed management in net pen systems are based on lowering the feed conversion ratio from 1.2 to 1.1, resulting in a removal efficiency of 8.3 % for all parameters. EPA site visits to net pen production facilities indicated FCRs of 1.1 could be obtained by salmon producers. The calculation for the removal efficiency is as follows:

Removal efficiency = (1 – (new FCR ÷ old FCR)) * 100

Where:

New FCR = the FCR obtained with implementation of a feed management program

Old FCR = the estimated FCR obtained by the industry at baseline

10.4.4 BMP Plan

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

10.4.4.1 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 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 removed solids and prevention of excess feed from entering the system." The BMP plan also ensures planning for proper operation and maintenance 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 operation and maintenance (O&M) activities that could result in decreased pollutant discharges.

10.4.4.2 Pollutant Removal Efficiencies

Pollutant reductions realized as a result of a BMP plan would be highly variable and specific to each facility; therefore, EPA used pollutant reductions in only the loading model for net pens.

The pollutant removals for the solids management BMP plan in net pen systems are based on lowering the feed conversion ratio from 1.1 to 1.0, resulting in a removal efficiency of 9.1 for all parameters. Information obtained during EPA site visits at net pen production facilities and research of AAP industry publications indicated FCRs of 1.0 could be obtained (Fish Farmer Magazine, 2002). The calculation for the removal efficiency is as follows:

$$\text{Removal efficiency} = (1 - (\text{new FCR} \div \text{old FCR})) * 100$$

Where:

New FCR = the FCR obtained with implementation of a solids management BMP plan

Old FCR = the estimated FCR obtained by the industry at baseline

10.4.5 Drug and Chemical BMP Plan

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

10.4.5.1 Description of Technology or Practice

The purpose of the drug and chemical BMP plan is to document the use of specific classes of drugs and chemicals in the production facility. The plan would also address the practices to minimize the accidental spill or release of drugs and chemicals.

10.4.5.2 Pollutant Removal Efficiencies

Pollutant reductions for BOD, TN, TP, and TSS are not expected to occur as a result of implementation of a drug and chemical BMP plan. This plan is proposed to reduce the discharge of special pollutants (drugs and chemicals) only. Therefore, EPA could not use pollutant reductions for BOD, TN, TP, and TSS in the loading model.

10.4.6 Additional Solids Removal (Solids Polishing)

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

10.4.6.1 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. Microscreen filters consist of fine mesh filters that are usually fitted to a rotating drum. The wastewater stream is pumped into the inside of the drum, and solids are removed from the effluent as the water passes through the screen. The screen size usually varies between 60 and 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).

EPA assumed that a rotary microscreen filter would be used so that clogging problems could be 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.

10.4.6.2 Pollutant Removal Efficiencies

EPA used CAPDET (Hydromantis, 2001) to estimate pollutant reduction rates for microscreen filters. CAPDET provided estimated pollutant reductions of 60% for TSS and 50% for BOD, TN, and TP. EPA found that these values were supported in the technical literature: Metcalf and Eddy (1991b) indicated pollutant removals for microscreens of between 10% and 80% for suspended solids; other sources indicated phosphorus removals of up to 80% with microscreens (Chen et al., 1994). EPA opted for the more conservative 60% removal for TSS and 50% removals for BOD, TN, and TP because of the scarcity of data from AAP facilities.

10.4.7 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.

10.4.7.1 Description of Technology or Practice

The goal of active feed monitoring is to further reduce pollutant loadings associated with feeding activities. A variety of technologies could be used, 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.

10.4.7.2 Pollutant Removal Efficiencies: Net Pen Systems

EPA estimated that pollutant reductions associated with active feed monitoring would be about 5.0% for all pollutants.

10.5 FREQUENCY FACTORS

Applying the frequency factors to the modules allows the loading model to account for the treatment units and BMPs already in place. Essentially, EPA adjusts the component loading removal to account for facilities that already have the component in place. Such facilities would not have to install and operate a new component as a result of the proposed regulation.

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 AAP screener survey was used to assess general practices of CAAP facility operations and how they vary among regions and size classes.
- EPA used observations on CAAP facility operations by industry experts, who were contacted to provide insight into operations and practices, especially where data were limited or not publicly available.
- *State Compendium: Programs and Regulatory Activities Related to Aquatic Animal Production* (see Chapter 9) was used to estimate frequency factors, based on current requirements for treatment technologies and BMPs that already apply to CAAP facilities in various states (MDA, 1995). 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.

10.5.1 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 10.5-1.

Table 10.5-1. 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
	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-Food-size-Commercial-Flow-through	Medium	0.67
	Large	1.00
Striped Bass-Food-size-Commercial-Flow-through	Medium	1.00
Salmon-Food-size-Other-Flow-through	Large	1.00

10.5.2 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 loading model for flow-through and recirculating CAAP facilities on the AAP screener survey results (Westat, 2002). The factors are presented in Table 10.5-2.

Table 10.5-2. 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

Species	Model	Frequency Factor
Trout-Stockers-Other-Flow-through	Medium	1.00
	Large	1.00
Tilapia-Food-size-Commercial-Flow-through	Medium	0.67
	Large	1.00
Tilapia-Food-size-Commercial-Recirculating	Large	1.00
Striped Bass-Food-size-Commercial-Flow-through	Medium	1.00
Striped Bass-Food-size-Commercial-Recirculating	Large	1.00
Salmon-Food-size-Other-Flow-through	Large	1.00

10.5.3 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). The factors are presented in Table 10.5-3.

Table 10.5-3. 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-Food-size-Commercial-Flow-through	Medium	0.00
	Large	0.00
Tilapia-Food-size-Commercial-Recirculating	Large	0.40
Striped Bass-Food-size-Commercial-Flow-through	Medium	0.00
Striped Bass-Food-size-Commercial-Recirculating	Large	0.00
Salmon-Food-size-Other-Flow-through	Large	0.00
Salmon-Food-size-Commercial-Net Pen	Large	0.13

10.5.4 Feed Management

Feed management is a commonly used practice in the CAAP facility industry because its benefits include both a cost savings for farms and reductions in pollutant loadings. EPA specified feed management as a management practice for net pen operations. The frequency factor EPA used in the loading model is based on the AAP screener survey results (Westat, 2002), and the factor is presented in Table 10.5-4.

Table 10.5-4. Feed Management Frequency Factor

Species	*Model*	*Frequency Factor*
Salmon-Food-size-Commercial-Net Pen	Large	0.88

The frequency factor for feed management was based on responses to the screener survey. Screener survey data indicated that about 88% of net pens are practicing feed management activities.

10.5.5 Drug and Chemical BMP Plan

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

10.5.6 Solids Polishing

Approximately 5% of the facilities responding to EPA's AAP screener survey 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 results (Westat, 2002), which are presented in Table 10.5-5.

Table 10.5-5. 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

Species	Model	Frequency Factor
	Large	0.00
Tilapia-Food-size-Commercial-Flow-through	Medium	0.00
	Large	0.00
Tilapia-Food-size-Commercial-Recirculating	Large	0.40
Striped Bass-Food-size-Commercial-Flow-through	Medium	1.00
Striped Bass-Food-size-Commercial-Recirculating	Large	0.67
Salmon-Food-size-Other-Flow-through	Large	0.00

10.5.7 Net Pen Active Feed Monitoring

EPA developed a frequency factor for active feed monitoring in net pen CAAP facilities from the AAP screener survey results (Westat, 2002). The factor is presented in Table 10.5-6.

Table 10.5-6. Active Feed Monitoring Frequency Factor

Species	Model	Frequency Factor
Salmon-Food-size-Commercial-Net Pen	Large	0.38

10.6 LOADING MODEL STRUCTURE

10.6.1 Loading Removal Flow Chart

Figures 10.6-1 through 10.6-3 show how the pollutant loading models for flow-through, recirculating, and net pen production systems combine pollutant removal components to form the proposed regulatory options (for example, Option 1 for flow-through systems includes quiescent zones, sedimentation basins, and a BMP plan; Option 2 is the drug and chemical BMP plan; and Option 3 is solids polishing). Each flow chart also indicates how each treatment technology or BMP component loading is applied only to those facilities in the model facility group that do not currently have the treatment technology or BMP in place. Multiplying the number of facilities in the model facility group by each component-specific frequency factor makes this adjustment.

EPA's modeling approach estimates a total pollutant loading before and after each pollutant removal component. EPA can then determine pollutant loadings resulting from the individual component or across several linked components (one or more regulatory options). The modeling approach also allows EPA to determine pollutant removals for one or more proposed options by subtracting the estimated loading after a pollutant removal component from the estimated loading before the same component.

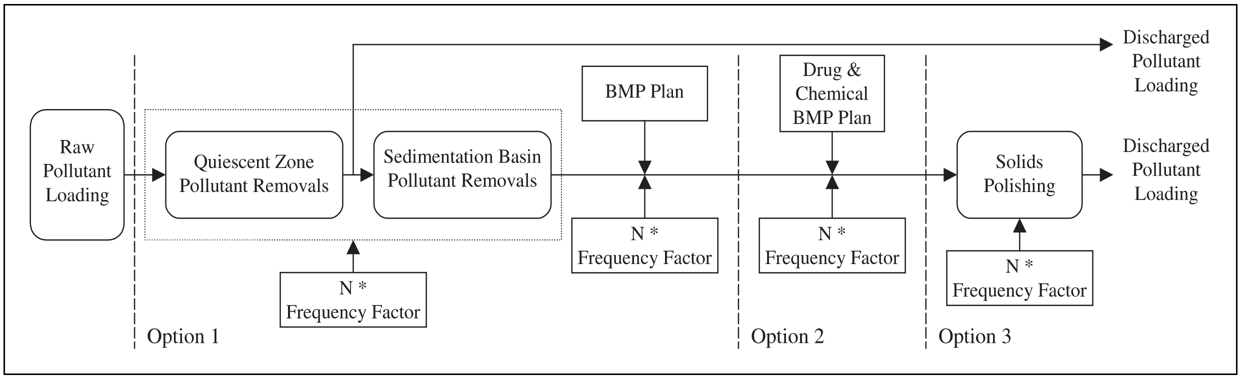

Figure 10.6-1. Schematic of Flow-through System Pollutant Loading Model

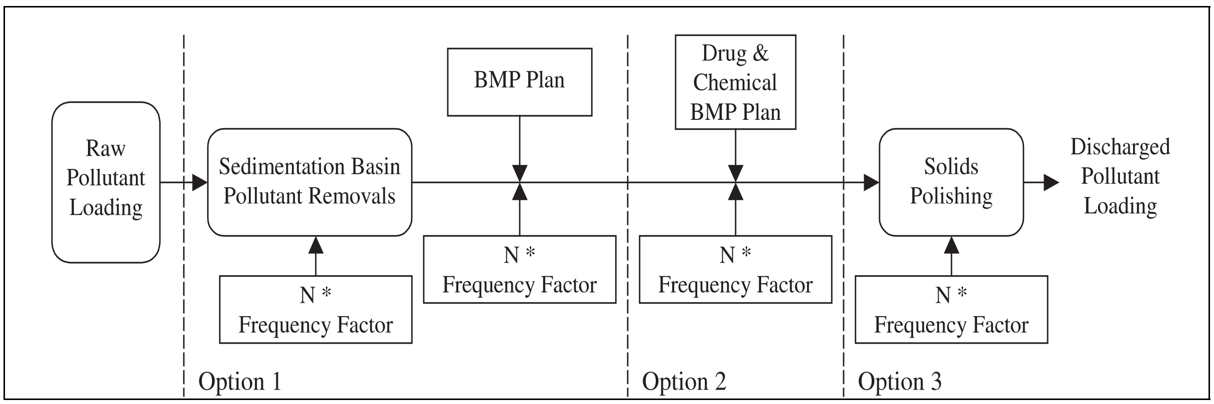

Figure 10.6-2. Schematic of Recirculating System Pollutant Loading Model

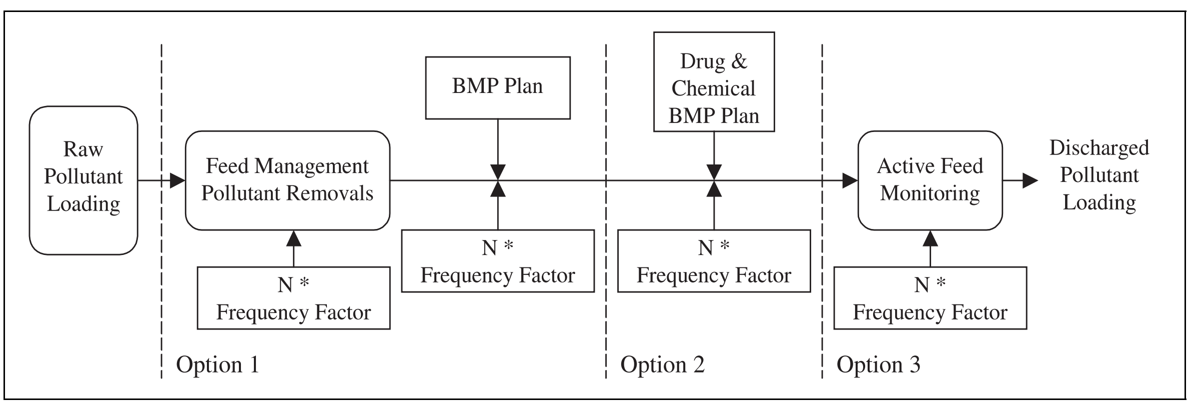

Figure 10.6-3. Schematic of Net Pen System Pollutant Loading Model

Baseline loadings for each pollutant are defined as the amount of pollutant currently being discharged by the facilities in a model facility group, including discharges from facilities that have existing treatment technologies in place. EPA calculated the baseline for a pollutant control technology as:

Component baseline loading = (raw pollutant loading * number of facilities) – baseline removal

Where:

Component baseline loading = pounds of a specific pollutant discharged prior to the application of a pollutant control technology, but includes control technologies currently in place at these facilities

Raw pollutant loading = pounds of raw pollutant

Number of Facilities = the count of facilities grouped as a model facility

Baseline Removal = pounds of a specific pollutant removed at the facilities, based on technologies currently in place

EPA calculated estimates of pollutant loadings for each pollutant removal component using the following general equation:

Component baseline pollutant removal = raw pollutant loading * technology removal rate number of facilities * frequency factor

Where:

Component baseline pollutant removal = pounds of pollutant currently removed from raw waste loadings

Raw pollutant loading = pounds of untreated pollutant from the facility

Technology removal rate = the percentage of pollutants removed by a treatment technology

Number of facilities = the count of facilities grouped as a model facility

Frequency factor = the percentage of facilities in the model facility group that have the specific treatment technology in place (see Tables 10.5-1 to 10.5-7)

The pollutant removal for a proposed option was calculated as follows:

Option pollutant removal = $[\text{input pollutant loading} * \text{technology removal} * \text{number of facilities} * (1 - \text{frequency factor})]_a + [\text{input pollutant loading} * \text{technology removal} * \text{number of facilities} * (1 - \text{frequency factor})]_b$

Where:

Option pollutant removal = pounds of a specific pollutant removed by the application of an option

Input pollutant loading = pounds of a pollutant prior to application of the option

Technology removal	=	percentage of pollutant removed by the treatment technology
Number of facilities	=	the count of facilities grouped as a model facility
Frequency factor	=	the percentage of facilities in the model facility group that have the specific treatment technology in place (see Tables 9.5-1 to 9.5-7)
a, b	=	each technology component

10.6.2 Loading Model Example

To illustrate the loading calculations, EPA has provided an example of one loading model facility. The example model facility is the medium-sized *federal-flow-through-trout-stockers* model. As shown in Table 10.3-1, this model facility represents seven facilities that produce between from 106,788 and 317,000 lb/yr, with an average production of 206,296 lb/yr.

For medium flow-through facilities, only regulatory Option 1 applies. The proposed Option 1 for flow-through systems includes quiescent zones, sedimentation basins, and a solids control BMP plan. The quiescent zone and sedimentation basin constitute a treatment control component. Note that the solids control BMP plan does not have any pollutant removal components, so the pollutant removal is zero. The schematic in Figure 10.6-4 shows how the components are grouped in Option 1.

EPA calculated baseline removal, baseline discharged loading, and the option removals using the equations shown in Section 10.6.1. The following shows the calculations.

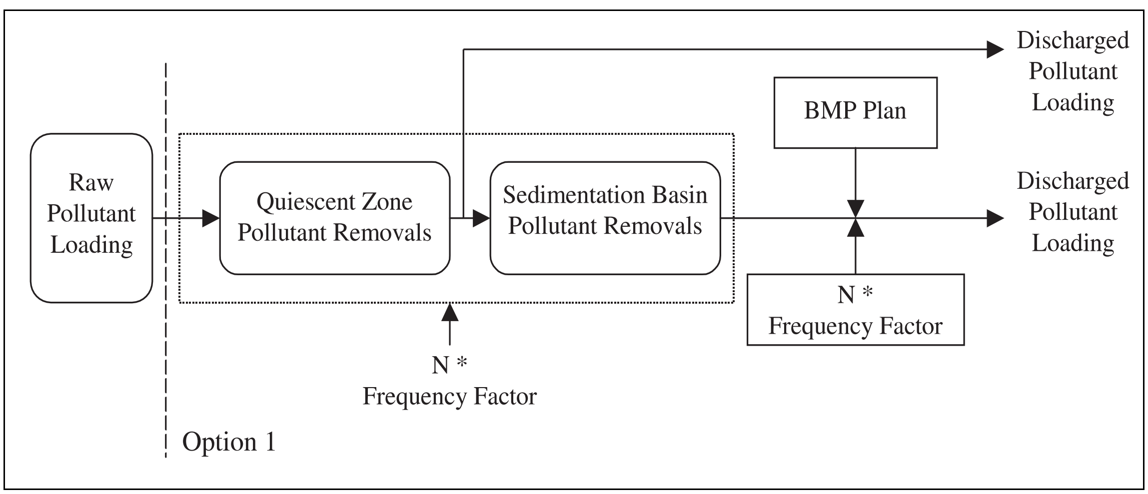

Figure 10.6-4. Schematic of Option 1 for Flow-through Systems

10.6.2.1 Estimation of Raw Loading

Because the raw pollutant loading is based on feed inputs (see Section 10.3-1 for more details), the loading model first calculates the annual feed input for the model facility using the facility annual production and feed conversion ratio. The equation for the annual feed input was:

Annual feed input = facility annual production * feed conversion ratio

Where:

Facility annual production = 208,296 lb of trout stockers

Feed conversion ratio = 1.4 lb of feed per pound of fish produced (Table 10.1-2)

Annual feed input = 208,296 lb of trout * 1.4 lb of feed per pound of trout

Annual feed input = 291,614 lb of feed

EPA calculated the raw pollutant loadings by multiplying the annual feed input by the feed- to-pollutant conversion ratio (see Table 10.1-3) for each pollutant modeled. The equation used for each pollutant was as follows:

Raw pollutant loading = annual feed input * feed-to-pollutant conversion ratio

Example:

Raw BOD loading = 291,614 lb of feed * 0.35 lb BOD per pound of feed

Raw BOD loading = 102,065 lb

The feed-to-pollutant conversion ratios and results of the raw pollutant loading calculations for the example model facility are shown in Table 10.6-1.

Table 10.6-1. Federal-Flow-through-Trout-Stockers Model Facility Raw Pollutant Loadings

Pollutant	***Feed-to-Pollutant Conversion Ratio***	***Raw Pollutant Loading (lb)***
BOD	0.35	102,065
TN	0.03	8,748
TP	0.005	1,458
TSS	0.3	87,484

10.6.2.2 Frequency Factors

EPA used frequency factors estimated from the AAP screener survey in the loading model to account for those existing *federal-flow-through-trout-stockers* facilities that already have the treatment technology (or equivalent) in place. The frequency factors for each component in Option 1 are presented in Table 10.6-2.

Table 10.6-2. Federal-Flow-through-Trout-Stockers Frequency Factors

Treatment Technology (source)	*Frequency Factor*	*(1 - Frequency Factor)*
Quiescent zone (Table 10.5-1)	0.57	0.43
Sedimentation basin (Table 10.5-2)	0.57	0.43
BMP plan (Table 10.5-3)	0.14	0.86

10.6.2.3 Baseline Removal

The baseline removal was calculated using the following equation:

Baseline removal = [raw loading * quiescent zone removal * sedimentation basin removal * N * frequency factor] + [loading_1 * BMP plan removal * N * frequency factor]

Where:

Raw loading = the untreated pollutant loading contained in the culture water from the model facility (Table 10.6-1)

Quiescent zone removal = the percentage of a specific pollutant removed by the quiescent zone (Table 10.6-3)

Sedimentation basin removal = the percentage of a specific pollutant removed by the sedimentation basin (Table 10.6-3)

Loading_1 = the loading from the first component

BMP plan removal = the percentage of a specific pollutant removed by the BMP plan (Table 10.6-3)

N = the number of facilities represented by the model facility

Frequency factor = the number of facilities indicating the use of primary settling operations in EPA's screener survey of the AAP industry (Table 10.6-2)

Because the BMP plan pollutant removals are zero for the pollutants EPA evaluated, the BMP plan component is eliminated from the calculations.

Example baseline removal calculation for BOD:

Baseline BOD removal = 102,065 lb BOD * 0.94 * 0.79 * 7 facilities * 0.57

<u>Baseline BOD removal = 302,416 lb</u>

Table 10.6-3. Summary of Quiescent Zone (QZ), Sedimentation Basin (SB), and BMP Plan (BMP) Removal Information for the Federal-Flow-through-Trout-Stockers Model Facility

Pollutant	*QZ Pollutant Removal Rate (%)*	*SB Pollutant Removal Rate (%)*	*BMP Pollutant Removal Rate (%)*
BOD	94.0	79.0	0
TN	8.5	7.1	0
TP	17.7	29.1	0
TSS	51.2	84.1	0

Table 10.6-4 shows the summary of baseline removals for remaining pollutants estimated for the *federal-flow-through-trout-stockers* model facility. EPA next calculated the baseline loading discharged:

Baseline loading discharged = (raw loading * N) – baseline removal

Where:

Raw loading = the untreated pollutant loading contained in the culture water from the model facility

N = the number of facilities represented by the model facility

Baseline removal = the removal obtained by the baseline treatment technologies

Example baseline loading discharged calculation for BOD:

Baseline loading discharged = (102,065 lb BOD * 7) – 304,416 lb BOD

<u>Baseline loading discharged = 412,039 lb BOD</u>

Table 10.6-4 summarizes the baseline discharge loadings for all of the pollutants for the *federal-flow-through-trout-stockers* model facility. The Option 1 removal is calculated using the following equation:

Option 1 removal = raw loading * quiescent zone removal * sedimentation basin removal * N * (1 - frequency factor)

Where:

Raw loading = the untreated pollutant loading contained in the culture water from the model facility

Quiescent zone removal = the percentage of a specific pollutant removed by the quiescent zone

Sedimentation basin removal = the percentage of a specific pollutant removed by the sedimentation basin

N = the number of facilities represented by the model facility

Frequency factor = the number of facilities indicating the use of primary settling operations in EPA's screener survey of the AAP industry

Example Option 1 removal calculation for BOD:

Option 1 removal = 102,065 lb BOD_5 * 0.94 * 0.79 * 7 * (1- 0.57)

Option 1 Removal = 228,138 lb

Table 10.6-4 summarizes the Option 1 removals for all of the pollutants for the *federal-flow-through-trout-stockers* model facility.

Table 10.6-4. Summary of Baseline Removals, Baseline Discharge Loading, and Option 1 Removals for the Federal-Flow-through-Trout-Stockers Model Facility

Pollutant	*Baseline Removal (lb)*	*Baseline Discharge Loading (lb)*	*Option 1 Pollutant Removals (lb)*
BOD	302,416	412,039	228,138
TN	210	61,029	158
TP	300	9,907	226
TSS	150,303	462,087	113,387

10.7 LOADING MODEL OUTPUT

EPA used the loading methodology described in this chapter to estimate the current discharge loadings of BOD, TN, TP, and TSS for the model facilities. EPA then applied the proposed regulatory options using the treatment trains illustrated in Section 10.6 to estimate pollutant reductions in these loadings, based on the option components for each system type. Table 10.7-1 presents the estimated total current discharge loadings for the model facilities. Table 10.7-2 presents the estimated total pollutant reductions for proposed regulatory Option 1. Table 10.7-3 presents the estimated total pollutant reductions for proposed regulatory Option 2. Table 10.7-4 presents the estimated total pollutant reductions for proposed regulatory Option 3. Table 10.7-5 presents the estimated current discharge loads for Alaska salmon facilities. Table 10.7-6 presents the estimated Option 1 total pollutant removals for Alaska salmon facilities. Table 10.7-7 presents the estimated Option 2 total pollutant removals for Alaska salmon facilities. Table 10.7-8 presents the estimated Option 3 total pollutant removals for Alaska salmon facilities.

Table 10.7-1. Estimated Current Discharge Loadings for the Model Facilities

Model Facility	Size	Count	BOD (lb/yr)	TN (lb/yr)	TP (lb/yr)	TSS (lb/yr)
Trout-Food-size-Commercial-Flow-through	Medium	22	730,457	192,046	30,675	1,174,378
Trout-Food-size-Commercial-Flow-through	Large	8	2,521,683	834,670	132,745	4,781,439
Trout-Food-size-State-Flow-through	Medium	<5	123,510	40,882	6,502	234,191
Trout-Food-size-State-Flow-through	Large	<5	69,369	22,961	3,652	131,533
Trout-Stockers-Commercial-Flow-through	Medium	5	121,167	40,106	6,378	229,749
Trout-Stockers-Federal-Flow-through	Medium	7	412,039	61,029	9,907	462,087
Trout-Stockers-Federal-Flow-through	Large	<5	844,093	114,734	18,686	903,037
Trout-Stockers-State-Flow-through	Medium	44	1,567,218	412,041	65,815	2,519,665
Trout-Stockers-State-Flow-through	Large	<5	62,539	20,700	3,292	118,582
Trout-Stockers-Other-Flow-through	Medium	<5	48,090	15,918	2,532	91,185
Trout-Stockers-Other-Flow-through	Large	<5	60,540	20,039	3,187	114,793
Tilapia-Food-size Commercial-Flow-through	Medium	<5	182,192	30,955	5,001	221,136
Tilapia-Food-size Commercial-Flow-through	Large	<5	126,126	41,747	6,639	239,151
Tilapia-Food-size Commercial-Recirculating	Large	5	850,555	46,568	11,847	249,235
Striped Bass-Food-size Commercial-Flow-through	Medium	<5	15,549	5,147	819	29,483
Striped Bass-Food-size Commercial-Recirculating	Large	<5	1,727,510	81,475	23,911	267,451
Salmon-Food-size-Other-Flow-through	Large	<5	298,808	98,905	15,730	566,579
Salmon-Food-size-Commercial-Net pen	Large	8	7,432,432	637,066	106,178	6,370,656

Table 10.7-2. Estimated Option 1 Total Pollutant Removals

Model Facility	Size	Count	BOD (lb/yr)	TN (lb/yr)	TP (lb/yr)	TSS (lb/yr)
Trout-Food-size-Commercial-Flow-through	Medium	22	150,568	105	149	74,834
Trout-Food-size-Commercial-Flow-through	Large	8	0	0	0	0
Trout-Food-size-State-Flow-through	Medium	<5	0	0	0	0
Trout-Food-size-State-Flow-through	Large	<5	0	0	0	0
Trout-Stockers-Commercial-Flow-through	Medium	5	0	0	0	0
Trout-Stockers-Federal-Flow-through	Medium	7	228,138	158	226	113,387
Trout-Stockers-Federal-Flow-through	Large	<5	498,507	346	494	247,763
Trout-Stockers-State-Flow-through	Medium	44	323,049	224	320	160,558
Trout-Stockers-State-Flow-through	Large	<5	0	0	0	0
Trout-Stockers-Other-Flow-through	Medium	<5	0	0	0	0
Trout-Stockers-Other-Flow-through	Large	<5	0	0	0	0
Tilapia-Food-size-Commercial-Flow-through	Medium	<5	88,858	62	88	44,163
Tilapia-Food-size-Commercial-Flow-through	Large	<5	0	0	0	0
Tilapia-Food-size-Commercial-Recirculating	Large	5	0	0	0	0
Striped Bass-Food-size-Commercial-Flow-through	Medium	<5	0	0	0	0
Striped Bass-Food-size-Commercial-Recirculating	Large	<5	0	0	0	0
Salmon-Food-size-Other-Flow-through	Large	<5	0	0	0	0
Salmon-Food-size-Commercial-Net pen	Large	8	661,700	56,717	9,453	567,172

Table 10.7-3. Estimated Option 2 Total Pollutant Removals

Model Facility	***Size***	***Count***	***BOD (lb/yr)***	***TN (lb/yr)***	***TP (lb/yr)***	***TSS (lb/yr)***
Trout-Food-size-Commercial-Flow-through	Medium	22	150,568	105	149	74,834
Trout-Food-size-Commercial-Flow-through	Large	8	0	0	0	0
Trout-Food-size-State-Flow-through	Medium	<5	0	0	0	0
Trout-Food-size-State-Flow-through	Large	<5	0	0	0	0
Trout-Stockers-Commercial-Flow-through	Medium	5	0	0	0	0
Trout-Stockers-Federal-Flow-through	Medium	7	228,138	158	226	113,387
Trout-Stockers-Federal-Flow-through	Large	<5	498,507	346	494	247,763
Trout-Stockers-State-Flow-through	Medium	44	323,049	224	320	160,558
Trout-Stockers-State-Flow-through	Large	<5	0	0	0	0
Trout-Stockers-Other-Flow-through	Medium	<5	0	0	0	0
Trout-Stockers-Other-Flow-through	Large	<5	0	0	0	0
Tilapia-Food-size-Commercial-Flow-through	Medium	<5	88,858	62	88	44,163
Tilapia-Food-size-Commercial-Flow-through	Large	<5	0	0	0	0
Tilapia-Food-size-Commercial-Recirculating	Large	5	0	0	0	0
Striped Bass-Food-size-Commercial-Flow-through	Medium	<5	0	0	0	0
Striped Bass-Food-size-Commercial-Recirculating	Large	<5	0	0	0	0
Salmon-Food-size-Other-Flow-through	Large	<5	0	0	0	0
Salmon-Food-size-Commercial-Net pen	Large	8	661,700	56,717	9,453	567,172

Table 10.7-4. Estimated Option 3 Total Pollutant Removals

Model Facility	Size	Count	BOD (lb/yr)	TN (lb/yr)	TP (lb/yr)	TSS (lb/yr)
Trout-Food-size-Commercial-Flow-through	Medium	22	352,914	7,009	1,987	160,666
Trout-Food-size-Commercial-Flow-through	Large	8	966,939	32,995	8,782	410,160
Trout-Food-size-State-Flow-through	Medium	<5	47,360	1,616	430	20,089
Trout-Food-size-State-Flow-through	Large	<5	26,600	908	242	11,283
Trout-Stockers-Commercial-Flow-through	Medium	5	46,462	1,585	422	19,708
Trout-Stockers-Federal-Flow-through	Medium	7	298,655	2,565	866	143,299
Trout-Stockers-Federal-Flow-through	Large	<5	631,022	4,868	1,697	303,973
Trout-Stockers-State-Flow-through	Medium	44	776,271	15,690	4,436	352,808
Trout-Stockers-State-Flow-through	Large	<5	23,980	818	218	10,172
Trout-Stockers-Other-Flow-through	Medium	<5	18,440	629	167	7,822
Trout-Stockers-Other-Flow-through	Large	<5	23,214	792	211	9,847
Tilapia-Food-size-Commercial-Flow-through	Medium	<5	124,647	1,283	413	59,344
Tilapia-Food-size-Commercial-Flow-through	Large	<5	48,363	1,650	439	20,515
Tilapia-Food-size-Commercial-Recirculating	Large	5	296,318	11,646	3,418	38,230
Striped Bass-Food-size-Commercial-Flow-through	Medium	<5	0	0	0	0
Striped Bass-Food-size-Commercial-Recirculating	Large	<5	342,047	13,443	3,945	44,129
Salmon-Food-size-Other-Flow-through	Large	<5	114,578	3,910	1,041	48,602
Salmon-Food-size-Commercial-Net pen	Large	8	868,899	74,477	12,413	744,771

Table 10.7-5. Estimated Current Discharge Loadings for the Alaska Salmon Facilities

Model Facility	*BOD (lb/yr)*	*TN (lb/yr)*	*TP (lb/yr)*	*TSS (lb/yr)*
Facility 1	51,322	4,399	733	43,990
Facility 2	98,515	8,444	1,407	84,442
Facility 3	100,028	8,574	1,429	85,738
Facility 4	70,774	6,066	1,011	60,663
Facility 5	66,400	5,691	949	56,914
Facility 6	197,722	16,948	2,825	169,476
Facility 7	73,903	6,335	1,056	63,345
Facility 8	61,603	5,280	880	52,802
Facility 9	75,152	6,442	1,074	64,416
Facility 10	101,748	8,721	1,454	87,213
Facility 11	482,745	41,378	6,896	413,781
Facility 12	57,152	4,899	816	48,987
Facility 13	179,355	15,373	2,562	153,733
Facility 14	119,826	10,271	1,712	102,708
Facility 15	279,837	23,986	3,998	239,860
Facility 16	71,094	6,094	1,016	60,937
Facility 17	108,922	9,336	1,556	93,362
Facility 18	122,523	10,502	1,750	105,020

Table 10.7-6. Estimated Option 1 Total Pollutant Removals for Alaska Salmon Facilities

Model Facility	*BOD (lb/yr)*	*TN (lb/yr)*	*TP (lb/yr)*	*TSS (lb/yr)*
Facility 1	38,111	26	38	18,942
Facility 2	73,158	51	72	36,360
Facility 3	74,281	52	74	36,918
Facility 4	52,557	36	52	26,121
Facility 5	49,309	34	49	24,507
Facility 6	146,029	102	145	72,975
Facility 7	54,880	38	54	27,276
Facility 8	45,746	32	45	22,736
Facility 9	55,808	39	55	27,737
Facility 10	75,558	52	75	37,553
Facility 11	358,486	249	355	178,171
Facility 12	42,441	29	42	21,093
Facility 13	133,189	92	132	66,196
Facility 14	88,983	62	88	44,225
Facility 15	207,807	144	206	103,282
Facility 16	25,996	18	26	12,920
Facility 17	80,886	56	80	40,201
Facility 18	90,986	63	90	45,221

Table 10.7-7. Estimated Option 2 Total Pollutant Removals for Alaska Salmon Facilities

Model Facility	*BOD (lb/yr)*	*TN (lb/yr)*	*TP (lb/yr)*	*TSS (lb/yr)*
Facility 1	38,111	26	38	18,942
Facility 2	73,158	51	72	36,360
Facility 3	74,281	52	74	36,918
Facility 4	52,557	36	52	26,121
Facility 5	49,309	34	49	24,507
Facility 6	146,029	102	145	72,975
Facility 7	54,880	38	54	27,276
Facility 8	45,746	32	45	22,736
Facility 9	55,808	39	55	27,737
Facility 10	75,558	52	75	37,553
Facility 11	358,486	249	355	178,171
Facility 12	42,441	29	42	21,093
Facility 13	133,189	92	132	66,196
Facility 14	88,983	62	88	44,225
Facility 15	207,807	144	206	103,282
Facility 16	25,996	18	26	12,920
Facility 17	80,886	56	80	40,201
Facility 18	90,986	63	90	45,221

Table 10.7-8. Estimated Option 3 Total Pollutant Removals for Alaska Salmon Facilities

Model Facility	*BOD (lb/yr)*	*TN (lb/yr)*	*TP (lb/yr)*	*TSS (lb/yr)*
Facility 1	43,177	199	84	21,090
Facility 2	82,881	383	161	40,485
Facility 3	84,154	388	163	41,106
Facility 4	59,542	275	116	29,084
Facility 5	55,862	258	108	27,287
Facility 6	166,344	768	323	81,253
Facility 7	62,174	287	121	30,370
Facility 8	51,826	239	101	25,315
Facility 9	63,225	292	123	30,883
Facility 10	85,601	395	166	41,813
Facility 11	406,133	1,875	788	198,382
Facility 12	48,082	222	93	23,486
Facility 13	150,891	697	293	73,705
Facility 14	100,810	465	196	49,242
Facility 15	235,426	1,087	457	114,998
Facility 16	29,451	136	57	14,386
Facility 17	91,636	423	178	44,761
Facility 18	103,079	476	200	50,350

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