



Supplemental Technical Development Document for Effluent Limitations Guidelines and Standards for the Pulp, Paper, and Paperboard Category

Subpart B (Bleached Papergrade Kraft
and Soda)
and
Subpart E (Papergrade Sulfite)

**SUPPLEMENTAL TECHNICAL DEVELOPMENT DOCUMENT FOR
EFFLUENT LIMITATIONS GUIDELINES AND STANDARDS
FOR THE PULP, PAPER, AND PAPERBOARD CATEGORY
SUBPART B (BLEACHED PAPERGRADE KRAFT AND SODA)
AND
SUBPART E (PAPERGRADE SULFITE)**

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Office of Science and Technology
U.S. Environmental Protection Agency
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SECTION 1

CONCLUSIONS

1.1 Introduction

The new regulations for the pulp, paper, and paperboard industry, also known as the "Cluster Rules," include effluent limitations guidelines and standards for the control of wastewater pollutants and national emission standards for hazardous air pollutants. Information and rationale supporting the proposed effluent limitations guidelines and standards were provided in "Proposed Technical Development Document for the Pulp, Paper, and Paperboard Category Effluent Limitations Guidelines, Pretreatment Standards, and New Source Performance Standards," (the TDD) October 1993, EPA-821-R-93-019. Technical information and rationale supporting the proposed air emission standards were provided in "Pulp, Paper, and Paperboard Industry - Background Information for Proposed Air Emission Standards," (the Background Information Document, or the BID) October 1993, EPA-453-R93-050a.

To support the final regulations, EPA chose not to rewrite the entire TDD and the BID but instead to prepare several technical support documents to supplement the TDD and the BID. This document, and several others referenced herein, support the final effluent limitations guidelines and standards. The TDD is superseded to the extent that this document or the other technical documents supporting the final rule are inconsistent with it. This document is referred to in the other support documents as the Supplemental Technical Development Document (STDD), Document Control Number (DCN) 14487. This section of the STDD highlights key aspects of the final effluent limitations guidelines and standards.

1.2 Subcategorization

EPA is revising the existing subcategorization scheme for effluent limitations guidelines and standards for this industry (40 CFR Parts 430 and 431). The new effluent limitations guidelines and standards that are being promulgated today affect only those mills in the new Bleached Papergrade Kraft and Soda Subcategory (Subpart B) and the new Papergrade Sulfite Subcategory (Subpart E). EPA has reprinted in their entirety the current effluent limitations guidelines and standards that remain applicable to mills subject to the new subcategories. Table 1-1 summarizes the new subcategories and the corresponding subcategories from the existing regulations.

1.3 Scope of Rules

The proposed rules applied to mills within the U.S. Department of Commerce, Bureau of the Census Standard Industrial Classifications (SIC) 2611 (pulp mills), 2621 (paper mills except building paper mills), 2631 (paperboard mills), and 2661 (building paper and building board mills). All of the mills affected by the new effluent limitations guidelines and standards are in SIC 2611 (pulp mills). Since the proposal, the Office of Management and

Budget began to use the North American Industry Classification System (NAICS). The applicable NAICS numbers are 32211 (pulp mills), 322121 (paper mills, except newsprint mills), 322122 (newsprint mills), and 32213 (paperboard mills). The components of these rules applicable to each subcategory of the Pulp, Paper, and Paperboard Point Source Category are shown on Table 1-2.

1.4 Best Practicable Control Technology Currently Available (BPT)

EPA proposed revisions to the existing BPT effluent limitations guidelines for five-day biochemical oxygen demand (BOD₅) and total suspended solids (TSS) for all subcategories of the pulp, paper, and paperboard industry. The proposed revisions were based on the application of secondary wastewater treatment with appropriate water use and reuse. However, for the reasons set forth in the preamble to the final rules, EPA in the exercise of its discretion has decided not to revise the BPT effluent limitations guidelines for conventional pollutants for Subparts B and E. The existing BPT guidelines will continue to apply.

1.5 Best Conventional Pollutant Control Technology (BCT)

EPA proposed revisions to the BCT effluent limitations guidelines for BOD₅ and TSS for all subcategories of the pulp, paper, and paperboard industry. After proposal, EPA considered further whether technologies are available for Subparts B and E that achieve greater removals of conventional pollutants than the current BPT effluent limitations guidelines, and whether those technologies are cost reasonable according to the BCT cost test. After evaluating the candidate BCT technologies for both Subparts B and E, EPA concluded that none of the candidate options passed the BCT cost test; therefore, more stringent BCT effluent limitations guidelines are not being promulgated for Subparts B or E.

1.6 Best Available Technology Economically Achievable (BAT)

EPA is promulgating BAT effluent limitations guidelines for Subparts B and E to control toxic and nonconventional pollutants in the bleach plant effluent and in the end-of-pipe effluent. For Subpart B mills, the technology basis for these effluent limitations guidelines is complete (100 percent) substitution of chlorine dioxide for chlorine in the bleaching process along with the other elements as presented in Section 8 of this document. For Subpart E mills, the technology basis for these effluent limitations guidelines is either complete (100 percent) substitution of chlorine dioxide for chlorine in the bleaching process and other elements, or totally chlorine-free (TCF) bleaching. Section 8 of this document explains these options in more detail.

In addition to the effluent limitations guidelines based on complete substitution, EPA is promulgating for Subpart B the Voluntary Advanced Technology Incentives Program for direct discharging mills that have or plan to install advanced technology beyond that which forms the basis of today's BAT and New Source Performance Standards (NSPS). The Incentives

Program is discussed in more detail in a separate document entitled "Technical Support Document for the Voluntary Advanced Technology Incentives Program, DCN 14488."

1.7 New Source Performance Standards (NSPS)

EPA is revising the NSPS for toxic, nonconventional, and conventional (BOD₅ and TSS) pollutants for Subpart B. For Subpart B mills, the technology basis for these limitations is extended delignification followed by complete (100 percent) substitution of chlorine dioxide for chlorine in the bleaching process, well-operated biological treatment, and other elements as presented in Section 8 of this document. For Subpart E mills, EPA is revising the NSPS for toxic and nonconventional pollutants. For Subpart E mills, the technology basis for these limitations is the same as the BAT limitations.

1.8 Pretreatment Standards for Existing Sources (PSES)

EPA is revising the PSES for toxic and nonconventional pollutants for Subparts B and E. The technology basis of these standards is the same as the basis for the BAT limitations promulgated today, with the exception of biological treatment. Mills must monitor for compliance with these standards at the bleach plant effluent.

1.9 Pretreatment Standards for New Sources (PSNS)

EPA is revising the PSNS for toxic and nonconventional pollutants for Subparts B and E. The technology basis of these standards is the same as the basis for the NSPS limitations promulgated today, with the exception of biological treatment. Mills must monitor for compliance with these standards at the bleach plant effluent.

1.10 Best Management Practices (BMP)

EPA is promulgating BMPs for direct and indirect discharging mills regulated under Subparts B and E. These BMPs are intended to prevent or otherwise contain leaks and spills and to control intentional diversions of spent pulping liquor, soap, and turpentine. The BMPs will reduce wastewater loadings of nonchlorinated toxic compounds and hazardous substances and, as an incidental matter, loadings of other pollutants. These BMPs are discussed in more detail in a separate document entitled "Technical Support Document for Best Management Practices for Spent Pulping Liquor Management, Spill Prevention, and Control, DCN 14489."

Table 1-1

**Comparison of the Final Codified Subcategorization Scheme
With the Previous Subcategorization Scheme**

New Subpart	New Subcategorization Scheme	Existing Subcategorization Scheme (With Existing 40 CFR Part 430 Subparts Noted)
A	Dissolving Kraft	Dissolving Kraft (F)
B	Bleached Papergrade Kraft and Soda	Market Bleached Kraft (G), BCT Bleached Kraft (H), Fine Bleached Kraft (I), Soda (P)
C	Unbleached Kraft	Unbleached Kraft (A) - Linerboard - Bag and Other Products Unbleached Kraft and Semi-Chemical (D, V)
D	Dissolving Sulfite	Dissolving Sulfite (K) - Nitration - Viscose - Cellophane - Acetate
E	Papergrade Sulfite	Papergrade Sulfite (J,U) - Blow Pit Wash - Drum Wash
F	Semi-Chemical	Semi-Chemical (B) - Ammonia - Sodium
G	Mechanical Pulp	GW-Thermo-Mechanical (M), GW-Coarse, Molded, News (N) GW-Fine Papers (O) GW-Chemi-Mechanical (L)
H	Non-Wood Chemical Pulp	Non-Wood Chemical Pulp Mills
I	Secondary Fiber Deink	Deink Secondary Fiber (Q) - Fine Papers - Tissue Papers - Newsprint
J	Secondary Fiber Non-Deink	Tissue from Wastepaper (T) Paperboard from Wastepaper (E) - Corrugating Medium - Non-Corrugating Medium Wastepaper-Molded Products (W) Builders' Paper and Roofing Felt (40 CFR Part 431 Subpart A)

Table 1-1 (Continued)

New Subpart	New Subcategorization Scheme	Existing Subcategorization Scheme (With Existing 40 CFR Part 430 Subparts Noted)
K	Fine and Lightweight Papers from Purchased Pulp	Non-Integrated Fine Papers (R) - Wood Fiber Furnish - Cotton Fiber Furnish Lightweight Papers (X) - Lightweight Papers - Lightweight Electrical Papers
L	Tissue, Filter, Non-Woven, and Paperboard from Purchased Pulp	Non-Integrated - Tissue Papers (S) - Filter and Non-Woven (Y) - Paperboard (Z)

See the Code of Federal Regulations (CFR), Title 40, Chapter I, volume including Parts 425 to 699, Part 430, edition as of July 1, 1997, for the subcategorization scheme being supercoded. See the CFR edition to be published as of July 1, 1998, for the final codified subcategorization scheme.

Table 1-2

Application of Rules to Pulp, Paper, and Paperboard Subcategories

New Effluent Guidelines Subcategory	New Effluent Guidelines Subpart	Clean Air Act NESHAP ^a	Clean Water Act		
			Toxic & Nonconventional ^b : BAT, NSPS, PSES, and PSNS	Conventional ^c : NSPS	BMP
Dissolving Kraft	A	X			
Bleached Papergrade Kraft and Soda	B	X	X	X	X
Unbleached Kraft	C	X			
Dissolving Sulfite	D	X			
Papergrade Sulfite	E	X	X	X ^d	X
Semi-Chemical	F	X			
Mechanical Pulp	G	X ^e			
Non-Wood Chemical Pulp	H	X ^e			
Secondary Fiber Deink	I	X ^e			
Secondary Fiber Non-Deink	J	X ^e			
Fine and Lightweight Papers from Purchased Pulp	K	X ^e			
Tissue, Filter, Non-Woven, and Paperboard from Purchased Pulp	L	X ^e			

^aNational Emission Standards for Hazardous Air Pollutants.

^bToxic and nonconventional pollutants in this rulemaking include: 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD), 2,3,7,8-tetrachlorodibenzofuran (TCDF), chloroform, 12 chlorinated phenolic compounds and adsorbable organic halides (AOX). The 12 chlorinated phenolic compounds include trichlorosyringol, 2,4,5-trichlorophenol, 2,4,6-trichlorophenol, 3,4,5-trichlorocatechol, 3,4,5-trichloroguaiacol, 3,4,6-trichlorocatechol, 3,4,6-trichloroguaiacol, 4,5,6-trichloroguaiacol, tetrachlorocatechol, tetrachloroguaiacol, 2,3,4,6-tetrachlorophenol, and pentachlorophenol.

^cConventional pollutants in this rulemaking include BOD₅ and TSS.

^dEPA is not promulgating NSPS for conventional pollutants for Subpart E. Existing standards continue to apply.

^eRule applies if these mills operate a bleach plant that uses chlorine or chlorine dioxide.

SECTION 2

SCOPE OF RULEMAKING

2.1 Introduction

Approximately 565 pulp, paper, and paperboard mills operate in the United States (1). Most of these mills are subject to effluent limitations guidelines or standards as a result of regulations promulgated in the 1970s and 1980s. These existing regulations are based on the division of the mills into 26 subcategories. Each subcategory is defined by processes employed and/or products manufactured, and has a separate set of effluent regulations.

In 1993, EPA proposed revisions to the existing effluent regulations for all 565 mills and new regulations for some mills. EPA also proposed to consolidate the existing 26 subcategories into 12 new subcategories, based primarily on the pulping process used at each mill. In today's rulemaking, EPA is promulgating the revised subcategorization scheme. However, at this time, EPA is not revising the existing effluent regulations for any mills except those mills in two of the revised subcategories: Bleached Papergrade Kraft and Soda mills (Subpart B) and Papergrade Sulfite mills (Subpart E). The number of mills in each of these subcategories is discussed in Section 4 of this document.

In 1993, EPA also proposed national emission standards for hazardous air pollutants (NESHAPs) for some of the 565 mills. EPA's proposed NESHAPs would affect pulp mills in six effluent guideline subcategories (see Tables 1-2 and 2-1). Although the industry was not originally subcategorized, EPA has subcategorized the industry since the proposal for the purposes of selecting the maximum achievable control technologies (MACT) which form the basis of the NESHAPs. EPA established four subcategories for mills that chemically pulp wood fiber: kraft, sulfite, soda, and semichemical. EPA's Office of Air and Radiation (OAR) also separated the MACT standards into three components: MACT I, MACT II, and MACT III. Each component of the MACT standards is described in Section 2.3.

2.2 Effluent Limitations Guidelines and Standards

The Clean Water Act (CWA) authorizes EPA to develop the regulations to control the amount of pollutants discharged to navigable waters of the United States by industrial dischargers. In 1993, for the Pulp, Paper, and Paperboard Point Source Category, EPA proposed the following regulations:

- BPT (best practicable control technology currently available);
- BCT (best conventional pollutant control technology);
- BAT (best available technology economically achievable);
- NSPS (new source performance standards);
- PSES (pretreatment standards for existing sources); and
- PSNS (pretreatment standards for new sources).

These regulations establish quantitative limits on the discharge of pollutants from industrial point sources. As explained in the preamble and in Section 12 of this document, EPA decided not to promulgate proposed regulations for BPT and BCT; however, previously promulgated BPT and BCT regulations remain in effect. Regulations for BAT, NSPS, PSES, and PSNS are being promulgated. The applicability of the various regulations is summarized below:

	Direct Discharge	Indirect Discharge	Existing Source	New Source	Conventional Pollutants	Toxic and Nonconventional Pollutants
BPT	X		X		X	
BCT	X		X		X	
BAT	X		X			X
NSPS	X			X	X	X
PSES		X	X			X
PSNS		X		X		X

All of these regulations are based upon the performance of specific technologies but do not require the use of any specific technology. The regulations applicable to direct dischargers are effluent limitations guidelines, applied to pretreatment individual facilities through National Pollutant Discharge Elimination System (NPDES) permits issued by EPA or authorized states under Section 402 of the CWA. The regulations applicable to indirect dischargers are pretreatment standards, administered by local permitting authorities (i.e., the government entity controlling the Publicly Owned Treatment Works (POTW) to which the industrial wastewater is discharged). The pretreatment standards are designed to control pollutants that pass through or interfere with POTWs.

EPA is now promulgating BAT, NSPS, PSES, and PSNS for two subcategories of the Pulp, Paper, and Paperboard Point Source Category: the Bleached Papergrade Kraft and Soda Subcategory (Subpart B) and the Papergrade Sulfite Subcategory (Subpart E). The Bleached Papergrade Kraft and Soda Subcategory is comprised of 86 mills that use a kraft or soda pulping process followed by a bleach plant (see Section 4). The Papergrade Sulfite Subcategory is comprised of 11 mills that use a sulfite pulping process; ten of these mills have a bleach plant while one mill makes unbleached pulp.

In 1993, EPA had also proposed regulations requiring the implementation of BMPs. EPA is now promulgating BMP regulations applicable to direct and indirect discharging mills with pulp production in Subpart B or Subpart E.

2.3 NESHAPs

In 1990, Congress passed comprehensive amendments to Section 112 of the Clean Air Act. The objective of these amendments is to reduce nationwide air toxic emissions. Congress identified 189 “hazardous air pollutants” (HAPs) to be controlled by a regulatory structure based on source categories. NESHAPs based on Maximum Achievable Control Technology (MACT) must be established for new and existing sources. In no case can the NESHAPs be less stringent than the “MACT floor” for existing sources, which, roughly paraphrasing, requires the standard to be at least as stringent as the average emission limitation achieved by the best performing 12 percent of sources (Clean Air Act (CAA) Section 112(d)(2)). For more detailed discussion, see Section VI.A of the preamble for the final rules.

NESHAPs for the pulp and paper manufacturing source category are divided into three parts:

MACT I controls emissions from noncombustion sources from pulping and bleaching operations at chemical (kraft, soda, and sulfite) and semi-chemical wood pulping mills.

MACT II (which is being proposed) controls emissions from combustion sources (e.g., recovery furnaces, lime kilns, smelt dissolving tanks) from chemical recovery operations at wood pulping mills (kraft, soda, sulfite, and semichemical).

MACT III addresses emissions from noncombustion sources from mills that mechanically pulp wood, pulp secondary fibers, or pulp nonwood materials, and those that use papermachine additives and solvents.

MACT I controls primarily volatile HAPs, while MACT II controls metal HAPs.

For bleached papergrade kraft and soda mills, MACT I (for the most important emission points) is based on the performance of the following control technologies:

Collection and destruction of organic HAPs emitted by pulping area vents;

Controls on condensate streams from the digester system, evaporator system, turpentine recovery system, and high volume low concentration (HVLC) vents (brown stock washers and oxygen delignification (OD)), if any, but under a delayed compliance schedule (eight years) to encourage upgrade of brown stock washers and installation of OD;

Collection and treatment (caustic scrubber) of bleach plant vents to control hydrogen chloride and other chlorinated HAPs (other than chloroform);

Compliance with BAT limits on chloroform or elimination of hypochlorite and complete substitution of chlorine dioxide for elemental chlorine; and

Collection and treatment of pulping area condensates, including evaporator “foul” condensates by steam stripping or biological treatment.

For sulfite mills, MACT I is based on the performance of:

Collection and destruction of organic HAPs emitted by digester system vents, evaporator system vents, and pulp washing system vents;

Collection and neutralization (caustic scrubber) of organic HAPs emitted by bleach plant vents to control hydrogen chloride and other chlorinated HAPs (note that the scrubber does not control chloroform); and

Compliance with BAT limits on chloroform (these limits are based on elimination of hypochlorite and complete substitution of chlorine dioxide for elemental chlorine or totally chlorine free bleaching).

The MACT II proposal is based on:

Control of particulate HAPs by electrostatic precipitators (for recovery furnaces and lime kilns) and venturi scrubbers (for lime kilns and smelt dissolving tanks).

MACT I was proposed on December 17, 1993 (the same time as the effluent limitations guidelines) and is being promulgated today. MACT II is being proposed today. On September 29, 1995 a Presumptive MACT report was issued for the MACT III source category. Presumptive MACT is an estimate of MACT based on an assessment of readily available information and information gathered through consultation with experts in state and local agencies, EPA, environmental groups, and the regulated industry. No information was identified during the Presumptive MACT process to suggest that sources associated with the MACT III source category warrant listing pursuant to Section 112(c)(3) of the CAA.

Further, MACT III sources have no air pollution control devices, so the floor for these sources is no control. In addition, available information indicates add-on controls would not be cost effective for most emission points. EPA, therefore, decided in most instances not to require controls beyond the floor. Mills covered by MACT III must still collect and treat bleach

plant vents if they operate bleach plants that use chlorine or chlorinated compounds.

EPA has taken no action on MACT standards for chemical additives and solvents at the paper machines. If information becomes available regarding cost-effective HAP controls beyond the floor for these sources, EPA will propose a MACT standard in the future.

2.4 References

1. Development Document for Proposed Effluent Limitations Guidelines and Standards for the Pulp, Paper, and Paperboard Point Source Category.
EPA-821-R-93-019, U.S. EPA, Washington DC, October 1993.

Table 2-1**Application of Rules to Pulp, Paper, and Paperboard Subcategories**

NESHAP Subcategory	New Effluent Guidelines Subpart	Today's Clean Water Act Rules	Clean Air Act Rules		
			MACT I	MACT II	MACT III
Dissolving Kraft Pulping	A		X	X	X
Papergrade Kraft and Soda Pulping	B	X	X	X	X
Unbleached Kraft Pulping	C		X	X	X
Dissolving Sulfite Pulping	D		X	X	X
Papergrade Sulfite Pulping	E	X	X	X	X
Semi-Chemical Pulping	F		X	X	X
Mechanical Pulping	G				X ^a
Non-Wood Pulping	H				X ^a
Secondary Fiber Pulping	I, J				X ^a
Papermaking Systems	K-L ^c				X ^b

^aIf these mills operate a bleach plant that uses chlorine or chlorine dioxide.

^bConsidered under MACT III but no controls are required.

^cApplicable to stand-alone papermaking systems; such systems at integrated mills are covered by the effluent limitations guidelines for the applicable subparts.

SECTION 3

SUMMARY OF DATA COLLECTION METHODS

3.1 Introduction

EPA collected information necessary for the development of the effluent limitations guidelines and standards from many sources, including several Agency and industry sampling programs, an industry-wide census questionnaire, questionnaire surveys submitted to mills in other countries, industry trade associations, public meetings, mill site visits, conferences, literature reviews, and other EPA offices. The data sources utilized for the proposed rules were described in the TDD. This section describes the data collected since proposal.

3.2 Data Received Since Proposal

EPA has gathered a substantial amount of new information and data since proposal. Much of this information was collected with the cooperation and support of the American Forest and Paper Association (AF&PA) and the National Council of the Paper Industry for Air and Stream Improvement Inc. (NCASI). Many individual mills in the U.S. and abroad, as well as environmental groups have also assisted in gathering this information. The comments received on the proposal and the July 1996 notice of data availability were also an important source of information. The data gathering activities for this final rule are summarized in detail in the proposal (58 FR at 66096), and in the July 15, 1996 notice of data availability (61 FR at 36837).

Some of the new information and data were generated through EPA-sponsored field sampling or visits at individual mills in the U.S., Canada, and Europe. Additional sampling data were voluntarily supplied by many facilities, along with information from laboratory and pilot-scale studies. In order to respond to and clarify comments on the proposal, the Agency also gathered and received voluntarily submitted information including data on secondary fiber mill processes, recovery furnace capacities, best management practices, capital and operating costs, process operations, and impacts of pollution prevention technology on the recovery cycle. Some of the major data collection activities are listed in Table 3-1 with references to the rulemaking record section(s) where the information can be found.

3.3 Integrated Regulatory Development

In 1990, EPA established the Pulp and Paper Regulatory Cluster, comprised of representatives from various EPA offices. One role of the Pulp and Paper Regulatory Cluster was to identify optimal approaches to solving environmental problems associated with the pulp and paper industry through regulatory coordination. As a result of the Cluster's efforts, the effluent limitations guidelines and the NESHAP rulemakings for the pulp and paper industry were integrated and jointly proposed. Regulation of land application of pulp and paper mill

sludge also was considered in the Agency's coordinated regulatory strategy. The joint proposal of the effluent limitations and NESHAPs eventually became known as the Cluster Rules.

The first step in developing the Cluster Rules was to collect mill-specific information from all facilities subject to both the effluent limitations and the NESHAPs. As described in Section 3.0 of the TDD, EPA used information from many sources to develop the integrated regulatory options proposed in 1993. The information collected includes the process and control technologies in use, data representing the performance of these technologies, and financial information used in the analysis of the economic impact of these options. This information was compiled in a mill-specific database for use in developing the effluent limitations and NESHAPs. Estimated costs, pollutant reductions, and other environmental impacts for each regulatory alternative were then developed and various combinations of these alternatives were analyzed. See the Economic Analysis (DCN 14649) for a detailed presentation of the economic and related analyses (3).

The control technologies considered as the bases for BAT, PSES, NSPS, and PSNS are described in Sections 7.0 and 8.0. The control technologies considered as the bases for BMP and NESHAP are described in separate documents (1,2). The control options for BAT and PSES involve pulping and bleaching process changes. The performance of existing secondary biological wastewater treatment systems employed by direct dischargers and POTWs also were considered in developing these options. The BMP requires prevention and control of leaks, spills, and intentional diversions of spent pulping liquor, soap, and turpentine. The NESHAP control technologies include steam strippers, combustion, and caustic scrubbing. Steam strippers are used to remove HAPs from pulping area condensates. The "clean condensate alternative" in the MACT I standards also allow mills as a compliance alternative to treat hard pipe condensates in end-of-pipe secondary biological treatment systems. See the preamble for the final rules at Section VI.A.3(d). Combustion devices are used to destroy non-chlorinated HAPs removed by steam strippers and hard-piped air emission streams. Combustion devices include stand-alone devices such as thermal incinerators or existing devices such as lime kilns, power boilers, and recovery furnaces. Caustic scrubbers and process changes are used to reduce chlorinated HAP emissions in the bleaching area.

EPA developed regulatory alternatives based on pulping and bleaching process changes alone, air emission control options alone, and combinations of process changes and air emission controls. Each regulatory alternative also included secondary wastewater treatment, and spill prevention and control components. The alternatives were designed to evaluate the most efficient application of control technologies to minimize the cross-media transfer of pollutants between air and water, and partitioning of pollutants (e.g., dioxins) to sludges and pulps. EPA's economic analysis summarizes the costs and benefits of each regulatory alternative evaluated by EPA for the final cluster rules (3).

EPA evaluated whether the pulping and bleaching process changes that form the basis of BAT and PSES reduce HAP emissions sufficiently to satisfy CAA requirements. Based on available data, the analyses showed that the use of the bleaching process technologies

decrease uncontrolled emissions of chlorinated HAPs (including chloroform, chlorine, and hydrochloric acid), but increase others. This decrease in uncontrolled air emissions of chlorinated HAPs is attributable to the elimination of hypochlorite as a bleaching agent and use of complete chlorine dioxide substitution. However, uncontrolled air emissions of some non-chlorinated HAPs, including methanol, methyl ethyl ketone, and formaldehyde, show modest increases as a result of the bleaching process changes (see Section 11). EPA decided that the bleaching process changes and existing bleach plant caustic scrubbers sufficiently reduced and controlled emissions of chlorinated HAPs. However, additional controls were needed in the pulping area to satisfy the CAA requirements for non-chlorinated HAPs.

EPA also considered the effect of the air pollution controls on effluent loadings of toxic and nonconventional pollutants. The analyses showed that the major air pollution controls that form the basis for NESHAP (steam stripping, combustion, and caustic scrubbing) did not significantly affect effluent loadings of these pollutants. Steam stripping systems remove compounds from pulping area condensates. Combustion destroys the compounds removed from the condensates along with most compounds emitted from process vents. Steam stripping and combustion reduce the amount of pollutants that could enter surface waters due to deposition and the volume of wastewater discharged to the wastewater treatment system. Chlorinated HAPs that remain in bleaching area wastewaters after process changes are implemented react with caustic in the scrubber, neutralizing the caustic effluent. Non-chlorinated HAPs that absorb into the caustic are bio-degradable, and are not estimated to significantly increase the pollutant load to the wastewater treatment system. Caustic scrubbing operations are also not expected to significantly increase the volume of wastewater discharges to the wastewater treatment system.

The analyses of multiple regulatory alternatives showed that no single control or process change technology is currently available to reduce pollutant discharges to the air and water to levels required by the respective statutes. The demonstrated control technologies that can serve as bases for BMP, BAT, PSES, NSPS, and PSNS pose no significant adverse impacts to and have some benefits for air quality. Similarly, the BMPs reduce leaks and spills and are capable of reducing intentional diversions of pulping liquors, soaps, and turpentine while increasing recovery of important process chemicals and energy (1); the air emissions control technologies that can serve as the basis for NESHAP pose no significant adverse impacts on and have some benefits for water quality. Therefore, combining the best control technology options for effluent limitations with the best control technology options for air emission standards represents a reasonable method for constructing the final regulatory alternative. EPA selected control options for the final rulemaking based on evaluation of pollutant reductions; costs; and economic, nonwater quality and non-air quality, and energy impacts (3). EPA also considered cost effectiveness and environmental impacts.

3.4 **References**

1. Technical Support Document for Best Management Practices for Spent Pulping Liquor Management, Spill Prevention, and Control. EPA, Washington DC, Record Section 30.9, DCN 14489, 1997.
2. Anderson, Donald F., Memorandum on Data Available for Development of COD Limitations. Record Section 22.4, DCN 14788, September 30, 1997.
3. Economic Analysis for the National Emission Standards for Hazardous Air Pollutants for Source Category: Pulp and Paper Production; Effluent Limitations Guidelines, Pretreatment Standards, and New Source Performance Standards: Pulp, Paper, and Paperboard Category - Phase I. Prepared by ERG for EPA. Record Section 30.5, DCN 14649, 1997.

Table 3-1**Major Post-Proposal Data Sources**

Data Source	Record Section
Public Comments	19.1
Voluntary Data Submissions from Industry (NCASI, AF&PA)	21.1
Secondary Fiber Questionnaires	21.1.1
Recovery Furnace Capacity Surveys	21.1.2
BMP Questionnaire	21.1.3
Capital and Operating Cost Requests	21.1.4
Operating Data Requests for Recently Installed Pulping and Bleaching Technologies	21.1.5
Request for Information About the Impact of Technologies on the Recovery Cycle	21.1.6
Data Supplied by Individual U.S. Mills	21.6.1.1
Data Collected by EPA at U.S., Canadian, and European Mills	21.6.1.2
Data Supplied by NCASI from Canadian Mills	21.6.1.7
Laboratory Trial Data Submitted by Individual Companies (Dissolving Mills and Papergrade Sulfite Mills)	21.11
Other Data Supplied by NCASI	21.12

SECTION 4

INDUSTRY PROFILE

4.1 Introduction

This section discusses the number of pulp and paper mills included in the effluent limitations guidelines analyses. The mill counts in this section have been updated for the Bleached Papergrade Kraft and Soda and Papergrade Sulfite subcategories only.

The Office of Water promulgation baseline is mid-1995. The EPA mid-1995 database includes 86 bleached papergrade kraft and soda mills and 11 papergrade sulfite mills. The total number of bleached kraft mills was reduced from 88 at proposal to 86 now, due to the closing of one bleached papergrade kraft mill (Simpson Paper, Fairhaven, CA) and the reclassification of another mill as unbleached kraft (Port Townsend, Port Townsend, WA). All 11 papergrade sulfite mills (one mill received BMP cost estimates only, Great Northern Paper, Millinocket, ME) and 84 of the 86 bleached papergrade kraft and soda mills have been included in EPA's mid-1995 cost and loading estimation efforts (See Section 10 and Section 9, respectively). Note that one mill manufactures both bleached papergrade kraft and papergrade sulfite pulp, so there are a total of 96 mills in the two subcategories.

Table 4-1 lists the mills not included in the costs and loadings analyses presented in the July 1986 notice. Costs and loadings estimates for the Georgia-Pacific specialty grade sulfite mill in Bellingham, WA were not included in the July 1996 Notice. Estimates for this mill are included, however, in the results presented in this document. As of mid-1995, the Bellingham mill was the only mill in the Specialty Grade segment of Subpart E. EPA expects another papergrade sulfite facility to enter the specialty-grade market in the near future. Also, Badger Paper's papergrade sulfite mill in Peshtigo, WI shut down its pulping process in September 1996 (paper making operations have continued) but is *still included* in the analyses because EPA's baseline remained mid-1995.

Table 4-2 provides a summary of applicability and mill counts by subcategory. The table shows each component of the joint rulemaking (MACT, BAT, PSES, and BMPs) and illustrates that **all** components apply to mills in the bleached papergrade kraft and soda and papergrade sulfite subcategories. Because EPA decided not to revise BPT and BCT, these regulations have been removed from this analysis. Table 4-3 shows the applicability of each component for each of the 97 mills currently included in EPA's database.

Additional details on applicability for each of the effluent guideline subcategories included in the rulemaking are presented in the following subsections.

4.2 Bleached Papergrade Kraft and Soda Subcategory

The bleached papergrade kraft and soda mills subject to BAT, PSES, MACT, and BMPs as well as specific mills that did not receive costs or loadings estimates are discussed below.

Of the 86 bleached papergrade kraft and soda mills, **84** mills produce bleached papergrade kraft products and **2** produce bleached papergrade soda products.

MACT applies to these **86** mills.

One mill (James River, Camas, WA) produces both bleached papergrade kraft and bleached papergrade sulfite products (and is counted in both subcategories).

One mill (Stone Container Corp., Snowflake, AZ) did not receive costs and loadings estimates even though BAT/PSES and BMPs apply. The mill has announced it will cease bleached kraft production. The mill currently has a functional bleach plant and is counted in the bleached kraft subcategory, but is expected to be reclassified as unbleached kraft after promulgation. Costs and loadings will be estimated in the phase II rulemaking for unbleached kraft production.

One mill (Port Townsend Paper, Port Townsend, WA) does not have a conventional bleach plant, and only brightens with peroxide and sodium hydroxide. This mill was counted as bleached papergrade kraft at proposal but has now been reclassified as unbleached kraft.

One mill (Longview Fibre, Longview, WA) shut down its chlorine-based bleach plant in March 1994. In 1995 and through October 1996, a small amount of semi-bleached pulp using one stage of peroxide bleaching was processed. EPA did not estimate compliance costs and loadings reductions for this mill. But, because the mill has a functional bleach plant, it has not been reclassified as unbleached kraft. BAT/PSES and BMPs apply but no costs or loadings were estimated, on the assumption that the mill would cease bleached kraft production rather than invest in new bleaching technology. Costs and loadings will be estimated in the phase II rulemaking for unbleached kraft production.

Of the 77 mills to which BAT applies, **75** received BAT cost and loading estimates. (As mentioned previously, cost and loading estimates were not prepared for Stone Container, Snowflake, and Longview Fibre, Longview.)

PSES applies to **9** mills.

BMPs apply to **86** mills. BMPs apply to Stone Container, Snowflake and Longview Fibre, Longview, but no BMP costs were estimated, based on the assumption they have or will cease bleached kraft production.

4.3 Papergrade Sulfite Subcategory

The papergrade sulfite mills subject to BAT, PSES, MACT, and BMPs along with the one mill that only received BMP costs are described below.

In the U.S., **11** mills currently produce papergrade sulfite products (the papergrade sulfite subcategory covers mills with both bleached and unbleached production).

One mill produces only unbleached sulfite products. BAT applies, but they are assumed to have no cost. BMP costs were estimated.

One mill (James River, Camas, WA) produces both bleached papergrade kraft and bleached papergrade sulfite products (and is counted in both subcategories).

One of the mills is both a direct and an indirect discharger. However, wastewater from its pulping and bleaching operations is discharged to a POTW, so this mill is covered by PSES for the papergrade sulfite subcategory, not BAT.

MACT applies to **11** mills.

Of the 10 mills to which BAT applies, **9** received cost and loadings estimates.

PSES applies to **1** mill.

BMPs apply to **11** mills.

4.4 Trends in the Industry

The development of increasingly more advanced process technologies that minimize the discharge of wastewater and wastewater pollutants is a critical step toward the Clean Water Act's ultimate goal of eliminating the discharge of pollutants into the nation's waters. EPA is interested in encouraging development of advanced technologies for broader commercial applications (1). As these technologies become proven and their efficiencies publicized, EPA hopes that they will become standard industry practice. Thus, EPA believes it is

in the public interest to encourage mills today to develop environmentally beneficial technology and to provide incentives for mills that are innovative and forward-looking in their use of new technologies that are more environmentally and cost effective despite their greater initial capital cost.

4.5 References

1. Technical Support Document for the Voluntary Advanced Technology Incentives Program. EPA, Washington DC, Record Section 22.8, DCN 14488.

Table 4-1**Mills Omitted from EPA's Mid-1995 BAT/PSES Cost and Loadings Estimates**

Subcat.	Company	Location	Reason for Omission
B	Stone Container Corp.	Snowflake, AZ	Mill is expected to cease bleached pulp production before Cluster Rules take effect. Removed from costs and loadings estimates.
B	Simpson Paper Co.	Fairhaven, CA	Closed in March 1993
E	Great Northern Paper	Millinocket, ME	Unbleached sulfite (BMP costs only)
C	Port Townsend Paper	Port Townsend, WA	No bleach plant but was misclassified as BPK at proposal
B	Longview Fibre Co.	Longview, WA	Chlorine-based bleaching curtailed March 1994

Table 4-2**Mid-1995 Applicability and Mill Counts by Subcategory**

Effluent Subcategory	Number of Mills in this Subcategory	Clean Air Act MACT	Clean Water Act		
			BAT	PSES	BMP
Bleached Papergrade Kraft and Soda	86	86	77	9	86
Papergrade Sulfite	11	11	10	1	11
Number of Mills Affected ^a	96	96	86	10	96

^aOne mill has production in both subcategories so total mills affected is one less than the sum of the mills in the two subcategories.

Table 4-3**Applicability by mill for the Bleached Papergrade Kraft and Soda and Papergrade Sulfite Facilities**

Company	Mill	State	Subcat	Discharge Status	MACT	BAT	PSES	BMP	Comments
Alabama Pine Pulp	Claiborne (Perdue Hill)	AL	B	Direct	`	`		`	
Alabama River Pulp Co. Inc.	Claiborne (Perdue Hill)	AL	B	Direct	`	`		`	
Appleton Papers Inc.	Roaring Spring	PA	B	Direct	`	`		`	
Badger Paper Mills Inc.	Peshtigo	WI	E	Direct, Indirect	`		`	`	Recently shut down its pulping process.
Boise Cascade Corp.	Deridder	LA	B	Direct	`	`		`	
Boise Cascade Corp.	International Falls	MN	B	Direct	`	`		`	
Boise Cascade Corp.	Jackson	AL	B	Direct	`	`		`	
Boise Cascade Corp.	St. Helens	OR	B	Indirect	`		`	`	
Boise Cascade Corp.	Wallula	WA	B	Direct	`	`		`	
Bowater Inc.	Calhoun	TN	B	Direct	`	`		`	
Bowater Inc.	Catawba	SC	B	Direct	`	`		`	
Champion International Corp.	Canton	NC	B	Direct	`	`		`	
Champion International Corp.	Cantonment (Pensacola)	FL	B	Direct	`	`		`	
Champion International Corp.	Courtland	AL	B	Direct	`	`		`	
Champion International Corp.	Houston (Sheldon)	TX	B	Direct	`	`		`	
Champion International Corp.	Lufkin	TX	B	Direct	`	`		`	
Champion International Corp.	Quinnesec (Norway)	MI	B	Direct	`	`		`	
Chesapeake Paper Products Co.	West Point	VA	B	Direct	`	`		`	
Consolidated Papers Co.	Wisconsin Rapids	WI	B	Direct	`	`		`	
Container Corp. of America (Jefferson Smurfit)	Brewton	AL	B	Direct	`	`		`	

Table 4-3 (Continued)

Company	Mill	State	Subcat	Discharge Status	MACT	BAT	PSES	BMP	Comments
Federal Paper Board Co. (International Paper)	Augusta	GA	B	Direct	`	`		`	
Federal Paper Board Co. (International Paper)	Riegelwood	NC	B	Direct	`	`		`	
Finch Pruyn & Co Inc.	Glens Falls	NY	E	Direct	`	`		`	
Fraser Paper (Cross Pointe)	Park Falls	WI	E	Direct	`	`		`	
Georgia-Pacific Corp.	Ashdown	AR	B	Direct	`	`		`	
Georgia-Pacific Corp.	Bellingham	WA	E	Direct	`	`		`	
Georgia-Pacific Corp.	Brunswick	GA	B	Direct	`	`		`	
Georgia-Pacific Corp.	Crossett	AR	B	Direct	`	`		`	
Georgia-Pacific Corp. (Nekoosa)	Nekoosa	WI	B	Direct	`	`		`	
Georgia-Pacific Corp. (Leaf River)	New Augusta	MS	B	Direct	`	`		`	
Georgia-Pacific Corp.	Palatka	FL	B	Direct	`	`		`	
Georgia-Pacific Corp. (Nekoosa)	Port Edwards	WI	E	Direct	`	`		`	
Georgia-Pacific Corp.	Woodland	ME	B	Direct	`	`		`	
Georgia-Pacific Corp.	Zachary (Port Hudson)	LA	B	Direct	`	`		`	
Gilman Paper Co.	St. Marys	GA	B	Direct	`	`		`	
Great Northern Paper Co.	Millinocket	ME	E	Direct	`	`		`	Only unbleached sulfite.
Gulf States Paper Corp.	Demopolis	AL	B	Direct	`	`		`	
International Paper Co.	Bastrop	LA	B	Direct	`	`		`	
International Paper Co.	Erie	PA	B	Indirect	`		`	`	
International Paper Co.	Georgetown	SC	B	Direct	`	`		`	
International Paper Co. (And'scogn)	Jay	ME	B	Direct	`	`		`	
International Paper Co.	Mobile	AL	B	Direct	`	`		`	
International Paper Co.	Moss Point	MS	B	Indirect	`		`	`	

Table 4-3 (Continued)

Company	Mill	State	Subcat	Discharge Status	MACT	BAT	PSES	BMP	Comments
International Paper Co.(Hammermill)	Pine Bluff	AR	B	Direct	`	`		`	
International Paper Co. (Riverdale)	Selma	AL	B	Direct	`	`		`	
International Paper Co.	Texarkana	TX	B	Direct	`	`		`	
International Paper Co.	Ticonderoga	NY	B	Direct	`	`		`	
James River Corp. (Crown Paper Co.)	Berlin	NH	B	Direct	`	`		`	
James River II Inc	Camas	WA	E	Direct	`	`		`	
James River II Inc	Camas	WA	B	Direct	`	`		`	
James River Corp. (Wauna Mill)	Clatskanie	OR	B	Direct	`	`		`	
James River Corp.	Old Town	ME	B	Direct	`	`		`	
James River Corp. (Naheola Mill)	Pennington	AL	B	Direct	`	`		`	
James River II Inc. (Crown Paper)	St. Francisville	LA	B	Direct	`	`		`	
Kimberly Clark Corp.	Coosa Pines	AL	B	Direct	`	`		`	
Kimberly-Clark Corp.	Everett	WA	E	Direct	`	`		`	
Lincoln Pulp & Paper Co.	Lincoln	ME	B	Direct	`	`		`	
Longview Fibre	Longview	WA	B	Direct	`	`		`	No costs estimated.
Louisiana-Pacific Corp.	Samoa	CA	B	Direct	`	`		`	TCF bleaching process.
Mead Corp.	Chillicothe	OH	B	Direct	`	`		`	
Mead Corp.	Escanaba	MI	B	Direct	`	`		`	
Mead Corp.	Rumford	ME	B	Direct	`	`		`	
P. H. Glatfelter Co.	Spring Grove	PA	B	Direct	`	`		`	
Pope & Talbot Inc.	Halsey	OR	B	Direct	`	`		`	

Table 4-3 (Continued)

Company	Mill	State	Subcat	Discharge Status	MACT	BAT	PSES	BMP	Comments
Port Townsend Paper	Port Townsend	WA	B	Direct					No bleach plant/Reclassified as unbleached kraft.
Potlatch Corp.	Cloquet	MN	B	Indirect	`		`	`	
Potlatch Corp.	Lewiston	ID	B	Direct	`	`		`	
Potlatch Corp.	McGehee	AR	B	Direct	`	`		`	
Procter & Gamble Paper	Mehoopany	PA	E	Direct	`	`		`	
S.D. Warren (SAPPI)	Hinckley (Skowhegan)	ME	B	Direct	`	`		`	
S.D. Warren (SAPPI)	Muskegon	MI	B	Indirect	`		`	`	
S.D. Warren (SAPPI)	Westbrook	ME	B	Direct	`	`		`	
Scott Paper Co./SAPPI	Mobile	AL	B	Direct	`	`		`	
Simpson Paper Co.	Anderson	CA	B	Direct	`	`		`	
Simpson Paper Co.	Fairhaven	CA	B	Direct					Closed in March 1993.
Simpson Paper Co.	Pasadena	TX	B	Indirect	`		`	`	
Simpson Tacoma Kraft Co.	Tacoma	WA	B	Direct	`	`		`	
St. Joe Forest Products Co.	Port St. Joe	FL	B	Indirect	`		`	`	
Stone Container Corp.	Missoula	MT	B	Direct	`	`		`	
Stone Container Corp.	Panama City	FL	B	Indirect	`		`	`	
Stone Container (Savannah River)	Pt. Wentworth	GA	B	Direct	`	`		`	
Stone Container Corp.	Snowflake	AZ	B	N	`	`		`	No costs and loadings estimated.
Temple Inland Forest Products	Evadale (Silsbee)	TX	B	Direct	`	`		`	
Union Camp Corp.	Eastover	SC	B	Direct	`	`		`	

Table 4-3 (Continued)

Company	Mill	State	Subcat	Discharge Status	MACT	BAT	PSES	BMP	Comments
Union Camp Corp.	Franklin	VA	B	Direct	`	`		`	One OZ-ECF SWD line.
Wausau Paper Mills Co.	Brokaw	WI	E	Direct	`	`		`	
Westvaco Corp.	Covington	VA	B	Direct	`	`		`	
Westvaco Corp.	Luke	MD	B	Indirect	`		`	`	
Westvaco Corp.	Wickliffe	KY	B	Direct	`	`		`	
Weyerhaeuser Paper Co.	Columbus	MS	B	Direct	`	`		`	
Weyerhaeuser Paper Co.	Longview	WA	B	Direct	`	`		`	
Weyerhaeuser Paper Co.	New Bern	NC	B	Direct	`	`		`	
Weyerhaeuser/Flint River Mill	Oglethorpe	GA	B	Direct	`	`		`	
Weyerhaeuser Paper Co.	Plymouth	NC	B	Direct	`	`		`	
Weyerhaeuser Paper Co.	Rothschild	WI	E	Direct	`	`		`	
Willamette Industries Inc.	Bennetsville	SC	B	Direct	`	`		`	
Willamette Industries Inc.	Hawesville	KY	B	Direct	`	`		`	
Willamette (Penntech Papers Div.)	Johnsonburg	PA	B	Direct	`	`		`	
Willamette Industries Inc.	Kingsport	TN	B	Direct	`	`		`	

NA - Not Applicable, no costs and loadings were determined for this mill.

Note: James River, Camas, WA has production in both subcategories.

SECTION 5

SUBCATEGORIZATION

5.1 Introduction

EPA proposed a new subcategorization scheme to replace the former subcategorization scheme found in 40 CFR Part 430 (Pulp, Paper, and Paperboard Point Source Category) and 40 CFR Part 431 (The Builder's Paper and Board Mills Point Source Category). The new subcategorization scheme consolidates into 12 subcategories what had once been 26 subcategories. EPA's reasons for combining and reorganizing the subcategories are described in the proposal (see 58 FR 66098-66100) and in a document entitled "Selected Issues Concerning Subcategorization" (1). EPA solicited comment on whether any specific subcategories proposed should be divided into smaller subcategories and whether any specific subcategories proposed should be combined to form larger subcategories. This section provides a description of the industry subcategorization in effect prior to the promulgation of this rule, describes EPA's methodology in developing the proposed subcategorization scheme, provides summaries of comments received on the proposed subcategorization scheme, provides EPA's assessment of the subcategorization comments, and presents EPA's final determinations on the subcategorization scheme.

5.2 Description of the Industry Subcategorization in Effect Prior to the Promulgation of this Rule

Manufacturing processes and untreated wastewater characteristics (i.e., pollutant loadings which varied somewhat by final product produced) were the principal factors used to subcategorize the industry prior to this rulemaking. Data used to determine that subcategorization represented the state of the industry during the early-to-mid 1970s. At that time, the overall level of wastewater treatment provided by the industry was not consistent among mills with similar manufacturing processes. EPA concluded at that time that untreated wastewater pollutant loadings provided a reasonable basis to subcategorize the industry principally because the costs of compliance for mills with similar untreated wastewater pollutants loadings to achieve uniform effluent levels were similar.

The subcategorization in effect prior to the promulgation of this rule was:

40 CFR Part 430

- ∨ Subpart A - Unbleached Kraft;
- ∨ Subpart B - Semi-Chemical;
- ∨ Subpart C - Reserved;
- ∨ Subpart D - Unbleached Kraft-Neutral Sulfite Semi-Chemical (Cross Recovery);
- ∨ Subpart E - Paperboard from Wastepaper;

- ˘ Subpart F - Dissolving Kraft;
- ˘ Subpart G - Market Bleached Kraft;
- ˘ Subpart H - Board, Coarse, and Tissue (BCT) Bleached Kraft;
- ˘ Subpart I - Fine Bleached Kraft;
- ˘ Subpart J - Papergrade Sulfite (Blow Pit Wash);
- ˘ Subpart K - Dissolving Sulfite Pulp;
- ˘ Subpart L - Groundwood-Chemi-Mechanical;
- ˘ Subpart M - Groundwood-Thermo-Mechanical;
- ˘ Subpart N - Groundwood-Coarse, Molded, and News (CMN) Papers;
- ˘ Subpart O - Groundwood-Fine Papers;
- ˘ Subpart P - Soda;
- ˘ Subpart Q - Deink Secondary Fiber;
- ˘ Subpart R - Non-Integrated-Fine Papers;
- ˘ Subpart S - Non-Integrated-Tissue Papers;
- ˘ Subpart T - Tissue from Wastepaper;
- ˘ Subpart U - Papergrade Sulfite (Drum Wash);
- ˘ Subpart V - Unbleached Kraft and Semi-Chemical;
- ˘ Subpart W - Wastepaper-Molded Products;
- ˘ Subpart X - Non-Integrated-Lightweight Papers;
- ˘ Subpart Y - Non-Integrated-Filter and Non-Woven Papers;
- ˘ Subpart Z - Non-Integrated-Paperboard; and

40 CFR Part 431

- ˘ Subpart A - Builders' Paper and Roofing Felt.

5.3 Revised Industry Subcategorization

Since the early-to-mid 1970s, all but one of the direct discharging mills have installed secondary wastewater treatment systems. End-of-pipe discharge data supplied in the 1990 Census Questionnaire for most mills show that the degree of end-of-pipe wastewater treatment provided by the industry is much more uniform than it was during the 1970s. In consideration of the factors in CWA Section 304(b), EPA has determined that the subcategorization analysis for this pulp, paper, and paperboard industry is more appropriately conducted based on manufacturing processes employed and engineering aspects of the application of various types of control techniques rather than raw waste loads. EPA believes that these factors more accurately represent a mill's ability to comply with effluent limitations guidelines and standards and achieve pollutant reductions.

As discussed in Section 5.3.1 of the Proposed Technical Development Document, the pulp, paper, and paperboard industry can be classified by major production processes. These production processes and the applicable former subcategories are listed below.

Integrated Pulp and Paper MillsChemical Pulp Mills

- Kraft and Soda Mills
 - Dissolving Kraft (Subpart F)
 - Bleached Papergrade Kraft (Subparts G, H, I)
 - Bleached Papergrade Soda (Subpart P)
 - Unbleached Kraft (Subparts A, D, V)
 - Sulfite Mills
 - Dissolving Sulfite (Subpart K)
 - Papergrade Sulfite (Subparts J and U)

- Non-Wood Fiber Pulp Mills

Semi-Chemical Pulp Mills (Subparts B, D, V)Mechanical Pulp Mills

- Stone Groundwood (Subparts N and O)
 - Refiner
 - Thermo-Mechanical (Subpart M)
 - Chemi-Mechanical (Subpart L)
 - Chemi-Thermo-Mechanical

Secondary Fiber Mills

- Deink Mills (Subpart Q)
 - Non-Deink Mills (Subparts E, T, W, and Part 431 Subpart A)

Non-Integrated Paper Mills (Subparts R, S, X, Y, Z) (producers of products from purchased pulp)

The classification of the industry by major production processes addresses many of the statutory factors set forth in CWA Section 304(b), including manufacturing processes and equipment (e.g., chemical, mechanical, and secondary fiber pulping; pulp bleaching; paper making); raw materials (e.g., wood, secondary fiber, non-wood fiber, purchased pulp); products manufactured (e.g., unbleached pulp, bleached pulp, finished paper products); and, to a large extent, untreated and treated wastewater characteristics (e.g., BOD₅ loadings, presence of toxic chlorinated compounds from pulp bleaching) and process water usage and discharge rates. EPA determined that other factors such as size, age, and geographical locations were not significant factors to explain the technical feasibility or economic achievability of effluent limitations guidelines and standards for this industry. As a result, the Agency used the production process classifications described above as a starting point for reviewing subcategorization.

Most manufacturing processes at pulp, paper, and paperboard mills generate wastewaters that contain substantial quantities of the conventional pollutants BOD₅ and TSS.

Furthermore, efficient BOD₅ removal is a principal design objective for pulp, paper, and paperboard mill wastewater treatment systems. For these reasons, BOD₅ and TSS are important measures of pollution generation and wastewater treatability for the pulp and paper industry. Although EPA is making no changes to BPT and BCT conventional pollutant limitations previously promulgated for any subcategories at this time, EPA is revising NSPS for the conventional pollutants BOD₅ and TSS for the Bleached Papergrade Kraft and Soda Subcategory. In addition, effective secondary biological treatment is a component of the revised BAT and PSES technology bases for the Bleached Papergrade Kraft and Soda and the Papergrade Sulfite Subcategories. Therefore, EPA has determined that BOD₅ loadings are an important component of the Agency's subcategorization analysis.

EPA examined the status of the industry with respect to treatment of BOD₅ to determine if the former subcategories adequately represent current industry characteristics. The Agency determined that, based upon the present status of the industry, many of the former subcategories are no longer necessary because mills with similar production processes have, at reasonable costs, achieved similar production normalized effluent quality, notwithstanding differences in untreated wastewater pollutant loadings. Accordingly, EPA used effluent quality, in terms of final effluent production normalized BOD₅ load, as a basis to further subcategorize the industry beyond the major process classifications set forth above.

Using the methodology described in Section 5.0 of the Technical Development Document for the proposed rule (2), the Agency compared average and range of production-normalized final effluent BOD₅ loadings of the mills selected to represent each former subcategory. Subcategories with similar process technologies were compared. Based upon these comparisons, the Agency determined that several former subcategories exhibited similar treated wastewater characteristics, and that these subcategories might be grouped or combined into revised subcategories. EPA's revised subcategorization scheme is listed below (see also Table 1-1).

40 CFR Part 430

- ˘ Subpart A - Dissolving Kraft;
- ˘ Subpart B - Bleached Papergrade Kraft and Soda;
- ˘ Subpart C - Unbleached Kraft;
- ˘ Subpart D - Dissolving Sulfite;
- ˘ Subpart E - Papergrade Sulfite;
- ˘ Subpart F - Semi-Chemical;
- ˘ Subpart G - Mechanical Pulp;
- ˘ Subpart H - Non-Wood Chemical Pulp;
- ˘ Subpart I - Secondary Fiber Deink;
- ˘ Subpart J - Secondary Fiber Non-Deink;
- ˘ Subpart K - Fine and Lightweight Papers from Purchased Pulp;
- ˘ Subpart L - Tissue, Filter, Non-Woven, and Paperboard from Purchased Pulp.

5.3.1 All Mills

Some commenters on the proposed rule indicated that EPA should retain the former subcategorization scheme, which was based on an evaluation of raw waste loads and flows. One commenter stated that if EPA insists on revising the subcategories, the Agency must also evaluate raw waste loads, product type, fiber furnish, and raw waste treatability in addition to effluent loads.

EPA has determined that the groupings in Subparts A through L (excluding Subparts B and E discussed in Sections 5.3.2 and 5.3.3, respectively) are appropriate since they are comprised of mills using similar processes and attaining similar effluent quality. EPA will consider evaluating the relationship between raw waste loads and treated effluent waste loads along with other factors suggested by commenters that may affect the reasonableness of the groupings when EPA determines whether new or revised effluent limitations guidelines and standards are appropriate for these subcategories. At that time, EPA would likely consider in addition to other factors identified in CWA Section 304(b):

- ∨ Specific processes, including papermaking processes;
- ∨ Products;
- ∨ Fiber furnish;
- ∨ Grade changes;
- ∨ Chemical usage;
- ∨ Non-fibrous material (fillers, additives, coatings, etc.);
- ∨ Shrinkage;
- ∨ Raw material (fiber) quality;
- ∨ Product quality/requirements;
- ∨ Water requirements;
- ∨ Pollutant loadings; and
- ∨ Effluent quality.

If after further analysis EPA determines that certain types of mills within a subcategory cannot achieve the same effluent quality without undue economic impact, EPA will consider further segmenting the subcategory as appropriate to better respond to material differences between facilities. In the interim, the subcategorization scheme for these subcategories is simply a redesignation of the old subcategories into the new subcategories. The limitations and standards promulgated under the old subcategorization scheme are recodified under the new subcategorization scheme in the form of segments corresponding to the old subparts. (In recodifying these limitations and standards, EPA has not changed the substance of the existing regulations.)

5.3.2 Subpart B - Bleached Papergrade Kraft and Soda Subcategory

Commenters on the proposed rule indicated that EPA should retain the existing subcategorization scheme which was based on an evaluation of raw waste loads and flows. One

commenter further stated that if EPA insists on revising the subcategories, raw waste loads, product type, fiber furnish, and raw waste treatability must also be evaluated in addition to effluent loads.

In response, for the Bleached Papergrade Kraft and Soda Subcategory, EPA undertook an analysis of the relationship between conventional pollutant loading (BOD₅ and TSS) in raw wastewater and treated effluent. No soda mills were included in the analysis because none had more than 85 percent of their final production in the subcategory. (EPA selected a final production cut-off of 85 percent within a single subcategory for the wastewater from the mill to be considered representative of that subcategory's wastewater. This approach is described in the Technical Development Document for the proposed rule (2) and in "Selected Issues Concerning Development of Conventional Pollutant Control Options" (3).) Specific analyses performed are documented and described in "Analysis of the Relationship Between Conventional Pollutant Loadings in Raw Wastewater and in Treated Effluent at Papergrade Kraft Mills" (4). The findings of this analysis include:

- ˘ The distribution of final effluent and raw wastewater BOD₅ and TSS loads support EPA's consolidation of the four current papergrade kraft and soda subcategories into a single subcategory;
- ˘ Final effluent conventional pollutant loads are not dependent on raw wastewater conventional pollutant loads;
- ˘ Final effluent conventional pollutant loads are dependent on treatment system removal efficiencies; and
- ˘ The data support EPA's assumption and demonstrate that the long-term average BOD₅ and TSS performance levels are achievable, regardless of raw wastewater loads.

The purpose of industry subcategorization is to provide a mechanism for addressing variations among raw materials, processes, products, and other parameters that can result in distinct effluent characteristics. Regulation of a category by subcategory ensures that each subcategory has a uniform set of effluent limitations that take into account technical achievability and economic impacts unique to that subcategory. EPA considered the processes, raw materials, wastewater treatability, and other factors unique to bleached papergrade kraft and soda mills as the basis for combining bleached papergrade kraft and soda mills in a unique subcategory separate from other pulping processes (e.g., papergrade sulfite and dissolving kraft and sulfite processes).

EPA evaluated whether additional subcategory segmentation was appropriate for development of effluent limitations guidelines and standards for toxic and nonconventional pollutants based primarily on process changes (e.g., BAT and PSES). EPA considered further segmentation of the Bleached Papergrade Kraft and Soda Subcategory by product brightness

(high versus low) and fiber furnish (hardwood versus softwood) because these factors may influence the technical feasibility of bleaching process technologies. EPA decided not to further segment the Bleached Papergrade Kraft and Soda Subcategory by product brightness because available data do not demonstrate that variation in this parameter results in significant differences in effluent characteristics. Moreover, at some mills, final product characteristics vary sufficiently (on a day-to-day basis) to make permitting and compliance impracticable. EPA was also concerned that mills might strive for higher brightness than their product required in order to qualify for less stringent limits, with the unintended result of having mills use more rather than less bleaching chemicals and hence discharging more pollution than they otherwise would.

EPA also considered fiber furnish (hardwood versus softwood) as a basis for further segmenting the Bleached Papergrade Kraft and Soda Subcategory. For toxic and nonconventional pollutants with compliance points at the bleach plant, EPA found no difference in achievability of limitations due to fiber furnish. However, for the bulk parameter adsorbable organic halides (AOX) with compliance point at the end-of-pipe, EPA found higher effluent loadings for softwood mills than for hardwood mills. EPA set limitations for AOX based on data for softwood mills to ensure that the limitations would be achievable for all furnishes. Since many mills pulp both hardwood in variable combinations, or “swing” between hardwood and softwood, effluent limitations based on fiber furnish would be very difficult to administer. For this reason, EPA found it unnecessary and inappropriate to further segment the Bleached Papergrade Kraft and Soda Subcategory by fiber furnish.

5.3.3 Subpart E - Papergrade Sulfite Subcategory

Several comments were submitted concerning the feasibility of “totally chlorine-free” (TCF) technology-based limits for certain sulfite pulping processes and products. Specifically, comments indicated that TCF bleaching processes are not technically feasible for manufacture of ammonium-based papergrade sulfite pulp from softwood and for manufacture of specialty papergrade sulfite products such as pulps for photographic papers and plastic molding products.

After reviewing the comments, EPA concurs that additional segmentation of the Papergrade Sulfite Subcategory is necessary to better reflect product considerations, the variation of manufacturing processes, and the demonstration of pollution prevention process changes within the category for the purpose of establishing BAT, PSES, NSPS, and PSNS. See “Segmenting the Papergrade Sulfite Subcategory” (5) for additional information concerning EPA’s rationale for segmenting the Papergrade Sulfite Subcategory. The segments for the Papergrade Sulfite Subcategory are:

- (a) Production of pulp and paper at papergrade sulfite mills that use an acidic cooking liquor of calcium, magnesium, or sodium sulfite unless those mills are specialty-grade sulfite mills.

- (b) Production of pulp and paper at papergrade sulfite mills that use an acidic cooking liquor of ammonium sulfite, unless those mills are specialty-grade sulfite mills.
- (c) Production of pulp and paper at specialty-grade sulfite mills. Specialty-grade sulfite mills are those mills where (1) 25 percent or more of production is characterized by pulp with a high percentage of alpha cellulose and high brightness sufficient to produce end products such as plastic molding compounds, saturating and laminating products, and photographic papers; or (2) those mills where 50 percent or more of production is 91 ISO (International Organization for Standardization) units brightness and above.

EPA is not revising NSPS for conventional pollutants for the Papergrade Sulfite Subcategory. Because the NSPS for conventional pollutants for former Subparts J and U were the same, EPA has recodified these standards in a single table for Subpart E (without distinguishing between the former subparts in the form of segments).

5.4 References

1. Comment Response Document, Volume I, "Selected Issues Concerning Subcategorization." U.S. Environmental Protection Agency, Washington DC, Record Section 30.11, DCN 14497, 1997.
2. Development Document for Proposed Effluent Limitations Guidelines and Standards for the Pulp, Paper, and Paperboard Point Source Category. EPA-821-R-93-019, U.S. Environmental Protection Agency, Washington DC, October 1993.
3. Comment Response Document, Volume I, "Selected Issues Concerning Development of Conventional Pollutant Control Options." U.S. Environmental Protection Agency, Washington DC, Record Section 30.11, DCN 14497, 1997.
4. Radian Corporation. Analysis of the Relationship Between Conventional Pollutant Loadings in Raw Wastewater and in Treated Effluent at Papergrade Kraft Mills. Herndon, Virginia, Record Section 22.1, DCN 14039, November 16, 1995.
5. Comment Response Document, Volume I, "Segmenting the Papergrade Sulfite Subcategory." U.S. Environmental Protection Agency, Washington DC, Record Section 30.11, DCN 14497, 1997.

SECTION 6

WATER USE AND WASTEWATER CHARACTERISTICS

6.1 Introduction

Section 6.0 of the TDD describes water use and wastewater recycle practices, and the general characteristics of wastewater at mills that manufacture pulp, paper, and paperboard in the U.S. This information was gathered in EPA's 1990 National Census Questionnaire of the industry. All pulp and papermaking processes use water; in fact, the pulp and paper industry is the largest industrial process water user in the U.S. Except as noted below, EPA believes that the information presented in Section 6.0 of the TDD is still representative of the industry today. This section discusses specific topics related to water use.

Water use in the industry decreased approximately 30 percent between 1975 and 1990, reflecting significant effort by the industry to reduce consumption and increase wastewater reuse and recycle (1). EPA believes that this trend has continued because mill modernizations have occurred and continue to occur. These projects generally include the installation of equipment that uses water more efficiently. The total effluent flow from an integrated bleached kraft mill is normally between about 50 to 150 m³/kgg of pulp produced, although a few mills discharge significantly lower or higher flows (2). In 1995, the average U.S. bleached kraft and soda mill discharged approximately 95 m³/kgg of pulp (3).

6.2 Mill Water Use - Bleach Plant Effluent Portion of Final Effluent

The final rule preamble and Section 8.2.3 of this document set forth EPA's reasons for regulating some pollutants at the bleach plant effluent rather than at the final effluent discharge to receiving waters. One reason is that most of the regulated chlorinated compounds are not present at detectable concentrations in the final effluent, and may or may not be present at detectable concentrations in the bleach plant effluent. Because the bleach plant effluent flow rate is a fraction of the influent to treatment flow rate (which is assumed to be the same as the final effluent flow rate for this analysis), EPA is concerned that the dilution of the bleach plant effluent in the final effluent will make it more difficult to detect the regulated chlorinated compounds in the final effluent. This section describes the fraction of the final effluent that is composed of bleach plant effluent.

The fraction of the final effluent that is composed of bleach plant effluent is described in various references as shown below. Although the figures listed in each reference differ, they agree that the final effluent is composed of a significant fraction of bleach plant effluent as well as other wastewaters from other areas of the mill. The data are believed to be similar for bleached papergrade kraft mills and for papergrade sulfite mills.

Source	Bleach Plant Effluent Flow Percentage of Final Effluent Flow
EPA Sampling Database (derived from bleached papergrade kraft mills) (4)	7% to 43%
Technical Development Document, (1990 Industry Census Questionnaire) (5) Average of Bleached Papergrade Kraft Mills Average of Papergrade Sulfite Mills	30 to 50% 30% 35%
Water Use Reduction in the Pulp and Paper Industry (6)	50%
Pulp Bleaching - Principles and Practice (7)	50 to 70%

The figures derived from the EPA sampling database are discussed in more detail below but the other references provide little more information than is listed in the table. The EPA sampling database contains information from mills sampled by EPA, and information supplied by NCASI and individual mills.

The mills in the EPA sampling database were divided into two groups: mills that make market pulp only, and mills that make pulp and paper. The amount of bleach plant effluent in the final effluent for market pulp mills ranged from 21 to 43 percent (among nine mills). For the pulp and paper mills the range was 7 to 38 percent (among nine mills). An integrated mill has more wastewater sources, mainly from the paper making operations, so the bleach plant effluent proportion is smaller. The lowest values in each group (7 and 21 percent) were reported by mills that make unbleached pulp in addition to bleached pulp. The mills included in this analysis used a variety of bleaching sequences. The values for the nine mills using elemental chlorine-free bleaching sequences to make only bleached pulp were 30 to 43 percent.

6.3 Mill Water Use For Option A and Option B Mills

Of the mills included in the EPA sampling database, mills using extended cooking and/or oxygen delignification (Option B technologies) generally discharged less wastewater than mills using conventional cooking (Option A technology). In addition, those mills using totally chlorine-free bleaching discharged less wastewater than the mills using elemental chlorine-free bleaching sequences, because in chlorine-free bleaching processes, the bleach plant filtrates are returned to the recovery system. Several reasons exist for these differences. The following table summarizes the average production-normalized bleach plant flow rates that EPA calculated using its sampling database. The following production-normalized bleach plant flow rates were used to calculate some of the pollutant loadings and reductions described in Section 9.0.

Production-Normalized Kraft Bleach Plant Flow Rates^a

Type of Mill ^b	Hardwood Lines		Softwood Lines	
	Average (m ³ /kkg)	No. Of Lines	Average (m ³ /kkg)	No. Of Lines
Mills Without EC or OD	24.7	12	37.1	13
Mills With EC and/or OD	19.7	4	24.7	12
TCF Mills	11.6	1	18.3	2

^aThe average flow rates presented in this table were derived from bleached papergrade kraft mills.

^bEC = extended cooking, OD = oxygen delignification, TCF = totally chlorine-free bleaching

Although retrofitting an oxygen delignification system (which would be a practical necessity for compliance with Option B) has no direct effect on effluent flows by itself, the data presented above indicate that mills with extended cooking and/or oxygen delignification have lower bleach plant flows than mills with conventional pulping. Several possible reasons exist for the lower flow. Some mills have reported reductions in effluent flow due to oxygen delignification projects because it is normal practice to close the screen room process and return these filtrates to the recovery cycle when oxygen delignification is installed. In some cases, when unbleached pulp kappa number-into-bleaching is reduced, it is possible to retire one or two complete bleaching stages (e.g., convert a C/DEoDED bleach plant to OD-DEopD). Such action could reduce effluent flows by about 15 m³/kkg pulp. In rare cases, oxygen delignification will result in some water conservation if lower unbleached pulp kappa number-into-bleaching allows the use of reduced wash water flow in the first bleaching stage.

The following discussion explains several reasons why EPA expects mills to continue to reduce effluent flow rates. Other changes in effluent flow rates as a result of the promulgated regulations are discussed in Section 11.3.

Water use in the industry decreased approximately 30 percent between 1975 and 1990 (1), reflecting significant effort by the industry to reduce consumption and increase wastewater reuse and recycle. These reductions may have resulted from specifically planned water conservation projects or they may have been secondary benefits of other mill modernization projects. During mill renovation, new equipment is not installed in isolation. Instead, it is common practice to modernize the entire mill area involved with the new equipment, at least to some extent. Modern equipment is generally designed to conserve water more effectively than older designs. Many details can be involved, such as the replacement of packing on shafts with modern mechanical seals that use little or no water, or reduction in cooling water requirements by more efficient design and increased use of cooling towers with subsequent recycle. These modifications will generally reduce effluent discharges, but it is difficult to provide realistic numeric estimates.

Two elements of the two BAT options that will reduce effluent flows directly are closing screen rooms and implementing BMPs. The application of current engineering practices to the design of new systems and equipment will result in conservation of water. The greatest improvements are likely to be seen in mills currently using relatively high quantities of water.

The kappa number of unbleached pulp entering the bleach plant is reduced by employing two types of extended delignification, extended cooking (EC) and oxygen delignification (OD). Mills that have recently installed EC and/or OD have also made related improvements. For example, new or upgraded washers use water more efficiently and may therefore generate less wastewater.

When upgrading the first chlorine/chlorine dioxide stage to high or 100 percent chlorine dioxide substitution for chlorine, it is common to convert from low consistency operation to medium consistency, or increase the use of recycled bleach filtrates for pulp dilution to raise the temperature without incurring the cost of direct steam heating. These changes can lead to an effluent reduction of about 12 m³/kkg pulp in softwood mills and 5 m³/kkg in hardwood mills. Such improvements are most likely to be made in mills which have high effluent flows.

6.4 Definition of Process Wastewater

The effluent limitations guidelines and standards for the pulp and paper industry are applicable to discharges of process wastewaters directly associated with the manufacturing of pulp and paper. In 1993, EPA proposed a definition of process wastewater as any water which during manufacturing or processing comes into direct contact with or results from the production or use of any raw material, intermediate product, finished product, byproduct, or waste product. The proposed definition also specifically included boiler blowdown, wastewaters from water treatment and other utility operations, blowdown from high rate (e.g., greater than 98 percent) recycled non-contact cooling water systems to the extent they are mixed and co-treated with other process wastewaters, and stormwaters from the immediate process areas to the extent they are mixed and co-treated with other process wastewaters. The proposed definition specifically stated that contaminated groundwaters from on-site or off-site groundwater remediation projects are not considered process wastewaters. Separate permitting was proposed to be required for the discharge of such groundwaters.

The proposed definition also specifically excluded certain process materials from the definition of process wastewater. These process materials included: green liquor at any liquor solids level, white liquor at any liquor solids level, black liquor at any liquor solids level resulting from processing knots and screen rejects, black liquor after any degree of concentration in the kraft or soda chemical recovery process, reconstituted sulfite and semi-chemical pulping liquors prior to use, any pulping liquor at any liquor solids level resulting from spills or intentional diversions from the process, lime mud and magnesium oxide, pulp stock, bleach chemical solutions prior to use, and paper making additives prior to use (e.g., alum, starch and size, clays and coatings). Because these materials were excluded from the proposed definition of

process wastewater, they would have been prohibited from discharge into POTWs or waters of the United States without a National Pollutant Discharge Elimination System (NPDES) permit and effluent limitation or other authorization.

In response to the comments opposing the exclusion of these process materials (8), EPA revised the proposed definition of process wastewaters to eliminate the exclusion of the named process materials (40 CFR Part 430.01(m)). As the commenters contended, the proposed language would have effectively required “closed-cycle” mills, which was not EPA’s intent. The proposed language was intended to prevent discharge of process materials during clean up in preparation for permanent mill closure. EPA’s definition continues to specify that process wastewater is generated “during manufacturing or processing.” Thus, the definition of process wastewater as promulgated today does not allow for discharges from a mill that is not engaged in manufacturing. Any mill wishing authorization to discharge in this manner must obtain authorization in an NPDES permit or individual control mechanism administered by a POTW.

The distinction that process wastewater is generated “during manufacturing or processing” should not be taken to exclude wastewaters generated during routine maintenance, including maintenance during a scheduled temporary mill shut-down. Maintenance wastewaters were not explicitly excluded from the definition of process wastewater at proposal, nor are they excluded from the definition finally promulgated. Wastewaters generated during routine maintenance are a result of pulp manufacturing processes and as such are included in the definition of process wastewater. Many mills commingle leachates from landfills receiving wastes associated with the processing or manufacturing operations. Therefore, EPA also has included these leachate wastewaters in the definition of process wastewaters.

6.5 Use of Biocides

The existing BAT regulations for Subparts G, H, I, J, P, and U (now the Bleached Papergrade Kraft and Soda and Papergrade Sulfite subcategories) establish effluent limitations guidelines and standards for pentachlorophenol and trichlorophenol when used as biocides. One way for dischargers to comply with these limitations is to certify that they do not use these compounds as biocides. Using the data collected in the 1990 National Census Questionnaire, EPA compared the names of biocide products reported as used by pulp mills in the Bleached Papergrade Kraft and Soda and Papergrade Sulfite subcategories with readily available information from the Office of Pesticide Programs to determine if these products contain pentachlorophenol or trichlorophenol. EPA was unable to identify any biocide products used by those pulp mills that contain these chemicals. Therefore, EPA expects that mills in these subcategories will be able to comply with these limitations by certifying that they do not use these compounds as biocides.

6.6 **References**

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SECTION 7

POLLUTION PREVENTION AND WASTEWATER TREATMENT TECHNOLOGIES

7.1 Introduction

This section describes technologies that are in use at pulp, paper, and paperboard mills to prevent the formation of wastewater pollutants or reduce the discharge of wastewater pollutants. Various combinations of these technologies were considered as the basis for the effluent limitations guidelines and standards for the industry.

Two major approaches may be used to improve effluent quality at pulp, paper, and paperboard mills: (a) in-process technology changes and controls to prevent or reduce the formation of wastewater pollutants of concern, and (b) end-of-pipe wastewater treatment technologies to remove pollutants from process wastewaters prior to discharge.

The Agency has defined pollution prevention as source reduction and other practices that reduce or eliminate the formation of pollutants. Source reduction includes any practice that reduces the amount of any hazardous substance or pollutant entering any waste stream or otherwise released into the environment, or any practice that reduces the hazards to public health and the environment associated with the release of such pollutants. Such practices may include equipment or technology modifications; process or procedure modifications; reformulation or redesign of products; substitution of raw materials; and improvements in housekeeping, maintenance, training, and inventory control. Other pollution prevention practices include increased efficiency in the use of raw materials, energy, water, and other resources.

The Agency has developed a model pollution prevention plan for the pulp and paper industry as part of the Agency's effort to encourage pollution prevention programs in U.S. industries. The model plan is discussed in a series of reports:

Pollution Prevention Opportunity Assessment and Implementation Plan for Simpson Tacoma Kraft Company, Tacoma, Washington (1);

Model Pollution Prevention Plan for the Kraft Segment of the Pulp and Paper Industry (2); and

Pollution Prevention for the Kraft Pulp and Paper Industry, Bibliography (3).

Pollution-preventing process changes may be implemented in the pulping, bleaching, chemical recovery, and papermaking areas of a mill. Many of the in-process controls that prevent or reduce wastewater pollution also result in improved product quality and/or fiber yield, as well as reduced operating costs through more efficient use of process materials and prevention and control of leaks and spills of spent pulping liquor, soap, and turpentine. Sections

7.2 and 7.3 describe applicable pollution prevention controls and technologies for the industry. These sections also provide information on the performance of each technology and the number of mills using each technology.

Additional information on pollution prevention technologies for the pulp and paper industry is available in these EPA documents:

Summary of Technologies for the Control and Reduction of Chlorinated Organics from the Bleached Chemical Pulping Subcategories of the Pulp and Paper Industry (4);

Pollution Prevention Technologies for the Bleached Kraft Segment of the U.S. Pulp and Paper Industry (5); and

Technical Development Document for the Pulp, Paper, and Paperboard Category Effluent Limitations Guidelines, Pretreatment Standards, and New Source Performance Standards (6).

End-of-pipe wastewater treatment includes physical, chemical, and biological processes that remove pollutants from mill effluent prior to discharge to a receiving stream or POTW. Section 7.4 describes end-of-pipe wastewater treatment technologies applicable to the industry.

7.2 Pollution Prevention Controls Used in Pulping and Delignification Processes

This section describes applicable technologies for reducing and preventing pollutant discharges from the pulping area of a chemical pulp mill. Pulping area processes include chipping, cooking, pulp washing, and screening. Pollution prevention technologies applicable to pulping area processes include chip quality control, use of dioxin precursor-free defoamers and pitch dispersants, extended cooking, effective brown stock washing, closing the screen room, oxygen delignification, steam stripping of condensates, and spent pulping liquor spill prevention and control.

7.2.1 Chip Quality Control

Chip thickness control is an important component of improving yield, reducing bleaching chemical requirements, and optimizing pulp quality. Chip thickness can be controlled by close control of chipping equipment tolerances or the use of chip thickness screens.

In preparation for chemical pulping, wood is reduced to chips approximately 2 to 5 millimeters thick and 10 to 30 millimeters long. Some mills use chips obtained from an off-site source such as a sawmill, although most mills perform at least some chipping on site. Several chipper designs are in use today, but the most common is the flywheel-type disc chipper, in which

logs are fed to one side of the disc at a pre-determined angle through a vertical directing chute.

After chipping, the chips pass a set of vibratory screens to separate chips of acceptable length and width from fines and oversized pieces. Oversized chips are rechipped, and fines are usually burned in an on-site hog fuel boiler.

Good quality chipping and screening equipment provides a uniform supply of chips to the digester, leading to more uniform cooking and reduced digester chemical consumption. The uniform pulp produced results in less variation in bleach plant feed and better control of the bleaching process, which reduces overbleaching of the pulp to remove shives and colored fiber. The effluent quality from the bleach plant is improved because when overbleaching is avoided, lower levels of chlorinated organics are formed. A more uniform pulp also reduces the amount of rejects from screening following brown stock washing.

Mills can improve the quality of chips going to the digester in several ways. Mills that receive chips from an off-site source can develop a chipping quality control program for suppliers to ensure that uniform, high-quality chips are received. Mills that chip on site can closely monitor the operation of the chipper to maintain optimum settings (e.g., consistent and effective blade settings) in order to produce chips of consistent size. This approach minimizes the quantity of off-specification chips produced, and eliminates the need for chip thickness screens (7).

Mills can also provide uniform chip dimensions with chip thickness screens. Chip thickness screens are rotating disc screens that separate overly thick chips, which are then sliced or crushed to the desired thickness for pulping. Chip thickness screening also removes knots and compression wood, in which dioxin precursors are reported to be concentrated (8). Providing chips of uniform thickness, free of knots and compression wood, results in improved pulping, reduced screen rejects, and improved bleaching, and may also reduce the load on the mill's wastewater treatment system. When knots and compression wood are removed prior to cooking, they are typically burned in the mill's power boiler. If these components are instead removed from the pulp by screening after cooking, they may be sent to the wastewater treatment system. New mills in the U.S. typically use chip thickness screening and many existing mills have installed chip thickness screens, usually as part of an overall woodyard or pulp mill upgrade. Therefore, EPA considers chip quality control to be a part of the baseline technology used today at bleached papergrade kraft mills and additional cost for this technology has not been included in the BAT/PSES options.

7.2.2 Defoamers and Pitch Dispersants

Defoamers are used to break and inhibit the formation of black liquor surface foam formed when air is entrained in the pulp during brown stock washing. Pitch dispersants are added to pulp to prevent wood resins and fatty acids from depositing on the paper at the paper machine. Both of these chemical additives are introduced into the pulp flow prior to brown stock washing and are carried with the pulp into the bleach plant. Defoamers and pitch dispersants have been

shown to contain the chlorinated dibenzo-p-dioxin (CDD) and chlorinated dibenzofuran (CDF) precursors dibenzo-p-dioxin (DBD) and dibenzofuran (DBF) (5,10). In the first (chlorine or chlorine dioxide) stage of bleaching, the DBD and DBF are chlorinated to form 2,3,7,8-TCDD and 2,3,7,8-TCDF.

Defoamers can be mineral oil based or water based. Mineral oil-based defoamers are a blend of 90 percent oil and 10 percent additives. Defoamers made from re-refined oil are particularly high in DBF concentration (11). DBD and DBF can be essentially eliminated from defoamer oils (i.e., to a level of less than 1 ppb of both) by using two-stage severe hydrotreating technology (11). Alternatively, completely oil-free defoamers that do not contain CDD and CDF precursors may be used (12). Switching to non-contaminated defoamers can contribute to reducing the content of 2,3,7,8-TCDF in bleached pulp and in mill effluent by at least 90 percent (13). The Agency believes that the U.S. pulp industry has generally converted to the use of precursor-free additives.

As evidenced by the drop in measured TCDD and TCDF discharges from bleaching pulp mills, use of either water-based defoamers or defoamers made with precursor-free mineral oils has been common industry practice since the early 1990s. At that time, it became widely known in the industry that use of precursor-free defoamers in the brown stock or bleach plant areas substantially reduces the dioxin formed in bleaching. Consequently, EPA assumes use of precursor-free defoamers to be part of the baseline technology used today at bleached papergrade kraft mills and costs have not been included in the BAT/PSES options.

7.2.3 Extended Cooking

At chemical pulping mills, wood chips or a non-wood fiber furnish are cooked in a chemical solution in a digester at elevated temperature and pressure to dissolve the lignin that holds the cellulose fibers together. Chemical pulping occurs in either a batch or continuous digester system.

The most common continuous digester is the vertical downflow type. The wood chips are preheated in a steaming vessel to remove air and some of the volatile wood constituents before the chips enter the digester. The chips are mixed with the cooking liquor and are fed into the top of the digester so that they move downward by gravity through the tower. The hydraulic pressure in the tower is kept at approximately 1,140 kPa (165 psi). After the chips have been impregnated with liquor, the temperature is raised to approximately 105 to 130 time of one to one and a half hours, until the pulping reaction is complete. The reaction is stopped in the lower region of the tower, where diffusion washing of the pulp is carried out, normally using a countercurrent flow of the filtrate from the first brown stock washer. The pulp is blown from the bottom of the digester at about 1,380 kPa (200 psi) to a tank at atmospheric pressure.

For batch cooking, a mill normally uses several vessels. Mills in the U.S. with batch digesters have reported using anywhere from 3 to 24 vessels. Wood chips and cooking

liquor are added simultaneously to the top of the digester, after which the digester is sealed and raised to a target operating pressure of approximately 700 to 900 kPa (102 to 131 psi) and temperature of approximately 170°C. After cooking for one to two hours, the pulp is blown into an atmospheric tank, from which it is pumped to the brown stock washing system. Usually a mill staggers the digester cycles to maintain a continuous flow of pulp through its washing and pulping sections.

The continuous process produces pulp at a consistent rate and with lower energy requirements; however, a batch pulping system enables a mill to pulp several different grades at once by using different digesters for different pulping conditions or fiber furnishes. Since the continuous process was commercialized in the 1950s, the amount of chemical pulp produced by continuous digesters has increased. Most new installations are now continuous systems.

Chemical pulp mills that bleach must remove enough residual lignin from the pulp prior to bleaching to achieve their required final pulp brightness. The kappa number (a measure of a pulp's lignin content) of the pulp entering the bleach plant dictates the amount of bleaching chemicals needed. Since decreasing bleaching chemical use lowers both the cost for bleaching chemicals and the environmental impact of the effluent from the bleach plant, it is generally desirable for mills that bleach to lower the prebleaching kappa number as much as possible, without seriously affecting pulp yield and strength.

Through work done by the Swedish Forest Products Research Institute (STFI) in the late 1970s (14), the concept of "extended cooking" for papergrade kraft pulps was developed and commercialized in the late 1980s. Extended cooking enables a mill to lower the kappa number of the pulp entering the bleach plant further than is possible with a traditional kraft pulping digester, while increasing pulp strength and maintaining or increasing pulp yield. During extended cooking, the pulp is mixed with the cooking liquor for a longer time than in traditional cooking, under modified temperature and alkalinity conditions. The process can be performed using either a batch or continuous pulping system. Thirteen of the 86 mills in the Bleached Papergrade Kraft and Soda Subcategory used extended cooking as of mid-1995. Extended cooking is not typically used for papergrade kraft pulps that will not be bleached, because achieving a low kappa number out of the digester is not as important as it is for pulps that will be bleached.

In 1992, approximately 11 million kkg/year of kraft pulp was produced worldwide using extended cooking (15). This figure represents about 20 percent of world bleached kraft capacity. Figure 7-1 shows the increase in the amount of kraft pulp produced by extended cooking from 1983 through 1992. Capacities shown are as reported by mills and vendors, and have been normalized to air dry kkg/day. Extended cooking for dissolving kraft and sulfite pulps has not been demonstrated on an industrial scale.

The types of continuous extended cooking processes most commonly used in the U.S. are the Modified Continuous Cooking (MCC®) developed by Kamyr Inc. and Kamyr AB and Iso Thermal Cooking (ITC®) process developed by Kvaerner, and Extended Modified

Continuous Cooking (EMCC®) processes developed by Kamyr Inc. Figure 7-2 shows a typical EMCC® installation. These processes are similar, in that fresh cooking liquor, comprised of sodium hydroxide and sodium sulfide, is added at several points in the digester, instead of at just one point as with traditional continuous cooking. More lignin is dissolved with these processes than is dissolved in the traditional digester, because the active chemical concentration is kept more uniform throughout the cooking process. At the same time, less damage is done to the wood fiber cellulose, because a high initial cooking liquor concentration is avoided. The resulting pulp is stronger and has a lower kappa number than traditional pulps, while the pulp yield is maintained.

Extended cooking in batch digesters yields similar results. Two systems are available commercially: the Rapid Displacement Heating (RDH®) System, sold by Beloit Inc., the Super Batch® System, sold by Sunds Defibrator, Inc., and VISBATCH® and ENERBATCH®, sold by Voest-Alpine. These processes maintain a more uniform cooking liquor concentration throughout the cook than traditional batch cooking. The wood chips are initially impregnated with warm black liquor under pressure to remove air in the chips. The warm black liquor is then displaced with hot black liquor and white liquor to begin the cook. After cooking, the spent cooking liquor is displaced with wash liquor from the first brown stock washer. The spent cooking liquor becomes the warm black liquor used for impregnation during another cook. The batch extended cooking process requires several large holding tanks to store liquor between the various stages of the cooking process, and many older mills do not have the space to install a batch extended cooking system. Most of the extended cooking installations in the world are continuous rather than batch, although several batch systems have recently been installed.

The unbleached kappa number of softwood kraft pulps typically ranges from 30 to 32 for traditional cooking. Extended cooking by either the continuous or batch processes can achieve softwood pulp unbleached kappa numbers ranging from 12 to 18. For hardwood kraft pulps, the unbleached kappa number of approximately 20 for traditional cooking can be reduced to 8 to 10 using extended cooking (5). As explained in Section 8, EPA has used higher kappa number targets for the development of the regulatory options.

7.2.4 Effective Brown Stock Washing

In a chemical pulping mill, after the pulp leaves the digester it is cleaned through a series of knotters, screens, and countercurrent washers to remove impurities and uncooked fiber and to recover as much spent cooking liquor as possible. In brown stock washing, spent pulping chemicals, along with any dissolved wood components, are separated from the pulp and sent to the recovery boiler for recovery of chemicals and energy (steam generation). Effective brown stock washing minimizes the amount of pulping liquor carried over to the bleach plant with the pulp. The mill's effluent quality is also improved because residual black liquor that is carried over to the bleach plant includes unchlorinated toxic substances, some of which appear to resist degradation in biological treatment plants (16). If chlorine-based bleaching chemicals are used,

the organic compounds that are carried over with the pulp to the bleach plant also react with the bleaching chemicals and, therefore, increase the mill's effluent load of chlorinated organics.

Effective brown stock washing also reduces the amount of bleaching chemicals required to bleach the pulp to a given brightness, because well-washed pulp carries less organic material, which competes with the pulp fiber for reaction with the bleaching chemicals. Finally, effective brown stock washing is essential for satisfactory operation of an oxygen delignification system.

Mills try to minimize the amount of water used for brown stock washing, because all water added at this stage is typically evaporated in the black liquor recovery cycle. Although using more water increases the removal of pulping liquor and dissolved organic material from the pulp, the maximum amount of water that can be used depends on the capacity of the black liquor evaporators and the additional energy requirements necessary to evaporate more black liquor.

Brown stock washing effectiveness at kraft mills is conventionally expressed as saltcake (Na_2SO_4) loss per mass of pulp, and is considered to be effective if the washing loss is less than 10 kg Na_2SO_4 /kkg of pulp (17,18,19). A loss of less than 10 kg Na_2SO_4 /kkg is approximately equivalent to 99 percent recovery of spent pulping chemicals. The average washing loss for the Bleached Papergrade Kraft and Soda Subcategory was 13.5 kg Na_2SO_4 /kkg in 1989, as reported in the 1990 census questionnaire. This washing loss is much lower than losses were ten years ago.

The traditional method of pulp washing using a rotary vacuum drum washer has been supplemented or replaced in many mills with other, high-efficiency washers, including pressure diffusion washers, belt washers, and presses of various types. All are capable of providing well-washed pulp.

Pressure diffusion washers are enclosed and operate at elevated pressure and temperature, resulting in good washing efficiency. The pulp enters a pressure diffusion washer at the top and moves downward as a fiber mat between the stationary central body of the washer and the moving perforated cylindrical screen surrounding it. The wash water flows from the center of the washer through the pulp mat and outer screen, and is extracted continuously from the system. The pulp continues through the vessel and is removed at the bottom. Pressure diffusion washers require relatively less floor space than other types of washers and are therefore often selected for upgrading a mill's washing system where little space is available.

In a belt washer, the pulp flows onto an endless moving horizontal filter cloth and is drawn off at the opposite end. Wash water is applied to the top of the pulp mat and is drawn through the pulp by vacuum boxes located beneath the cloth. Each wash water addition point is considered to be one "stage" of washing, and the wash water moves countercurrently from the final stage through to the first stage on the belt. A belt washer can provide up to seven stages of washing. The system can be enclosed to minimize air emissions. Belt washers are not currently

used to incrementally increase brown stock washing capacity, but are efficient systems for replacing an entire washing line.

A wash press consists of a cylindrical washer and a press roll. Pulp that is washed in a wash press leaves the system at a higher consistency than with other washing systems. The geometric configuration of the cylindrical washer causes the pulp to be dewatered during washing, because the pulp is forced into a smaller space and ultimately passes through a nip between the washing cylinder and the press roll. Instead of leaving the washer at the usual consistency of between 10 and 15 percent solids, the pulp mat leaves at a consistency of between 30 and 40 percent. This type of washer is beneficial when high consistency is required downstream of the brown stock washing area.

7.2.5 Closed Screen Room Operation

After brown stock washing, pulp is usually screened to remove oversized particles. The pulp is first diluted with fresh water, screened using gravity or pressure screens, and then thickened in a decker to an appropriate consistency for the next process operation. In an open screen room, the filtrate from the decker goes to the sewer. This sewer stream carries residual organics and cooking liquor solids from the pulping operation. Closing the screen room eliminates the overflow of decker filtrate to the sewer. This operation optimizes the water balance around the washing and screening operations, because all of the decker filtrate is reused as dilution water for the screening operation, or as brown stock wash water. Residual organics and cooking liquor are thus returned to the chemical recovery cycle. Implementing closed screening effectively allows the decker to be used as an extra stage of brown stock washing.

The closed screen room concept has been discussed in literature for many years. The use of closed screening lowers the overall waste load to the mill wastewater treatment system, including the chemical oxygen demand (COD) load. Closed screening is standard equipment for mills using oxygen delignification because it is an integral part of the brown stock area in which an appropriate flow balance must be maintained for the efficient operation of oxygen delignification. The use of closed screening is becoming the common industry practice. Based on information collected by EPA in mid-1995, 44 of 86 bleached papergrade kraft mills in the United States used closed screen rooms.

The ability to operate the screen room as a closed process depends on a systematic optimization of the pulping, washing, screening, and liquor recovery cycles, and the type of washing and screening equipment available. Effective brown stock washing should be used to minimize the amount of cooking liquor solids carried to the screening operation. In addition, many mills are replacing gravity flow screens with pressure screens to prevent air entrainment and resultant foaming problems (20).

7.2.6 Oxygen Delignification

Oxygen delignification uses oxygen gas to remove lignin from pulp after brown stock washing and prior to bleaching. Using oxygen delignification between the kraft or sulfite pulping processes and the bleach plant results in lower bleaching chemical demands than a traditional bleaching sequence, because the unbleached kappa number drops by approximately 50 percent and the subsequent bleaching chemical requirements also drop in a relative manner (5). In addition, bleaching to a particular brightness can often be accomplished using fewer bleaching stages than a traditional bleach line if oxygen delignification is used prior to bleaching. Decreased bleaching chemical use reduces pollutant levels in the mill's bleach plant effluent. Although the operation of an oxygen delignification system in itself does not decrease the effluent flow from the bleach plant, it can lessen water use if older, less efficient bleaching towers are bypassed and if filtrates are sent to recovery boilers.

Over one-half of the world's bleached kraft production is subject to oxygen delignification. This number includes 100 percent of mills in Sweden and Japan, all but one mill in Finland, and essentially all new mills built worldwide in the last 10 years. As of mid-1995, 22 mills in the Bleached Papergrade Kraft and Soda Subcategory reported using oxygen delignification. The amount of bleached papergrade kraft pulp produced by these mills using oxygen delignification represented approximately 30 percent of the total U.S. production. One mill in the Papergrade Sulfite Subcategory reported using oxygen delignification. Figure 7-3 illustrates the rate of increase in the use of oxygen delignification systems in the U.S. and worldwide. Oxygen delignification has been adopted much more extensively in foreign mills than in U.S. mills, while U.S. mills have adopted extended cooking more rapidly than foreign mills.

Figures 7-4 and 7-5 show medium- and high-consistency oxygen delignification systems, respectively, both of which are in use today. In both cases, oxygen delignification must start with well-washed pulp, and magnesium salt ($MgSO_4$) must be added to protect the cellulose fibers from degradation. After oxygen delignification, the pulp must be washed well to remove organic material so that the subsequent bleaching stages can operate effectively.

High-consistency oxygen delignification is accomplished at a consistency of approximately 25 to 30 percent, which is attained using a press prior to the oxygen delignification tower. The pulp is then fed to a pressurized reactor into which oxygen and sodium hydroxide (or oxidized white liquor) are added. The pulp is fluffed using baffles inside the tower to achieve a more consistent reaction, and gaseous reaction products are purged from the vessel to avoid a fire hazard. Pulp degradation has been a problem with high-consistency systems, even though magnesium salt is added for pulp stabilization.

Medium-consistency oxygen delignification takes place at a consistency of between 10 and 20 percent, which is attained using a brown stock decker. The decker averts the need for the more expensive press that is required for a high-consistency oxygen delignification system.

Prior to entering the reaction tower, the pulp is mixed with oxygen and sodium hydroxide (or oxidized white liquor). Since fewer gaseous compounds are formed, the risk of fire is eliminated with the medium-consistency system. The medium-consistency system has less potential for pulp degradation than in a high-consistency system, but slightly less delignification occurs than with a high-consistency reaction due to a lower reaction rate.

The filtrate from the post-oxygen delignification washers is sent to the recovery boiler, marginally increasing the load on the boiler, but concurrently increasing the amount of recovered chemicals and energy (21). Recycling the filtrate from the oxygen delignification washers, rather than sending it to wastewater treatment, reduces the bleach plant effluent flow, load of BOD₅ by 30 to 50 percent, COD by 40 percent, color by approximately 60 percent, and chlorinated organics by approximately 35 to 50 percent (5,8). Currently, all kraft and sodium-based sulfite mills with oxygen delignification recycle the associated filtrate.

7.2.7 Steam Stripping

Wastewater streams in the pulping and chemical recovery areas of a chemical pulp mill contain organic and sulfur compounds that may be emitted to the air or conveyed to the wastewater treatment system. Condensate streams from evaporators, digester blow tanks, and turpentine recovery systems at kraft mills contain the highest loadings of these compounds, with evaporator condensate representing the major volume of pulping area condensate flow. Steam strippers are used to control air emissions of organic and sulfur compounds from pulping area condensate streams, and at the same time reduce the organic load of the stripped wastewater on the wastewater treatment system.

Steam stripping is a fractional distillation process that involves the direct contact of steam with wastewater. Figure 7-6 presents a schematic of a continuous steam stripper system. Wastewater is pumped into the top of the stripping column, and steam is injected near the bottom of the column. The column is typically equipped with perforated trays or packing to increase contact between the vapor and the liquid. Heat from the steam vaporizes the volatile compounds in the wastewater, which are carried out the top of the column with the steam. This overhead vapor stream is typically incinerated on site with attendant energy recovery (steam generation) (22). In the future, the overhead vapor stream may be concentrated or rectified to produce a methanol-rich stream that can be used to replace other fuels burned on site. Wastewater leaving the steam stripper passes through a heat exchanger to preheat the unstripped wastewater entering the steam stripper. The stripped wastewater is then discharged to the wastewater treatment system or reused in the mill for fresh hot water applications. The removal efficiency of volatile compounds is determined by the steam-to-feed ratio in the column. The steam stripper may be a stand-alone piece of equipment, or, at some mills, it may be integrated into the evaporator set.

A properly designed steam stripper can reduce the BOD₅ load to a mill's wastewater treatment system by removing organic compounds, primarily methanol, from the pulping area condensate streams. Mills that currently use steam stripping to reduce the load of organic constituents discharged to wastewater treatment report using steam-to-feed ratios ranging

from 145 to 215 kg/m³. A steam-to-feed ratio of 180 kg/m³ achieves approximately 90 percent removal of methanol. Total reduced sulfur (TRS) compounds can be removed at lower steam rates. Steam stripping is not part of the BAT/PSES model technology, but is part of MACT. Therefore, costs for steam stripping were incorporated in the basis for the MACT I standards rather than the BAT/PSES options. See the preamble at Section VI.A.

7.2.8 Spent Pulping Liquor Management, Spill Prevention, and Control

Mills that perform chemical or semi-chemical pulping of wood or other fibers generate spent pulping liquors that are generally either recovered in a chemical recovery system or treated in a wastewater treatment system. These mills may lose pulping liquor through spills, equipment leaks, and intentional diversions from the pulping and chemical recovery areas of the mill. Spills and intentional diversions of pulping liquor are a principal cause of upsets in biological wastewater treatment systems, the type of treatment system used at most chemical and semi-chemical pulp mills. Spent pulping liquor losses also increase the need for pulping liquor make-up chemicals, decrease energy generated from pulping liquor solids combustion, and increase hazardous air pollutant emissions.

Unintentional pulping liquor losses at pulp mills are most commonly caused by process upsets, equipment breakdowns, and tank overfillings. Maintenance and construction in a mill's pulping and chemical recovery areas may cause intentional diversions of pulping liquor to the wastewater treatment system. Spent pulping liquor may also be lost during normal mill operations, such as planned shutdowns and start-ups and pulp grade changes.

In addition to the potential harm to biological wastewater treatment systems and possible increased releases of toxic and hazardous substances associated with spills and other releases of spent pulping liquor, the discharge of substantial quantities of soap and turpentine has been shown to be extremely harmful to biological wastewater treatment systems and has resulted in violations of NPDES permit levels. The provision of secondary containment for turpentine storage tanks and other curbing, along with diversion and containment measures in soap and turpentine handling areas, constitute another element of a management program aimed at protecting wastewater treatment effectiveness and protecting the receiving waters.

Management programs, combined with engineered controls and monitoring systems, can prevent or control spent pulping liquor losses. These efforts should be both proactive to prevent pulping liquor losses and reactive to control spills after they have occurred.

Practices to prevent or control spent pulping liquor losses at chemical pulp mills include the following:

- Management of process operations to minimize variability.

- Preventative maintenance programs for equipment in spent pulping liquor service.

Automated spill detection, such as conductivity sensors in sewers in the pulping and chemical recovery areas.

Frequent operator surveillance of pulping and chemical recovery areas to quickly detect and repair leaks.

Secondary containment or annual integrity tests and high-level alarms on pulping liquor bulk storage tanks.

Secondary containment for turpentine storage tanks and other collection, containment, and control measures for soap and turpentine areas.

Spill collection systems for the pulping and chemical recovery areas with sufficient capacity to store collected spills and planned liquor diversions. The collected liquor may then be recovered in the chemical recovery system or slowly released to the wastewater treatment system at a rate that does not adversely impact the wastewater treatment system.

Mills with effective pulping liquor spill prevention and control programs have instituted a combination of these practices to substantially eliminate black liquor losses. It has been reported that the practical maximum reduction in BOD₅ raw wastewater loading that can be attained from spill prevention is 5 kg/kkg (23). Based upon site visits by the Agency, it appears that sulfite mills are less likely than kraft or soda mills to have engineered controls for collecting spills and leaks of pulping liquors at the immediate process areas.

Details of the practices listed above, and the associated estimated costs and effluent reduction benefits for mills that chemically pulp wood or other fibers are in the document entitled, "Technical Support Document for Best Management Practices for Spent Pulping Liquor Management, Spill Prevention, and Control" (24).

7.2.9 Maximizing Recovery Boiler Capacity

At kraft mills, spent cooking liquor (black liquor) from the digester and from brown stock washing is sent to the chemical recovery area, where it is concentrated in multiple-effect evaporators and then burned as part of the chemical recovery process. Section 4.2.4 in the TDD describes this process in detail. The organic fraction of the concentrated black liquor solids generates heat (captured as steam generated in the boiler) as it is burned, and the inorganic material produces a molten smelt in the hearth that is dissolved to regenerate the cooking chemicals.

When a mill improves its brown stock washing or installs oxygen delignification or extended cooking, it is common practice to recycle the resulting filtrates to the recovery boiler, thus increasing the amount of organics sent to the recovery boiler. The heating value of these

additional organics is an important factor in determining whether a mill needs to increase the burning capacity of its recovery boiler when it makes these process changes.

The increase in the heating load on the recovery boiler (referred to in this section as an increase in boiler capacity) depends not only upon the amount of organics coming from the process, but also upon their heating value. The heating value of the organics differs depending upon the wood (hardwood or softwood) and the process from which the organics are obtained. For example, the solids recycled from an oxygen delignification process have been oxidized and therefore have a lower heating value than those solids recycled from a brown stock washer or digester. Also, more organics are recovered from softwood pulp than from hardwood pulp.

In U.S. mills, the increase in recovery boiler capacity that results from improving brown stock washing alone is minimal (generally less than 1 percent) because, as indicated in Section 7.2.4, U.S. mills, on average, have fairly good brown stock washing. This contribution to the recovery boiler is negligible when the accuracy of boiler flow measurements is taken into account. However, the impact of extended delignification processes such as extended cooking and oxygen delignification is an important consideration in determining increases in recovery boiler capacity.

EPA prepared a detailed analysis of the impacts of extended cooking, oxygen delignification, screen room closure, improved brown stock washing, and other components of BAT and BMP on the kraft recovery system. This analysis is presented in the Analysis of Impacts of BAT Options on the Kraft Recovery Cycle (21). The main conclusion is that heat load on the boiler, not black liquor solids (BLS), is the key parameter determining boiler capacity. EPA's BAT cost model was adjusted to account for the impacts on the recovery system of additional black liquor recovered.

EPA estimated that the increase in thermal load from Option A will average 1.5 percent, with a maximum of 5 percent. For Option B, the average increase in thermal load is 2.2 percent, with a maximum of 8.7 percent. In estimating mill-specific costs, if the increase in thermal load to the boiler was estimated to be less than 1 percent, EPA provided no capital costs, assuming that this increase in load could be accommodated by improving boiler operation. For thermal load increases exceeding 1 percent, three options were available: the addition of anthraquinone, implementation of oxygen-based black liquor oxidation, and boiler upgrades (air system upgrades, improving liquor delivery, and firing high concentration black liquor, among others). Boiler upgrades are high-cost modifications that typically increase boiler capacity by 10 percent, and thus are not appropriate for accommodating the smaller thermal load increases EPA estimated would result from BAT. The TDD (Section 8.2.9) also discussed several other methods of increasing recovery boiler capacity.

Anthraquinone and oxygen-based black liquor oxidation are not recovery boiler modifications; they are means of reducing the thermal load on the boiler that can be employed even if a mill is recovery-boiler-limited. Anthraquinone is a catalyst that increases pulp yield and thus decreases the quantity of BLS to be burned for a fixed quantity of production.

Antraquinone is only an option for reducing the thermal load on the boiler for mills not already adding it to the digester. Oxygen-based black liquor oxidation is not a common practice in the United States, but equipment for this process is sold by two major industrial gas vendors. In this process, black liquor is partially oxidized before it is fired to the recovery boiler, reducing the thermal load of the black liquor by about 5 percent. This technology could be applied only to mills with non-direct contact evaporator recovery boilers (because most direct contact evaporation recovery boilers are already equipped with black liquor oxidation to reduce odor emissions).

Because of concerns about which boilers at bleached papergrade kraft mills can accommodate the increase in thermal load that will result from BAT, NCASI surveyed the industry in 1995. NCASI provided the results of this survey to EPA. A recovery boiler has a margin of capacity to accommodate an increased black liquor load unless all possible modifications to a boiler have been made. Of 190 boilers represented in the survey, 78 (41 percent) show evidence of being operated at their maximum capacity. Even for these boilers, however, the reductions in thermal load provided by anthraquinone or oxygen-based black liquor oxidation can accommodate the small increased loadings from BAT and BMP.

While estimating the costs of BAT, EPA used the status of each boiler reported in the 1995 survey to determine if an adjustment to recover boiler capacity was required. For the 84 bleached kraft and soda mills for which compliance costs were estimated, EPA estimated the following recovery boiler capacity adjustments would be required:

	Option A (Number of mills requiring recovery boiler capacity adjustment)	Option B (Number of mills requiring recovery boiler capacity adjustment)
None	61	57
Anthraquinone	9	10
Oxygen Black Liquor Oxidation	13	16
Recovery Boiler Air System Upgrade	1	1

Thus, EPA concluded that most mills would not require adjustments to the thermal load to the recovery boiler (or upgrades to the boiler) to accommodate the increase in black liquor thermal load to the boiler that will result from BAT. No mills require recovery boiler rebuilds or replacements.

7.3 Pollution Prevention Controls Used in the Bleach Plant

This section describes applicable technologies for reducing and preventing pollutant discharges from bleach plants at chemical pulp mills. For most facilities, the Agency defines the bleach plant as including the stage where bleaching agents (e.g., chlorine, chlorine dioxide, ozone, sodium or calcium hypochlorite, peroxide) are first applied, each subsequent extraction stage, and each subsequent stage where bleaching agents are applied to the pulp. A limited number of mills produce specialty grades of pulp using hydrolysis or extraction stages prior to the first application of bleaching agents. For those mills, EPA considers the bleach plant to include those pulp pretreatment stages. Although oxygen delignification systems are integrated with pulping and chemical recovery systems, the convention in the industry is to include oxygen delignification when specifying bleach sequences (e.g., O D/C E_{op} D). The Agency is using that convention in this document, although it considers oxygen delignification to be part of pulping (prebleaching) rather than bleaching. Section 4.2.6.1 of the TDD presents an overview of bleach plant operation.

7.3.1 Ozone Bleaching

Ozone, a powerful oxidizer, has been studied for over 20 years as a potential replacement for chlorine and chlorine dioxide in the first stage of pulp bleaching. Historically, two major drawbacks have inhibited the adoption of industrial-scale ozone bleaching: high cost and poor selectivity (i.e., a high degree of carbohydrate degradation and therefore viscosity drop) (25). Recent technological developments, such as the introduction of medium-consistency ozone bleaching and improvements in ozone efficiency and selectivity, have removed these disadvantages to using ozone (25,26). Ozone bleaching technology continues to evolve. The first full-scale ozone bleaching systems in a sulfite mill and a kraft mill started up in 1991 and 1992, respectively.

Ozone is generated either from oxygen or air, though it is normally produced using oxygen. The oxygen (O₂) passes through a series of tubes and a high voltage is applied, causing the oxygen molecules to dissociate. The dissociated molecules recombine to form ozone (O₃), which is relatively unstable. Since ozone can easily decompose back to oxygen, ozone must be generated on site for immediate use in the bleach plant.

Ozone bleaching has been researched at low, medium, and high consistencies. No full-scale low-consistency systems are in existence at this time. Most currently operating full-scale systems process the pulp at medium consistency (10 to 15 percent). Medium-consistency systems have lower capital costs than high-consistency systems do (26).

Oxygen delignification with effective post-oxygen washing is necessary prior to ozone bleaching to lower the lignin content of the pulp and therefore reduce the ozone charge required. No “target” kappa numbers are currently defined for the pulp entering the ozone stage; for ozone bleaching, target kappa numbers tend to be site-specific. Ozone oxidizes the carbohydrates in pulp as well as the lignin, so the ozone charge must be optimized to achieve the

maximum pulp delignification while minimizing the effects on pulp viscosity. Mills currently operating ozone bleaching systems use between 5 and 12 kg ozone per kkg of pulp, although actual application rates and operating conditions for this technology are usually confidential. A high-consistency system allows a higher ozone application rate than a medium-consistency system.

The processes and equipment used for ozone bleaching and oxygen delignification are similar. Prior to being fed to the ozone bleaching tower, the pulp is treated with either acetic or sulfuric acid to lower the pH. As with oxygen delignification, the pulp may be fluffed in the reactor to facilitate a more uniform reaction. Ozone is delivered to the reactor with an oxygen carrier gas. This carrier gas can be recovered after ozone bleaching, cleaned, and recycled to the ozone generator, or used elsewhere in the mill (e.g., in an oxygen delignification system or an oxygen-enhanced extraction stage).

The reaction of the pulp with the ozone normally takes a few minutes, as opposed to a few hours with other bleaching agents. The ozone bleaching reactor is therefore much smaller than other reaction vessels in traditional bleach plants.

Process effluents from ozone bleaching can be recycled to the recovery boiler, which decreases the volume of bleach plant effluent and the amount of non-chlorinated compounds discharged from the bleach plant. Because chlorine and chlorine derivatives are not used for first stage bleaching, chlorinated organic compounds (e.g., CDDs/CDFs, chlorinated phenolics) are not formed. The increase in the load of solids on the recovery boiler from recycling the ozone stage filtrate is lower than the increase from an oxygen delignification stage. The increase in solids for the ozone and subsequent extraction stages cause an additional heating load on the recovery boiler of approximately 1 percent (27).

In September 1992, a U.S. kraft mill began to produce lower brightness kraft pulp using ozone bleaching. This mill pulps and bleaches softwood to approximately 82-83 ISO; however, the bleaching sequence at this mill (OZED) includes a final chlorine dioxide brightening stage. The following description of this mill is based upon a recent publication (28).

This mill reports significant environmental benefits from the OZED bleaching sequence compared to sequences CEDED and OD/CED for both hardwood and softwood for parameters such as color, BOD₅, COD, chloroform, and AOX. Although chlorine dioxide is used in the final bleaching stage, 2,3,7,8-TCDD has not been detected in D-stage filtrate or bleached pulp. Another advantage of this sequence is the potential to recycle filtrates from the oxygen, ozone, and extraction stages to the recovery system. Compared to bleaching sequences of CEDED and OD/CED, the OZED sequence achieves equivalent pulp properties, except for viscosity, for both hardwood and softwood. Since pulp viscosity and strength have a different correlation for oxygen/ozone bleached pulps than for chlorine compound bleached pulps, the mill reports that the decrease in viscosity has not been a problem.

Additional environmental benefits and further recycling of filtrates could be achieved if the final chlorine dioxide stage were to be converted to use a non-chlorine containing compound. The mill has studied combinations of oxygen and ozone with peroxide and believes that an acceptable softwood TCF pulp can be made. The mill does not currently use a TCF bleaching sequence because it would substantially increase operating costs over the cost of the OZED sequence.

7.3.2 Improved Mixing and Process Control

To realize the full benefits of technologies such as high chlorine dioxide substitution, oxygen-enhanced extraction, and oxygen delignification on the bleach plant effluent, the pulp and bleaching agents must be well mixed and the chemical addition rate controlled as precisely as possible. Normally, when these technologies are installed, mixing and process control are also upgraded.

High shear mixers, introduced in the late 1970s, dramatically increased the contact of the pulp with gases such as oxygen, making the oxygen-enhanced extraction stage a practical, effective bleaching technology (29). High shear mixing has similarly become a vital part of a medium-consistency oxygen delignification system. To ensure uniform application of the chemicals in a high chlorine dioxide substitution stage, the pulp must be well-mixed with the chlorine dioxide. EPA has included costs for high shear mixers at individual mills as necessary.

7.3.3 Chlorine Dioxide Substitution

In the late 1980s and early 1990s, bleached kraft mills began substituting chlorine dioxide (ClO_2) for some or all of the molecular chlorine normally used in the first bleaching stage. This process became known as chlorine dioxide substitution, and became common practice in the industry at that time because ClO_2 substitution reduces the formation of chlorinated organics in the bleach plant effluent and lowers bleach plant chemical consumption (4).

As mills used more and more ClO_2 , additional benefits were realized such as further reductions in chlorinated organics in bleach plant effluent and more consistent and improved pulp quality because it minimizes cellulose degradation. Then mills began to use complete (100 percent) substitution of ClO_2 for chlorine. By mid-1995, over 32 percent of bleached kraft production in the United States was made using complete ClO_2 substitution, and many companies had committed to installing the technology on additional bleach plants. By 1996, 67 percent of bleached kraft production in Canada was made using complete ClO_2 substitution (30).

The amount of ClO_2 used is expressed as percent substitution and is defined as the percentage of the total chlorine bleaching power of the first bleaching stage that is provided by chlorine dioxide. It is calculated by the following formula:

$$\text{Percent Substitution} = \frac{2.63 (\text{ClO}_2 \text{ in kg/kg})}{2.63 (\text{ClO}_2 \text{ in kg/kg}) + (\text{Cl}_2 \text{ in kg/kg})} \quad (1)$$

where 2.63 equals the oxidizing power of chlorine dioxide compared to chlorine. Chlorine dioxide is a stronger oxidizing agent than chlorine. Consequently, less chemical is required when chlorine dioxide is substituted for chlorine.

Chlorine dioxide must be generated on site because it is unstable and cannot be transported in a pure form by truck or rail. As of January 1, 1993, most mills that bleach chemically pulped wood pulps generated chlorine dioxide on site, and more than 60 percent of those mills used chlorine dioxide substitution in the first bleaching stage, as shown below:

Subcategory	Total Number of Mills	Number With ClO_2 Generation On Site	Number With ClO_2 Substitution in First Bleaching Stage
Bleached Papergrade Kraft and Soda	87	79	60
Papergrade Sulfite	10	5	4

In generating chlorine dioxide, byproducts are produced. Sodium sulfate (Na_2SO_4) and chlorine are generated in different amounts, depending on the chlorine dioxide generator, as shown below (31):

Chlorine Dioxide Generator	Cl_2 (kg/kg ClO_2)	Na_2SO_4 (kg/kg ClO_2)
Solvay	0	3.5
Mathieson	0	3.5
R2	0.66	7
R3	0.66	2.4
R8	0	1.4

It is important to control the ratio of chlorine applied in the first bleaching stage to lignin content of the pulp entering the first bleaching stage, as well as the amount of ClO_2 substitution, to most effectively reduce the formation of chlorinated compounds (4). The ratio of total chlorine (from molecular chlorine and chlorine dioxide) in the first bleaching stage

(expressed as percent on pulp) to kappa number of the pulp entering the first bleaching stage is referred to as the active chlorine multiple (ACM) or kappa factor:

$$\text{Kappa Factor (ACM)} = \frac{[\text{Cl}_2 \text{ (kg/100 kg brown stock)} + 2.63 \text{ ClO}_2 \text{ (kg/100 kg brown stock)}]}{\text{Pre-chlorination kappa number}} \quad (2)$$

A Canadian study evaluated the formation of 2,3,7,8-TCDD and 2,3,7,8-TCDF in the final effluent from bleached kraft mills relative to ClO₂ substitution and ACM (29). The study developed an equation for the relationship between ClO₂ substitution and ACM which is described in Section 8.3.5 of the TDD. For complete ClO₂ substitution, the study equation predicts that TCDDs and TCDFs will not be formed if an ACM of 0.48 or less is used. The detection limits in the study were 10 ppq for 2,3,7,8-TCDD and 30 ppq for 2,3,7,8-TCDF.

EPA's data, described in a separate document (32), show that 2,3,7,8-TCDD is normally not detected at mills using complete ClO₂ substitution but that 2,3,7,8-TCDF is occasionally detected below 30 ppq (even when the ACM is below 0.48). This document also shows that the 12 chlorinated phenolic compounds regulated by this rule are normally not detected at mills using complete ClO₂ substitution and that chloroform generation is substantially reduced for these mills compared to conventional bleaching sequences.

7.3.4 Enhanced Extraction

In the alkaline extraction stages of the bleach plant, lignin reaction products from the preceding acid stages are dissolved, or extracted, by applying sodium hydroxide (caustic) solutions to the pulp. These dissolved products are then washed from the pulp. The first caustic extraction stage of the bleach plant can be enhanced with oxygen, hydrogen peroxide, or both (shown as E_o, E_p, and E_{op}, respectively) to replace equivalent quantities of chlorine-based bleaching chemicals in other bleaching stages (34). Enhanced extraction is a low capital cost measure that improves effluent quality by reducing chlorine consumption, therefore reducing the amount of chlorinated organics in the bleach plant effluent. Mills implementing enhanced extraction typically reduce molecular chlorine use in the first bleaching stage, while keeping the chlorine dioxide addition rate constant (resulting in a higher level of chlorine dioxide substitution).

Oxygen-enhanced extraction became commercially feasible in the early 1980s due to the development and introduction of high shear mixers for pulp stock. A high shear mixer is required to ensure good mixing of the gaseous oxygen with the pulp. The extraction must be carried out in either an upflow extraction tower or a downflow tower preceded by a small upflow pre-retention tube to maintain the pressure required to keep the oxygen gas in solution until it has reacted with the pulp. Adding oxygen to the extraction stage improves delignification by approximately 25 percent (35), while allowing the mill to use less chlorine or chlorine dioxide in the overall bleaching sequence. Adding between 4 and 6 kg of oxygen per kkg of pulp saves approximately 2 kg of active chlorine per kg of oxygen (29).

Oxygen-enhanced extraction normally reduces overall bleaching chemical costs, thus justifying, in many cases, the capital cost of the additional mixing power and piping required. Data from many mills in the U.S. that converted their bleaching sequences from E to E_o operation during the 1980s support this fact.

Hydrogen peroxide is usually added at the inlet to the oxygen mixer when E_{op} is used, or at the inlet to the stock pump for E_p alone. Adding hydrogen peroxide in the first extraction stage improves delignification and reduces chlorine-based chemical requirements either in the first chlorination stage or further along in the bleaching sequence. Applying 1 kg of peroxide per kkg of pulp results in an active chlorine savings of approximately 2 to 3 kg (31). If hydrogen peroxide-enhanced extraction is used following 100 percent chlorine dioxide substitution, a higher final brightness can be achieved (29).

Mills that use hydrogen peroxide-enhanced extraction are able to reduce the amount of either molecular chlorine or chlorine dioxide in other bleaching stages. The cost of hydrogen peroxide is currently much higher than the cost of molecular chlorine and slightly lower than the cost of chlorine dioxide (see Section 10). Therefore, a mill operating hydrogen peroxide enhancement increases its operating costs if it reduces molecular chlorine use, but decreases operating costs if it reduces chlorine dioxide use.

Adding oxygen to an extraction stage is more capital intensive than adding peroxide because, as described above, a high shear mixer and other equipment must be used for the bleaching stage to operate effectively. Therefore, the simplest way for a mill to enhance its extraction stage is with hydrogen peroxide. Unlike oxygen, hydrogen peroxide is also effective in enhancing the second extraction stage. In addition, the bleaching power of the E_{op} stage can be increased by raising the temperature, which is another strategy to reduce bleaching chemical charge at relatively low cost.

A significant number of U.S. bleached pulp mills have implemented enhanced extraction. As of January 1, 1993 and mid-1995, the number of mills using some form of enhanced extraction were:

Subcategory	Total Number of Mills	Number With Enhanced Extraction in 1993 (E _o , E _p , or E _{op})	Number With Enhanced Extraction in 1995 (E _o , E _p , or E _{op})
Bleached Papergrade Kraft and Soda	87	65	77
Papergrade Sulfite	10	4	6

7.3.5 Elimination of Hypochlorite

Sodium hypochlorite and calcium hypochlorite are effective bleaching agents that attack lignin. Sulfite pulps are more easily bleached with hypochlorite than kraft pulps because the lignin is more easily solubilized (19). Hypochlorite can also degrade cellulose, decreasing pulp viscosity. To limit cellulose degradation, hypochlorite is usually applied in an intermediate bleaching stage for kraft pulps.

Chloroform is generated when pulp is bleached with hypochlorite (36). Mills that use sodium or calcium hypochlorite in one or more bleaching stages generate approximately ten times as much chloroform as mills using a CEDED bleaching sequence (37). Controlling chloroform releases generally entails eliminating hypochlorite as a bleaching agent. The bleaching power of hypochlorite can be replaced by chlorine, chlorine dioxide, peroxide, and/or oxygen. However, replacing hypochlorite with chlorine is counterproductive if the purpose is to reduce chloroform generation, because bleaching with molecular chlorine also generates chloroform.

For some mills, particularly mills with short bleaching sequences (e.g., CEH), eliminating hypochlorite requires replacing the hypochlorite bleaching tower with a new chlorine dioxide tower, washer, and auxiliaries made of materials resistant to the more corrosive environment of chlorine dioxide bleaching. Some mills may be able to modify the bleaching chemical additions to other stages (i.e., adding oxygen and/or peroxide to the first extraction stage) and abandon the hypochlorite stage, rather than replacing it. Mills with a CEHDED-type of bleaching sequence and mills that use hypochlorite only in extraction stages may be able to eliminate the hypochlorite stage.

Replacing hypochlorite reduces direct operating costs, because hypochlorite is more expensive than chlorine dioxide, oxygen, and peroxide. Hypochlorite also has a lower chlorine equivalence factor (see Section 10). The number of mills using a hypochlorite stage or hypochlorite-reinforced extraction as of January 1, 1993 and mid-1995 are shown below:

Subcategory	Total Number of Mills	Mills Using Hypochlorite in 1993	Mills Using Hypochlorite in 1995
Bleached Papergrade Kraft and Soda	87	36	20
Papergrade Sulfite	10	9	7

7.3.6 Strategies to Minimize Kappa Factor and DBD and DBF Precursors

As noted in Section 7.3.3 in this document, the control of the kappa factor (or ACM) in the first bleaching stage is an important process control parameter. EPA's data and the data of other researchers indicate that particular chlorinated organic pollutants are not detected in bleach plant effluent when bleaching kappa factors are maintained below certain values. In

particular, Shariff et al. (38) studied TCDF and, for ClO₂ bleaching, developed the following relationship:

$$\text{TCDF} \sim (\text{precursor concentration}) (\text{kappa factor})^4$$

Assuming this relationship is correct, to minimize the formation of TCDD/F, process operators should minimize:

1. Kappa factor; and
2. Precursors contained in the pulp entering the bleach plant.

Each strategy is discussed separately below. This discussion also appears in EPA's Comment Response Document (39). Some of the strategies for minimizing kappa factor are discussed in more detail in separate subsections of this section but are briefly repeated here for completeness of this discussion.

Minimizing Kappa Factor

Strategies for minimizing kappa factor include:

Reducing first stage kappa factor and shifting bleaching to later stages that are not implicated in TCDD/F formation;

Optimizing conditions in the first bleaching stage for most efficient use of the ClO₂ applied;

Improving process control so that kappa factors are not permitted to fluctuate;

Modifying the extraction stages by peroxide and/or oxygen reinforcement and operating at a higher temperature;

Reducing knots, compression wood, dirt, and shives by improving screening or operating oxygen delignification; and

Reducing black liquor carryover by improving pulp washing.

Each of these strategies is discussed below.

Shifting bleaching to later stages - Bleaching is a multi-stage process in which, historically, acid chlorine bleaching stages are alternated with alkaline extraction stages. This multi-stage process provides considerable flexibility to mill operators in terms of where they make the bleaching reactions happen. Mills producing high brightness pulp generally have five bleaching stages (D₀ED₁ED₂). They can reduce the kappa factor in the D₀ stage and increase the

bleaching power of later stages by reinforcing the extraction stages with oxygen and peroxide and if necessary, increasing the ClO_2 charge in the D_1 and D_2 stages.

Optimizing first stage bleaching conditions - Reeve (40) reports that ClO_2 required to reach a target kappa number (CEK) is a function of pH, chloride ion concentration, the type of pulp, and extraction stage conditions. If pH is too high, for example, required kappa factor will increase. Georgia-Pacific reported that control of first stage pH was key to effective low kappa factor bleaching (41). Insufficient chloride ion concentration will also increase the required kappa factor. Pulp mill bleaching conditions such as pulp consistency, temperature, retention time, and pulp cleanliness are extremely varied. In addition, the objective of bleaching, in terms of target brightness, cleanliness and strength differ among products and mills. Because of this variety, bleaching conditions must be optimized for each product produced at each mill.

Improving process control - At some mills, the quality of unbleached pulp entering the first stage of bleaching is poor and inconsistent. The kappa number may vary widely over space and time. If a constant bleaching chemical application rate is used, the kappa factor also varies widely. To control kappa factor thus means controlling the kappa number. Extended cooking and oxygen delignification produce pulps with a more uniform and constant kappa number than the pulp produced by many conventional pulping operations. Improved mixing also produces a more uniform pulp. In addition, in-line kappa number measuring instruments with feed-back controls are used to adjust the chemical application rate to the measured kappa number. A charge of bleaching chemical can also be applied stepwise to improve process control (42).

Peroxide and oxygen reinforced extraction - It has become common practice to compensate for a lower kappa factor by using peroxide and/or oxygen in the second stage (E_p or E_{op}). This strategy can also reduce operating costs, because peroxide is less expensive than chlorine dioxide. In addition, the bleaching power of the E_{op} stage can be increased by raising the temperature, which will reduce the required kappa factor at relatively low cost.¹

Reducing dirt and shives entering the bleach plant - Conventionally pulped wood contains dirt (colored particulate matter) and shives (intact fiber bundles). Dirt and shives can be removed by bleaching. Often, the ClO_2 charge is established to meet dirt specifications, and may exceed the charge necessary to meet brightness specifications. Improved chip size control (to remove knots and compression wood for improved pulping), improved brown stock screening, oxygen delignification, and extended cooking reduce dirt and shives entering the bleach plant making possible the use of lower bleaching chemical charge (a lower kappa factor).

¹In addition to reducing the potential for the formation of TCDD/F, reduced kappa factor minimizes bleaching costs. Reeve and Dence (1996) report that after balancing the ClO_2 applied in the first stage with the ClO_2 , peroxide, and oxygen used in later stages, the most cost effective kappa factor is 0.14 to 0.16, depending on wood species.

Reducing black liquor carry-over by improving pulp washing - Poorly washed pulp carries a large quantity of black liquor into the bleach plant. Black liquor contains the non-fibrous fraction of raw wood that is separated from the fiber during pulping, as well as the spent cooking chemicals. This black liquor carry-over consumes oxidizing (bleaching) chemicals. For a poorly washed pulp, a higher kappa factor is required to achieve the same degree of delignification in the first bleaching stage than is required for a well-washed pulp.

Minimizing Precursors

The results reported by EPA and Shariff et al. indicated that TCDF can still be formed at mills that have eliminated obvious sources of DBD and DBF precursors such as contaminated defoamers and kerosene. Thus, some TCDF precursors must be contained in brown stock pulp. This pulp is a mixture of cellulose fiber, lignin, and black liquor carry-over. Hise (43) and Hrutfiord (44) have speculated that precursors could originate from lignin fragments that accumulate in the black liquor after pulping.

Berry (45) found that precursor concentration can be decreased by steam stripping brown stock pulp to remove volatile components. Berry (46) explains that steam stripping is an inherent part of high consistency oxygen delignification and also occurs when brown stock pulp is released from the digester at a temperature at which steam is driven from the pulp. Berry (45) found that processing pulp through an oxygen delignification stage using nitrogen-gas instead of oxygen removed precursors. Because no oxidation occurred under these test conditions, Berry concluded that the precursor removal was a result of the physical actions of the washing and steam stripping. Others conclude that oxygen delignification will oxidize a significant portion of the lignin monomers (47), again, resulting in reduced precursor levels.

Hrutfiord (44) found that greater quantities of TCDD/F are formed in the chlorination of compression wood than normal wood. Compression wood, prevalent in knots, is the main source of *p*-hydroxyphenyl which can form DBD and DBF.

Pulping digester and evaporator condensates, derived from black liquor, contain many of the same constituents as the black liquor itself. The condensates are frequently treated to remove foul-smelling TRS and then to wash pulp prior to bleaching. It has been hypothesized that inadequately treated condensates used to wash oxygen delignified pulp are a source of TCDD/F precursors (Francis, Personal Communication, 1992).

Removal of TCDD/F precursors, including lignin monomers² contained in black liquor, could be accomplished through:

²If the TCDF precursors are actually in the lignin, a relationship should exist between kappa number into bleaching and TCDF. Data collected by EPA and data submitted by Shariff et al. do not demonstrate this conclusion, possibly because kappa factor has a much more significant impact on the formation of TCDF than precursor concentration.

Brown stock washing that achieves extremely low carry-over of organic compounds;

Oxygen delignification (through increased washing, steam stripping, or other physical mechanisms or, possibly, by chemical oxidation of precursors);

Removal of knots (compression wood) from brown stock pulp prior to bleaching; and

Use of only precursor-free pulping and evaporator condensates in post-oxygen delignification washing.

7.3.7 Enzyme Bleaching

Enzymes are organic compounds that act as catalysts in reactions. Xylanase enzymes improve the bleachability of wood pulps by partially hydrolyzing the xylan (the primary bonding agent between the cellulose and the lignin) although the exact mechanism by which they aid in bleaching is not known (48). The lignin is therefore more easily removed in subsequent bleaching stages. Xylanase may be added to the pulp after brown stock washing or after oxygen delignification to reduce or eliminate the need for bleaching with chlorine compounds. The optimum conditions for the xylanase reaction are temperatures between 40 and 55 between 4 and 6, and retention time between 0.5 and 3 hours (48). The xylanase is applied at less than 1 kg/kkg of pulp.

Several mills worldwide have conducted full-scale trials with xylanase on kraft pulps with resulting increases in brightness and viscosity and no loss of pulp strength (48). More experimental work has been done using enzymes to bleach kraft pulps than to bleach sulfite pulps.

7.3.8 Peroxide Bleaching

Though hydrogen peroxide is primarily used to reinforce caustic extraction stages, hydrogen peroxide can replace chlorine compounds in bleaching chemical pulps. The brightness achievable using peroxide can be increased by lowering the lignin content of the pulp as much as possible prior to bleaching (e.g., by using oxygen delignification).

While bleaching stages that use chlorine compounds inherently remove metal ions (e.g., Ca, Mg, Na, etc.) from the pulp, these ions will react with peroxide to form hydroxyl radicals that can degrade cellulose. Therefore, the metal ions must be removed from solution by using chelating agents, followed by effective pulp washing prior to applying peroxide (49). When a peroxide stage follows a chlorine compound bleaching stage, separate addition of a chelating agent is not required. One method of peroxide bleaching using chelating agents is the Lignox® process developed by Eka Nobel (50).

The peroxide charge required for a full peroxide stage is approximately 2.5 percent on pulp. To fully use the peroxide charge and achieve high brightness requires a temperature of between 70 and 90 decrease pulp viscosity (49).

Peroxide bleaching has been demonstrated in full-scale applications at both kraft and sulfite mills outside the U.S. The capital cost of implementing peroxide bleaching is minimal, assuming use of existing bleaching towers. Because the unit cost for hydrogen peroxide is higher than for chlorine, operating costs for peroxide bleaching may be higher depending upon the amount of peroxide used. The cost of the large amount of peroxide that is necessary to bleach a pulp to full brightness has limited the use of peroxide bleaching.

7.3.9 Totally Chlorine-Free Bleaching of Papergrade Kraft Pulps

Totally chlorine-free bleaching is performed without the use of chlorine, sodium or calcium hypochlorite, chlorine dioxide, chlorine monoxide, or any other chlorine-containing compound. TCF bleaching is performed using a combination of enzymes, ozone, oxygen, and/or peroxide. In the last several years, numerous TCF bleaching processes have been developed and are now used at bleached papergrade kraft mills worldwide.

Section 8.3.11 of the TDD reported briefly the status of TCF bleaching at papergrade kraft mills in 1993. At that time about 15 mills worldwide were making some TCF bleached pulp but few of the mills were dedicated to TCF production due to a lack of market demand. Also, most of the TCF pulps were bleached to a lower brightness than market kraft grades (75-80 ISO vs 88-90 ISO). Therefore, EPA concluded that TCF was not an available pollution prevention technology because of limited worldwide experience with this process and a lack of data for TCF bleaching of softwood to full market brightness.

EPA received many comments that it should continue to investigate TCF bleaching because dioxin and furan are not generated at any level with TCF bleaching, thus assuring that these pollutants are not released to the environment. The Agency conducted two sampling programs at the one U.S. mill that produces softwood TCF bleached kraft pulp. EPA collected samples of bleach plant filtrates but could not collect samples of treated effluent because the mill does not employ secondary treatment. The Agency also conducted a sampling program at a Nordic mill that produces hardwood and softwood kraft pulp on two bleach lines that alternate between elemental chlorine-free (ECF) and TCF bleaching. Samples collected at this mill could not be used to characterize treated TCF bleaching effluents, because the TCF bleaching effluents are combined with ECF bleaching effluents for treatment.

Both of the sampled softwood TCF fiber lines employed oxygen delignification followed by multiple stages of peroxide bleaching. The U.S. mill's unbleached pulp kappa number was between 7 to 10. The bleach sequence for the U.S. mill is $QE_{op}PPPS$ (51). Q represents an acidic chelant stage, followed by an enhanced extraction stage (E_{op}), three alkaline peroxide stages (PPP), and the addition of sodium bisulfite (S). Bleached pulp brightness was

approximately 79 during the first sampling episode at the U.S. mill, but by the time of the second sampling episode pulp brightness had increased to 83 ISO. The Nordic mill uses extended cooking, and was able to reduce the lignin content of unbleached pulp to a low kappa number of four. The Nordic mill bleach sequence is QPPP. At the time of sampling, this mill bleached pulp to a brightness of 83 ISO.

At neither mill was chloroform or chlorinated phenolic pollutants detected in samples collected by EPA. At the U.S. mill, dioxin, furan, and AOX were not detected above the analytical minimum level during sampling fully representative of TCF operations. The average bleach plant AOX loading measured by EPA at the Nordic mill was 0.002 kg/ADMT (compared to a long-term average of 0.51 kg/ADMT for Option A). EPA's dioxin sampling results for the Nordic mill were surprising. Dioxin was detected at a concentration just above the minimum level in one sample of combined bleach plant filtrate, when the mill was bleaching without the use of chlorine or any chlorinated compounds. Furan was not detected. EPA believes the dioxin results were unique to the operation of this mill and does not conclude that TCF bleaching generates dioxin.

Neither of the two sampled mills produced softwood pulp at full market brightness. By the end of 1996, two mills were producing exclusively TCF pulp that was fully bright and fully strong (see Section 8.7.2 of this document). Data in EPA's record are insufficient to confirm that TCF bleaching processes are technically demonstrated for the full range of products made with bleached kraft pulp. Despite these impediments, EPA believes that the progress being made in TCF process development is substantial, and that additional data may demonstrate that TCF processes are indeed available for the full range of market products. TCF mills will qualify for at least Tier I of the Voluntary Advanced Technology Incentives Program.

7.3.10 Totally Chlorine-Free Bleaching of Papergrade Sulfite Pulps

Section 8.3.14 of the TDD reported briefly the status of TCF bleaching at papergrade sulfite mills in 1993. At that time at least 10 mills worldwide were making TCF bleached sulfite pulp. EPA visited one of these mills to collect bleach plant effluent samples. As of 1995, two U.S. sulfite mills were using TCF bleaching processes.

The bleaching sequences at most of the TCF papergrade sulfite mills are based on oxygen delignification, followed by one or more peroxide bleaching stages. Many of these mills describe their oxygen delignification stage as an enhanced extraction stage (E_{op}); however, in form and function it is the same as oxygen delignification (i.e., a pressurized tower is used to introduce oxygen to lower the pulp lignin content). Further delignification, or bleaching, is performed with one or more peroxide stages. The peroxide stages are operated at consistencies ranging from 12 to 30 percent; peroxide charges vary between 30 and 40 kg/ADMT. To prevent side reactions of metal ions in the peroxide stages, some mills use acid washes or add chelating agents before, between, or in the peroxide stages. Some mills also add sodium silicate or nitrilamine to peroxide stages to further brighten the pulp.

The furnish used by papergrade sulfite mills using TCF bleaching include a variety of hardwoods (predominately birch and beech) and softwoods (mostly spruce). These TCF sulfite mills also make a variety of products including market pulp, tissue, and printing and writing grades. Bleached pulp properties vary by product. Most mills report brightnesses near 85 ISO; the range reported is 70 to 90 ISO.

7.4 End-of-Pipe Wastewater Treatment Technologies

This section describes the BAT component of efficient biological treatment. More detailed information about the wastewater treatment processes in use at pulp and paper mills is presented in Section 8.5 of the TDD.

According to EPA's 1990 Census Questionnaire, more than 80 percent of direct discharging pulp and paper mills in the United States use primary and secondary (biological) wastewater treatment, while only 2 percent use tertiary treatment. Indirect discharging mills discharge to POTWs, which also use secondary wastewater treatment.

Primary treatment is the removal of suspended solids. Primary treatment may also include other pre-biological treatment processes such as equalization, neutralization, or cooling. Secondary treatment involves a biological process to remove organic matter through biochemical oxidation. In the pulp and paper industry, activated sludge systems and aerated/non-aerated basin systems are the most commonly used biological processes. Tertiary treatment is advanced treatment, beyond secondary, to remove particular contaminants. Examples of tertiary treatment are the removal of phosphorus by alum precipitation and removal of toxic refractory organic compounds by activated carbon adsorption.

Common elements of wastewater treatment, as practiced in the pulp and paper industry, include (but are not limited to):

Primary sedimentation;

Neutralization;

Equalization;

Precooling;

Nutrient addition;

Aeration;

Multi-basin systems, some of which act as polishing ponds;

Mixed or hybrid treatment systems (activated sludge and basin systems operated in series or parallel); and

Addition of flocculants to secondary clarifiers to improve settling.

As noted in Section 8.5 of the TDD, the operation of treatment systems is important to achieving optimum effluent quality, particularly the activated sludge systems which require careful day-to-day attention to numerous important operating parameters. EPA defined efficient biological treatment as that which removes 90 percent or more of the influent BOD₅. Most papergrade kraft and sulfite mills are achieving 90 percent BOD₅ removal (see TDD Table 9-8 based on data from the 1990 Census Questionnaire data). NCASI also reported greater than 90 percent BOD₅ removals for direct discharging mills and for POTWs receiving chemical pulp mill wastewater.

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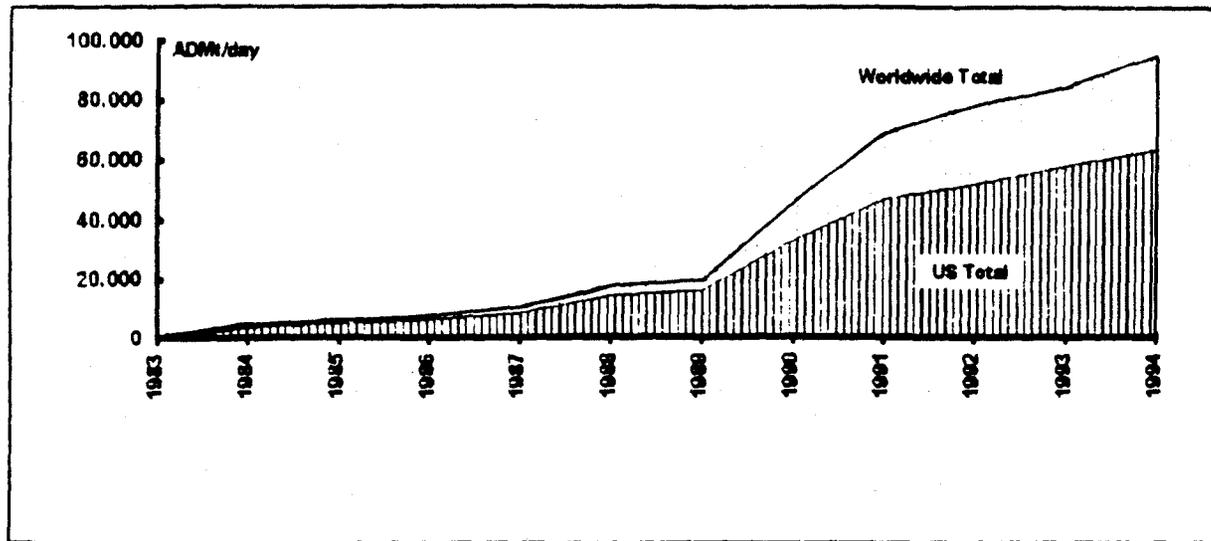


Figure 7-1. U.S. and Worldwide Increase in Kraft Pulp Produced by Extended Cooking, 1983-1992

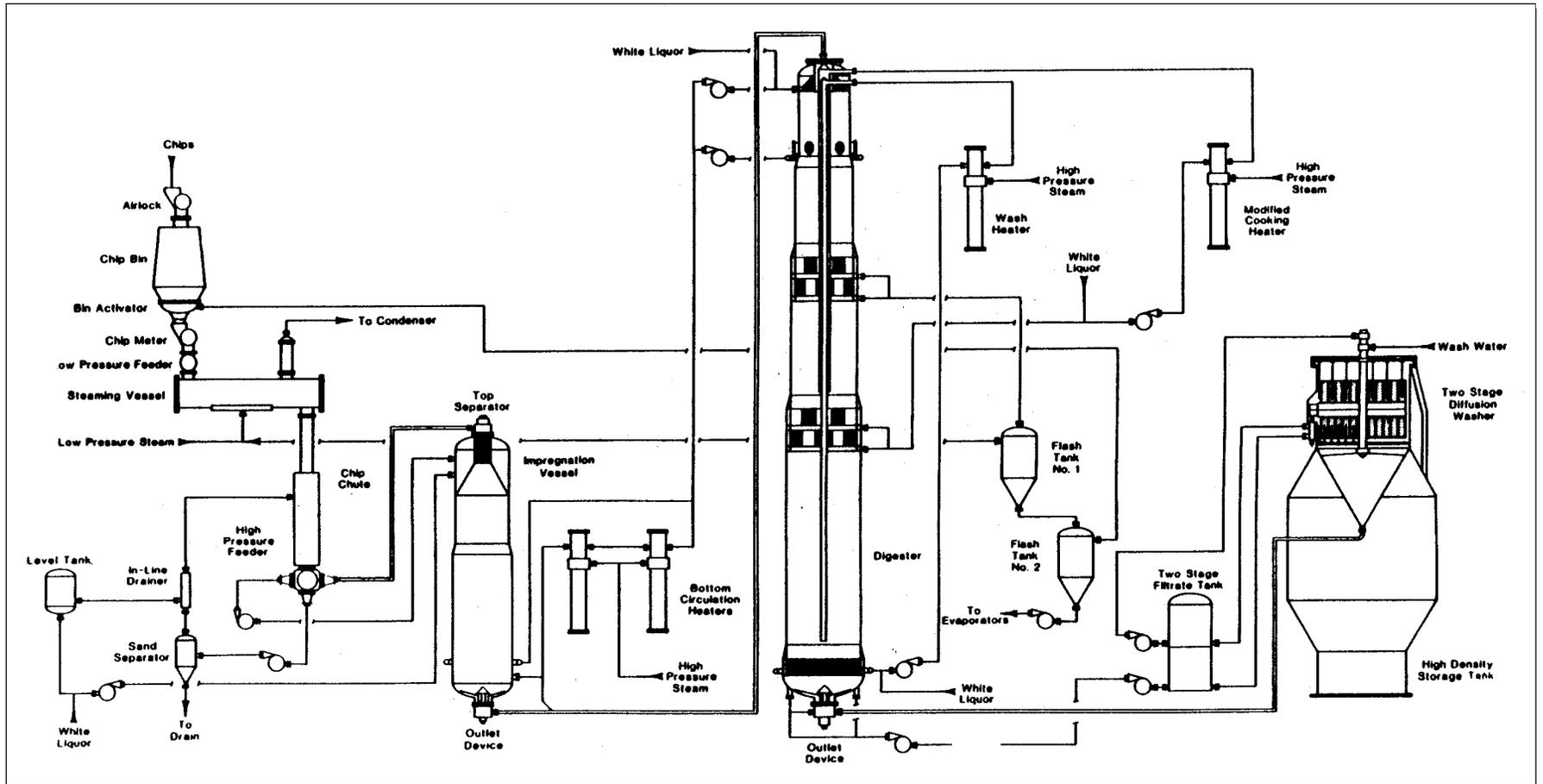


Figure 7-2. Extended Cooking Continuous Digester System (EMCC®)

Courtesy of Kamyr, Inc., Glens Falls, New York.

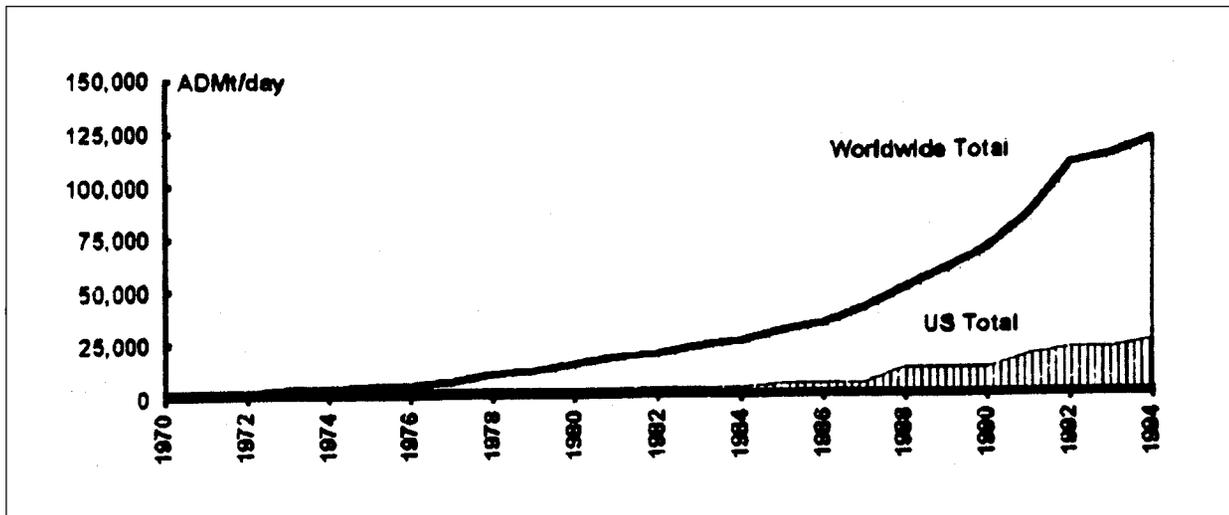


Figure 7-3. U.S. and Worldwide Increase in Kraft Pulp Produced by Oxygen Delignification, 1970-1992

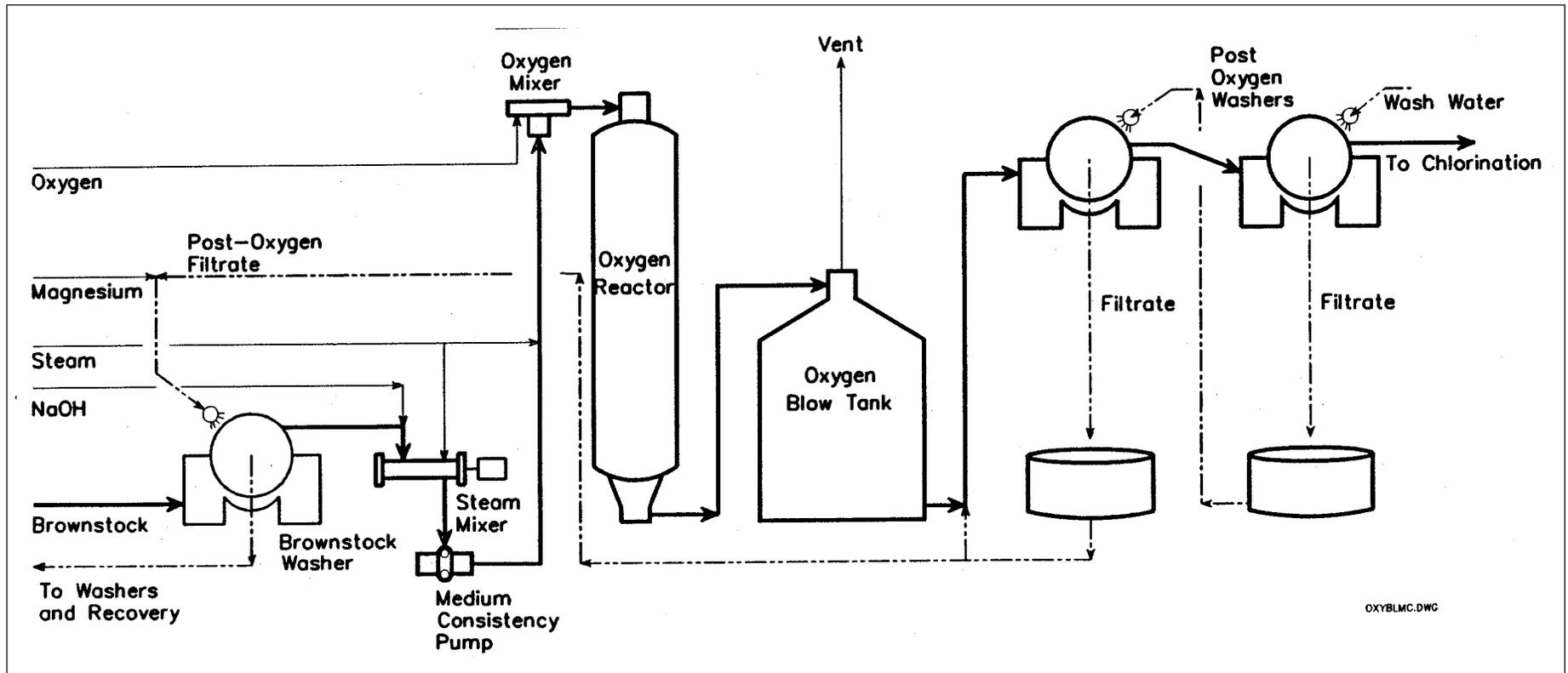


Figure 7-4. Typical Medium-Consistency Oxygen Delignification System

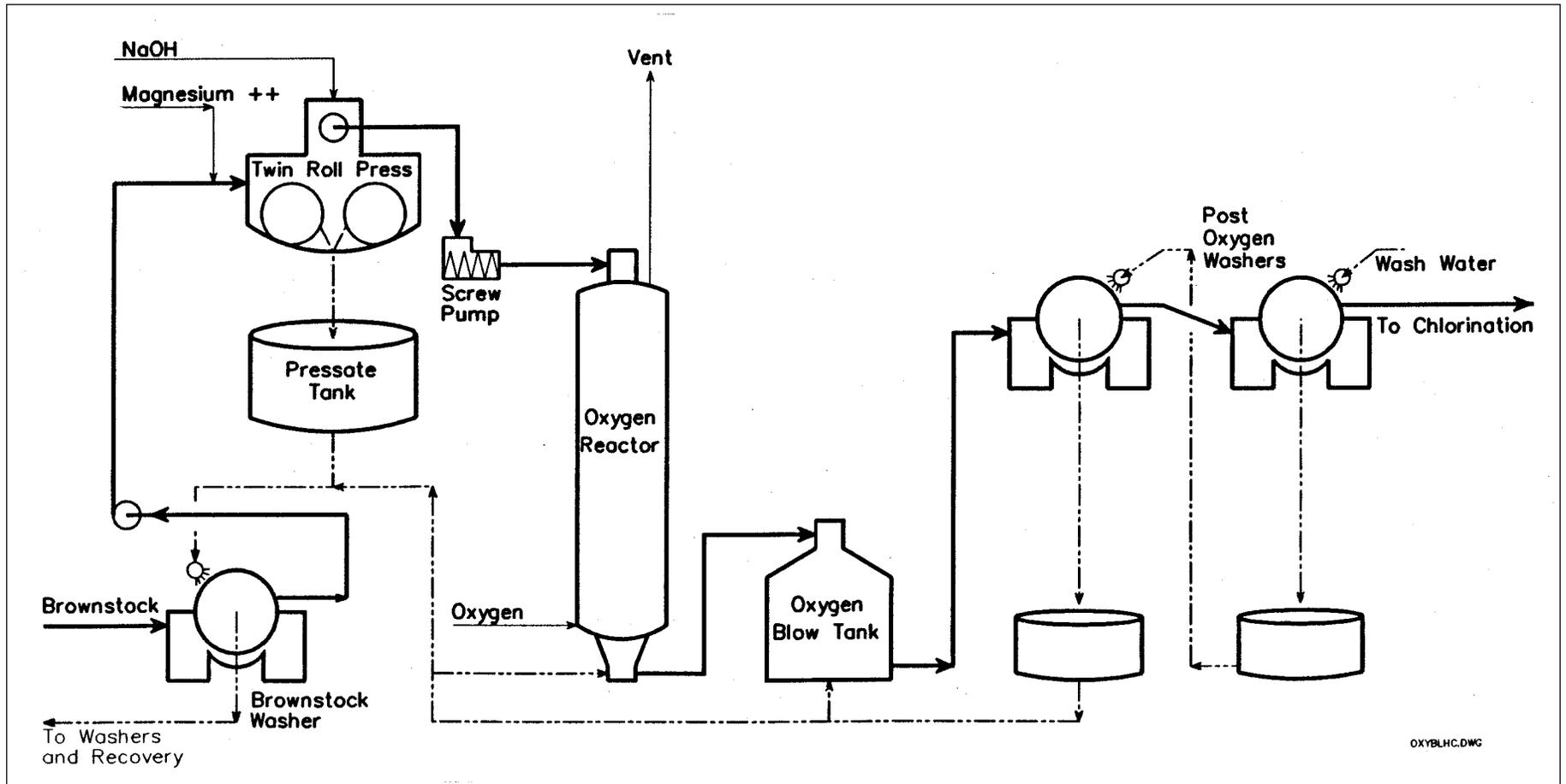


Figure 7-5. Typical High-Consistency Oxygen Delignification System

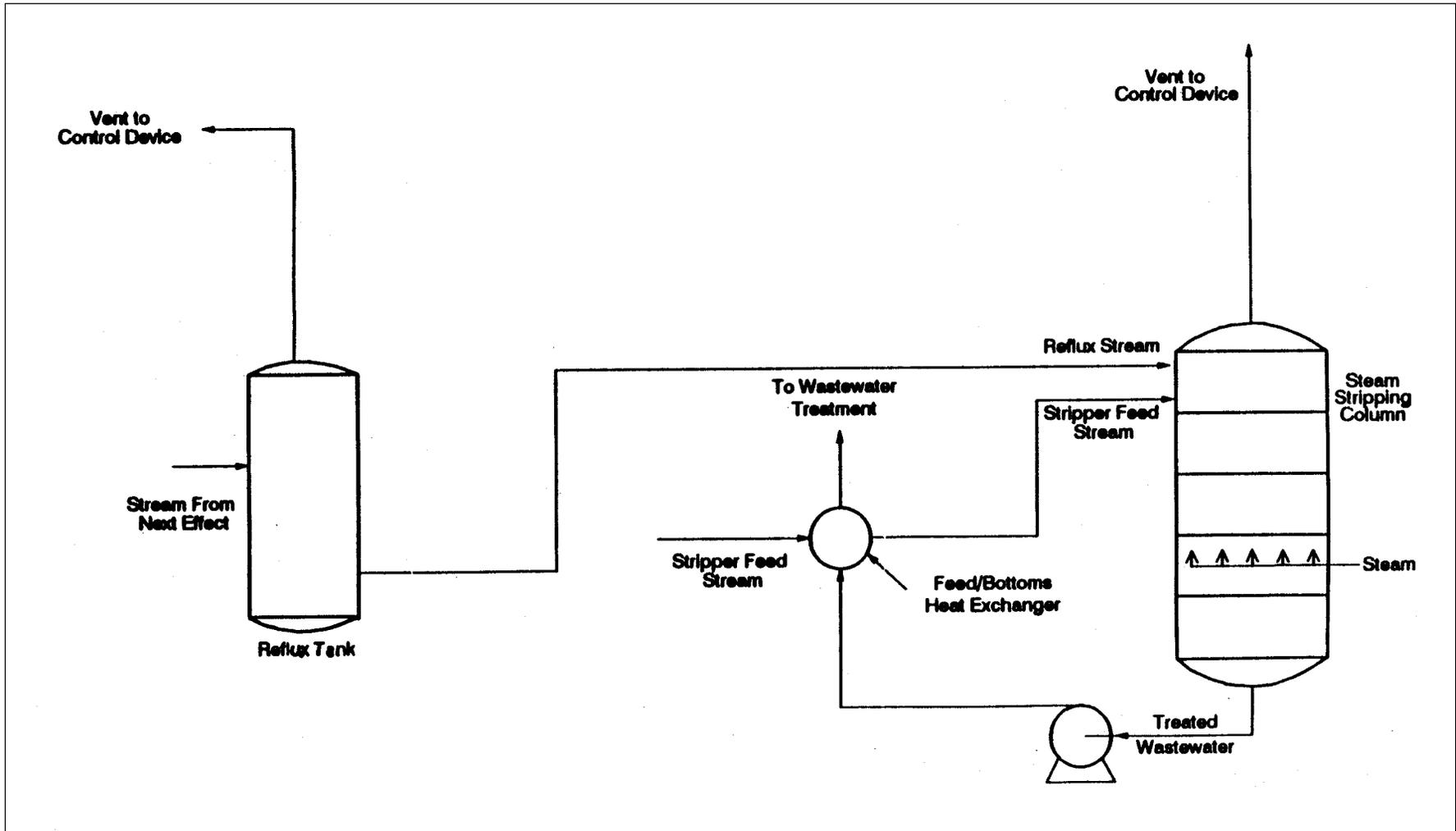


Figure 7-6. Continuous Steam Stripper System

SECTION 8

DEVELOPMENT OF CONTROL AND TREATMENT OPTIONS

8.1 Introduction

This section describes the combinations of pulping and bleaching technologies, in-process water conservation practices, and end-of-pipe wastewater treatment that the Agency configured as technology options for consideration as bases for the following regulations:

- ˘ BPT (best practicable control technology currently available);
- ˘ BCT (best conventional pollutant control technology);
- ˘ BAT (best available technology economically achievable);
- ˘ NSPS (new source performance standards);
- ˘ PSES (pretreatment standards for existing sources); and
- ˘ PSNS (pretreatment standards for new sources).

These regulations establish quantitative limits on the discharge of pollutants from industrial point sources. As explained in the preamble and in Section 12 of this document, EPA decided not to promulgate the proposed regulations for BPT and BCT. BPT and BCT limitations for the pulp and paper industry, therefore, are based on the formerly promulgated BPT and BCT limitations. EPA is promulgating BAT, NSPS, PSES, and PSNS today. The applicability of the various regulations is summarized below:

	Direct Discharge	Indirect Discharge	Existing Source	New Source	Conventional Pollutants	Toxic and Nonconventional Pollutants
BPT	X		X		X	
BCT	X		X		X	
BAT	X		X			X
NSPS	X			X	X	X
PSES		X	X			X
PSNS		X		X		X

All of these regulations are based on the performance of specific technologies but do not require the use of any specific technology. The regulations applicable to direct dischargers are effluent limitations guidelines which are applied to individual facilities through NPDES permits issued by EPA or authorized states under Section 402 of the CWA. The regulations applicable to indirect dischargers are standards, and are administered by local permitting authorities (i.e., the government entity controlling the POTW to which the industrial

wastewater is discharged). The pretreatment standards are designed to control pollutants that pass through or interfere with POTWs.

8.2 Toxic and Nonconventional Pollutants

The toxic and nonconventional pollutants consist of AOX, chloroform, 2,3,7,8-TCDD, 2,3,7,8-TCDF, and 12 chlorinated phenolic compounds. Regulations are being promulgated for these pollutants for mills in the Bleached Papergrade Kraft and Soda (Subpart B) and Papergrade Sulfite (Subpart E) subcategories.

8.2.1 Bleached Papergrade Kraft and Soda Subcategory (BPK)

EPA developed four options to reduce wastewater discharges of toxic and nonconventional pollutants. Two options focused on elemental chlorine-free bleaching technologies and two focused on totally chlorine-free bleaching technologies. The ECF options are identified as Option A and Option B. The TCF options are identified as TCF-peroxide and TCF-ozone. Each option is described in the following sections.

8.2.1.1 BPK Option A

Option A consists of conventional pulping followed by complete substitution of chlorine dioxide for elemental chlorine, as well as the nine elements identified below:

- (i) Adequate chip thickness control;
- (ii) Closed brown stock pulp screen room operation, such that screening filtrates are returned to the recovery cycle;
- (iii) Effective brown stock washing, i.e., washing that achieves a soda loss of less than or equal to 10 kg Na₂SO₄ per ADMT of pulp (equivalent to 99 percent recovery of pulping chemicals from the pulp);
- (iv) Use of TCDD- and TCDF-precursor-free defoamers (water-based defoamers or defoamers made with precursor-free oils);
- (v) Elimination of hypochlorite, i.e., replacement of hypochlorite with equivalent bleaching power in the form of additions of peroxide and/or oxygen to the first extraction stage and/or additional chlorine dioxide in final brightening stages;
- (vi) Use of strategies to minimize kappa factor and TCDD- and TCDF-precursors in brown stock pulp;

- (vii) High shear mixing to ensure adequate mixing of pulp and bleaching chemicals;
- (viii) Oxygen and peroxide enhanced extraction, which allows elimination of hypochlorite and/or use of a lower kappa factor in the first bleaching stage; and
- (ix) Efficient biological wastewater treatment, achieving removal of 90 percent or more of influent BOD₅.

8.2.1.2 BPK Option B

Option B is identical to Option A, with the addition of extended delignification (oxygen delignification and/or extended cooking). In a slight change from the definition of the proposed option, EPA has defined Option B not only in terms of the presence of extended delignification technology (i.e., oxygen delignification or extended cooking) but also by the pre-bleaching kappa number achieved by extended delignification. EPA defines extended delignification as the operation of such technologies that result in a kappa number of 20 or less for softwoods and less than 13 for hardwoods. Sections 7.2.3 and 7.2.6 contain more detailed descriptions of each technology.

8.2.1.3 TCF-Peroxide

EPA evaluated a peroxide-based TCF bleaching option which is performed without the use of chlorine, sodium hypochlorite, calcium hypochlorite, chlorine dioxide, chlorine monoxide, or any other chlorine-containing compound. This option contains all but two of the elements listed for Option A. The two elements not included in this option are: 1) use of dioxin- and furan-precursor-free defoamers, and 2) strategies to minimize kappa factor and TCDD- and TCDF-precursors in brown stock pulp because the option uses peroxide, and not chlorine-based, bleaching. For the purpose of estimating costs, the TCF-Peroxide option included anthraquinone pulping and oxygen delignification to achieve unbleached pulp kappa numbers of 10 for softwood and 6 for hardwood.

8.2.1.4 TCF-Ozone

EPA evaluated an oxygen-based TCF bleaching option which is performed without the use of chlorine, sodium hypochlorite, calcium hypochlorite, chlorine dioxide, chlorine monoxide, or any other chlorine-containing compound. This option contains all but two of the elements listed for Option A. The two elements not included in this option are: 1) use of dioxin- and furan-precursor-free defoamers, and 2) strategies to minimize kappa factor and TCDD- and TCDF-precursors in brown stock pulp because the option uses ozone and peroxide, and not chlorine-based, bleaching. For the purpose of estimating costs, TCF-ozone option included anthraquinone pulping and oxygen delignification to achieve unbleached pulp kappa numbers of 10 for softwood and 6 for hardwood.

8.2.2 Papergrade Sulfite Subcategory (PS)

EPA had proposed a TCF bleaching option for all PS mills. Some commenters questioned the achievability of TCF bleaching to produce all the existing PS products. In response to these comments, EPA divided the PS subcategory into three segments:

- A) Calcium, magnesium, or sodium sulfite pulping;
- B) Ammonium sulfite pulping; and
- C) Production of pulp and paper at specialty-grade sulfite mills. These mills produce 25 percent or more pulp with a high percentage of alpha cellulose and high brightness for end products such as plastic molding compounds, saturating and laminating products, and photographic papers or these mills produce 50 percent or more pulp with 91 ISO brightness and above.

After the proposal, EPA focused on one option for each segment. Each option has the following elements in common:

- (i) Use of TCDD- and TCDF-precursor-free defoamers (water-based defoamers or defoamers made with precursor-free oils);
- (ii) For segments with ECF bleaching, elimination of hypochlorite, i.e., replacement of hypochlorite with equivalent bleaching power in the form of additions of peroxide and/or oxygen to the first extraction stage and/or additional chlorine dioxide in final brightening stages; and
- (iii) Efficient biological wastewater treatment.

Segment A (calcium, magnesium, or sodium sulfite) includes:

- ˘ Totally chlorine-free bleaching (bleaching with peroxide);
- ˘ Oxygen and peroxide enhanced extraction; and
- ˘ Improved pulp cleaning.

Segment B (ammonium sulfite) includes:

- ˘ Complete substitution of chlorine dioxide for chlorine;
- ˘ Peroxide enhanced extraction; and
- ˘ High shear mixing.

Segment C (specialty-grade sulfite) includes:

- ˘ Complete substitution of chlorine dioxide for chlorine;

- ∨ Oxygen and peroxide enhanced extraction; and
- ∨ High shear mixing.

Thus, EPA has developed one option for each PS subcategory segment.

8.2.3 Point of Compliance Monitoring

EPA is requiring mills in Subparts B and E to demonstrate compliance with effluent limitations guidelines and standards on dioxin, furan, 12 chlorinated phenolic pollutants, and (for Subpart B mills) chloroform inside the discharger's facility at the point where the wastewater containing those pollutants leaves the bleach plant. EPA is also requiring indirect dischargers in Subpart B to demonstrate compliance with AOX pretreatment standards at the bleach plant. For direct dischargers, EPA is authorized by the Clean Water Act and EPA's regulations at 40 CFR Parts 122.44(i), 122.45(h), and 125.3(e) to specify an in-plant point of compliance monitoring for technology-based limitations. For indirect dischargers, EPA relies on 40 CFR Part 403.6(d), which prohibits dilution to achieve a categorical pretreatment standard. Hereafter, EPA refers to the limitations and standards for which compliance must be demonstrated in-plant as "in-plant limitations."

As set forth in more detail below, EPA is establishing in-plant limitations on bleach plant effluent because limitations imposed on those pollutants at the point of discharge are impractical and infeasible as measures of the performance of process technologies representing the technology-based levels of control. Moreover, in-plant effluent limitations are consistent with the MACT standards for chloroform, which independently require achievement of BAT limitations on dioxin, furan, chloroform, the 12 chlorinated phenolic pollutants, and (for indirect dischargers) AOX at the bleach plant in order to ensure that the removals represented by the MACT technology floor -- complete substitution of chlorine dioxide for elemental chlorine and elimination of hypochlorite -- are attained.

EPA's data show that mills using the model BAT, NSPS, PSES and PSNS technologies for Subparts B and E are able to achieve at the bleach plant concentrations of dioxin and the 12 chlorinated phenolic pollutants at levels below the minimum levels of currently available analytical methods. Furan concentrations, in turn, are very near the analytical minimum levels at Subpart B mills using the applicable model technologies and are below the minimum level for Subpart E mills using the model technologies corresponding to the segments in that Subpart. (At the end of the pipe, furan cannot be detected by available analytical methods in the effluent of many Subpart B mills.)

Because only 10 to 40 percent of the wastewater discharged by mills in Subpart B originates in the bleach plant, the concentrations of pollutants in the mills' final effluent would be one-tenth to two-fifths of their concentrations at the bleach plant. Substantial dilution can also occur at Subpart E mills. In the biological wastewater treatment system, the pollutants may be present but in concentrations below the applicable analytical minimum levels. When they are discharged to receiving streams, however, dioxin and furan bioaccumulate in aquatic organisms.

Were EPA to allow compliance monitoring of the final effluent, no way would be available to determine whether the bleach plant effluent has been adequately controlled, or whether the effluent has simply been diluted to below the analytical minimum level by other flows. Diluting pollutants in this manner rather than preventing their discharge is inconsistent with achieving the removals represented by the technology-based levels of control, and hence with the purpose of the resulting limitations and standards. Dilution is also inconsistent with the goals of the Clean Water Act in general. Sections 101(a) and 301(b)(2)(A). While no mill is required to install EPA's model technologies, establishing limitations at the bleach plant is the only way EPA can ensure that none of these pollutants will be discharged at concentrations greater than the levels achievable through implementation of the best available technology. See E.I. du Pont de Nemours & Co. v. Train, 430 U.S. 112, 129 (1977).

With respect to the 12 chlorinated phenolic pollutants, EPA acknowledges that these pollutants could be degraded by biological treatment of the facility's combined wastewater. However, the same process technologies necessary to address dioxin and furan also reduce the levels of chlorinated phenolic pollutants to concentrations below minimum levels at the bleach plant. Commenters have supplied no data showing that the chlorinated phenolic pollutants should or indeed, as a practical matter, could be segregated from the dioxin- or furan-bearing wastestreams in order to fully use a mill's secondary treatment system. Nor is there any assurance that BAT limitations for these pollutants, if monitored at the end of the pipe, would be achieved by treatment rather than simply by the effects of dilution. See 40 CFR Part 122.45(h). Thus, EPA concludes that it is appropriate to require compliance monitoring for the limitations and standards on the 12 chlorinated phenolic pollutants at the point they most easily can be achieved and measured -- at the bleach plant.

In the case of chloroform, in-plant limits at Subpart B mills are authorized by 40 CFR Part 122.45(h) (for direct discharging mills) and 40 CFR Part 403.6(d) (for indirect discharging mills) because they offset the effects of dilution, in this case, the occurrence of uncontrolled volatilization. (Section 403.6(d) prohibits indirect dischargers from employing dilution as a substitute for treatment.) Limitations and standards at the point of effluent discharge are impractical and infeasible because chloroform would be lost as air emissions in wastewater conveyances and treatment facilities (e.g., collection boxes and aeration tanks). (For a discussion of the volatility of chloroform at Subpart B and E mills, see DCN 03815 and DCN 09323.) Such incidental air stripping not only would cause chloroform to be present in the final effluent at levels below detection (thus complicating compliance monitoring), but it also would be inconsistent with the model technology EPA has used as a basis for its limits. See CWA Section 301(b)(2)(A), 304(b)(2)(A) & (B). As is the case with dilution, EPA would have no way of knowing whether reductions in wastewater discharges are being achieved by application of BAT- or NSPS-level technologies or by air emissions (or dilution) in the wastewater conveyance and treatment facilities. In-plant limitations for chloroform also allow EPA to evaluate the environmental effectiveness of each mill's treatment and process technologies, information that could assist EPA at a later date in revising these effluent limitations guidelines and standards as the Clean Water Act contemplates. See CWA Section 308(a)(1). Moreover, in other regulatory contexts, EPA recognizes that dilution includes not only mixing a pollutant of concern with other

wastestreams, but also mixing it with excess air in the form of uncontrolled volatilization. See 52 FR 25760, 25778-79. Volatilization, like dilution, does nothing to remove, destroy, or immobilize pollutants, and for this reason is not in itself a form of treatment. *Id.* at 25779. The policy reasons supporting that principle in the hazardous waste context similarly apply here.

Finally, EPA is setting effluent limitations and standards at the bleach plant in order to avert the non-water quality environmental impacts caused by the volatilization of chloroform to the air and in order to be consistent with its Clean Air Act determination that the MACT floor for chloroform consists of bleach plant process modifications, i.e., complete chlorine dioxide substitution and elimination of hypochlorite as bleaching agents. Specifically, EPA is requiring under the Clean Air Act that chloroform emissions be controlled by complying with the BAT requirements for all regulated pollutants. See 40 CFR Part 63.445(d). Therefore, EPA has determined under its Clean Air Act authority that bleach plant technologies -- and bleach plant limitations on dioxin, furan, chloroform, the 12 chlorinated phenolics, and (for indirect dischargers) AOX -- are necessary to regulate air emissions of chloroform. The situation presented here is very different from the situation EPA faced when promulgating effluent limitations guidelines and standards for the organic chemicals, plastics, and synthetic fibers industrial category in 1987. See 52 FR 42522, 42658-62. In that rulemaking, the issue before EPA was whether to use in-plant limitations and standards to regulate air emissions of certain volatile and semi-volatile pollutants; EPA chose not to set in-plant requirements for that purpose because it determined that the regulation of such emissions was best accomplished in a Clean Air Act proceeding, which EPA was commencing at that time. See *id.* at 42560-62. In contrast, EPA in this rulemaking integrated its decision-making under the Clean Water Act and the Clean Air Act expressly to address these cross-media issues. (Indeed, the statutory provisions authorizing establishment of BAT limitations and NSPS, PSES, and PSNS specifically require EPA to consider non-water quality environmental impacts in promulgating such limitations and standards.) Taking into account both the air and water objectives of these Cluster Rules, EPA therefore concludes that it is highly appropriate for EPA to set effluent limitations and standards under the Clean Water Act to correspond to and support its concurrent regulation of air emissions under the Clean Air Act.

As noted above, EPA is requiring indirect dischargers subject to Subpart B to demonstrate compliance with AOX pretreatment standards at the bleach plant. (EPA is not specifying a point of compliance monitoring for AOX for direct discharging mills in Subpart B in this rule.) Like the pretreatment standards for dioxin, furan, chloroform, and the 12 chlorinated phenolic pollutants, the pretreatment standards for AOX are based exclusively on process changes. EPA expects that removals achieved by indirect dischargers employing the PSES or PSNS model technology (or its equivalent), in combination with removals achieved by biological treatment systems at POTWs, will be comparable to the AOX removals achieved by direct dischargers complying with BAT limitations or NSPS. Because biological treatment is not part of the PSES or PSNS model technology, EPA concluded that an end-of-pipe standard for AOX would simply reflect the effects of dilution, not treatment. Dilution is expressly prohibited by EPA's pretreatment regulations as a substitute for treatment. See 40 CFR Section 403.6(d). Therefore, EPA determined that the only practicable way of enforcing that provision and,

incidentally, measuring the effectiveness of a discharger's chosen PSES and PSNS technology is to require mills to demonstrate compliance with the AOX pretreatment standard at the bleach plant.

EPA received comments inquiring why EPA believed it was infeasible to measure compliance with a limitation of below the minimum level (or "<ML") at the end of the pipe, but not infeasible to measure compliance with the same <ML limitation at the bleach plant. (This comment is relevant to EPA's limitations and standards for dioxin and the 12 chlorinated phenolic pollutants, which are expressed as <ML at the bleach plant, but not to furan and chloroform, which have numeric values.) EPA concludes that the answer to this question lies in the fact that bleach plant effluent is not subject to dilution by other wastestreams. An effluent limitation of "<ML" measured at the end of the pipe (after the dioxin-bearing wastestream is diluted by a factor ranging from 2 to 10) is simply not equivalent to an effluent limitation of "<ML" measured at the bleach plant. Indeed, EPA's policy basis for establishing in-plant limitations rests largely on those differences. First, as required by CWA Section 304(b)(2)(A), bleach plant limitations of "<ML" represent, "in terms of amounts of constituents . . . , the degree of effluent reduction attainable through the application of the best control measures and practices achievable including treatment techniques, process and procedure innovations, operating methods, and other alternatives . . ." (emphasis supplied). A limitation of "<ML" at end-of-pipe could simply represent the degree of effluent reduction attainable through the effects of dilution; no assurance is given that the quantities of the pollutant -- in terms of mass -- have been reduced. Nor does a feasible way exist of determining the efficacy of the chosen treatment technology. Second, in-plant limitations in this rulemaking come closer to realizing the national goal of eliminating the discharge of pollutants. Although, for example, dioxin levels measured at end-of-pipe and dioxin levels measured at the bleach plant both would fall below the minimum level, dioxin-bearing wastestreams that are measured at "<ML" at the bleach plant and then diluted with other non-dioxin bearing wastewater may result in lower ultimate dioxin discharges than end-of-pipe limits alone could ensure. The same is true of furan and the chlorinated phenolic pollutants. Thus, requiring compliance monitoring at the bleach plant for these pollutants is far more consistent with the CWA's direction that BAT limitations "result in reasonable further progress toward the national goal of eliminating the discharge of all pollutants" than the approach of requiring monitoring at the end of the pipe. See CWA Section 301(b)(2)(A). Finally, the environmental significance of in-plant versus end-of-pipe limits is very different, even though the receiving water receives, in both cases, amounts of the pollutants that are below the applicable minimum levels. Certain pollutants, like dioxin, are dangerous even in immeasurably small concentrations. To put this fact in perspective, EPA notes that the water quality criteria for dioxin is 0.013 ppq; in contrast, the minimum level at which current analytical methods can reliably measure dioxin is 10 ppq. Thus, even if the amount of dioxin in a mill's effluent is below 10 ppq, measured at the end of the pipe, the discharge could still result in pollutant loadings that are far greater than the quantities the water quality criterion deems acceptable to the environment. In contrast, if compliance is monitored at the bleach plant prior to dilution, EPA is assured that the pollutant loadings that are ultimately discharged are no greater than contemplated by the model technologies (if still unmeasurable). EPA is also aware that dioxin persists in the aquatic ecosystem and bioaccumulates in the food chain, thus

presenting long-term risks to human health, aquatic life and wildlife; consequently, each unit of mass removed from wastewater effluent is beneficial to the environment. For these reasons, EPA believes it has acted reasonably in interpreting the Clean Water Act to require dischargers to demonstrate compliance with technology-based limitations and standards at the bleach plant in this instance.

EPA exercised this authority in the effluent limitations guidelines and standards EPA promulgated in 1984 for the nonferrous metals manufacturing point source category (secondary aluminum smelting subcategory) as can be found in 40 CFR Part 421.32(e) (BAT), Part 421.34(e) (NSPS), Part 421.35(e) (PSES), Part 421.36(e) (PSNS); see 49 FR 8742, 8758-59. Under those regulations, dischargers must demonstrate compliance with the BAT limitations, new source performance standards, and pretreatment standards for total phenolics “at the source,” which EPA defined as “at or before the commingling of delacquering scrubber liquor blowdown with other process or nonprocess wastewater.” 40 CFR Part 421.31(c); see 49 Fed. Reg. at 8758-59. EPA based this decision on the possibility of significant dilution. See 49 Fed. Reg. at 8758-59. As explained in the preamble of that rule, EPA was concerned there, as here, that plants would be able to meet the limits for these toxic organic pollutants through dilution because, as is the case here, the pollutants are present in wastewater only from certain unit operations and in concentrations that could be reduced below analytical detection levels after commingling with other process wastewater. 49 Fed. Reg. at 8758-59; 48 Fed. Reg. 7032, 7056 (Feb. 17, 1983). EPA concluded that requiring compliance at the end of the pipe would contravene the strong policy of the Clean Water Act that pollutants be removed, not diluted, and for that reason proposed limitations on internal wastestreams. This provision was not contested and continues to apply today.

EPA received support from commenters, including at least one state, for its proposal to establish in-plant limitations in the Cluster Rules. The state commenter supported the use of in-plant limitations for dioxin and other pollutants as a way of ensuring that these pollutants have been “eliminated.” While EPA cannot say on today’s record that mills using chlorine or chlorine-containing compounds as part of their bleaching processes have “eliminated” dioxin discharges (even if the effluent is reported at below the applicable minimum level for dioxin), EPA agrees for the reasons set forth above that bleach plant limitations are necessary in order to ensure that limitations expressed as “<ML” are not achieved simply by dilution.

Industry commenters raise four principal objections to EPA’s decision to impose limitations on certain pollutants at the point where the wastewater containing those pollutants leaves the bleach plant. First, they assert that the Clean Water Act authorizes EPA to regulate only discharges to waters of the United States and that EPA is overstepping this authority in imposing limits on internal wastestreams. Second, commenters assert that internal limitations may ignore or fail adequately to account for reductions in pollutant loadings that will occur before discharge, such as reductions attributable to secondary treatment. Third, commenters assert that limitations on internal points in effect constitute an unwarranted and unauthorized specification of technology and in effect may force a discharger to ignore or under-utilize expensive end-of-pipe treatment technologies, such as secondary treatment. Fourth, commenters

assert that, even if EPA possessed the legal authority to regulate internal wastestreams, EPA has failed to identify any exceptional circumstances that would justify in-plant limitations.

EPA disagrees with the first comment that it lacks the legal authority to impose limitations on internal wastestreams. EPA's regulation at 40 CFR Part 122.45(h) explicitly authorizes such limitations on a case-by-case basis; that regulation, which was promulgated in 1979, has been upheld by both U.S. Courts of Appeals that considered it. See Public Service Company of Colorado, Fort St. Vrain Station v. EPA, 949 F.2d 1063 (10th Cir. 1991); Texas Municipal Power Agency (TMPA) v. EPA, 836 F. 2d 1482 (5th Cir. 1988). EPA believes it is reasonable to exercise this case-by-case authority on a subcategory-wide basis because EPA's record shows that every permit writer is likely to encounter the same facts that EPA has identified to justify these in-plant limitations; indeed, no commenter has come forward with information demonstrating that the removals expected by the effluent limitations and standards for dioxin, furan and chloroform can be achieved by treatment after the bleach plant, or that the 12 chlorinated phenolic pollutants can be segregated from other wastestreams to avoid the problem of dilution. For these reasons, EPA foresees no situation at this time when a permit writer would reach a different conclusion on an individual permit basis. If over time, however, mills are able to demonstrate that they can achieve the applicable removals at the end of the pipe by treatment rather than by dilution or volatilization, or if new, approved analytical methods make it feasible to demonstrate compliance with the limitations or standards measured at the end of the pipe (taking dilution into account), then EPA will consider amending the rule to authorize those dischargers to demonstrate compliance at the end of the pipe rather than at bleach plant.

Commenters do not deny that, as a consequence of bleach plant operations, an "addition" of pollutants occurs to navigable waters or that such "addition" constitutes a discharge of pollutants subject to Clean Water Act regulation. However, they assert that EPA is authorized to control that "addition" only at the point at which the pollutant physically enters the receiving water. EPA disagrees that the Clean Water Act must be read so narrowly -- especially when applied to technology-based limitations. To the contrary, Congress defined the term "effluent limitations" to mean "any restriction" on "quantities, rates, and concentrations of . . . constituents which are discharged from point sources into navigable waters." Section 502(11). The term "discharge," in turn, applies to "any addition," and is to be broadly construed. Section 502(12); see United States v. Earth Sciences, Inc., 599 F.2d 368, 374 (10th Cir. 1979); SED, Inc. v. City of Dayton, 519 F. Supp. 979, 989 (S.D. Ohio 1981). Like section 301(a)'s prohibition on the discharge of "any pollutant," these definitions authorize EPA to impose any reasonable form of restriction on pollutants that will "eventually" be discharged into waters of the United States. Public Service Company of Colorado, 949 2d at 1065; see TMPA, 836 F. 2d at 1488-90. As the Fifth Circuit recognized in upholding EPA's internal wastestream rule, "it is sometimes necessary to regulate discharges within the treatment process to control discharges at the end." TMPA, 836 F.2d at 1488. The authority to establish effluent limitations thus includes, where appropriate, the authority to impose limitations on internal wastestreams. This authority is especially broad when, as here, the in-plant restrictions are designed to promote the Act's goals of eliminating, and not simply diluting or dispersing, pollution in effluent through technology-based limitations. See Chevron, U.S.A., Inc. v. NRDC, 467 U.S. 837, 843-44, 861 (1984); see,

e.g., Sections 101(a)(1), 101(a)(3), 301(b)(2)(A). The legislative history of the Clean Water Act also emphasizes that dischargers are not to employ dilution as an alternative to treatment.

Establishment of in-plant limitations is also authorized by section 402(a)(2), which directs EPA to prescribe conditions for NPDES permits to assure compliance with the requirements of section 402(a)(1), including section BAT limitations promulgated under section 301. See TMPA, 836 F.2d at 1489; Montgomery Environmental Coalition v. Costle, 646 F.2d 568, 586-87 (D.C. Cir. 1980). As the D.C. Circuit recognized, EPA's broad authority under section 402(a)(2) includes the authority to regulate inflows to treatment works, e.g., in the form of moratoria on sewer hook-ups to POTWs. Montgomery Environmental Coalition v. Costle, 646 F.2d at 588. EPA also relies on the regulation prohibiting the use of dilution to meet categorical pretreatment standards, 40 CFR Part 403.6(d), for authority to impose in-plant limitations on indirect dischargers.

EPA also acknowledges comments asserting that EPA lacks authority to regulate internal wastestreams because they are not waters of the United States. Because EPA is not basing its authority on the possible status of internal wastestreams as waters of the United States, this additional argument by commenters requires no response.

EPA acknowledges that the U.S. Court of Appeals for the District of Columbia Circuit recently ruled that EPA lacks the legal authority to impose "water quality-based standards upon internal facility waste streams." American Iron and Steel Institute (AISI) v. EPA, 115 F.3d 979, 996 (D.C. Cir. 1997). The issue arose in the context of a challenge to EPA's regulations implementing the Great Lakes Critical Programs Act, 33 U.S.C. Part 1268. In its regulations, EPA promulgated a procedure, applicable only to states in the Great Lakes System, that provides that when a permit includes a water quality-based effluent limitation below the level of quantification, the permit must also require the permittee to develop and conduct a pollutant minimization program (PMP), which includes among other things, a control strategy. See 40 CFR Part 132 App. F, Procedure 8.D. Procedure 8.D.1. states that the goal of a PMP is "to reduce all potential sources of the pollutant to maintain the effluent at or below the Water Quality Based Effluent Limitations." It further states that the control strategies should be "designed to proceed toward the goal of maintaining all sources of the pollutant to the wastewater collection system below the WQBEL." See Procedure 8.D.3. Industry litigants challenged these provisions, claiming that they would be used to set internal waste stream WQBELs. The Court held that although EPA has the authority to require monitoring of internal wastestreams, see AISI, 115 F.3d at 995, the Clean Water Act does not authorize EPA to require compliance with a WQBEL at a point inside the facility and thereby deprive a permittee of the ability to choose its own control system to meet the WQBEL, see id. at 996. Therefore, the Court vacated Procedure 8.D. "insofar as it would impose the point-source WQBEL upon a facility's internal waste streams." Id.

EPA does not believe that decision controls here. First, the court did not consider or rule upon the regulations upon which EPA bases the in-plant limitations for these Cluster Rules, to wit, 40 CFR Part 122.44(i), 122.45(h), 125.3(e), and 403.6(d). Therefore, those

regulations, upheld by the Fifth and Tenth Circuits, continue to have force and effect. Second, the AISI court did not consider the question whether EPA has authority to regulate internal wastestreams in the context of technology-based controls. Unlike water quality-based effluent limitations, which are calculated to ensure that water quality standards for the receiving water are attained, technology-based limitations and standards are derived to measure the performance of specific model technologies that EPA is required by statute to identify. In identifying these technologies, EPA is directed to consider precisely the type of internal controls that are irrelevant to the development of water quality-based effluent limitations, such as the processes employed, process changes, and the engineering aspects of applying various types of control techniques. See CWA Sections 304(b)(2)(B), 306(a)(1), 307(b) & (c). Indeed, EPA's regulations must identify the degree of effluent reduction attainable through the application of BAT-level process and procedure innovations, operating methods, and other control measures and practices for the subcategory being regulated. CWA Section 304(b)(2)(A). Limitations applied at the bleach plant represent the degree of effluent reduction EPA has determined is attainable by the BAT, NSPS, PSES, and PSNS model technologies. Thus, they are consistent with the long-recognized principle that technology-based limitations are intended to reflect, for each industrial category or subcategory, the "base level" of technology (including process changes) and to ensure that "in no case . . . should any plant be allowed to discharge more pollutants per unit of production than is defined by that base level." E.I. du Pont de Nemours & Co. v. Train, 430 U.S. at 129, quoting S. Rep. No. 414, 92d Cong., 1st Sess 50, reprinted in A Legislative History of the Water Pollution Control Act Amendments of 1972, at 1468 (1973).

EPA also rejects as inapposite the commenters' second objection -- that in-plant limitations may ignore or fail adequately to account for reductions in pollutant loadings that will occur after the bleach plant but before discharge, such as reductions attributable to secondary treatment. Under Sections 301(b)(2) and 304(b)(2), EPA is required to establish effluent limitations guidelines and standards that reflect, for example, the best available technology economically achievable for the particular pollutants of concern. While the model BAT and NSPS technologies for Subcategory B includes secondary biological treatment to address AOX loadings, the model BAT and NSPS technologies for dioxin, furan, chloroform and the 12 chlorinated phenolic compounds (and, for PSES and PSNS, AOX) consist exclusively of a sequence of in-plant processes, including improved brown stock washing, elimination of hypochlorite and complete substitution of chlorine dioxide for elemental chlorine, which are employed at the pulp mill and the bleach plant. The bleach plant limitations and standards codified today thus fully account for the model technologies and processes upon which they were based. In EPA's view, these processes, not end-of-pipe biological treatment, represent the best, most efficient methods of minimizing the discharge of dioxin, furan, chloroform, the 12 chlorinated phenolics, and (for indirect dischargers) AOX, and moving toward the ultimate BAT goal of eliminating their discharge altogether. See CWA Sections 101(a)(1) and 301(b)(2)(A). Moreover, commenters have failed to supply any data demonstrating that dioxin and furan can be effectively treated by biological treatment processes. Results of the Five-Mill Study and the 104-Mill Study show that dioxin and furan are not removed by biological treatment systems at direct discharging BPK and PS mills (8,9). Rather, these pollutants were found to either partition to the secondary sludge of a biological treatment system or pass through untreated. The partitioning

was neither consistent nor predictable. (If dischargers ultimately can make this showing, EPA would consider amending the regulation.) With respect to the 12 chlorinated phenolic compounds, EPA acknowledges that these pollutants can be treated using biological treatment. However, as noted above, the same process technologies necessary to address dioxin and furan also, as an ancillary matter, reduce the levels of chlorinated phenolics to nondetectable concentrations at the bleach plant. Moreover, without bleach plant limitations on these pollutants, EPA would have no assurance that limitations are being achieved by treatment rather than simply dilution, and that the pollutants are being removed.

EPA also disagrees with the third comment. Contrary to the commenters' assertions, the establishment of in-plant limitations does not have the effect of unlawfully dictating a particular technology or process. While EPA's model technologies indisputably rely on a particular sequence of process changes, which is expressly authorized under section 304(b)(2)(A)&(B), mills remain free to develop and implement any combination of processes and technologies, including but not limited to chemical substitution, to achieve the limitations and standards. The only "treatment" essentially precluded by the in-plant limitations and NSPS, PSES, and PSNS is dilution of bleach plant effluent with effluent from other mill processes, which is not BAT/NSPS and, in the case of pretreatment standards, is explicitly prohibited by other regulations. See 40 CFR Part 403.6(d).

EPA concludes that commenters' fourth objection also has no merit. They argue that EPA's determination in this rulemaking that end-of-pipe limitations BAT on pulp and paper effluent are infeasible or impracticable is inconsistent with 1990 guidance to permit writers that characterized such limitations as appropriate. EPA disagrees with commenters' interpretation of that guidance. Entitled "Strategy for the Regulation of Discharges of PHDDs and PHDFs from Pulp and Paper Mills to Waters of the United States" (May 21, 1990) (DCN 03960), the guidance specifically urged permit writers to impose limitations on dioxin at the bleach plant when measuring discharges of those pollutants at the end of the pipe was impracticable or infeasible. This guidance was consistent with EPA's custom of giving the permit writer discretion to determine the appropriate point of regulation on a case-by-case basis and reflected EPA's belief at the time that some mills could demonstrate dioxin removals by wastewater treatment facilities. DCN 03960 at 20. Based on the data assembled as part of this rulemaking, however, EPA has determined that no mills today have made that showing. Therefore, as discussed in more detail above, EPA concluded that it is appropriate to impose in-plant limitations on dioxin on a categorical, rather than case-by-case, basis.

Several commenters also challenge EPA's finding that chloroform volatilizes en route to and during wastewater treatment, although they offer no data to contradict the data and analyses supporting EPA's conclusion. Indeed, EPA's data show that chloroform levels are easily quantified at the bleach plant but cannot be reliably measured in the final effluent. These data refute some commenters' unsupported assertion that chloroform levels can be reliably measured at the end of the pipe. EPA has found that bleach plant chloroform loadings are lower at mills that have greater contact between bleach plant filtrates and air (e.g., mills that use high air flow vacuum drum washers) compared to those mills that have less air contact (e.g., low air

flow pressure diffusion washers or compaction baffle washers). This suggests that much of the chloroform generated in the bleach plant is easily stripped by exposure to air. Thus, EPA has concluded that the majority of chloroform removed in biological treatment systems is removed by air stripping, not biological degradation. NCASI studied air and water concentrations of chloroform around four bleached kraft mill wastewater treatment systems and concluded that “significant reductions in aqueous chloroform concentrations were observed across flumes and other points of turbulence in the treatment system. Typically the majority of the chloroform was removed in the first third of the effluent treatment systems.” (NCASI Technical Bulletin 642, DCN 09323).

In addition, EPA disagrees with comments asserting that volatilization is not an “exceptional circumstance” justifying limitations on internal wastestreams. While EPA agrees that volatilization is not listed as an “exceptional circumstance” identified in the internal wastestream rule to justify in-plant limitations, see 40 CFR Part 122.45(h)(2), EPA notes that the list is merely illustrative and not exhaustive. Moreover, volatilization is reasonably equivalent to the dilution example provided in the regulation, insofar as the particular pollutant is reduced to non-quantifiable levels for reasons unrelated to treatment. See supra. Therefore, EPA believes that volatilization, like dilution, constitutes an exceptionable circumstance within the scope of 40 CFR Part 122.45(h).

Finally, EPA disagrees that EPA lacks the legal authority to consider air impacts when setting BAT effluent limitations. EPA is clearly authorized under Section 304(b)(2)(B) to consider non-water quality environmental impacts when choosing BAT and, consequently, setting effluent limitations based on that model BAT technology. See also CWA Sections 306(b)(1)(B), 307(b) & (c). It follows therefore that EPA can take non-water quality environmental impacts into account when choosing the point of regulation for its BAT limits. Indeed, the legislative history and case law interpreting this statutory authority emphasize that EPA was not to achieve effluent reductions at the expense of other environmental media. See, e.g., BP Exploration & Oil, Inc. v. EPA, 66 F.2d 784, 800-02 (6th Cir. 1995); Weyerhaeuser Co. v. Costle, 590 F.2d 1011, 1052-53 (D.C. Cir. 1978). Thus, in this instance, not only is chloroform reliably and feasibly measured at the bleach plant (when this is not the case at the end of the pipe), but in-plant limitations also prevent adverse air impacts that might ensue from end-of-pipe limits. Finally, chloroform’s volatile nature and the significance of air impacts from volatilization is evidenced by EPA’s decision to impose MACT standards for chloroform at the bleach plant.

8.3 Conventional Pollutants

EPA proposed revised effluent limitations guidelines for control of conventional pollutant discharges via the following regulations: BPT, BCT, and NSPS. This section provides a description of EPA’s approach to control option development for conventional pollutants for the proposed rule, revisions to EPA’s approach and data set used to develop the control options, revised control option performance levels for the final rule, and descriptions of the technology bases for the final conventional pollutant control options.

8.3.1 Approach to Option Development

Secondary treatment includes biological or chemical processes used to remove suspended and soluble organic matter from wastewater. Secondary treatment, in conjunction with good water conservation practices, constitutes the technology basis for the current conventional pollutant limitations for bleached papergrade kraft and soda mills and papergrade sulfite mills. With the exception of one bleached papergrade kraft mill that discharges to territorial seas of the United States and one which uses land disposal for its primary treated waste, all of the direct-discharging bleached papergrade kraft and soda mills and direct-discharging papergrade sulfite mills operate secondary biological wastewater treatment systems. Secondary biological wastewater treatment removes organic matter through biochemical oxidation. Activated sludge systems and aerated/non-aerated basin systems are the most commonly used biological processes. As needed, secondary biological treatment in the pulp and paper industry is preceded by pretreatment (e.g., equalization, neutralization, cooling) and primary treatment (e.g., clarifiers) for the removal of settleable solids.

Tertiary treatment is advanced treatment, beyond secondary biological treatment, to remove particular contaminants. Common tertiary treatment operations in municipal and industrial wastewater treatment systems are the removal of phosphorus by alum precipitation, removal of toxic refractory organic compounds by activated carbon adsorption, and removal of TSS by multimedia filtration. Tertiary treatment is not common in the pulp and paper industry.

The Agency proposed to develop effluent limitations guidelines for conventional pollutants based on secondary biological wastewater treatment with appropriate water use and reuse because almost all direct-discharging mills used secondary treatment. Elements of a secondary biological wastewater treatment train, as practiced in the pulp and paper industry, may include (but are not limited to):

- ˘ Equalization;
- ˘ Neutralization;
- ˘ Precooling;
- ˘ Primary sedimentation;
- ˘ Nutrient addition;
- ˘ Aeration;
- ˘ Addition of flocculants to secondary clarifiers to improve settling;
- ˘ Multi-basin systems, some of which act as polishing ponds; and

Mixed or hybrid treatment systems (activated sludge and basin systems operated in series or parallel).

Some of the aerated stabilization basin treatment systems in use in the industry cover large areas. Some mills operate their treatment systems to meet water quality-based discharge limitations. Other treatment systems were enlarged in an add-on manner as the capacity of the mill increased over time. The Agency considers all of these scenarios as typical of pulp and paper industry wastewater treatment practice, and included all of them in characterizing pulp and paper industry secondary biological wastewater treatment performance.

The proposed revised effluent limitations guidelines were developed in seven steps:

1. Identification of mills representing the performance of secondary wastewater treatment in each subcategory;
2. Analysis of the performance (in terms of production-normalized final effluent BOD₅ load) of the representative mills to determine "the average of the best existing performance";
3. Identification of combinations of in-process flow reduction and end-of-pipe wastewater treatment used by the industry to achieve these performance levels;
4. Estimation of the cost of applying these identified technologies at mills that do not currently achieve "the average of the best existing performance";
5. Estimation of the benefits of applying the identified technologies, in terms of the reduction in the mass of conventional pollutants discharged;
6. Comparison of the estimated costs and benefits; and
7. Review of non-water quality environmental impacts.

The remainder of this section describes Items 1, 2, and 3: the identification of mills representing secondary treatment performance, the determination of conventional pollutant control option performance levels, and identification of technologies used by the industry to achieve the conventional pollutant control option performance levels.

8.3.2 Identification of Mills Representing Secondary Wastewater Treatment Performance in Each Subcategory

To identify mills representing the performance of secondary wastewater treatment in each subcategory, the Agency began with the list of mills that responded to the 1990 census questionnaire (1) and deleted mills from the list that were not considered representative of secondary biological treatment system design, operation, and performance as practiced by mills in each subcategory. Deleted mills included primarily indirect-discharging mills and "multiple" subcategory mills (discussed below).

Ideally, only mills with all of their final off-machine production in a single subcategory would be used to represent the performance of secondary biological wastewater treatment for that subcategory. After application of the mill selection parameters, both the Bleached Papergrade Kraft and Soda and the Papergrade Sulfite subcategories included few or no mills with all of their production in a single subcategory, reflecting the actual composition of the U.S. pulp and paper industry (a typical mill has operations in more than one subcategory). To account for this situation, while at the same time reflecting the characteristics of the principal subcategory at a mill, the Agency chose to use mills with a large percentage of their final production in a single subcategory to represent the subcategory. For the Bleached Papergrade Kraft and Soda Subcategory, the Agency selected a final production cut-off of 85 percent within this subcategory for a mill to be considered representative of the subcategory. For the Papergrade Sulfite Subcategory, the Agency selected mills with papergrade sulfite pulp comprising 37 to 96 percent of their final production.

8.3.2.1 Summary and Analysis of Comments Submitted Concerning Identification of Mills Representing the Performance of Secondary Biological Wastewater Treatment

Several comments were submitted concerning the selection of mills representing the performance of secondary biological wastewater treatment. Commenters expressed concern that EPA used several mills to represent the Bleached Papergrade Kraft and Soda Subcategory that commenters believed had wastewater treatment operations that are not common practice in the industry, or that commenters believed achieved performance levels better than those levels achieved by the BPT/BCT technology basis. Specific issues are described below.

- ∩ EPA included mills with multiple basins, particularly holding and polishing ponds, that have residence times longer than those typical in the industry.
- ∩ EPA included mills with equalization of wastewater prior to secondary biological treatment, which were asserted not to be common industry practice.

EPA included mills that have mixed treatment systems (i.e., treatment systems including both activated sludge treatment and basins), which was asserted as not common industry practice.

EPA included mills that have chemically assisted clarification to enhance pollutant removals, which was asserted not to be common industry practice. In particular, mills using unusually large amounts of coagulant should have been excluded.

EPA included mills that discharge to water quality limited streams.

Because several commenters criticized EPA for using mills with "atypical" treatment to represent the subcategory, the Agency undertook an analysis to determine what constituted typical wastewater treatment for the Bleached Papergrade Kraft and Soda Subcategory. To describe "typical" wastewater treatment at bleached kraft mills, EPA reviewed and summarized the treatment systems for all direct-discharging mills that have the highest percentage of their production in the bleached kraft subcategory. EPA also analyzed treatment operation and performance data in response to the commenters' criticisms mentioned above. Data used for the analysis were obtained from mill responses to the 1990 census questionnaire and supplemental data from comments and site visit reports, where available. Note that for this analysis, treatment performance is measured by final effluent production-normalized loads, consistent with development of BPT/BCT performance levels, not treatment efficiency (i.e., percent removal) or effluent concentrations. The results of these analyses are discussed in the rulemaking record (2) and are summarized below.

Basin System Residence Times - EPA analyzed the relationship between total basin (aerated plus non-aerated basins) residence time versus effluent BOD₅ and TSS loads by plotting residence time versus load. The plots do not suggest any obvious relationship between basin residence time and treatment performance; the best performing mills have a wide range of residence times. BOD₅ and TSS loads were also plotted versus aerated basin residence time. These plots also show that no well-defined correlation exists between aerated basin residence time and performance.

Polishing/Holding Ponds - EPA ranked mills in order of both effluent BOD₅ and TSS loads, distinguishing between mills with and without polishing/holding ponds. A mill was considered to have a polishing/holding pond if the last treatment unit in its wastewater treatment system before discharge was a non-aerated basin. The rankings indicate that use of polishing/holding ponds is common practice - 46 percent of mills have at least one such pond - and that mills without polishing ponds perform as well (or as poorly) as mills with polishing ponds.

Several mills have large holding ponds to control effluent flow during low flow seasons. Data from one mill that controls effluent flow indicate that performance was approximately the same when the holding pond was bypassed as when it was used, suggesting that holding ponds function as flow-control devices, not treatment units (3).

Equalization - EPA ranked mills in order of both effluent BOD₅ and TSS loads, distinguishing between mills with and without equalization. Equalization in the industry is used predominantly prior to activated sludge treatment to dampen the effect of shock loads on activated sludge systems which are more sensitive to upsets than basins. The rankings indicate that approximately 15 percent of activated sludge systems industry wide and 20 percent of bleached kraft activated sludge systems have equalization, and that mills without equalization achieve the same level of performance as mills with equalization.

Mixed Treatment Systems - EPA ranked mills in order of both effluent BOD₅ and TSS loads, distinguishing between mills with and without mixed treatment systems. More than one-third of bleached papergrade kraft activated sludge systems and about 24 percent of activated sludge systems industry wide are mixed systems, indicating that mixed systems are common. The range of treatment performance at mills with mixed treatment systems is comparable to the range at mills without mixed treatment systems.

Chemically Assisted Clarification - EPA ranked mills in order of both effluent BOD₅ and TSS loads, distinguishing between mills with and without chemically assisted clarification. Mills having chemically assisted clarification achieve BOD₅ and TSS levels across a smaller and overall lower range than mills without chemically assisted clarification; however, the three and six best performing mills in terms of BOD₅ and TSS, respectively, do not use chemically assisted clarification.

EPA further investigated treatment systems that include addition of coagulants/flocculants to secondary clarifiers to learn more about why this chemical addition was practiced. Data used for the analysis included NCASI's 1993 survey of coagulant used at 33 bleached kraft mills (4) and phone contacts with nine mills (5). Based on this analysis, EPA determined that the secondary biological wastewater treatment systems of two mills are not considered typical secondary treatment as practiced by the Bleached Papergrade Kraft and Soda Subcategory because they added very high quantities of chemicals (i.e., chemical addition costs in excess of \$5,000 per day) for the removal of color--a treatment that is not necessary to achieve the proposed TSS limitations. Treatment performance data for these systems were eliminated from the data set used to characterize typical treatment effluent loadings of conventional pollutants.

Discharge to Water Quality Limited Streams - Simply because a mill is required to meet water quality-based effluent limits for BOD₅ and/or TSS does not mean that its treatment system is atypical. Unusual equipment or unusual operating practices do not appear to be required to meet the water quality-based effluent limits. Rather, secondary biological treatment systems are capable of discharging at levels that will achieve water quality-based effluent limits in certain streams.

Based on these analyses, EPA believes that it would be inappropriate and arbitrary to eliminate mills from the secondary wastewater treatment performance data set simply because they operate wastewater treatment systems with relatively long aerated basin residence times, or

operate common biological treatment components such as polishing/holding ponds, equalization, mixed treatment systems, or chemically assisted clarification.

8.3.2.2 Adjustments to the Selection of Data to Represent the Performance of Secondary Biological Wastewater Treatment

This section discusses the adjustments EPA made after proposal to the selection of data used to represent the performance of secondary biological wastewater treatment. Adjustments include revisions to the performance data, clarification of the conventional pollutant control option technology bases, and revision of the data selection methodology for the Papergrade Sulfite Subcategory.

Revisions to the Performance Data

One mill was not used to represent secondary wastewater treatment effluent loads for the Bleached Papergrade Kraft and Soda Subcategory during the development of the proposed conventional pollutant limitations because it was incorrectly classified as having less than 85 percent of its production in the subcategory. In fact, 100 percent of its production is bleached kraft. Therefore, performance data for this mill were included in the development of the final secondary biological wastewater treatment performance levels for the Bleached Papergrade Kraft and Soda Subcategory.

EPA determined that the production data used at proposal to characterize the loadings from another mill were not correct. This sulfite mill sold virtually all of its production in the form of slush pulp to a neighboring paper mill (that had no other source of pulp). The effluent from the two mills was combined for treatment. For the proposed rule, EPA evaluated the performance data for the combined wastewater treatment system based on the combined final production from both mills (i.e., slush pulp and pulp sold off-site from the pulp mill plus paper from the paper mill) consistent with the methodology used for other combined wastewater treatment systems in the industry. Because the pulp is transported to the second mill as slush pulp, EPA determined that a more appropriate methodology for evaluating performance data for this combined wastewater treatment system would be to use the total off-machine production from the two mills (i.e., pulp sold off-site from the pulp mill and paper from the paper mill). With this change, more than 85 percent of the combined mill final production was derived from sulfite pulp manufactured at the mill complex.

EPA determined that one mill whose data were used at proposal to represent the performance of the proposed conventional pollutant control options for the Papergrade Sulfite Subcategory was not representative of the subcategory as a whole because it treats wastewater from liquor by-products manufactured on site. Because this mill is unique among papergrade sulfite mills, performance data from this mill were eliminated from development of the final secondary biological wastewater treatment performance levels for the Papergrade Sulfite Subcategory.

Clarification of the Conventional Pollutant Control Option Technology Basis

As discussed previously, EPA further investigated treatment systems that include addition of coagulant/flocculants to secondary clarifiers. Based on this analysis, EPA determined that the secondary biological wastewater treatment systems at two mills are not considered typical secondary treatment as practiced by the Bleached Papergrade Kraft and Soda Subcategory because of the addition of large quantities of chemicals for the removal of color. Treatment performance data for these two systems were eliminated from the data set used to characterize typical treatment effluent loadings of conventional pollutants for this subcategory.

EPA also further evaluated wastewater treatment operations at one mill to determine whether the treatment system represents typical secondary biological wastewater treatment for the Papergrade Sulfite Subcategory. This facility uses a high rate activated sludge treatment system to treat only a portion of their total mill wastewater effluent. The facility decided to treat only a portion of its wastewater flow due to land availability limitations, and treats only the most concentrated BOD₅ wastewater streams to a higher removal efficiency. The treated effluent is then combined with the untreated wastestream resulting in a combined effluent which meets the facility's permit limitations. This practice of treating only the most concentrated wastewater streams results in a great reduction in the size of the wastewater treatment facility required, saving both space and cost. Because the total effluent BOD₅ load discharged from this facility is less than the current effluent limitations guidelines which were the basis for the design of the wastewater treatment facility, EPA considers this treatment system to be representative of the performance attainable through secondary treatment as typically practiced at similar facilities, and considers performance data from this facility as appropriate for use developing the conventional pollutant control option performance levels.

Data Selection Methodology for the Papergrade Sulfite Subcategory

The Papergrade Sulfite Subcategory is characterized by mills whose final production is often comprised of a large portion of purchased pulp. For the proposed rule, BPT and BCT option performance levels for the subcategory were calculated using data from mills with 37 to 96 percent on their final production in the subcategory in order to expand the population of data used. This approach was a relaxation of the criteria used for other subcategories which included data from only mills with at least 85 percent of their final production in the subcategory.

After proposal, EPA reassessed the impact of purchased pulp on the final effluent BOD₅ load at papergrade sulfite mills. EPA performed further analyses of the data set, after incorporating the revisions discussed above, to evaluate the relationship between final effluent BOD₅ and TSS loads and the percentage of sulfite production at each mill. EPA determined that mills with 85 percent or more of final off-machine production derived from sulfite pulp produced on site discharged substantially higher BOD₅ loads from secondary biological wastewater treatment than mills with less than 85 percent of final off-machine production derived from sulfite pulp produced on site. Consequently, EPA revised the methodology used to identify mills

representing the performance of secondary wastewater treatment for the Papergrade Sulfite Subcategory to include a final production cut-off of 85 percent for this subcategory.

Final List of Mills Identified as Representing Secondary Biological Wastewater Treatment

Tables 8-1 and 8-2 present the final list of mills identified as representing secondary wastewater treatment performance for both the Bleached Papergrade Kraft and Soda and the Papergrade Sulfite Subcategories, respectively. Using performance data from these mills, EPA calculated final conventional pollutant control option performance levels for both subcategories as discussed in the following subsection.

8.3.3 Control Options and Performance Levels

EPA's methodology for calculating conventional pollutant control option performance levels is described in Section 9.2.3 of the Proposed Technical Development Document. This methodology is unchanged from the proposed rule with the exceptions described below.

8.3.3.1 BPT

For the proposed rule, EPA developed two options based on the average of the best existing performance. These options were:

- Option 1: The performance level representing the average of the best 90 percent of mills in each subcategory; and
- Option 2: The performance level representing the average of the best 50 percent of mills in each subcategory.

Although the Agency has the statutory authority to revise BPT, the Agency also has the discretion to determine whether to revise BPT effluent limitations guidelines in particular circumstances. For the final rule, the Agency is exercising its discretion not to revise BPT for conventional pollutants for Subpart B and E at this time.

8.3.3.2 BCT

For the proposed rule, EPA developed four options based on the best conventional pollutant control technology. These options were:

- Option A.1: The performance level represented by the best-performing mill in each subcategory assuming the baseline performance is equal to the proposed BPT Option 2;

- Option A.2: Multimedia filtration assuming the baseline performance is equal to the proposed BPT Option 2;
- Option B.1: The performance level representing the average of the best 90 percent of mills in each subcategory assuming the baseline performance is equal to current industry performance; and
- Option B.2: The performance level representing the average of the best 50 percent of mills in each subcategory assuming the baseline performance is equal to current industry performance.

Two of these options, Options A.1 and A.2, assumed the baseline performance to be equal to the proposed BPT Option 2. Because EPA has decided not to revise BPT limitations for conventional pollutants, these two BCT options are no longer applicable. Therefore, for the final rule for the Bleached Papergrade Kraft and Soda Subcategory, EPA only considered BCT Options B.1 and B.2, known now simply as BCT Options 1 and 2.

For the final rule for the Papergrade Sulfite Subcategory, EPA revised the BCT development methodology to include only one treatment option as follows:

- Option 1: The performance level representing the average performance of all mills identified as representing the performance of secondary wastewater treatment for the subcategory.

EPA believes this revision is appropriate since the revised data set for this subcategory contains performance data from only three mills.

The proposed BCT option performance levels and the final BCT option performance levels are listed below. The best performing mills whose long-term average production-normalized mass loadings were used to calculate BCT Options 1 and 2 performance levels for the Bleached Papergrade Kraft and Soda Subcategory and BCT Option 1 performance levels for the Papergrade Sulfite Subcategory are indicated in Tables 8-1 and 8-2, respectively.

**Bleached Papergrade Kraft and Soda Subcategory
Long-Term Average Loads**

BCT Option	BOD ₅ Performance Level (kg/OMMT)		TSS Performance Level (kg/OMMT)	
	Proposed	Final	Proposed	Final
Option 1	2.65	2.73	4.46	4.40
Option 2	1.57	1.73	2.72	2.72

**Papergrade Sulfite Subcategory
Long-Term Average Loads**

BCT Option	BOD ₅ Performance Level (kg/OMMT)		TSS Performance Level (kg/OMMT)	
	Proposed	Final	Proposed	Final
Option 1	4.97	7.05	5.46	8.37
Option 2	3.60	Not Applicable	4.74	Not Applicable

8.3.4 Description of Technology Bases

For the proposed and final rules, the conventional pollutant technology bases include two components, good water conservation practices and secondary biological wastewater treatment. These two technology components are discussed in detail in Section 9.2.5 of the Proposed Technical Development Document.

8.4 BAT

After re-evaluating technologies for mills in the Bleached Papergrade Kraft and Soda Subcategory, EPA determined that the model technology for effluent limitations guidelines based on BAT should be Option A. The key process technology for Option A is complete (100 percent) substitution of chlorine dioxide for chlorine, along with other in-process technologies and existing end-of-pipe biological treatment technologies listed in Section 8.2.1.1. Section 7 contains a description of the pollution prevention technologies considered for Option A. The reasons for EPA's selection of Option A as the basis of BAT for the Bleached Papergrade Kraft and Soda Subcategory are stated in the preamble.

The basis for BAT for the three segments of the papergrade sulfite subcategory is as described in Section 8.2.2, i.e., the option that EPA developed for each segment also serves as the basis for BAT for each segment.

8.5 BPT

Although the Agency has the statutory authority to revise BPT, the Agency also has the discretion to determine whether to revise BPT effluent limitations guidelines in particular circumstances. For the final rule, the Agency is exercising its discretion not to revise BPT for conventional pollutants for Subpart B and E at this time.

8.6 BCT

EPA evaluated two technology options for BCT for the Bleached Papergrade Kraft and Soda Subcategory and one technology option for the Papergrade Sulfite Subcategory.

EPA is not revising BCT limitations for these subcategories because more stringent effluent limitations for conventional pollutants did not pass the BCT cost test.

8.7 **NSPS**

NSPS for conventional and toxic and nonconventional pollutants are discussed below.

8.7.1 **Conventionals**

For the control of conventional pollutants in the proposed rule, EPA considered the best demonstrated end-of-pipe treatment. The performance level for this option was equivalent to that for proposed BCT Option A.1 (the performance level represented by the best-performing mill in each subcategory).

For the final rule for the Bleached Papergrade Kraft and Soda Subcategory, the Agency considered two options as follows:

- Option 1: The performance level represented by the best-performing mill in the subcategory (equivalent to the proposed NSPS option); and
- Option 2: The performance level representing the average of the best 50 percent of mills in the subcategory (equivalent to BCT Option 2).

For the final rule, EPA selected NSPS Option 2 because the Agency determined that the performance of the single best mill does not account for all sources of process-related variability in conventional pollutant generation and treatability expected in the entire subcategory, including raw materials (i.e., furnish), process operations, and final products. In selecting the final NSPS technology basis for conventional pollutants, EPA found it necessary to consider the secondary wastewater treatment performance of the best 50 percent of existing mills in this subcategory in order to ensure that the resulting standards reflect the full range of processes and raw materials to produce the full range of products covered by this subcategory. Therefore, EPA is promulgating NSPS for the conventional pollutants BOD₅ and TSS, based on efficient biological treatment achieving removal of 90 percent or more of influent BOD₅ and is retaining the pH NSPS promulgated in 1982.

For the final rule for the Papergrade Sulfite Subcategory, the Agency concluded that data in the record are not representative of the performance that can be achieved in the papergrade subcategory as a whole. Therefore, the conventional pollutant limitations in the 1982 NSPS regulation will be retained in the final NSPS regulations.

8.7.2 Toxics and Nonconventionals

For bleached papergrade kraft and soda mills, the Agency focussed its analysis on Option B as the technology basis for defining NSPS for toxics and nonconventional pollutants. This option includes all the elements of Option A with the addition of oxygen delignification and/or extended cooking. Section 8.2.1.2 describes this key difference between Option A and Option B (Sections 7.2.3 and 7.2.6 contain more detailed descriptions of each technology).

EPA received comments that NSPS should be based on TCF bleaching technologies and flow reduction technologies such as those technologies that form the basis of the Voluntary Advanced Technology Incentives Program Tiers II and III. EPA does not intend that NSPS should prevent the manufacture of any products currently made by the U.S. pulp and paper industry. Thus, EPA assumed at proposal, and continues to assume that the same grades of pulp will be made by new source mills as are made by existing mills. In addition, these new source mills will produce pulp for the same range of paper and paperboard products as do existing pulp producers. As discussed in this section, EPA has determined that data available in the record are not sufficient to confirm that TCF bleaching processes are technically demonstrated for the full range of products made with bleached kraft pulp. For the majority of applications, the most important bleached kraft pulp quality requirements are strength and brightness. EPA's record discussed in Sections 8.7.2.2 to 8.7.2.4, confirms that fully bright and strong kraft pulps can be made using TCF bleaching processes (7,8). EPA however, lacks data on the use of TCF for certain applications with other quality requirements, specifically:

Tissue, which requires soft, absorbent pulp, with good runnability on tissue machines; and

Food-grade liner board, which requires pulp with low extractives content to prevent taste and odor transfer.

The data are not sufficient to confirm that pulp made with TCF processes is or is not feasible for these applications, i.e., EPA does not have sufficient data to establish subcategories based on end products for which TCF pulp is usable. EPA is inviting interested parties to supply more data on the full range of products currently made with TCF-bleached kraft pulps. EPA will evaluate these data, and determine whether to propose revisions to NSPS based on TCF and, if appropriate, flow reduction technologies.

EPA evaluated TCF bleaching as part of the technology basis for the Voluntary Advanced Technology Incentives Program. EPA has identified a "Toward-TCF" option as one of the technology bases of Incentive Tier II, and a TCF option as one of the technology bases of Incentive Tier III. See the Voluntary Advanced Technology Incentives Program Technical Support Document for additional detail on these options.

The basis for NSPS for the three segments of the papergrade sulfite subcategory is the same as the basis for BAT as described in Section 8.2.2.

8.7.2.1 Properties of Paper Products

Paper is made from pulp fiber and fiber fragments bonded together into a web-like structure. Paper is typically made from a mixture of two or more different types of fibers representing different wood species and/or different pulping methods. Paper also contains non-fibrous components such as starch, clay, titanium dioxide, and a variety of other additives. Prior to forming into paper, wood fiber undergoes a mechanical process called beating. The objective of beating is to cause structural changes in the pulp fibers, such as, development of new fiber surfaces; fiber cutting, which modifies the fiber size distribution; and partial dissolving of polysaccharides from the fiber wall. The properties of the final paper product are determined to a large extent by the composition and qualities of the furnish, such as:

- Pulp wood species;
- Pulping method (kraft, sulfite, mechanical, etc);
- Beating conditions; and
- Fillers and additives.

The shortcomings of one component of a furnish are compensated for by adjustments in the other components. For example, hardwood fibers are relatively small and form a paper that is smooth and dense, but not very strong. Softwood fibers are longer and contribute to the strength of the finished paper. In general, bleached kraft pulps are important components of many paper products because they contribute strength and brightness.

8.7.2.2 TCF Bleaching at Metsä-Rauma and SCA-Östrand

By the end of 1996, two mills were producing exclusively TCF pulp that was fully bright and fully strong. The SCA-Östrand pulp mill in Timrå, Sweden began to produce TCF pulp in May 1995 and stopped all production of ECF pulp in June 1996. The Metsä-Rauma pulp mill, in Rauma, Finland was constructed in 1994-1996, and began to produce TCF pulp in 1996. Full details of the history and operations of these mills are available in the record (7,8). Characteristics of the TCF softwood pulp produced at Metsä-Rauma and SCA-Östrand are presented below, with characteristics of oxygen delignified ECF softwood pulp, for comparison.

TCF Pulp Manufactured at SCA-Östrand and Metsä-Rauma				
Product	Wood Type	Brightness (ISO)	Tensile Strength (Nm/g)	Tear Strength (Nm ² /kg)
Oxygen Delignified ECF ¹	SW	88.7 to 89.4	70	14.2 to 15.1
Östrand TCF (7)	SW	88	80	up to 13
BotniaVerde 85 (8)	SW	~85	70	over 15
BotniaVerde 88 (8)	SW	87.1 to 90.7	70	13.7 to 14

BotniaVerde is the trademark for Rauma's TCF pulps.

As discussed below, the 75 to 85 ISO TCF softwood pulp made at SCA-Östrand is used in the manufacture of wood-containing printing papers (lightweight coated and supercalendared papers), while 88+ ISO TCF softwood pulp is used to manufacture fine paper. Similarly, the lower brightness TCF pulp made at Metsä-Rauma is used in the manufacture of wood-containing printing papers, while the high brightness TCF pulp, BotniaVerde 88, is used in the manufacture of wood-free fine papers.

8.7.2.3 EPA Concludes that TCF Bleaching is An Available, Demonstrated Technology for Some Products

After examining the data available from SCA-Östrand and Metsä-Rauma, EPA has determined that TCF bleaching is an available, demonstrated technology for the production of high brightness and high strength hardwood and softwood kraft pulps used for the manufacture of wood-containing printing papers and wood-free fine papers.

8.7.2.4 EPA Concludes that Its Record is Not Sufficient to Determine if TCF Bleaching is an Available, Demonstrated Technology for All Products

Data available to EPA about the use of TCF-bleached kraft pulp for various paper products is summarized in Table 8-3. EPA has determined that these data are not sufficient to confirm that TCF bleaching processes are technically demonstrated for the full range of products made with bleached kraft pulp. EPA lacks data on the use of TCF kraft pulp for certain applications with other quality requirements, specifically:

Tissue, which requires soft, absorbent pulp, with good runnability on tissue machines; and

¹From: (9), Table 13. Data taken from Malinen, R., T. Rantanen, R. Rauronen, and L. Toikkanen. "TCF Bleaching to high brightness-bleaching sequences and pulp properties," International Pulp Bleaching Conference Proceedings, CPPA, Montreal, 1994.

Food grade, which requires pulp with low extractives content to prevent taste and odor transfer. EPA has no data on the extractives content, after TCF bleaching, of kraft pulp made from wood species that U.S. manufacturers use for food grade liner board.

Further, EPA concludes that the data are not sufficient to determine if pulp made with TCF processes is or is not feasible for these applications, i.e., EPA does not have sufficient data to define a range of product specifications that can be made with TCF-bleached kraft pulp, and thus is not able to define a subcategory for which TCF bleaching is an available, demonstrated technology.

8.8 **PSES**

Under the CWA, EPA is authorized to establish categorical pretreatment standards for existing sources and new sources that discharge pollutants that *pass through* POTWs or *interfere with* treatment processes or sludge disposal methods at POTWs. EPA's definition of POTW pass through is presented in a January 28, 1981 Federal Register Notice. The Federal Register Notice defines pass through for the purposes of developing national categorical standards as follows:

"In determining whether a particular pollutant is passing through the POTW and is, therefore, appropriately subject to regulation through categorical pretreatment standards, the Agency compares POTW removal with removal obtained by a direct discharger. A pollutant will be deemed to pass through a POTW, and will thus be characterized as incompatible, where the average treatment provided by POTWs nationwide does not realize the same percentage of removal of the regulated parameter as would be required of direct dischargers with national effluent standards for that pollutant. Thus, if in order to comply with their direct discharge BAT standards, direct dischargers in Category Y were required to remove 85 percent of pollutant X, then POTWs must achieve an average of at least 85 percent removal of pollutant X in order to avoid the conclusion that pollutant X presents a Pass-Through problem."

Based on this guidance, pass through is determined by comparing the average treatment provided by POTWs nationwide (expressed as a percentage removal) to the average treatment provided by direct discharging bleached papergrade kraft and soda (BPK) and papergrade sulfite (PS) mills that control pollutants to the level of BAT (or NSPS, for new sources).

The ten indirect discharging facilities in the BPK and PS subcategories each contributes the majority of flow or pollutant loadings to a POTW. EPA refers to these POTWs as

“industrial POTWs.” A list of these mills and their corresponding industrial POTW is shown in Table 8-4.

At proposal, using very limited data, EPA concluded that biological treatment systems used at these POTWs were not designed to the same standards as the biological treatment systems installed and operating at direct-discharging BPK and PS mills. As a result, EPA concluded that the treatment systems at direct discharging mills achieve greater removals of BOD₅ and TSS than are achieved by the industrial POTWs, that is, BOD₅ and TSS *pass through* the industrial POTWs. By extension, EPA concluded that other pollutants more difficult to biodegrade than BOD₅ (such as AOX, dioxin, furan, and other chlorinated compounds) also pass through the industrial POTWs.

In order to prevent pass through, EPA determined that PSES (and PSNS, for new sources) were necessary. EPA proposed PSES and PSNS based on the same technologies that it used as the basis for BAT and NSPS, respectively. EPA also proposed that compliance with these standards be demonstrated at the same points as it proposed for BAT and NSPS. That is, EPA proposed PSES and PSNS for dioxin, furan, 12 chlorinated phenolic compounds, and certain volatile compounds and required compliance monitoring at the bleach plant effluent. In addition, EPA proposed PSES and PSNS for AOX, COD, and color and required compliance monitoring at the point of discharge to the industrial POTW. These proposed standards would have required indirect-discharging mills to construct complete secondary treatment facilities duplicating the treatment systems currently operated by POTWs. In 58 FR at 66123-66125, (December 17, 1993) EPA also discussed other PSES options intended to obviate the need for complete secondary treatment at the indirect discharging mills.

Several commenters on the proposed PSES reported that POTWs adequately treat BOD₅ and TSS from pulp mill wastewaters. Further, commenters asserted that POTWs also remove AOX from pulp mill wastewaters. These commenters concluded that pretreatment standards for BOD₅, TSS, and AOX set at the point of discharge to the POTW are unnecessary.

As discussed below, EPA reviewed the comment submittals and other available data and determined that they could be used for a pass-through analysis for conventional pollutants. EPA had no data characterizing POTW removals of the toxic and nonconventional pollutants considered for regulation (other than AOX). Such data were not provided by the commenters and were not available from other sources. Because available data were sufficient, however, to indicate that POTW and mill treatment system control of BOD₅ and AOX appear to be comparable, EPA used mill treatment system data to characterize POTW removals of toxic and nonconventional pollutants.

The remainder of this section makes the following points:

- 1) The control of BOD₅, TSS, and AOX by biological wastewater treatment systems at POTWs receiving BPK and PS mill wastewaters appears to be

comparable to the control provided by biological wastewater treatment systems at direct discharging mills (8.8.2).

- 2) EPA concluded that BOD₅ and TSS do not pass through POTWs (8.8.2).
- 3) Because (as presented in 8.8.2) POTW and mill treatment system removals of BOD₅ and AOX appear to be comparable, EPA assumed that the treatment of other pollutants generated at BPK and PS mills (i.e., dioxin, furan, chlorinated phenolic compounds, and chloroform) in POTWs is comparable to their treatment in mill-operated biological treatment systems (8.8.3).
- 4) Dioxin and furan are not removed in mill treatment systems, thus, EPA concludes dioxin and furan pass through POTWs (8.8.3).
- 5) Chloroform is extremely volatile and as such is air stripped during conveyance to and initial stages of biological wastewater treatment, thus EPA considers chloroform to pass through POTWs (8.8.3).
- 6) Model BAT technologies remove all 12 of the chlorinated phenolic compounds to concentrations less than the minimum level at the bleach plant. Mill treatment systems achieve less removal, thus, EPA concludes that the 12 chlorinated phenolic compounds pass through POTWs (8.8.3).
- 7) Model BAT technologies reduce AOX discharges by approximately 82 percent of the AOX generated at a conventionally operated bleach plant. Mill-operated biological treatment systems achieve only 43 percent removal, thus, EPA concludes that AOX passes through POTWs (8.8.3).
- 8) Limited data characterizing the performance of biological treatment systems receiving PS wastewaters appear to indicate that control of BOD₅ and TSS is similar to the control provided by treatment systems receiving BPK wastewaters. For the purpose of conducting a pass-through analysis, EPA assumed that the treatment of other pollutants generated at PS mills (i.e., dioxin, furan, chlorinated phenolic compounds, and chloroform) in POTWs is comparable to their treatment in mill-operated biological treatment systems treating BPK wastewaters (8.8.4).
- 9) As discussed in Section 8.8.4, below, EPA concluded that dioxin, furan, chlorinated phenolic compounds, chloroform, and AOX pass through POTWs for segments of the Papergrade Sulfite Subcategory for which it is setting BAT limitations at this time.

EPA's pass-through determinations are summarized in the following table. EPA is establishing PSES and PSNS for the pollutants it has determined pass through POTWs.

Pollutant	Bleached Papergrade Kraft and Soda Subcategory	Papergrade Sulfite; Calcium, Magnesium, or Sodium Segment	Papergrade Sulfite; Ammonium Segment	Papergrade Sulfite; Specialty-Grade Segment
dioxin	<i>pass through</i>	<i>pass through</i>	<i>pass through</i>	<i>pass through</i>
furan	<i>pass through</i>	<i>pass through</i>	<i>pass through</i>	<i>pass through</i>
chlorinated phenolics	<i>pass through</i>	<i>pass through</i>	<i>pass through</i>	<i>pass through</i>
chloroform	<i>pass through</i>	<i>pass through</i>	<i>no determination</i>	<i>no determination</i>
AOX	<i>pass through</i>	<i>pass through</i>	<i>no determination</i>	<i>no determination</i>
BOD ₅	<i>does not pass through</i>	<i>does not pass through</i>	<i>does not pass through</i>	<i>does not pass through</i>
TSS	<i>does not pass through</i>	<i>does not pass through</i>	<i>does not pass through</i>	<i>does not pass through</i>

8.8.1 Performance of End-of-Pipe Secondary Biological Treatment Systems

EPA compared pollutant control provided by direct-discharging mill biological treatment systems and POTWs accepting similar wastewaters. Because BOD₅ control is the primary objective of secondary treatment, secondary treatment systems are designed for optimal BOD₅ removal and may not be optimized for TSS removal. TSS are generated during biological treatment, thus TSS percent removal must be considered along with BOD₅ removal and final effluent TSS concentrations, to completely evaluate the performance of a secondary biological treatment system. Data available to EPA indicate that the removals of BOD₅ and AOX at direct-discharging mill treatment systems and POTWs accepting similar wastewaters appear to be comparable. TSS control is also similar.

POTWs - Summaries of removals achieved by secondary biological treatment systems operated by POTWs receiving BPK and PS mill wastewaters are presented in Table 8-5. The removals presented in Table 8-5 were calculated from data provided in comments on the proposed rule, and from EPA's Permit Compliance System (PCS). Table 8-5 also presents the average removals achieved by secondary biological treatment systems supplied by NCASI in comments on the proposed rule (DCN 20026 A31).

Commenters supplied BOD₅, TSS, and AOX data for the ten POTWs receiving BPK or PS mill wastewaters, as shown below:

Pollutant	Number of POTWs for which Average Pollutant Removals were Submitted	Number of POTWs for which Influent/Effluent Data were Supplied to Support Average Pollutant Removals
BOD ₅	5	3
TSS	3	2
AOX	4	2

The average removals for each pollutant for the POTWs were calculated by first arithmetically averaging all data supplied for each POTW in comment submittals and from EPA PCS data (as presented in Table 8-5). (Note that the low AOX removal data from the Jackson County Port Authority were deleted before the average for this facility was calculated because the treatment system was disrupted during sampling due to changes in the process at the mill.) Then, average pollutant removals for all POTWs were arithmetically averaged to yield one average pollutant removal for each pollutant. These averages were compared to the NCASI data (presented in Table 8-6) and to average pollutant removals from direct-discharging BPK mills.

Mill Treatment Systems - For the purpose of comparing the performance of POTWs and mill biological treatment systems, EPA used data from three mills employing Option A technology and four mills employing Option B technology for which treatment system influent and effluent data were available. EPA combined these data because it believed that treatment system removals of BOD₅, TSS, and AOX did not differ significantly between mills using Option A and Option B pulping and bleaching technologies. The average removals were calculated by arithmetically averaging removals achieved by the three Option A mills (Georgia-Pacific's Brunswick and Leaf River mills (see Record Section 21.6.1.3) and the James River Wauna Mill (see Record Section 21.6.1.5)) and the removals from four Option B mills sampled by EPA (12).

Comparison - Table 8-7 shows a comparison of pollutant removals between POTWs receiving BPK wastewaters and treatment systems operated by direct-discharging BPK mills. These results are also summarized in the table below.

Average Treatment System Removals (percent)				
		BOD ₅	TSS	AOX
POTW	Average	93 (6 POTWs)	86 (5 POTWs)	49 (4 POTWs)
	Range	86 to 97	56 to 95	41 to 58
NCASI POTWs	Average	94.3 (9 POTWs)	80.5 (9 POTWs)	53.4 (6 POTWs)
	Range	86 to 98.8	4 ^a to 98.5	30 to 100
Mill Treatment Systems	Average	95	74	49
	Range	91 to 98 (5 mills)	31 to 98 (6 mills)	11 to 78

^aWithout this value, the range of TSS removals reported by NCASI is 77 to 98.5 percent. The POTW reporting this low removal has a relatively low influent concentration (55 mg/L), contributing to the low percent removal.

These data appear to indicate that the removals of BOD₅, TSS, and AOX achieved by secondary biological treatment systems at these industrial POTWs are comparable to the removals achieved by secondary biological treatment systems operated by direct-discharging BPK mills. The comparability of the effectiveness of POTW and mill-operated biological treatment systems in the control of TSS is further supported by TSS effluent concentrations. EPA compared the POTW final effluent TSS concentrations reported by NCASI to the concentrations achieved at 32 bleached kraft mills EPA used to characterize the performance of biological treatment. POTW TSS effluent concentrations ranged from 4.5 to 56 mg/L, and averaged 31 mg/L. Mill treatment system TSS effluent concentrations ranged from 4.6 to 140 mg/L, and averaged 55 mg/L. EPA concluded that BOD₅ and TSS *do not pass through* POTWs and thus is not promulgating PSES or PSNS for BOD₅ or TSS. EPA's pass-through determination for AOX is described in 8.8.3 below.

8.8.2 Bleached Papergrade Kraft and Soda Pass-Through Analysis for PSES and PSNS

EPA compared the pollutant removals achieved by BPK mills implementing the model BAT technologies (process changes and biological wastewater treatment) to the pollutant removals achieved by biological wastewater treatment systems treating BPK mill wastewater. As discussed above, EPA had data from POTWs treating BPK and PS wastewater for three pollutants (BOD₅, TSS, and AOX). For the purpose of conducting the pass-through analyses discussed below, EPA assumed that the treatment of other pollutants generated at BPK and PS mills (i.e., dioxin, furan, chlorinated phenolic compounds, and chloroform) in secondary biological treatment systems at POTWs is comparable to their treatment in mill-operated end-of-pipe secondary biological treatment systems. This assumption is reasonable because:

- 1) The majority of the wastewater flow and pollutant loading at these POTWs is contributed by BPK or PS mills; and

- 2) The data indicate that the control of BOD₅, TSS, and AOX pollutants in POTW treatment systems receiving BPK and PS mill wastewaters appears to be comparable to the control of these pollutants by biological treatment systems at direct discharging mills.

Commenters supplied AOX removal data for four POTWs. EPA, however, chose to use its database of mill treatment system AOX removals to characterize POTW performance. EPA chose to use its database because it had full information to evaluate the accuracy, precision, and representativeness of its data. This approach was reasonable because the data supplied by commenters showed that removals of AOX in POTWs were similar to removals in mill treatment systems. The conclusions of EPA's pass-through analysis are presented below for each regulated toxic and nonconventional pollutant.

Dioxin and furan - Results of the Five-Mill Study and the 104-Mill Study show that dioxin and furan are not removed by biological treatment systems at direct-discharging BPK and PS mills (13,14). Rather, these pollutants were found to either partition to the secondary sludge of a biological treatment system or pass through untreated. The partitioning was neither consistent nor predictable. In contrast, as discussed in Section 9.0 of this document, EPA estimated that for BPK mills, the model BAT technology would remove 91 percent of the baseline bleach plant loading of dioxin and furan. In addition, EPA estimated that the model NSPS technology would remove 93 percent of the baseline bleach plant loading of dioxin and furan. Compared to the 0.0 percent removal of dioxin and furan achieved by biological wastewater treatment systems employed by POTWs, the model BAT and NSPS technologies achieve substantially greater removals. For this reason, EPA concluded that dioxin and furan pass through POTWs.

Dioxin and furan that remain untreated are discharged to receiving streams. In contrast, mills implementing the model BAT technologies achieve substantial reductions of dioxin and furan prior to secondary biological treatment. EPA found that in bleach plant wastewaters dioxin is removed to less than the minimum level, and furan is removed to less than the minimum level or to concentrations slightly above the minimum level. EPA also has determined that use of the model BAT technologies and compliance with limitations for these pollutants at the bleach plant will reduce concentrations of dioxin and furan in sludges from those found in the Five-Mill and 104-Mill Studies to levels near the minimum level for the analytical method for solids (15).

As a result of EPA's finding that dioxin and furan pass through POTWs, EPA is promulgating PSES and PSNS for these pollutants. In addition to preventing pass through of dioxin and furan, PSES and PSNS will also reduce possible interference with a POTW's sludge disposal options. The technology basis, numerical limitations, and point of compliance for PSES are equivalent to BAT while PSNS is equivalent to NSPS.

Chloroform - Chloroform is an extremely volatile compound, with a Henry's Law Constant¹ of 3.39×10^{-3} atm/gmole/m³ (slightly less volatile than benzene, toluene and the xylene isomers, but more volatile than isopropyl ether or diethyl ether). The more volatile a pollutant, the higher its Henry's Law Constant, and the less likely that it will be treated by a POTW. The pollutant is likely to be volatilized as it flows to the POTW, in either the piping system, the head works, or the collection systems at the POTW. When the pollutant volatilizes before treatment, the amount of pollutant influent to the POTW and therefore the amount being biodegraded at the POTW is reduced. EPA considers that very volatile compounds pass through POTWs because a significant portion of the compound is air stripped and not biodegraded by the POTW.

NCASI studied air and water concentrations of chloroform around four bleached kraft mill wastewater treatment systems and concluded "significant reductions in aqueous chloroform concentrations were observed across flumes and other points of turbulence in the treatment system. Typically, the majority of the chloroform was removed in the first third of the effluent treatment systems" (16). NCASI's finding confirms EPA's position that volatile compounds such as chloroform are air stripped, not degraded in POTWs. EPA has consistently refused to regard transfers of pollutants from wastewater to air as treatment. Thus, EPA concludes that chloroform removal in POTWs approaches 0 percent.

EPA compared the negligible chloroform removal achieved in POTWs to the percent removal expected from a mill using the model BAT technologies. EPA made this evaluation based on bleach plant effluent loadings, summarized below.

Mill Type	Bleach Plant Effluent Chloroform Loading (g/kgg)
Conventional bleaching (hypochlorite and various levels of chlorine dioxide substitution)	> 140
Model BAT Technologies (6,17)	3.09
percent removal	>98

EPA concluded that chloroform removals at mills implementing the model BAT technologies are vastly greater than the removal achieved by POTWs (>98 percent compared to approaching 0 percent); chloroform, therefore, *passes through* POTWs. As a result of EPA's findings that chloroform passes through POTWs, as well as because of potential unacceptable non-water quality environmental impacts from air emissions, EPA is promulgating PSES and PSNS for chloroform. The technology basis, limitations, and point of compliance for PSES and PSNS are equivalent to BAT.

¹Henry's Law Constants reflect the partitioning of chemical compounds between a liquid phase (in this case water) and a gas phase. A compound with a high Henry's Law Constant has a high vapor pressure and a low solubility in water and thus will preferentially partition to air.

Chlorinated phenolic compounds - EPA determined that chlorinated phenolic compounds pass through POTWs. This determination is based on data in the record (18,19,20) showing that the model BAT technologies remove all 12 of the chlorinated phenolic compounds to concentrations less than minimum levels for these pollutants in bleach plant wastewaters, prior to end-of-pipe biological wastewater treatment. In comparison, mills employing conventional pulping and bleaching technologies were found to discharge one or more of the chlorinated phenolic pollutants at measurable levels (6).

To assess whether the chlorinated phenolic compounds pass through, EPA used the total subcategory baseline and option discharge loading estimates presented in Section 9 of this document. EPA used this approach in order not to overstate the removals of pollutants reduced to concentrations less than analytical method minimum levels. Loadings of pollutants measured at less than the sample-specific detection limit were estimated using one-half the minimum level of the analytical method (see Section 9.2.1). If EPA had assumed that loadings of compounds not detected were zero, Option A (the model BAT technology) and Option B (the model NSPS technology) would achieve 100 percent removal of chlorinated phenolic compounds.

The following table summarizes EPA's estimated removals of chlorinated phenolic compounds. EPA assumed, based on an NCASI study (21), that 45 percent of the estimated bleach plant load was removed in biological treatment systems. As discussed in Section 8.8.2 and in Section 9.3, EPA has assumed that POTW removals will be the same as removals achieved by mill-operated wastewater treatment systems. EPA estimated the baseline load of chlorinated phenolic compounds discharged by the BPK subcategory prior to the imposition of new limitations and standards. EPA also estimated the overall chlorinated phenolic compound removals achieved by the model BAT technologies (Option A) and the model NSPS technologies (Option B). (See Section 9.3.1.)

Overall Chlorinated Phenolic Compounds Removals at Baseline and for Model Technologies			
	Bleach Plant Effluent Loading (kg/yr)	Treated Effluent Loading (kg/yr)	Removal of Baseline Bleach Plant Loading (Percent)
Baseline	100,000	55,000	45
Model BAT Technologies (Option A)	18,000	10,000	90
Model NSPS Technologies (Option B)	14,000	7,900	92

Source: Table 9-24 of this document.

For the model BAT technologies (Option A), the estimated bleach plant chlorinated phenolic compounds loading is 18,000 kg/year and the final effluent chlorinated phenolic compounds loading is 10,000 kg/year. Similarly, for mills using the model NSPS technologies (Option B), the estimated bleach plant chlorinated phenolic compounds loading is 14,000 kg/yr and the final effluent chlorinated phenolic compounds loading is 7,900 kg/yr.

To assess whether chlorinated phenolic compounds pass through, EPA compared the overall percent removal achieved by biological wastewater treatment systems treating the estimated baseline bleach plant loadings to the percent removal expected if the BPK subcategory mills implemented the model BAT technologies (Option A). Option A includes well-operated biological treatment. The calculated baseline removal is 45 percent (comparing 100,000 to 55,000 kg/yr). The BAT removal is 90 percent (comparing 100,000 to 10,000 kg/yr). The BAT removal includes the combined effect of the chlorinated phenolic compounds reduction attributable to in-plant process changes and the chlorinated phenolic compounds removal due to biological treatment. Furthermore, the estimated subcategory bleach plant loading (18,000 kg/yr) for Option A is lower than baseline treated effluent load without Option A technology. Therefore, EPA concluded that because overall chlorinated phenolic compounds removals with implementation of the model BAT technologies are substantially greater than the removals achieved by POTWs, chlorinated phenolic compounds *pass through* POTWs.

Similarly, EPA compared the overall percent removal achieved by biological wastewater treatment systems treating the estimated baseline bleach plant loadings to the percent removal expected if the BPK subcategory mills implemented the model NSPS technologies (Option B). Option B includes well-operated biological treatment. Again, the calculated POTW removal is 45 percent (comparing 100,000 to 55,000 kg/yr). The NSPS removal is 92 percent (comparing 100,000 to 7,900 kg/yr). Furthermore, the estimated subcategory bleach plant loading (14,000 kg/yr) for Option B is lower than baseline treated effluent load with neither Option A nor Option B technology. Therefore, EPA concluded that because overall chlorinated phenolic compounds removals with implementation of the model NSPS technologies are substantially greater than the removals achieved by POTWs, chlorinated phenolic compounds from new sources also *pass through* POTWs.

As a result of EPA's finding that the 12 chlorinated phenolic compounds pass through POTWs, EPA is promulgating PSES and PSNS for those pollutants. The technology basis, limitations, and point of compliance for PSES are equivalent to BAT while PSNS are equivalent to NSPS.

AOX - EPA also determined that AOX passes through industrial POTWs. EPA bases this conclusion on its review of data (presented and discussed below) comparing the removals of AOX achieved by POTWs treating wastewater from mills using conventional bleaching to the AOX removals achieved by direct dischargers meeting limitations based on the model BAT process technologies. The mills using the model BAT process technologies consistently achieve far greater AOX removals than indirect discharging mills using conventional bleaching technologies that discharge to industrial POTWs. Therefore, in the absence of PSES, the affected industrial POTWs cannot achieve the same overall removals of AOX as achieved by direct dischargers complying with the BAT limitations for AOX. The same is also true when considering removals achieved by new sources complying with NSPS. Thus, EPA concludes that AOX passes through POTWs and is setting pretreatment standards for AOX for existing and new indirect-discharging mills.

The following table lists final effluent AOX loadings for three softwood bleach lines sampled by EPA (during the short term study sampling program) that use conventional bleaching (e.g., less than complete chlorine dioxide substitution). The average bleach plant AOX loading for these three mills is 2.8 kg/kkg (kilograms of AOX per metric ton of unbleached pulp entering the bleach plant). This AOX loading is used in the following discussion to represent the typical bleach plant AOX loading from a softwood mill using conventional pulping and bleaching technologies.

Bleach Plant Loadings for Mills With Conventional Pulping and Bleaching				
Mill	Furnish	Bleach Sequence	Approximate Chlorine Dioxide Substitution (Percent)	Bleach Plant AOX Loading (kg/kkg)
A	softwood	C/DEopDD	50	1.6
B	softwood	C/DEHED	60	2.4
C	softwood	C/DEDED	30	4.3
Average				2.8

The following table summarizes the overall removal of the conventional bleaching AOX load (2.8 kg/kkg) achieved by biological wastewater treatment, and achieved by the model BAT technologies (Option A) and the model NSPS technologies (Option B).

Overall AOX Removals for Conventional Bleaching and Option Mills			
Mill Type	Long-Term Average Bleach Plant Effluent AOX Loading (kg/kkg)	Long-Term Average Treated Effluent AOX Loading (kg/kkg)	Removal of Conventional Bleach Plant Loading (Percent)
Conventional Bleaching	2.8	1.6	43
Model BAT Technologies (Option A)	1.3	0.51	82
Model NSPS Technologies (Option B)	0.77	0.21	93

Final effluent AOX loadings were not available from the three mills for which bleach plant AOX loadings are presented. Using other data collected at proposal, EPA determined that the final effluent AOX loading after secondary biological treatment for conventional bleaching mills is 1.6 kg/kkg (22). For mills using the model BAT technologies (Option A), the average bleach plant AOX loading is 1.3 kg/kkg and the final effluent AOX loading is 0.51 kg/kkg (6,17). Similarly, for mills using the model NSPS technologies (Option B), the average bleach plant AOX loading is 0.77 kg/kkg and the final effluent AOX loading is 0.21 kg/kkg (6,17).

To assess whether AOX passes through, EPA compared the overall percent removal achieved by a biological wastewater treatment system treating bleach plant effluent from a mill using a conventional bleaching technology, to the percent removal expected from a mill using the model BAT technologies (Option A). Option A includes well-operated biological treatment. (For the reasons discussed in Section 8.8.2, EPA has assumed that POTW loadings would be comparable to the mill treated effluent loadings presented above.) The calculated POTW removal is 43 percent (comparing 2.8 to 1.6 kg/kkg). The BAT removal is 82 percent (comparing 2.8 to 0.51 kg/kkg). The BAT removal includes the combined effect of the AOX reduction attributable to in-plant process changes and the AOX removal due to biological treatment. Furthermore, the average bleach plant loading (1.3 kg/kkg) for a mill employing Option A is lower than treated effluent from secondary biological treatment without Option A technology. Therefore, EPA concluded that because overall AOX removals at mills implementing the model BAT technologies are substantially greater than the removals achieved by POTWs, AOX *passes through* POTWs.

Similarly, EPA compared the overall percent removal achieved by a biological wastewater treatment system of treating bleach plant effluent from a mill using a conventional bleaching technology, to the percent removal expected from a mill using the model NSPS technologies (Option B). Option B includes well-operated biological treatment. Again, the calculated POTW removal is 43 percent (comparing 2.8 to 1.6 kg/kkg). The NSPS removal is 93 percent (comparing 2.8 to 0.21 kg/kkg). Furthermore, the average bleach plant loading (0.77 kg/kkg) for a mill employing Option B is lower than treated effluent from secondary biological treatment with neither Option A nor Option B technology. Therefore, EPA concluded that overall AOX removals at mills implementing the NSPS process technologies are substantially greater than for mills without these technologies. Therefore, EPA concluded that because overall AOX removals at new source mills implementing the model NSPS technologies are greater than the removals achieved by POTWs, AOX from new sources also *passes through* POTWs.

As a result of EPA's findings that AOX passes through POTWs, EPA is promulgating PSES and PSNS for AOX. The technology basis for PSES is equivalent to the model BAT technologies, except the PSES basis does not include biological wastewater treatment. Similarly, the technology basis for PSNS is equivalent to the model NSPS technologies without biological wastewater treatment. Because secondary biological wastewater treatment is used at industrial POTWs, neither the model pretreatment technology for PSES nor PSNS includes secondary biological wastewater treatment.

The pretreatment standards promulgated today for AOX reflect the AOX loadings present in the bleach plant wastewaters prior to biological treatment at direct-discharging mills that employ model process technologies. EPA expects that AOX reductions achieved by indirect dischargers employing the PSES or PSNS model process technology, in combination with removals achieved by biological treatment systems at industrial POTWs, will be comparable to the overall removals achieved by direct dischargers complying with BAT limitations or NSPS. AOX limitations based on the performance of the PSES/PSNS process technology are appropriately set, and compliance demonstrated, at the bleach plant, prior to mixing with other wastestreams.

8.8.3 Papergrade Sulfite Pass-Through Analysis

For the purpose of establishing BAT and NSPS limitations for the Papergrade Sulfite (PS) subcategory, EPA divided the subcategory into three segments: (a) calcium, magnesium, or sodium sulfite pulping; (b) ammonium sulfite pulping; and (c) specialty-grade sulfite pulping. To conduct a pass-through analysis for the PS subcategory, EPA compared the pollutant removals achieved by PS mills implementing the model BAT technologies for each segment, to the removals achieved by biological wastewater treatment systems treating pulp mill wastewater. Commenters provided EPA with data from one POTW treating PS wastewater for only three pollutants: AOX, BOD₅, and TSS (see Table 8-6). For the purposes of conducting the pass-through analyses discussed below, EPA assumed that the treatment of pollutants generated by PS mills in POTWs is comparable to the treatment of these pollutants in mill operated treatment systems treating BPK wastewaters. This assumption is reasonable because the limited data characterizing PS mill treatment systems show that removals of pollutants are similar to the removals in BPK mill treatment systems.

Calcium, magnesium, or sodium sulfite pulping - For the calcium-, magnesium-, or sodium-based segment, the model BAT technology is based on TCF bleaching. Mills employing this model technology will achieve the maximum possible reduction in the discharge of chlorinated pollutants from bleaching. Because chlorine or chlorine-containing bleaching chemicals are not used, chlorinated pollutants are not generated during bleaching. EPA concluded that dioxin, furan, the 12 chlorinated phenolic compounds, chloroform, and AOX removals at mills implementing the model BAT technologies are greater than the removals achieved by POTWs. EPA finds that TCF bleaching will reduce AOX discharge loads from the 1 to 3 kg/kkg typically found at conventional bleaching mills to less than minimum levels, even at indirect-discharging facilities with no on-site biological treatment. This reduction is greater than 99 percent, which far exceeds the AOX reduction that can be demonstrated by POTW treatment. Thus EPA concludes that these pollutants all pass through POTWs.

EPA is establishing PSES and PSNS for AOX (expressed as below the minimum level of the analytical method) for mills in this segment of the Papergrade Sulfite Subcategory, with the limitation expressed as less than the minimum level. One reason EPA is not establishing specific pretreatment standards for dioxin, furan, the 12 chlorinated phenolic compounds, or chloroform is that when AOX is controlled to this level, these pollutants will not be generated by calcium, magnesium, or sodium sulfite bleaching processes.

Ammonium sulfite and specialty-grade sulfite segments - EPA concluded that dioxin, furan, and the 12 chlorinated phenolic pollutants pass through or interfere with POTW operations for the ammonium and specialty-grade segments for the same reasons described in Section 8.2.3, for the BPK Subcategory (i.e., EPA concludes that dioxin, furan, and the 12

chlorinated phenolic compounds from PS mills will be removed to the same extent in POTWs as dioxin, furan, and the 12 chlorinated phenolic compounds from BPK mills). The BAT and NSPS model technologies for both the BPK and PS Subcategories (ammonium and specialty-grade segments) are based on ECF bleaching process technologies. As a result of EPA's finding that dioxin, furan, and the 12 chlorinated phenolic compounds pass through POTWs, EPA is promulgating national pretreatment standards for new and existing sources for those pollutants for those segments. The technology basis, numerical limitations, and point of compliance for PSES and PSNS are equivalent to BAT for these segments.

With respect to chloroform and AOX in the ammonium and specialty-grade segments of the PS Subcategory, EPA has insufficient data at this time to characterize the performance of the model BAT technologies (12). EPA needs these data to conduct a pass-through analysis. When these data become available, EPA will make pass-through determinations and (if warranted) will set pretreatment standards for chloroform and AOX.

8.9 **PSNS**

For bleached papergrade kraft and soda mills, EPA is promulgating PSNS based on the model technology for NSPS, which is Option B, excluding effective biological treatment (which is presumed to occur at the receiving POTW). The basis for PSNS for the three segments of the PS subcategory is the same as the basis of BAT and NSPS for these mills, as described in Section 8.2.2.

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Table 8-1

**Mills Representing the Performance of Secondary Wastewater Treatment
Bleached Papergrade Kraft and Soda Subcategory**

Observation Number	Final Conventionals Option 1 Mill? (Y/N)	Final Conventionals Option 2 Mill? (Y/N)	Long-Term Average BOD ₅ Effluent Load (kg/OMMT)	Long-Term Average TSS Load Effluent (kg/OMMT)	Wastewater Treatment Type
1	Y	Y	0.26	0.24	B
2	Y	Y	0.61	1.31	S
3	Y	Y	0.70	2.23	S
4	Y	Y	1.06	2.74	S
5	Y	Y	1.16	3.97	S
6	Y	Y	1.45	2.11	B
7	Y	Y	1.55	1.40	B
8	Y	Y	1.60	3.11	S
9	Y	Y	1.60	3.48	B
10	Y	Y	1.92	2.29	B
11	Y	Y	1.98	2.25	B
12	Y	Y	2.42	1.95	B
13	Y	Y	2.57	5.44	S
14	Y	Y	2.80	2.05	B
15	Y	Y	2.97	3.04	B
16	Y	Y	3.02	6.07	B
17	Y	N	3.25	8.43	S
18	Y	N	3.16	3.55	B
19	Y	N	3.35	7.01	B
20	Y	N	3.57	9.16	B
21	Y	N	3.58	4.60	S
22	Y	N	3.68	7.13	B
23	Y	N	3.78	8.37	S
24	Y	N	4.34	8.73	B
25	Y	N	4.34	3.31	B
26	Y	N	4.82	2.91	B
27	Y	N	5.41	9.67	B
28	Y	N	5.53	6.88	B
29	Y	N	5.55	4.56	B
30	Y	N	5.69	9.64	S
31	N	N	5.70	8.62	B
32	N	N	6.68	9.79	B

B - Mills that operate secondary wastewater treatment in basins.

S - Mills that operate secondary wastewater treatment in activated sludge systems or a combination of activated sludge systems and basins.

Table 8-2

**Mills Representing the Performance of Secondary Wastewater Treatment
Papergrade Sulfite Subcategory**

Observation Number	Long-Term Average BOD ₅ Effluent Load (kg/OMMT)	Long-Term Average TSS Load Effluent (kg/OMMT)	Wastewater Treatment Type
1	nd	nd	nd
2	nd	nd	nd
3	nd	nd	nd

nd - Not disclosed to prevent compromising confidential business information.

Table 8-3
Data Available on the Use of TCF-Bleached Kraft Pulp

Major Product Type	Bleached Kraft Pulp Contribution	Key Bleached Kraft Pulp Qualities	TCF Kraft Data?
Newsprint (wood-containing)	up to 25% semi-bleached SW kraft used for reinforcement	Strength	no; but LWC properties exceed the quality needed for newsprint
Magazine Printing (wood-containing, uncoated, super-calendared)	up to 30% bleached or semi-bleached SW kraft	Strength	yes: Östrand (7)
Light Weight Coated (wood-containing, e.g., catalog grade)	40 - 50% bleached chemical pulp for strength	web strength, uniformity, low freeness	yes: Östrand and Metsä-Rauma (7,8)
Uncoated Free Sheet (wood free; e.g., office paper)	>90% bleached kraft, HW&SW mixed at variable proportions, for strength and brightness stability	Strength, high brightness and brightness stability, HW for light scattering power (opacity), and formation	yes: Ostrand and Metsä-Rauma (7,8)
Coated Wood-Free and Other Fine Graphics Papers	up to 70% HW kraft for uniformity	Same as uncoated free sheet and more HW for uniformity of base sheet	yes: Sodra (10)
Packaging Papers	SW kraft for strength	strength, stretchability (from high shrinkage potential)	yes: Wisaforest reports food contact sackgrade can be made from 100% TCF pulp (11)
Tissue: -cellulose wadding -facial & napkin -toilet -towel	added for strength; must not detract from absorbency, softness, runnability contributed by sulfite or CTMP pulps or secondary fiber	strength, absorbency, softness	None identified in record
Board Grades	top layer made from bleached SW&HW kraft for printability and tensile strength	strength, brightness	None identified in record
Food-Grade Liner Board	bleached kraft of semi-bleached with bleached kraft overlay for strength mechanical pulp needed for stiffness	strength, extractives-free to prevent migration of odor and taste	None identified in record

HW - hardwood

SW - softwood

CTMP - chemi-thermo-mechanical pulp

Table 8-4
POTWs Receiving Chemical Pulp Mill Wastewaters

POTW Name	POTW Permit No.	Location	Mill Discharging to the POTW
Bleached Papergrade Kraft and Soda Subcategory			
Gulf Coast Waste Disposal Authority	TX0052591	Pasadena, Texas	Simpson Pasadena Paper Co.
Muskegon County Wastewater Management System	MI0027391	Muskegon, Michigan	S. D. Warren (SAPPI)
Upper Potomac River Commission	MD0021687	Westernport, Maryland	Westvaco Corporation (Luke, MD mill)
City of St. Helens	OR0020824	St. Helens, Oregon	Boise Cascade Corporation
Jackson County Port Authority	MS0002674	Pascagoula, Mississippi	International Paper Co. (Moss Point, MS)
Western Lake Superior Sanitary District	MN0049786	Duluth, Minnesota	Potlatch Corporation (Cloquet, MN mill)
Bay County Wastewater Treatment Plant	FL0002631	Panama City, Florida	Stone Container Corporation*
Erie City Wastewater Treatment Facility	PA0026301	Erie, Pennsylvania	International Paper Co.
City of Port St. Joe Wastewater Treatment Plant	FL0020206	Port St. Joe, Florida	St. Joe Forest Products Co.*
Papergrade Sulfite Subcategory			
Peshtigo Joint Wastewater Treatment Plant	WI0030651	Peshtigo, Wisconsin	Badger Paper Mills, Inc.

*Also produces unbleached kraft pulp

Table 8-5
Pollutant Removals at POTWs Receiving Chemical Pulp Mill Wastewaters
(Calculated from Comment Submittals and EPA Permit Compliance System Data)

POTW Name	BOD5	TSS	AOX	COD	COLOR
Bleached Papergrade Kraft and Soda Subcategory					
Gulf Coast Waste Disposal Authority Pasadena, Texas	*	*	*	*	*
Muskegon County Wastewater Management System (Muskegon, Michigan)	*	95%(PCS**)	*	*	*
Upper Potomac River Commission (Westernport, Maryland) No influent/effluent data provided in DCNs 20030 or 20021.	94.4% for 1993(DCN 20030-UPRC comments; DCN 20021-Westvaco comments)	93.0% for 1993 (DCN 20030-UPRC comments; DCN 20021-Westvaco comments)	44.6% for 1993 (DCN 20030-UPRC comments; DCN 20021-Westvaco comments)	72.2% for 1993 (DCN 20030-UPRC comments; DCN 20021-Westvaco comments)	12.1% for 1993 (DCN 20030-UPRC comments; DCN 20021-Westvaco comments)
City of St. Helens (St. Helens, Oregon) Influent/effluent data provided in DCN 20099.	86% (PCS**); 90% for 7/93-6/94 (DCN 20099-City of St. Helens comments)	*	41% for 7/93-6/94 (DCN 20099-City of St. Helens comments)	*	*

Table 8-5 (Continued)

POTW Name	BOD5	TSS	AOX	COD	COLOR
Jackson County Port Authority (Pascagoula, Mississippi) Influent/effluent data supplied in DCN 12724; no influent/effluent data supplied in DCN 20042; influent/effluent data supplied in DCN 13832.	90% for 1993 (DCNs 12724 and 20042-Port of Pascagoula comments)	56% for 1993 (DCNs 12724 and 20042-Port of Pascagoula comments)	20% for 11/93 (DCN 12724-Port of Pascagoula comments-Note that treatment system disruption occurred because of process changes; 51% for 3/95 through 11/95 (DCN 13832-IP data submittal (see Attachment 2B)	47% for 1993 (DCNs 12724-Port of Pascagoula comments)	*
Western Lake Superior Sanitary District (Duluth, Minnesota) No influent/effluent data supplied in DCNs 20028 or 20044.	97% (PCS**); 97.4% for 2/94 (DCN 20028-Potlatch comments); 96.7% for 1993 (DCN 20044-Western Lake SD comments)	93% (PCS**) 97.8% for 2/94 (DCN 20028-Potlatch comments); 94.9% for 1993 (DCN 20044-Western Lake SD comments)	58% for 3/94 (DCN 20028-Potlatch comments)	81% for 3/94 (DCN 20028-Potlatch comments); 80% (DCN 20044-Western Lake SD comments)	36% for 3/94 (DCN 20028-Potlatch comments); 30% (DCN 20044-Western Lake SD comments)
Bay County Wastewater Treatment Plant (Panama City, Florida) No influent/effluent data supplied in DCN 20066A1.	95% (DCN 20066A1-Stone Container comments)	*	*	*	*
Erie City Wastewater Treatment Facility (Erie, Pennsylvania)	*	*	*	*	*
City of Port St. Joe Wastewater Treatment Plant (Port St. Joe, Florida)	92% (PCS**)	92% (PCS**)	*	*	*

Table 8-5 (Continued)

POTW Name	BOD5	TSS	AOX	COD	COLOR
Papergrade Sulfite Subcategory					
Peshtigo Joint Wastewater Treatment Plant (Peshtigo, Wisconsin)	94% (PCS**)	62% (PCS**)	*	*	*

* = No data available.

** = Calculated from Environmental Protection Agency Permit Compliance System (PCS) data, included in Attachment 2A.

Table 8-6
National Council of the Paper Industry for Air and Stream Improvement, Inc. (NCASI) Data
Pollutant Removals at POTWs Receiving Chemical Pulp Mill Wastewaters

	Conventional Pollutant Removals (Average Removals)		Nonconventional Pollutant Removals (Average Removals)		
	BOD5	TSS	AOX	COD	Color
Bleached Papergrade Kraft and Soda mills	94.3 %* (for 9 mills)	80.5 %* (for 9 mills)	53.4 %** (for 6 mills)	81.6 %** (for 6 mills)	-4.8 %** and ***** (for 4 mills)
	94.6 % *** (for 7 mills)	90 %* (for 8 mills--after removing one mill with unusually low TSS removal)	44.6 %***** (for 6 mills)	74.7 %***** (for 5 mills)	
	93 % ***** (for 5 mills)				
Papergrade Sulfite mill (one mill)	95 %*	84 %*	25.9 %**	no data available	no data available

All data presented are from NCASI comments "An Analysis of the Relative Performance of POTW and Paper Industry Wastewater Treatment Systems on Conventional and Non-Conventional Pollutants," April 1994, DCN 20026 A31:

- * = Appendix B, page 3. Calculated by arithmetically averaging removal data reported in table.
- ** = Appendix B, page 4. Calculated by arithmetically averaging removal data reported in table.
- *** = page 5, Table 2. Influent/effluent data used for this table not presented.
- **** = page 6, Table 3. Influent/effluent data used for this table not presented.
- ***** = page 8, Table 5. Influent/effluent data used for this table not presented.

Note that the subcategories of the mills used to calculate the averages in Tables 2, 3, and 5 are not specified. Therefore, the papergrade sulfite mill could be included in these averages. Average influent/effluent data for the 10 POTWs were presented in Appendix B.

Table 8-7
Comparison of Pollutant Removals at POTWs Receiving Wastewaters from Bleached Papergrade Kraft and Soda Mills and Direct-Discharging Bleached Papergrade Kraft and Soda Mills

Pollutant Removal Percentages	BOD5	TSS	AOX
POTWs Receiving Wastewaters from Mills in the Bleached Papergrade Kraft and Soda Subcategory*			
Average	93 (6 POTWs)	86 (5 POTWs)	49 (4 POTWs)
Range	86 to 97	56 to 95	41 to 58
NCASI Data for POTWs Receiving Wastewaters from Mills in the Bleached Papergrade Kraft and Soda Subcategory from DCN 20026 A31 Appendix B, page 3-4			
Average	94.3 (9 POTWs)	80.5 (9 POTWs)	53.4 (6 POTWs)
Range	86 to 98.8	4 to 98.5	30 to 100
Direct-discharging Mills in the Bleached Papergrade Kraft and Soda Subcategory - 7 Mills (Combination of 3 Mills with Option A Technology Basis** and 4 Mills with Option B Technology Basis***)			
Average	95	74	49
Range	91 to 98 (5 mills)	31 to 98 (6 mills)	11 to 78

* Averages were calculated by arithmetically averaging the removal data for each POTW in Table 2 and then arithmetically averaging the removals for all POTWs (Note: Low AOX removal data from Jackson Co. Port Authority due to treatment system upset were excluded from average).

** Averages were calculated by arithmetically averaging removal data from 1995 data supplied by Georgia-Pacific Corporation for the Brunswick and Leaf River mills (see Record Section 21.6.1.3) and by James River for the Wauna mill (see Record Section 21.6.1.5) and then arithmetically averaging the removals for the three mills.

*** Averages were calculated by arithmetically averaging the removal efficiencies from EPA-sponsored sampling data for 4 mills. The sampling was conducted in 1993-1994. Data are presented in the June 1996 "Summary Report for Pulp and Paper Mill Sampling Program" in Record Section 21.6.2 DCN#13968.

SECTION 9

POLLUTANT REDUCTION ESTIMATES

9.1 Introduction

After the 1993 proposal of effluent limitations guidelines and standards for the pulp and paper industry (58 FR 66078), EPA updated the calculation of effluent loadings reductions for each bleached papergrade kraft and soda mill and each papergrade sulfite mill potentially subject to those guidelines and standards to establish a new baseline of mid-1995. In addition, EPA revised and simplified the methodology used to estimate the baseline. These revised estimates were reported in the July 1996 Notice of Data Availability (61 FR 36835). After the notice, EPA recalculated the effluent loadings reductions using the same methodology and the same base year of mid-1995, but made minor changes in loadings for a few particular mills (consistent with cost model changes). For the final loadings estimates presented here, EPA also revised the methodology used to interpret concentration measurements for TCF bleaching processes reported as less than the method minimum level.

Mills in the Bleached Papergrade Kraft and Soda and Papergrade Sulfite Subcategories will be subject to revised discharge limitations based on BAT or revised PSES. EPA is promulgating BAT limitations and PSES for TCDD, TCDF, chloroform, 12 chlorinated phenolic compounds and AOX. The 12 chlorinated phenolic compounds include trichlorosyringol, 2,4,5-trichlorophenol, 2,4,6-trichlorophenol, 3,4,5-trichlorocatechol, 3,4,5-trichloroguaiacol, 3,4,6-trichlorocatechol, 3,4,6-trichloroguaiacol, 4,5,6-trichloroguaiacol, tetrachlorocatechol, tetrachloroguaiacol, 2,3,4,6-tetrachlorophenol, and pentachlorophenol.

Indirect dischargers subject to Subpart B must demonstrate compliance with PSES for all regulated pollutants at the bleach plant; direct dischargers subject to Subpart B must demonstrate compliance with BAT limitations for all regulated pollutants (except AOX) at the bleach plant.

EPA is promulgating BAT limitations and PSES for a subset of these pollutants for the Papergrade Sulfite Subcategory (Subpart E). For mills in the calcium-, magnesium-, or sodium-based sulfite pulp segment, EPA is promulgating BAT limitations and PSES for AOX only, with compliance demonstrated at the end of pipe. For mills in the ammonium-based sulfite pulp and specialty-grade pulp segments, EPA is promulgating BAT limitations and PSES for the same pollutants covered by Subpart B except for chloroform and AOX, with compliance demonstrated at the bleach plant.

EPA had proposed limitations for COD and color. The in-plant process changes that form the bases of the BAT limitations, PSES, and BMPs, reduce final effluent COD and color loadings. For this reason, EPA estimated the effluent loadings reductions for COD and color. For reasons stated in the preamble, EPA intends to develop COD limitations for kraft and sulfite mills in a future rulemaking and EPA has decided not to develop a national regulation for

color. Instead, permit writers are expected to continue to develop local color effluent limitations based on applicable water quality standards.

This section describes the approach used to estimate the baseline mass (kg/yr) of these pollutants in bleach plant effluents and final effluents discharged from bleached kraft and soda and papergrade sulfite mills. The estimates are based on information available from each mill as of mid-1995. This section also describes the estimate of pollutant mass that would be discharged after implementation of the technology options EPA considered in selecting the basis of the final effluent limitations guidelines and standards. The difference between the baseline mass discharge and the mass that would be discharged after implementation of a technology option is referred to here as the pollutant reduction. Pollutant reductions were estimated for all the pollutants named above.

At present, 96 mills are subject to these regulations. Eighty-six mills discharge wastewater directly and are regulated under BAT; 10 mills discharge wastewater indirectly and are regulated under PSES. (See Section 4 for more details about the number and type of mills.) For Subparts B and E, the BAT limitations and PSES are identical for all regulated pollutants except AOX. Loadings and reductions calculated for indirect-discharging mills are included in subcategory and industry totals. Of the ten indirect-discharging mills, nine are in the Bleached Papergrade Kraft and Soda Subcategory and one is in the Papergrade Sulfite Subcategory.

For those pollutants for which all Subpart B and E mills must demonstrate compliance at the bleach plant (i.e., all pollutants identified above except AOX in the case of direct dischargers), EPA calculated baseline loadings, loadings after implementation of the technology options, and pollutant reductions based on bleach plant effluent data. For AOX, EPA made the estimates described above using final effluent data (i.e., after secondary treatment at the mill's wastewater treatment plant or at a POTW). EPA employed this approach even for indirect-discharging mills in Subpart B (which must demonstrate compliance with the AOX pretreatment standard at the bleach plant) because EPA expects that the combination of pretreatment for AOX consistent with the promulgated AOX standard, coupled with additional removals achieved by the POTW, will produce the same final effluent loading reductions achieved by direct-discharging facilities subject to Subpart B.

A series of computer programs was used to calculate production-normalized mass loadings of each pollutant from EPA or industry-supplied mill sampling data. The production-normalized loadings were then incorporated into a series of spreadsheets. The series of spreadsheets estimates a baseline pollutant discharge rate (kg pollutant/kg brown stock pulp into bleaching) for each mill and compares these loads to production-normalized loadings that would be achieved after implementation of the technology options. After making this comparison, the production-normalized loadings and the pollutant reductions are multiplied by each mill's annual brown stock (unbleached pulp) production to convert to units of kg/yr.

9.2 Pollutant Loading Calculations and Data Sources

EPA does not have data from each mill subject to Subpart B or E that characterizes the discharge of all pollutants for which EPA is establishing limitations and standards. Instead, EPA calculated pollutant loadings using data characterizing the generation of these pollutants by a variety of pulping and bleaching technologies. EPA also used information about the pulping and bleaching technologies in place at each mill.

The data used to calculate production-normalized pollutant loadings were derived from six sources:

- 1) Short-term studies (1988-1993);
- 2) EPA/industry long-term variability study (1991-1992);
- 3) Self-monitoring data (supplied by mills subject to Subparts B or E);
- 4) Data collected by EPA and industry since the proposal of these regulations;
- 5) The 1994 NCASI dioxin survey; and
- 6) Bleach plant chloroform data collected by NCASI.

The short-term sampling database contains the results of two- to three-day sampling episodes at thirteen mills. These sampling episodes took place in 1988 through 1993. The long-term variability study database contains the results of intensive sampling efforts at eight mills in 1991 and 1992. The self-monitoring database contains the results of analyses performed by individual mills which were collected from responses to Question 49 of the EPA 1990 National Census of Pulp, Paper, and Paperboard Manufacturing Facilities Questionnaire (reflecting the period from 1985 through 1991). The data collected by EPA and industry since the proposal of these regulations were mainly from mills using complete substitution of chlorine dioxide for chlorine, including mills using extended cooking and/or oxygen delignification. EPA also collected data from three mills using TCF bleaching. The 1994 NCASI dioxin survey is, in part, a tabulation of end-of-pipe effluent loadings for TCDD and TCDF reported by mills during 1994, or in earlier years if the mill did not analyze for these pollutants during 1994.

9.2.1 Pollutant Loading Calculations

The data in each database are used to calculate production-normalized pollutant loadings for the bleach plant and/or final effluent for each mill. Three types of data are needed to calculate a production-normalized loading: a pollutant concentration, a wastewater flow rate, and a brown stock pulp flow rate. For example, the concentration of AOX in the final effluent from a mill may be 15,000 g/L. The final effluent flow rate from this mill may be 25,000 m³/day. The

brown stock pulp flow rate into bleaching for this mill may be 1,200 kkg brown stock pulp/day (kkg/day). These data are used to calculate daily (kg AOX/day) and production-normalized (kg AOX/kkg brown stock pulp) mass loadings for the final effluent for this mill.

Daily Mass Loading	$15,000 \frac{\mu\text{g}}{\text{L}} \times 1,000 \frac{\text{L}}{\text{m}^3} \times 25,000 \frac{\text{m}^3}{\text{day}} \times 10^{-9} \frac{\text{kg}}{\mu\text{g}} = 375 \frac{\text{kg}}{\text{day}}$
Production-Normalized Mass Loading	$\frac{375 \frac{\text{kg}}{\text{day}}}{1,200 \frac{\text{kkg}}{\text{day}}} = 0.313 \frac{\text{kg}}{\text{kkg}}$

Another example is shown below for a bleach plant effluent. Depending on the mill, the bleach plant effluent may be characterized by one or more separate samples. At some mills, all bleach plant wastewaters are discharged to a single sewer. For these mills, production-normalized mass loadings are calculated as in the previous example. More commonly, however, bleach plant wastewaters are discharged to two separate sewers: one that handles acidic wastewaters (e.g., discharges from chlorine, chlorine dioxide, hypochlorite, and ozone stages) and one that handles alkaline wastewaters (e.g., discharges from extraction stages). At these mills, separate samples of acid and alkaline sewers (or filtrates that are discharged to sewers) were collected and analyzed. For these mills, EPA calculated separate mass loadings for each pollutant in each sewer for each day and then summed the production-normalized loadings to obtain a "bleach plant effluent" loading for that day, as shown below. The flow rates of the acid and alkaline sewers are usually measured (or estimated) separately, but only one brown stock production value is applicable to the calculation.

	Chloroform Concentration (Wastewater Flow Rate (m³/day)	Brown Stock Pulp Flow Rate (kkg/day)
Acid Filtrate	25	18,000	1,200
Alkaline Filtrate	15	15,000	
Acid Filtrate Mass Loading	$25 \frac{\mu\text{g}}{\text{L}} \times 10^3 \frac{\text{L}}{\text{m}^3} \times 18,000 \frac{\text{m}^3}{\text{day}} \times 10^9 \frac{\text{kg}}{\mu\text{g}} = 0.450 \frac{\text{kg}}{\text{day}}$		
Alkaline Filtrate Mass Loading	$15 \frac{\mu\text{g}}{\text{L}} \times 10^3 \frac{\text{L}}{\text{m}^3} \times 15,000 \frac{\text{m}^3}{\text{day}} \times 10^9 \frac{\text{kg}}{\mu\text{g}} = 0.225 \frac{\text{kg}}{\text{day}}$		
Bleach Plant Mass Loading	$0.450 \frac{\text{kg}}{\text{day}} + 0.225 \frac{\text{kg}}{\text{day}} = 0.675 \frac{\text{kg}}{\text{day}}$		
Production-Normalized Bleach Plant Mass Loading	$\frac{0.675 \frac{\text{kg}}{\text{day}}}{1,200 \frac{\text{kkg}}{\text{day}}} = 5.625 \times 10^{-4} \frac{\text{kg}}{\text{kkg}}$		

The results of some chemical analyses were reported as less than a sample-specific detection limit, for example, less than 10 agents, pollutant mass loadings were estimated using one-half the minimum level of the analytical method. In the previous example, if chloroform was not detected in the alkaline filtrate, because 10 loading of 6.25×10^{-5} kg/kkg of chloroform in the alkaline filtrate. For mills using TCF bleaching, EPA assumed that chlorinated pollutants were not present. In the previous example if chloroform was not detected at a TCF-bleaching mill, the mass loading was assumed to be zero.

Separate computer programs are used to calculate the production-normalized mass loadings for each sampling database. EPA determined that separate computer programs were necessary because of differences in the sampling programs in organization, objectives, amount of data collected, and type of data collected, resulting in databases with different formats. A brief description of the loadings calculations for each sampling program is provided in this section. More details on each sampling episode and production-normalized pollutant loading calculations are provided in separate documents in the EPA rulemaking record for these regulations.

9.2.2 Data Sources

The data sources used to calculate production-normalized pollutant loadings are described in the following sections.

9.2.2.1 Short-Term Studies

For the short-term studies, loadings for each pollutant were calculated at the bleach plant and the final effluent for 11 mills. These sampling episodes were either two or three days in length. Specific details varied from mill to mill. Depending on the mill, sampling location, and pollutant, two- or three-day composite samples were collected, three consecutive 24-hour composite samples were collected, or three nonconsecutive 24-hour composite samples were collected. Where multi-day composite samples were collected, average wastewater and brown stock pulp flow rates for the multi-day period were also obtained. Where 24-hour composite samples were collected, 24-hour average wastewater and brown stock pulp flow rates were obtained. From these data, EPA calculated an average pollutant mass loading for each stream at each mill regardless of the number of days of samples collected or the number of analytical measurements available. EPA calculated each mass loading based on between one and three analytical data values.

For the short-term studies, EPA performed a preliminary review of the data quality associated with each of the 11 mills and discarded from the database some individual analytical data points that did not meet the criteria of the preliminary review (1). A second review was performed by EPA's Sample Control Center (SCC) for four mills (of the 11) that represented technology options EPA considered at proposal (2). SCC used the same data quality review criteria for data from the short-term sampling episodes as for the variability study.

9.2.2.2 EPA/Industry Long-Term Variability Study

The long-term variability study consisted of nine 24-hour composite samples collected in the summer of 1991 and nine 24-hour composite samples collected in the winter of 1991-92 at eight mills. Like the short-term sampling episodes, the average wastewater and brown stock pulp flow rates were obtained for each 24-hour sampling period. Again, SCC reviewed the quality of the individual analytical data points and discarded from the database the analytical results that did not meet the method quality control criteria (3). In general, when data were not discarded, 18 data points were available for each pollutant at each sampling point. From the available data, an average mass loading was calculated for each pollutant, at each sampling point, for each mill.

9.2.2.3 Self-Monitoring Data

The self-monitoring data consisted of a wide range of analyses varying from one pollutant in one stream at some mills to many pollutants in many streams at other mills. The analytical results submitted by each mill for various pollutants in various streams over the period

from 1985 through 1992 were entered into a database. Average annual flow rates for each mill (bleach plant effluent, final effluent, and brown stock pulp) and fiber furnish and other operating data were obtained from responses to EPA's 1990 Census Questionnaire (reflecting data for 1989) and follow-up letters for mills that made subsequent process changes (primarily reflecting data for 1990 and 1991, but also 1992 for some mills). Because of changes in the industry's pulping and bleaching practices since 1985-92 and the availability of more recent data, EPA limited the use of the self-monitoring data. Self-monitoring AOX data were used to estimate the baseline loadings of mills that have not made any major process changes in recent years.

9.2.2.4 Data Collected Since Proposal of the Regulations

Since the December 1993 proposal of these regulations, EPA, NCASI, and various mills have collected additional wastewater monitoring data. Most of the data were collected at mills using complete substitution of chlorine dioxide for chlorine (ECF bleaching) on at least one bleach line. Some of the mills also used extended cooking, oxygen delignification, and/or TCF bleaching.

Many of these additional studies followed the format of the short-term studies, i.e., three consecutive days of sampling at the bleach plant and final effluents with analysis of the samples for the pollutants proposed for regulation at each sampling point. However, specific details varied from mill to mill and several mills collected samples over longer periods of time.

A thorough review of the results of the pollutant analyses was performed by SCC for all results submitted with supporting quality assurance/quality control data. SCC reviewed the pollutant analytical data quality and discarded analytical results that did not meet method quality control criteria. SCC used similar data quality review criteria for data from these sampling episodes as for the long-term variability study. From the resultant database, EPA calculated an average pollutant concentration or mass loading for each stream at each mill. The results of the SCC review were reported in a series of quality assurance data review memoranda which can be found in Section 21.6 of the docket supporting these regulations.

Since proposal, EPA also received some final effluent AOX data from bleached papergrade kraft mills in Alberta, Canada. While some of these data were used to develop the AOX limitations for each option, these data were not used to estimate the baseline AOX loadings of the industry.

9.2.2.5 1994 NCASI Dioxin Survey

Each year since the 104-Mill Study (4) was conducted in 1988, NCASI has asked each mill for its most recent TCDD and TCDF data for bleached pulps, final mill effluents, and wastewater treatment sludges. If a mill does not respond to the request in a particular year, NCASI uses data from a previous year for its annual compilation. EPA used the final effluent

data from the 1994 survey to estimate the baseline discharges of TCDD and TCDF for the industry (5). The list of currently operating bleached papergrade kraft and sulfite pulp mills in NCASI's 1994 survey matches the list in EPA's baseline database (reflecting mid-1995 operations). The survey also includes data for dissolving kraft and dissolving sulfite mills which EPA did not use in the analysis reported here.

NCASI calculates effluent mass loadings using detected concentrations or one-half the reported detection limits. (Note that this approach is slightly different than the approach EPA used to make a separate estimate using its own database and one-half of the minimum level for non-detect values.) NCASI reports results in units of milligrams/day. EPA multiplied the detected concentrations or one-half the reported detection limits by the 1994 average daily wastewater discharge for each mill (as reported in the survey) and by 350, an estimate of the number of days that each mill produced bleached pulp. After several unit conversions, EPA reported results in units of g/yr of TCDD and TCDF discharged by each mill.

9.2.2.6 NCASI Bleach Plant Chloroform Data

In December 1988, NCASI published Technical Bulletin No. 558, which presented total bleach plant chloroform generation rates for a variety of kraft and sulfite bleaching sequences (6). The report also provided information that could be used to estimate the bleach plant effluent chloroform loading. These data were used to supplement EPA's sampling data for the bleach sequences studied.

9.3 Industry Baseline Pollutant Loadings

In support of the 1993 proposal, EPA developed a procedure for estimating the baseline bleach plant and final effluent pollutant mass loadings for each mill. The procedure used all available data from each mill. EPA created a model with which to estimate loadings where data were not available. The model estimated the average pollutant loadings achieved by mills using several combinations (one combination for each option evaluated for each subcategory) of pulping and bleaching technologies. Even though the procedure was complicated and labor-intensive, EPA received few public comments on this baseline estimation procedure.

Instead, commenters objected to EPA's use of data dating, in some cases, to the 1988 104-Mill Study, to characterize the industry's 1993 pollutant discharges. As discussed above, EPA has addressed this comment by updating the estimate of the baseline pollutant loadings. Changes to the baseline estimate include:

Updated data collected by EPA, NCASI, and individual facilities;

Limited use of self-monitoring data dating from 1985-1992 (where more recent data were not available); and

Incorporation of the results of NCASI's 1994 Dioxin Survey into the analysis, made available to EPA in late 1995.

EPA has simplified the baseline estimation procedure used at proposal. The revised procedure uses three models to reflect process technology status and thereby estimate the baseline loadings for all mills. These models replace the complicated baseline-estimation procedure used at proposal where sampling data were used to represent the mills from which sampling data were available, and models were used to fill data gaps for mills from which no data (or out-of-date data) were available. The three models were developed for different pollutant groups:

- 1) AOX, chlorinated phenolic compounds, TCDD, and TCDF;
- 2) Chloroform; and
- 3) COD and color.

EPA determined that separate models were necessary because, for each group of pollutants, different process criteria more accurately predict pollutant loadings. For example, for final effluent AOX loads, the furnish pulped, the use of extended pulping technologies, and the percent chlorine dioxide substitution were strongly related to the pollutant loading. The three models are summarized below, and are described in detail in subsequent sections.

Model	Pollutants	Main Process Criteria Predictive of Pollutant Loadings
1	AOX, chlorinated phenolic compounds, TCDD, TCDF	Furnish pulped; Extended pulping status; Percent ClO ₂ substitution
2	Chloroform	Hypochlorite use; Percent ClO ₂ substitution
3	COD, color	Screen room status; Pre-bleaching kappa number

9.3.1 AOX, Chlorinated Phenolic Compounds, TCDD, and TCDF

The model used for AOX, chlorinated phenolic compounds, TCDD, and TCDF ("AOX model") is shown in Table 9-1. Each bleach line at each papergrade kraft and sulfite mill was assigned to one of the eleven baseline groups. These groups are similar to the groups used at proposal to estimate baseline loadings (although fewer groups exist now than at proposal). The groups are based on the furnish pulped, extended pulping equipment in place, pre-bleaching kappa number achieved, and bleach sequence of each bleach line.

Because a mill may have more than one type of bleach line, assigning a complete mill to a group is more subjective than assigning a single bleach line. Sixteen of the 84 mills in the Bleached Papergrade Kraft and Soda Subcategory for which EPA estimated pollutant reductions operate with bleach lines in more than one group. In these cases, judgment was used to select a group that would result in the best estimate of the combined mill effluent.

EPA assigned the AOX model groups at the same time that EPA made preliminary estimates of the costs of compliance with the revised options. Because capital costs are related to equipment, group assignments were based on pulping equipment in place rather than strict adherence to the pre-bleaching kappa number ranges reported in Table 9-1.

AOX Group F was formed to aggregate the data from mills that did not achieve the kappa numbers expected from the pulping technologies they employ. Three softwood bleach lines with some form of extended delignification and ECF bleaching did not achieve kappa numbers as low as expected for mills in Group H. (EPA believes that these mills were not operating optimally.) Conversely, two hardwood mills achieved kappa numbers lower than expected. As shown in Table 9-2, to estimate AOX baseline loads, these bleach lines were grouped with bleach lines employing no extended pulping and ECF bleaching (i.e., Groups E and F were combined).

9.3.1.1 AOX

The average AOX loadings for papergrade kraft and sulfite baseline groups are summarized in Table 9-2. Sampling data were not available for all the groups identified in Table 9-1; therefore, several groups identified in Table 9-1 were consolidated (as shown in Table 9-2). EPA assumed that the effluent characteristics from mills in groups with similar bleach plant operating conditions were similar. EPA also used self-monitoring data to characterize the effluent AOX loadings for the consolidated Group A, B, and C.

In general, the AOX baseline loadings listed in Table 9-2 represent the average of the values available from mills producing either hardwood or softwood but not from mills producing both hardwood and softwood. Average final effluent AOX production-normalized loadings were also calculated for mills in each group (where data were available) that produce both hardwood and softwood, and usually fell within the range of the values listed above. However, the only data available from mills in Groups G and I were from mills producing both hardwood and softwood, so this loading (0.38 kg/kkg) was applied to both the hardwood and softwood columns in Table 9-2. For TCF mills (Group K), final effluent AOX loadings were assumed to be zero.

In the baseline model, each mill was designated as a mill normally producing only hardwood, only softwood, or as a mill producing both hardwood and softwood. Mills producing only hardwood or softwood were assigned the baseline loadings listed in Table 9-2 (in accordance with its assigned grouping). Mills producing both hardwood and softwood were assigned a baseline loading by multiplying the loadings listed in Table 9-2 by the percent of hardwood and

softwood brown stock pulp that is bleached at each mill. (The hardwood and softwood brown stock pulp rates that were used here were also used in the compliance cost model.) For these mills, the baseline loadings would be between the two loadings listed for mills in each consolidated AOX group.

9.3.1.2 TCDD, TCDF, and the 12 Chlorinated Phenolic Compounds

EPA used the same AOX model but a slightly different procedure to estimate the baseline loadings of TCDD, TCDF, and the chlorinated phenolic compounds. These pollutants are not consistently detected in pulp mill effluents, particularly at higher levels of chlorine dioxide substitution or at TCF mills. The mills that use extended delignification technologies have lower bleach plant effluent flows than mills using conventional pulping because they have modernized and use less water to wash pulp more efficiently. To account for these flow differences, EPA estimated average bleach plant concentrations of TCDD, TCDF, and chlorinated phenolic compounds. The concentrations were calculated by averaging any detected values with the number of non-detected values multiplied by one-half the minimum level of the analytical method for each pollutant. For example:

$$\left[a \quad b \quad c \quad \left(n \frac{ML}{2} \right) \right] \frac{1}{n+3} \quad \text{average concentration}$$

where a, b, and c are detected concentrations, n is the number of results reported as "not detected", and ML is the minimum level for the analytical method. The ML for the analytical method was used rather than using various sample-specific detection limits (some of which may be greater than the method ML, due in most cases to reduced sample volume), in order to simplify the procedure. This calculation was used for all data except for TCF mills, EPA assumed that the concentration and loading of these pollutants at TCF mills was zero.

To calculate a mass loading, the average group concentration was multiplied by an average production-normalized bleach plant flow rate for the mills in each group. Production-normalized bleach plant flow rates (based on sampling data collected at bleached papergrade kraft mills) are shown in Table 9-3. Although the flow rates were derived from kraft mill data, because of limited sampling data for papergrade sulfite mills, these flow rates were used to estimate pollutant loadings from papergrade sulfite mills. The group average concentrations for TCDD, TCDF, and the 12 chlorinated phenolic compounds are shown in Tables 9-4 through 9-17. Group average concentrations are reported as "ND" when the compound was never detected among the data available for that group of mills. For these cases, a concentration of one-half the minimum level for the compound was used to calculate the mass loading for that group of mills.

EPA calculated average concentrations and production-normalized flow rates using sampling results from mills bleaching either hardwood or softwood but not from mills bleaching a mixture of hardwood and softwood. For mills bleaching a mixture of hardwood and softwood, EPA calculated baseline loadings by multiplying the appropriate concentrations and

flows by the percent of hardwood and softwood brown stock pulp that is bleached at each mill.

After a baseline mass loading was calculated for each bleach line at each mill, the individual pollutant loads were summed for mills with multiple bleach lines to give the total bleach plant pollutant load for the mill. Final effluent mass loadings were calculated from the estimated bleach plant loadings. For TCDD and TCDF, the final effluent loads were assumed to be the same as the bleach plant loads for each mill because EPA's data do not show that TCDD or TCDF are degraded by biological treatment. This method provides an upper-bound estimate of the final effluent loads because some of the TCDF (and perhaps TCDD if present) may adsorb to the sludge.

For the 12 chlorinated phenolic compounds, 45 percent of the bleach plant load at each mill was assumed to be removed in the treatment system (or the associated POTW for indirect discharging mills). The 45 percent removal efficiency was based on an NCASI study of the removal of specific chlorinated phenolic compounds in various wastewater treatment systems (7).

For TCDD and TCDF, a second baseline calculation was made using data compiled by NCASI for 1994. EPA used the NCASI data to calculate effluent mass loadings for each mill using the detected concentrations or one-half the reported detection limits multiplied by the 1994 average daily wastewater discharge for each mill (as reported in the survey) and by 350, an estimate of the number of days that each mill produced bleached pulp. After several unit conversions, the results were reported in units of g/yr of TCDD and TCDF discharged by each mill. (Note that one-half the reported detection limits were used rather than one-half the minimum level because 1) the analytical methods used are not reported and 2) the reported detection limits are generally lower than the minimum level for Method 1613.)

The two dioxin baseline estimates are presented below:

Baseline Final Effluent Discharge from All Bleached Papergrade Kraft and Soda Mills	Estimate Using Bleach Plant Loads (g/yr)	Estimate Using 1994 NCASI Dioxin Survey Results (g/yr)
TCDD	15.2	13.1
TCDF	115	41.7

The TCDD baseline estimates using the two calculation procedures are very close. The TCDF baseline estimates are not as close because TCDF is occasionally detected just above the method minimum level in some bleach plant effluents but is diluted to concentrations below the minimum level at the final mill effluent. Because of this fact, EPA believes the TCDF baseline estimate based on the bleach plant data is more appropriate.

After July 1996, EPA again recalculated the effluent reductions. The baseline remained mid-1995, but the methodology outlined above was modified slightly. EPA used two different procedures for handling concentrations of chlorinated pollutants reported as less than the detection limit. For mills that used chlorine-containing bleaching agents, EPA used one-half the method minimum level to estimate effluent discharge loadings, i.e., EPA assumed the chlorinated pollutants were present at concentrations too low to measure by current analytical methods. (This approach is the same one used previously for handling non-detected concentrations.) For mills that used TCF bleaching, EPA assumed that chlorinated pollutants were not present; EPA assumed that TCF mills would discharge zero kilograms per year of AOX and the individual chlorinated pollutants (chloroform, TCDD, TCDF, and the 12 chlorinated phenolic compounds).

This minor methodology change affects the baseline discharges for two mills (one kraft and one sulfite) that currently use TCF bleaching sequences and seven mills (one kraft and six sulfite) that are expected to use a TCF bleach sequence after promulgation of these regulations. These same baseline and post-promulgation loading changes were also applied to the 1994 NCASI dioxin profile data (for TCDD and TCDF) for the affected mills to adjust EPA's effluent reduction estimates based on these data in the same manner.

9.3.2 Chloroform

The model used for chloroform is shown in Table 9-18. Kraft and sulfite mills were divided into six baseline groups. The groups are defined by the bleach sequence used at each mill, specifically whether mills used hypochlorite in the bleach sequence and what level of chlorine dioxide substitution was used in the first bleaching stage. For the July 1996 Notice, EPA used the same value for ECF and TCF bleach lines because chloroform was not detected in final effluents from either type of mill. For this recalculation, EPA used the same loading for ECF mills (Group E) but used zero for TCF mills (Group F). Mills with more than one bleach line were assigned a group based on whether hypochlorite was used on any bleach line and what the average production-normalized chlorine dioxide substitution in the first bleaching stage was for all the fiber lines at the mill.

In addition to bleach sequence, the type of washers used in the bleach plant (8) may affect bleach plant effluent chloroform loadings. Bleach plant effluent chloroform loadings are somewhat greater at mills using low air-flow washers (e.g., pressure or diffusion washers) than at mills using high air-flow washers (e.g., vacuum-drum washers). This effect on bleach plant chloroform loadings was not accounted for in the baseline model because EPA does not know what type of washers are used on each bleach line at each mill in the country. In general, most mills use vacuum-drum washers and the most data are available from mills using these washers.

The average bleach plant and final effluent loadings for mills in the various groups are summarized in Table 9-19. For bleach plants, EPA and NCASI data were used (6,9). For final effluents, no NCASI data were available so only EPA data were used. (Note: Although EPA calculated bleach plant effluent chloroform reductions, they were not used directly in the benefit

analyses. Air emission reductions of chloroform were estimated to assess an important non-water quality environmental benefit (see Section 11 of this document) while final effluent pollutant reductions were used to evaluate aquatic environmental impacts.)

9.3.3 COD and Color

EPA proposed limitations for COD and color. The in-plant process changes that form the bases of the BAT limitations, PSES, and the BMPs reduce final effluent COD and color loadings. For this reason, and to fully evaluate the options considered, EPA estimated effluent loadings reductions for COD and color. For reasons stated in the preamble and a separate document (10), EPA intends to develop COD limitations for kraft and sulfite mills in a future rulemaking. EPA also decided not to develop national effluent limitations guidelines and standards for color for Subparts B and E; instead, permit writers must continue to develop site-specific effluent limitations for color as necessary to achieve applicable water quality standards (see 33 U.S.C. 1311(b)(1)(c)).

The model used for estimating baseline COD and color loadings was based on screen room status and pre-bleaching kappa number. EPA assumed that the available final mill effluent loadings were derived from the pulping and bleaching operations at each mill. The model did not specifically account for unusual loadings from papermaking or other on-site pulping (e.g., mechanical or secondary fiber) operations although these operations were used at some of the mills for which data were available.

As shown in Table 9-20, kraft and sulfite mills were divided into four baseline groups. Mills with more than one fiber line were assigned a group based on whether any screen room at the mill was open and on the average production-normalized pre-bleaching kappa number for all the lines at the mill. COD and color baseline loadings and reductions were calculated for pulp mill final effluents, but not for bleach plant effluents. The average final effluent baseline loadings for mills in the four groups are presented in Table 9-21.

9.4 Pollutant Loadings After Implementation of the Control Options

After estimating baseline loadings for each mill, EPA estimated the reduction in pollutants discharged to receiving streams attributable to the three principal BAT and PSES technology options considered by EPA. The long-term average (LTA) performance of each option for each pollutant was subtracted from each mill's baseline discharge. The LTA pollutant loadings for each option are presented in Table 9-22.

See Section 8 for a description of the technology options considered for BAT and PSES for the Bleached Papergrade Kraft and Soda and Papergrade Sulfite Subcategories.

EPA evaluated the performance of each technology option described above by calculating a LTA loading for each pollutant of concern. EPA used data from facilities that employed processes most similar to the technology components of each option. The sampling

data that were used to calculate the performance of each option are presented in a separate document (11). These data were a subset of the data used to develop baseline pollutant loadings. As described previously, for the estimation of baseline, EPA estimated pollutant loadings for several combinations of pulping and bleaching operations in addition to the BAT options.

The LTAs used in these estimates for AOX, TCDF, and chloroform are not exactly the same values as the LTAs used to develop the limitations but they are reasonably close. The reason that EPA employed slightly different LTAs to estimate loading reductions than to calculate limitations is that the two LTAs served different purposes. EPA used the LTAs for load reductions to help in its evaluation of the technology options being considered; while highly informative, the reductions were not statutory decision criteria. In contrast, EPA refined its LTAs before using them to calculate limitations, because the calculations would lead to the imposition of enforceable permitting and pretreatment requirements. Therefore, EPA concluded that it needed to exercise more analytical rigor in determining the limitations-related LTAs than the LTAs used ultimately for the non-statutory benefits analysis. This document presents the estimated loadings and reductions used to select the options. The final LTAs used to develop the limitations are described in the Statistical Support Document for the Pulp and Paper Industry: Subpart B (12).

The long-term averages for AOX and TCDF used in the pollutant reduction calculations for kraft Options A and B were calculated in early 1997. The AOX LTAs are based on more data than the LTAs presented in EPA's July 1996 Notice. The TCDF long-term average is based on the data presented in EPA's July 1996 Notice.

The chloroform LTA calculated for kraft Option A, 0.0003 kg/kg (calculated from non-detect results using one-half the method minimum level), was also applied to kraft Option B because chloroform is not expected to be detected in the final effluent from mills with either technology. TCDD and the 12 chlorinated phenolic compounds are also not expected to be detected in the final effluent from kraft Option A or B mills. The LTAs for these pollutants were calculated in the manner described in Section 9.1.2: one-half the minimum level for each pollutant was multiplied by a group-average production-normalized bleach plant effluent flow rate. For kraft Options A and B, the LTA loadings are the same as the baseline loadings for Groups E and H/J, respectively. The COD and color LTAs for kraft Options A and B were calculated by EPA in February 1996 (13).

EPA had little end-of-pipe data with which to calculate LTA pollutant loads for sulfite mills. For the calculation of pollutant reductions, EPA assumed that TCF mills would not discharge any chlorinated compounds, including AOX, and the pollutant concentrations measured at ECF sulfite mills would be similar to those concentrations at ECF kraft mills (i.e., mostly not detected). The sources of data used for sulfite mills are summarized in Table 9-23. For the calculation of pollutant reductions, pollutant concentrations for the sulfite ECF option were transferred from kraft Option A.

Table 9-22 presents the estimated loadings for each pollutant. The loadings in Table 9-22 were subtracted from the baseline loadings to determine the pollutant reductions for

each mill and then were summed for all mills in each subcategory. If the baseline loading for any mill(s) was lower than the option LTA, the removal was set to zero.

9.5 Pollutant Reductions

The pollutant reductions calculated using the methodology described in this document are summarized in Table 9-24. Mill-by-mill estimates are confidential business information (CBI) and are included as such in the CBI portion of the rulemaking record (14). In Table 9-24, for bleached papergrade kraft mills, the column headings in the table differentiate between Options A and B. For papergrade sulfite mills, the same results are shown in each column because only one option was evaluated for each segment: TCF for the calcium-, magnesium-, or sodium-based segment and ECF for the ammonium-based and specialty-grade segments. Note that the values in each column may not add, due to rounding.

For the kraft mill TCF options that were evaluated by EPA, the estimated pollutant reductions for AOX and the individual chlorinated pollutants are the same as the baseline loading estimates, because EPA assumes that these compounds would not be present in measurable quantities in the effluent from these mills. These values are not shown in Table 9-24. For COD and color, EPA would expect the pollutant reductions for the TCF options (including oxygen delignification, closed screen rooms, and improved brown stock washing) to be at least equivalent to those that were estimated for kraft Option B.

9.6 References

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Table 9-1

**Baseline Technology Groups for Bleached Papergrade
Kraft and Soda, and Papergrade Sulfite Mills:
AOX, Chlorinated Phenolic Compounds, TCDD, and TCDF**

AOX Group ^a	Example Bleach Sequence(s)	EC or OD? ^b	Chlorine Used?	Hypochlorite Used? ^c	Percent of ClO ₂ Used	Kraft Mill Kappas	
						HW	SW
A	CEH ^d	No	Yes	Yes	none on site	> 13	> 27
B	CEHD, CED	No	Yes	Maybe	0 in first stage		
C	C/DEH, C/DEHDED, C/DED, C/DEDED	No	Yes	Maybe	< 70		
D	D/CEDED, D/CEopDEpD	No	Yes	Maybe	70 to 100		
E	DEDED, DEopDD	No	No	No	100		
F	HW: C/DEDED, C/DEoDEP	No	Yes	Maybe	< 100	10 to 13	--
	SW: EC or OD with DEDED, DEopDD	Yes	No	No	100	--	20 to 27
G	EC or OD with C/DEDED, D/CEDED	Yes	Yes	Maybe	< 100	10 to 13	15 to < 20
H	EC or OD with DEDED, DEopDD	Yes	No	No	100		
I	EC and OD with C/DEDED, D/CEDED	Both	Yes	Maybe	< 100	< 10	< 15
J	EC and OD with DEDED, DEopDD	Both	No	No	100		
K	TCF ^d	Maybe	No	No	none		

^aGroups E and H include the bleached papergrade kraft mills that represent the two ECF options under consideration for that subcategory. Groups E and K include the papergrade sulfite mills that represent the TCF and ECF options under consideration for that subcategory.

^bEC is extended cooking (e.g., MCC, EMCC, RDH or SuperBatch) and OD is oxygen delignification.

^c“Maybe” indicates that the pollutant loadings are not significantly different for mills using or not using hypochlorite.

^dMills using this bleaching sequence do not usually bleach to full brightness.

Table 9-2**AOX Baseline Loadings**

Consolidated AOX Groups	Final Effluent (kg/kg)	
	Hardwood	Softwood
Kraft A, B, C	1.61	3.00
Kraft D	0.56	1.50
Kraft E, F	0.27	0.39
Kraft G, I	0.38 ^a	0.38 ^a
Kraft H, J	0.153	0.153
Kraft & Sulfite K	0.00	0.00
Sulfite A	5.82	5.82
Sulfite B, C	1.61	3.00

^aThe only data available from mills in Groups G and I were from mills producing both hardwood and softwood so this loading was applied to both the hardwood and softwood columns.

Table 9-3**Production-Normalized Kraft Bleach Plant Flow Rates^a**

AOX Groups ^b	Type of Mill	Hardwood Mills (m ³ /kkg)	Softwood Mills (m ³ /kkg)
A, B, C, D, E, F(HW)	Mills Without EC or OD	24.7	37.1
F(SW), G, H, I, J	Mills With EC and/or OD	19.7	24.7
K ^c	TCF Mills	11.6	18.3

^aThe average flow rates presented in this table were derived from bleached papergrade kraft mills. However, these flow rates were used to estimate mass loads of chlorinated phenolic compounds, TCDD, and TCDF from papergrade sulfite mills as well as bleached papergrade kraft and soda mills.

^bPapergrade sulfite mills fall in groups A, B, C, and K.

^cThese flow rates were not used to calculate the final set of reduction estimates in 1997; instead, EPA assumed that TCF mills discharged no chlorinated organic pollutants.

Table 9-4**TCDD Baseline Concentrations**

Consolidated AOX Groups ^a	Bleach Plant Effluent (pg/L) Minimum Level = 10 pg/L					
	Hardwood			Softwood		
	Concentration	Detects	Non-detects	Concentration	Detects	Non-detects
A, B, C	5.63	2	70	64.6	12	6
D	5.24	1	41	6.38	3	37
E	ND	0	6	ND	0	29
F	7.80	1	4	ND	0	30
G, I	5.27	1	43	8.09	6	39
H, J	9.54	4	24	ND	0	86
K	ND	0	4	ND	0	10

^aPapergrade sulfite mills fall in groups A, B, C, and K.

Table 9-5**TCDF Baseline Concentrations**

Consolidated AOX Groups ^a	Bleach Plant Effluent (pg/L) Minimum Level = 10 pg/L					
	Hardwood			Softwood		
	Concentration	Detects	Non-detects	Concentration	Detects	Non-detects
A, B, C	6.99	12	60	593	15	2
D	8.83	10	32	6.47	5	35
E	ND ^b	0	6	ND ^b	0	29
F	52	2	3	ND	0	24
G, I	4.87	4	40	7.93	3	41
H, J	10.6	8	20	9.62	13	73
K	ND	0	4	ND	0	13

^aPapergrade sulfite mills fall in groups A, B, C, and K.

^bTCDF was not detected at the mills for which data are included in EPA's database but comments on the July 1996 Notice indicate that TCDF is detected at some mills of this type. Therefore, the reductions may be underestimated.

Table 9-6**Trichlorosyringol Baseline Concentrations**

Consolidated AOX Groups ^a	Bleach Plant Effluent (g/L) Minimum Level = 2.5 g/L					
	Hardwood			Softwood		
	Concentration	Detects	Non-detects	Concentration	Detects	Non-detects
A, B, C	12.2	57	25	1.30	1	31
D	16.4	22	22	ND	0	38
E	ND	0	17	ND	0	79
F	20.9	5	8	ND	0	28
G, I	7.63	26	15	ND	0	43
H, J	ND	0	44	ND	0	100
K	ND	0	4	ND	0	5

^aPapergrade sulfite mills fall in groups A, B, C, and K.

Table 9-7**2,4,5-Trichlorophenol Baseline Concentrations**

Consolidated AOX Groups ^a	Bleach Plant Effluent (g/L) Minimum Level = 2.5` g/L					
	Hardwood			Softwood		
	Concentration	Detects	Non-detects	Concentration	Detects	Non-detects
A, B, C	ND	0	82	1.80	5	27
D	4.18	5	40	ND	0	38
E	ND	0	17	ND	0	79
F	8.92	5	8	ND	0	28
G, I	ND	0	41	1.35	1	42
H, J	ND	0	44	ND	0	102
K	ND	0	9	ND	0	10

^aPapergrade sulfite mills fall in groups A, B, C, and K.

Table 9-8**2,4,6-Trichlorophenol Baseline Concentrations**

Consolidated AOX Groups ^a	Bleach Plant Effluent (g/L) Minimum Level = 2.5` g/L					
	Hardwood			Softwood		
	Concentration	Detects	Non-detects	Concentration	Detects	Non-detects
A, B, C	18.2	59	23	46.3	20	10
D	8.34	31	14	12.8	36	0
E	ND	0	17	ND	0	79
F	25.8	11	2	ND	0	28
G, I	7.42	35	9	44.5	38	7
H, J	ND	0	44	1.36	1	101
K	ND	0	9	ND	0	10

^aPapergrade sulfite mills fall in groups A, B, C, and K.

Table 9-9**3,4,5-Trichlorocatechol Baseline Concentrations**

Consolidated AOX Groups ^a	Bleach Plant Effluent (g/L) Minimum Level = 5.0` g/L					
	Hardwood			Softwood		
	Concentration	Detects	Non-detects	Concentration	Detects	Non-detects
A, B, C	8.37	14	56	112	10	17
D	47.8	19	24	82.2	19	17
E	ND	0	17	ND	0	79
F	ND	0	13	ND	0	28
G, I	14.6	17	18	64.3	20	19
H, J	ND	0	44	ND	0	98
K	ND	0	4	ND	0	5

^aPapergrade sulfite mills fall in groups A, B, C, and K.

Table 9-10**3,4,5-Trichloroguaiacol Baseline Concentrations**

Consolidated AOX Groups ^a	Bleach Plant Effluent (g/L) Minimum Level = 2.5` g/L					
	Hardwood			Softwood		
	Concentration	Detects	Non-detects	Concentration	Detects	Non-detects
A, B, C	5.61	24	54	36.8	11	20
D	1.55	3	42	49.4	37	0
E	ND	0	17	ND	0	79
F	2.00	1	12	ND	0	28
G, I	7.83	17	23	52.7	27	15
H, J	ND	0	44	ND	0	103
K	ND	0	4	ND	0	5

^aPapergrade sulfite mills fall in groups A, B, C, and K.

Table 9-11**3,4,6-Trichlorocatechol Baseline Concentrations**

Consolidated AOX Groups ^a	Bleach Plant Effluent (g/L) Minimum Level = 5.0` g/L					
	Hardwood			Softwood		
	Concentration	Detects	Non-detects	Concentration	Detects	Non-detects
A, B, C	ND	0	54	ND	0	0
D	9.39	24	15	2.96	2	34
E	ND	0	17	ND	0	79
F	ND	0	0	ND	0	28
G, I	2.65	1	30	3.00	5	28
H, J	ND	0	44	ND	0	98
K	ND	0	4	ND	0	5

^aPapergrade sulfite mills fall in groups A, B, C, and K.

Table 9-12**3,4,6-Trichloroguaiacol Baseline Concentrations**

Consolidated AOX Groups ^a	Bleach Plant Effluent (g/L) Minimum Level = 2.5` g/L					
	Hardwood			Softwood		
	Concentration	Detects	Non-detects	Concentration	Detects	Non-detects
A, B, C	1.49	6	64	6.33	5	17
D	4.38	17	27	1.72	8	30
E	ND	0	17	ND	0	79
F	3.04	3	10	ND	0	28
G, I	ND	0	35	1.61	5	32
H, J	ND	0	44	ND	0	100
K	ND	0	4	ND	0	5

^aPapergrade sulfite mills fall in groups A, B, C, and K.

Table 9-13**4,5,6-Trichloroguaiacol Baseline Concentrations**

Consolidated AOX Groups ^a	Bleach Plant Effluent (g/L) Minimum Level = 2.5` g/L					
	Hardwood			Softwood		
	Concentration	Detects	Non-detects	Concentration	Detects	Non-detects
A, B, C	4.04	17	62	25.9	16	16
D	62.4	19	24	14.0	31	6
E	ND	0	17	ND	0	79
F	8.19	3	10	ND	0	28
G, I	2.97	14	28	10.7	16	24
H, J	ND	0	44	1.27	1	103
K	ND	0	4	ND	0	5

^aPapergrade sulfite mills fall in groups A, B, C, and K.

Table 9-14**Tetrachlorocatechol Baseline Concentrations**

Consolidated AOX Groups ^(a)	Bleach Plant Effluent (g/L) Minimum Level = 5.0` g/L					
	Hardwood			Softwood		
	Concentration	Detects	Non-detects	Concentration	Detects	Non-detects
A, B, C	3.21	5	69	28.1	21	10
D	6.59	13	26	8.57	14	20
E	ND	0	17	ND	0	79
F	10.6	6	7	ND	0	28
G, I	4.55	6	33	9.20	16	26
H, J	ND	0	44	ND	0	100
K	ND	0	4	ND	0	5

^aPapergrade sulfite mills fall in groups A, B, C, and K.

Table 9-15**Tetrachloroguaiacol Baseline Concentrations**

Consolidated AOX Groups ^a	Bleach Plant Effluent (g/L) Minimum Level = 5.0` g/L					
	Hardwood			Softwood		
	Concentration	Detects	Non-detects	Concentration	Detects	Non-detects
A, B, C	2.81	4	79	13.9	13	19
D	2.54	2	43	4.31	13	26
E	ND	0	17	ND	0	79
F	8.19	2	11	ND	0	28
G, I	ND	0	38	2.89	5	34
H, J	ND	0	44	ND	0	104
K	ND	0	4	ND	0	5

^aPapergrade sulfite mills fall in groups A, B, C, and K.

Table 9-16**2,3,4,6-Tetrachlorophenol Baseline Concentrations**

Consolidated AOX Groups ^a	Bleach Plant Effluent (g/L) Minimum Level = 2.5` g/L					
	Hardwood			Softwood		
	Concentration	Detects	Non-detects	Concentration	Detects	Non-detects
A, B, C	1.63	9	66	ND	0	32
D	1.47	1	43	ND	0	38
E	ND	0	17	ND	0	79
F	ND	0	13	ND	0	28
G, I	1.38	5	36	2.88	4	39
H, J	ND	0	44	ND	0	102
K	ND	0	9	ND	0	10

^aPapergrade sulfite mills fall in groups A, B, C, and K.

Table 9-17**Pentachlorophenol Baseline Concentrations**

Consolidated AOX Groups ^a	Bleach Plant Effluent (g/L) Minimum Level = 5.0 g/L					
	Hardwood			Softwood		
	Concentration	Detects	Non-detects	Concentration	Detects	Non-detects
A, B, C	ND	0	83	2.26	6	26
D	ND	0	46	2.74	1	39
E	ND	0	17	ND	0	79
F	2.44	1	12	ND	0	28
G, I	2.62	2	42	10.8	1	44
H, J	ND	0	44	ND	0	103
K	ND	0	9	ND	0	10

^aPapergrade sulfite mills fall in groups A, B, C, and K.

Table 9-18**Baseline Technology Groups for Chloroform**

Chloroform Group	Hypochlorite Use	Chlorine Dioxide Substitution
A	Yes	0%
B	Yes	>0%
C	No	<50%
D	No	50 to 99%
E	No	100%
F	No	TCF

Table 9-19**Chloroform Baseline Loadings**

Chloroform Group ^a	Bleach Plant (g/kkg)	Final Effluent (g/kkg)
A	220	5.4
B	142	5.4
C	61	1.1
D	19	0.90
E	0.70	0.30 ^b
F	0.0	0.0

^aPapergrade sulfite mills fall in groups A, C, and F.

^bCalculated from non-detect results using one-half the minimum level.

Table 9-20**Baseline Technology Groups for COD and Color**

COD/Color Group	Screen Room Status	Pre-Bleaching Kappa Number
A	Open	\` 20
B	Closed	\` 20
C	Open	<20
D	Closed	<20

Table 9-21**COD and Color Baseline Loadings
for Bleached Kraft and Papergrade Sulfite Operations Only**

COD/Color Group^a	Final Effluent COD Loading (kg/kg)	Final Effluent Color Loading (kg/kg)
A	51	89
B	37	85
C	33	60
D	28	43

^aPapergrade sulfite mills fall in groups A, C, and D.

Table 9-22

**Final Effluent Long-Term Average Loadings
After Implementation of the BPK and PS Options
(kg/kkg)**

Pollutant	Units are kg/kkg where kkg is air-dry metric tons of pulp into bleaching except for COD and color where it is air-dry metric tons of brown stock pulp produced on site.			
	Kraft Option A	Kraft Option B	Sulfite TCF ^a	Sulfite ECF ^b
AOX	0.512	0.208	0.0	0.512
Chloroform	0.0003	0.0003	0.0	0.0003
TCDD ^c	1.85×10^{-10}	1.25×10^{-10}	0.0	1.85×10^{-10}
TCDF	4.18×10^{-10}	2.83×10^{-10}	0.0	4.18×10^{-10}
Trichlorosyringol ^c	4.63×10^{-5}	3.13×10^{-5}	0.0	4.63×10^{-5}
2,4,5-Trichlorophenol ^c	4.63×10^{-5}	3.13×10^{-5}	0.0	4.63×10^{-5}
2,4,6-Trichlorophenol ^c	4.63×10^{-5}	3.13×10^{-5}	0.0	4.63×10^{-5}
3,4,5-Trichlorocatechol ^c	9.25×10^{-5}	6.25×10^{-5}	0.0	9.25×10^{-5}
3,4,5-Trichloroguaiacol ^c	4.63×10^{-5}	3.13×10^{-5}	0.0	4.63×10^{-5}
3,4,6-Trichlorocatechol ^c	9.25×10^{-5}	6.25×10^{-5}	0.0	9.25×10^{-5}
3,4,6-Trichloroguaiacol ^c	4.63×10^{-5}	3.13×10^{-5}	0.0	4.63×10^{-5}
4,5,6-Trichloroguaiacol ^c	4.63×10^{-5}	3.13×10^{-5}	0.0	4.63×10^{-5}
Tetrachlorocatechol ^c	9.25×10^{-5}	6.25×10^{-5}	0.0	9.25×10^{-5}
Tetrachloroguaiacol ^c	9.25×10^{-5}	6.25×10^{-5}	0.0	9.25×10^{-5}
2,3,4,6-Tetrachlorophenol ^c	4.63×10^{-5}	3.13×10^{-5}	0.0	4.63×10^{-5}
Pentachlorophenol ^c	9.25×10^{-5}	6.25×10^{-5}	0.0	9.25×10^{-5}
All 12 chlorinated phenolics ^c	8.33×10^{-4}	5.63×10^{-4}	0.0	8.33×10^{-4}
COD	38.2	25.5	25.5	38.2
Color	84.5	53.4	53.4	84.5

^aTCF is the BAT option for papergrade sulfite mills using calcium-, magnesium-, or sodium-based cooking liquor.

^bECF is the BAT option for papergrade sulfite mills using ammonium-based cooking liquor, or mills that make specialty-grade sulfite products. (The only difference between the ECF options for these two segments is that the ECF option for the ammonium-based mills includes peroxide-enhanced extraction, while the ECF option for the specialty-grade sulfite mills includes peroxide- and oxygen-enhanced extraction.)

^cThe LTAs for these pollutants for Kraft Options A and B and the Sulfite ECF Option are based on one-half the minimum level for each pollutant multiplied by a group-average production-normalized bleach plant effluent flow rate.

Table 9-23

Sources of Estimated Long-Term Average Pollutant Loadings For Papergrade Sulfite BAT Options

Pollutant	Sulfite TCF^a	Sulfite ECF^b
AOX	Zero	Kraft Option A
Chloroform	Zero	Kraft Option A
TCDD & TCDF	Zero	Kraft Option A
Chlorinated phenolic compounds	Zero	Kraft Option A
COD	Kraft Option B	Kraft Option A
Color	Kraft Option B	Kraft Option A

^aTCF is the BAT option for papergrade sulfite mills using calcium-, magnesium-, or sodium-based cooking liquor.

^bECF is the BAT option for papergrade sulfite mills using ammonium-based cooking liquor or those making specialty grade sulfite pulps.

Table 9-24**Summary of Subcategory Loads and Reductions**

	Bleach Plant Baseline Load	Final Effluent Baseline Load	Kraft Option A and Sulfite Discharge Load^a	Kraft Option B and Sulfite Discharge Load^a	Kraft Option A and Sulfite Reduction^b	Kraft Option B and Sulfite Reduction^b
AOX (kkg/yr)						
All Mills		41,000	12,000	6,200	28,000	34,000
All Kraft		36,000	12,000	5,800	24,000	30,000
BAT Kraft		33,000	11,000	5,400	22,000	28,000
PSES Kraft		3,000	910	420	2,100	2,600
All Sulfite		4,400	370	370	4,000	4,000
BAT Sulfite		4,000	370	370	3,600	3,600
PSES Sulfite		380	0	0	380	380
All Direct		37,000	12,000	5,800	26,000	32,000
All Indirect		3,400	910	420	2,500	3,000
COD (kkg/yr)						
All Mills		1,200,000	1,100,000	830,000	130,000	370,000
All Kraft		1,200,000	1,000,000	800,000	110,000	350,000
BAT Kraft		1,100,000	960,000	740,000	100,000	320,000
PSES Kraft		97,000	88,000	65,000	8,900	32,000
All Sulfite		70,000	51,000	51,000	20,000	20,000
BAT Sulfite		59,000	42,000	42,000	17,000	17,000
PSES Sulfite		3,300	2,500	2,500	830	830
All Direct		1,100,000	1,000,000	780,000	120,000	330,000
All Indirect		100,000	90,000	67,000	9,700	33,000

Table 9-24 (Continued)

	Bleach Plant Baseline Load	Final Effluent Baseline Load	Kraft Option A and Sulfite Discharge Load^a	Kraft Option B and Sulfite Discharge Load^a	Kraft Option A and Sulfite Reduction^b	Kraft Option B and Sulfite Reduction^b
Color (kkg/yr)						
All Mills		2,200,000	2,100,000	1,700,000	55,000	510,000
All Kraft		2,100,000	2,000,000	1,600,000	41,000	490,000
BAT Kraft		1,900,000	1,800,000	1,400,000	38,000	440,000
PSES Kraft		180,000	180,000	130,000	3,400	47,000
All Sulfite		120,000	94,000	94,000	13,000	13,000
BAT Sulfite		120,000	100,000	100,000	14,000	14,000
PSES Sulfite		5,800	5,500	5,500	290	290
All Direct		2,000,000	1,900,000	1,500,000	52,000	460,000
All Indirect		190,000	180,000	140,000	3,600	47,000
Chloroform (kg/yr)						
All Mills	1,400,000	54,000	9,000	9,000	45,000	45,000
All Kraft	1,300,000	48,000	8,800	8,800	40,000	40,000
BAT Kraft	1,200,000	44,000	8,100	8,100	35,000	35,000
PSES Kraft	140,000	4,900	610	610	4,300	4,300
All Sulfite	140,000	5,400	210	210	5,200	5,200
BAT Sulfite	120,000	5,000	210	210	4,800	4,800
PSES Sulfite	14,000	350	0	0	350	350
All Direct	1,300,000	49,000	8,400	8,400	40,000	40,000
All Indirect	160,000	5,200	610	610	4,600	4,600

Table 9-24 (Continued)

	Bleach Plant Baseline Load	Final Effluent Baseline Load	Kraft Option A and Sulfite Discharge Load^a	Kraft Option B and Sulfite Discharge Load^a	Kraft Option A and Sulfite Reduction^b	Kraft Option B and Sulfite Reduction^b
2,3,7,8-TCDD (g/yr)^c						
All Mills	16	16	4.5	3.6	12	12
All Kraft	15	15	4.4	3.4	11	12
BAT Kraft	14	14	4.1	3.2	9.9	11
PSES Kraft	1.3	1.3	0.33	0.25	0.92	1.0
All Sulfite	0.78	0.78	0.13	0.13	0.65	0.65
BAT Sulfite	0.78	0.78	0.13	0.13	0.64	0.64
PSES Sulfite	0.0092	0.0092	0.0	0.0	0.0092	0.0092
All Direct	15	15	4.2	3.3	11	11
All Indirect	1.3	1.3	0.33	0.25	0.93	1.0
2,3,7,8-TCDF (g/yr)^c						
All Mills	120	120	7.9	6.3	110	120
All Kraft	120	120	7.6	6.0	110	110
BAT Kraft	110	110	7.1	5.6	98	100
PSES Kraft	9.5	9.5	0.54	0.43	8.9	9.0
All Sulfite	6.7	6.7	0.30	0.30	6.4	6.4
BAT Sulfite	6.7	6.7	0.30	0.30	6.4	6.4
PSES Sulfite	0.011	0.011	0.0	0.0	0.011	0.011
All Direct	110	110	7.4	5.9	100	110
All Indirect	9.5	9.5	0.54	0.43	9.0	9.1

Table 9-24 (Continued)

	Bleach Plant Baseline Load	Final Effluent Baseline Load	Kraft Option A and Sulfite Discharge Load^a	Kraft Option B and Sulfite Discharge Load^a	Kraft Option A and Sulfite Reduction^b	Kraft Option B and Sulfite Reduction^b
Trichlorosyringol (kg/yr)^c						
All Mills	6,800	3,800	680	490	3,100	3,300
All Kraft	6,600	3,600	660	480	3,000	3,100
BAT Kraft	6,000	3,300	610	440	2,700	2,900
PSES Kraft	520	290	49	35	240	250
All Sulfite	270	150	18	18	130	130
BAT Sulfite	250	140	18	18	120	120
PSES Sulfite	20	11	0.0	0.0	11	11
All Direct	6,300	3,500	630	460	2,800	3,000
All Indirect	540	300	49	35	250	260
2,4,5-Trichlorophenol (kg/yr)^c						
All Mills	1,100	600	550	450	52	150
All Kraft	1,100	580	540	440	43	140
BAT Kraft	980	540	500	410	39	130
PSES Kraft	86	47	43	35	4.6	13
All Sulfite	33	18	9.6	9.6	8.8	8.8
BAT Sulfite	31	17	9.6	9.6	7.7	7.7
PSES Sulfite	2.0	1.1	0.0	0.0	1.1	1.1
All Direct	1,000	550	510	420	46	140
All Indirect	88	48	43	35	5.7	14

Table 9-24 (Continued)

	Bleach Plant Baseline Load	Final Effluent Baseline Load	Kraft Option A and Sulfite Discharge Load^a	Kraft Option B and Sulfite Discharge Load^a	Kraft Option A and Sulfite Reduction^b	Kraft Option B and Sulfite Reduction^b
2,4,6-Trichlorophenol (kg/yr)^c						
All Mills	16,000	8,700	680	500	8,100	8,200
All Kraft	15,000	8,500	660	480	7,800	8,000
BAT Kraft	14,000	7,800	610	440	7,200	7,400
PSES Kraft	1,200	650	49	35	600	620
All Sulfite	440	240	18	18	230	230
BAT Sulfite	420	230	18	18	210	210
PSES Sulfite	30	16	0.0	0.0	16	16
All Direct	15,000	8,100	630	460	7,400	7,600
All Indirect	1,200	670	49	35	620	630
3,4,5-Trichlorocatechol (kg/yr)^c						
All Mills	39,000	22,000	1,400	990	20,000	20,600
All Kraft	38,000	21,000	1,300	950	20,000	20,000
BAT Kraft	36,000	20,000	1,200	880	19,000	19,000
PSES Kraft	2,000	1,100	97	69	1,000	1,000
All Sulfite	1,300	740	36	36	700	700
BAT Sulfite	1,300	730	36	36	700	700
PSES Sulfite	14	7.5	0.0	0.0	7.5	7.5
All Direct	37,000	20,000	1,300	920	19,000	20,000
All Indirect	2,000	1,100	97	69	1,000	1,000

Table 9-24 (Continued)

	Bleach Plant Baseline Load	Final Effluent Baseline Load	Kraft Option A and Sulfite Discharge Load^a	Kraft Option B and Sulfite Discharge Load^a	Kraft Option A and Sulfite Reduction^b	Kraft Option B and Sulfite Reduction^b
3,4,5-Trichloroguaiacol (kg/yr)^c						
All Mills	13,000	7,300	670	490	6,600	6,800
All Kraft	13,000	7,000	660	480	6,400	6,500
BAT Kraft	12,000	6,600	610	440	6,000	6,200
PSES Kraft	730	400	49	35	350	370
All Sulfite	470	260	18	18	240	240
BAT Sulfite	460	250	18	18	240	240
PSES Sulfite	9.1	5.0	0.0	0.0	5.0	5.0
All Direct	12,000	6,900	630	460	6,200	6,400
All Indirect	740	410	49	35	360	370
3,4,6-Trichlorocatechol (kg/yr)^c						
All Mills	2,000	1,100	1,000	910	72	200
All Kraft	2,000	1,100	1,000	890	59	190
BAT Kraft	1,800	1,000	950	830	55	180
PSES Kraft	160	85	81	69	3.9	16
All Sulfite	54	30	17	17	13	13
BAT Sulfite	50	28	17	17	11	11
PSES Sulfite	4.1	2.2	0.0	0.0	2.2	2.2
All Direct	1,900	1,000	960	840	66	190
All Indirect	160	88	81	69	6.1	18

Table 9-24 (Continued)

	Bleach Plant Baseline Load	Final Effluent Baseline Load	Kraft Option A and Sulfite Discharge Load^a	Kraft Option B and Sulfite Discharge Load^a	Kraft Option A and Sulfite Reduction^b	Kraft Option B and Sulfite Reduction^b
3,4,6-Trichloroguaiacol (kg/yr)^c						
All Mills	2,100	1,100	590	470	550	670
All Kraft	2,000	1,100	580	460	510	630
BAT Kraft	1,800	1,000	530	430	470	580
PSES Kraft	160	89	46	35	44	54
All Sulfite	87	48	14	14	33	33
BAT Sulfite	84	46	14	14	32	32
PSES Sulfite	2.4	1.3	0.0	0.0	1.3	1.3
All Direct	1,900	1,100	550	440	500	610
All Indirect	160	91	46	35	45	56
4,5,6-Trichloroguaiacol (kg/yr)^c						
All Mills	8,400	4,600	680	490	3,900	4,100
All Kraft	8,100	4,400	660	480	3,800	4,000
BAT Kraft	7,500	4,200	610	440	3,500	3,700
PSES Kraft	530	290	49	35	240	250
All Sulfite	330	180	18	18	170	170
BAT Sulfite	330	180	18	18	160	160
PSES Sulfite	6.6	3.6	0.0	0.0	3.6	3.6
All Direct	7,900	4,300	630	460	3,700	3,900
All Indirect	530	290	49	35	240	260

Table 9-24 (Continued)

	Bleach Plant Baseline Load	Final Effluent Baseline Load	Kraft Option A and Sulfite Discharge Load^a	Kraft Option B and Sulfite Discharge Load^a	Kraft Option A and Sulfite Reduction^b	Kraft Option B and Sulfite Reduction^b
Tetrachlorocatechol (kg/yr)^c						
All Mills	7,800	4,300	1,300	980	3,000	3,300
All Kraft	7,400	4,100	1,300	950	2,800	3,100
BAT Kraft	6,900	3,800	1,200	880	2,600	2,900
PSES Kraft	570	310	93	69	220	240
All Sulfite	350	190	36	36	160	160
BAT Sulfite	340	190	36	36	150	150
PSES Sulfite	5.2	2.9	0.0	0.0	2.9	2.9
All Direct	7,200	4,000	1,200	910	2,700	3,000
All Indirect	570	320	93	69	220	250
Tetrachloroguaiacol (kg/yr)^c						
All Mills	4,300	2,300	1,200	940	1,200	1,400
All Kraft	4,100	2,200	1,100	910	1,100	1,300
BAT Kraft	3,700	2,100	1,000	840	1,000	1,200
PSES Kraft	340	190	90	69	97	120
All Sulfite	190	100	30	30	72	72
BAT Sulfite	180	100	30	30	70	70
PSES Sulfite	4.6	2.5	0.0	0.0	2.5	2.5
All Direct	3,900	2,200	1,100	870	1,100	1,300
All Indirect	340	190	90	69	100	120

Table 9-24 (Continued)

	Bleach Plant Baseline Load	Final Effluent Baseline Load	Kraft Option A and Sulfite Discharge Load^a	Kraft Option B and Sulfite Discharge Load^a	Kraft Option A and Sulfite Reduction^b	Kraft Option B and Sulfite Reduction^b
2,3,4,6-Tetrachlorophenol (kg/yr)^c						
All Mills	1,100	600	590	470	16	130
All Kraft	1,100	590	580	460	7.5	120
BAT Kraft	980	540	530	430	5.5	110
PSES Kraft	87	48	46	35	1.9	13
All Sulfite	31	17	8.8	8.8	8.3	8.3
BAT Sulfite	29	16	8.8	8.8	6.9	6.9
PSES Sulfite	2.7	1.5	0.0	0.0	1.5	1.5
All Direct	1,000	550	540	430	12	120
All Indirect	89	49	46	35	3.4	14
Pentachlorophenol (kg/yr)^c						
All Mills	2,300	1,200	1,100	930	130	320
All Kraft	2,200	1,200	1,100	910	120	310
BAT Kraft	2,100	1,100	1,000	840	110	290
PSES Kraft	160	85	81	69	3.9	16
All Sulfite	54	30	17	17	13	13
BAT Sulfite	50	28	17	17	11	11
PSES Sulfite	4.1	2.2	0.0	0.0	2.2	2.2
All Direct	2,100	1,200	1,000	860	120	300
All Indirect	160	88	81	69	6.1	18

Table 9-24 (Continued)

	Bleach Plant Baseline Load	Final Effluent Baseline Load	Kraft Option A and Sulfite Discharge Load^a	Kraft Option B and Sulfite Discharge Load^a	Kraft Option A and Sulfite Reduction^b	Kraft Option B and Sulfite Reduction^b
All 12 Chlorophenolics (kg/yr)^c						
All Mills	100,000	57,000	10,000	8,100	47,000	49,000
All Kraft	100,000	55,000	10,000	7,900	45,000	47,000
BAT Kraft	94,000	52,000	9,400	7,300	42,000	44,000
PSES Kraft	6,500	3,600	770	590	2,800	3,000
All Sulfite	3,700	2,000	240	240	1,800	1,800
BAT Sulfite	3,600	2,000	240	240	1,700	1,700
PSES Sulfite	100	57	0.0	0.0	57	57
All Direct	98,000	54,000	9,700	7,500	44,000	46,000
All Indirect	6,600	3,700	770	590	2,900	3,000
NCASI 2,3,7,8-TCDD (g/yr)						
All Mills		14	4.5	3.3	9.3	10
All Kraft		13	4.3	3.2	8.8	10
BAT Kraft		12	4.0	3.0	8.2	9.3
PSES Kraft		0.88	0.33	0.23	0.56	0.66
All Sulfite		0.59	0.13	0.13	0.46	0.46
BAT Sulfite		0.59	0.13	0.13	0.46	0.46
PSES Sulfite		0.0025	0.0	0.0	0.0025	0.0025
All Direct		13	4.2	3.1	8.7	8.7
All Indirect		0.89	0.33	0.23	0.56	0.56

Table 9-24 (Continued)

	Bleach Plant Baseline Load	Final Effluent Baseline Load	Kraft Option A and Sulfite Discharge Load^a	Kraft Option B and Sulfite Discharge Load^a	Kraft Option A and Sulfite Reduction^b	Kraft Option B and Sulfite Reduction^b
NCASI 2,3,7,8-TCDF (g/yr)						
All Mills		45	8.6	6.7	37	38
All Kraft		42	8.4	6.5	33	35
BAT Kraft		41	7.8	6.0	33	35
PSES Kraft		1.1	0.60	0.44	0.44	0.61
All Sulfite		3.4	0.28	0.28	3.2	3.2
BAT Sulfite		3.4	0.28	0.28	3.1	3.1
PSES Sulfite		0.013	0.0	0.0	0.013	0.013
All Direct		44	8.0	6.3	36	38
All Indirect		1.1	0.60	0.44	0.46	0.62

Note: Columns may not add, due to rounding.

^aFor papergrade sulfite mills, results from analysis of only one option is presented for each segment: TCF for the calcium-, magnesium-, or sodium-based segment and ECF for the ammonium-based and specialty-grade segments. The same results are shown in the columns labeled for kraft Options A and B.

^bReduction = Baseline Load minus Option Discharge Load (if Option Discharge Load is less than the Baseline Load).

^cEPA found no measurable differences between Kraft Options A and B in the concentrations of these pollutants in bleach plant effluent. The slightly greater removals of the bleach plant pollutants by Option B mills are a result of the reduced bleach plant flow rates found at mills employing Option B technology.

SECTION 10

BAT, PSES, NSPS, and BMP FINAL COMPLIANCE COSTS

10.1 Introduction

This section describes EPA's final compliance cost estimates for BAT, PSES, NSPS, and BMPs for mills in the Bleached Papergrade Kraft and Soda subcategory and mills in the Papergrade Sulfite subcategory. EPA cost estimates for the proposed BAT, PSES, and BMPs were presented in the Proposal TDD (1). Following the proposal, EPA collected and analyzed additional data and issued a Notice of Data Availability (Notice) on July 15, 1996 (61 FR 36835). In this notice, EPA presented revised cost estimates for two of the options evaluated at proposal. Thus, the mid-1995 status of each mill served as the "baseline" to estimate the compliance cost to implement BAT, PSES, and BMPs option technologies presented in the July notice. The costs presented in the Notice were based on the estimates provided in the June 18, 1996 version of the BAT and BMP Compliance Cost Estimates Report (2).

EPA estimated final costs of BAT, PSES, and BMPs taking into account comments received on the costs presented in the Notice. In this section, EPA presents the final compliance costs for all mills in each subcategory (direct and indirect dischargers) to complete the process changes that comprise the BAT and PSES model technologies and to implement the BMPs. In addition, several additional analyses, including costs reflecting corporate commitments (Section 10.2.5), costs for two TCF option costs (Section 10.2.6), costs for EPA's Voluntary Advanced Technology Incentives Program (Incentives Program) (Section 10.2.7), and costs for a typical mill to install the technology that forms the basis of NSPS (Section 10.4) are included in this section.

10.1.1 **BAT and PSES Cost Estimation**

EPA developed the BAT cost model to estimate costs for each mill in the BPK and PS subcategories. For PSES, EPA evaluated the same process change technology options as it evaluated for BAT. EPA determined the same in-plant BAT process changes are appropriate to achieve effective pollutant reductions for preventing "pass through" at a POTW. Therefore, EPA used the same cost model to estimate the costs of PSES and BAT. EPA's estimates include the costs for new, upgraded, or modified process units (i.e., evaporators, recovery boiler, and recausticizing) that are incidentally affected by the implementation of BAT and PSES options.

Using the BAT cost model, EPA estimated costs in two ways: (1) an extrapolation of cost model results for ten mills that represent the 86 bleached papergrade kraft and soda mills covered by the rule and (2) a mill-by mill cost estimate for the 86 mills covered by the rule. EPA estimated costs for BAT/PSES Options A and B for the bleach papergrade kraft and soda subcategory based on the mill-by-mill method, and estimated TCF costs based on the extrapolation of ten mills to represent the 86 mills covered by the rule. For papergrade sulfite mills, EPA used the mill-by-mill method.

10.1.1.1 Preliminary Evaluation of Cost Model

In response to comments on the BAT, PSES, and BMPs regulations proposed in 1993, the cost model used to estimate compliance costs was revised significantly. To ensure the proper function of the revised cost model, it was used to obtain a preliminary, order-of-magnitude estimate of the costs of the revised options. In order to perform this preliminary evaluation, EPA developed 10 technology groups, or “cost groups,” to represent the range of baseline pulping and bleaching operations used by BPK mills. The 10 groups, labeled A through K are depicted in Table 10-1. In general, mills in lower groups (i.e., A through D) require the most extensive process technology changes and thus are projected to incur the highest costs to comply with the proposed rule. Mills in the higher groups (i.e., E through K) generally have process technologies already in place equivalent to or better than the BAT options.

EPA classified each BPK mill into a costing group. First, each pulping and bleaching line at every mill was classified as Group A through Group K based on the technologies already in place. If a mill had only one bleach line, the group classification applied to the mill as well as the bleach line. Because a mill may have more than one type of bleach line, assigning a complete mill to a group is more subjective than assigning a single line. For such mills, engineering judgment was used to assign the mill to a cost group that would provide the most reasonable estimate of the cost that the mill would incur to implement each option.

EPA chose 10 model mills, one from each group, to estimate the average cost of compliance for all the mills in a group. The estimated compliance costs for each model mill were extrapolated for the entire technology group by multiplying the model mill’s costs by the total annual brown stock production for all mills in that group. After summing the results for all 10 groups, EPA obtained total estimated compliance costs. Results of this preliminary cost model evaluation that were compared to the subsequent mill-by-mill (mid-1995) costs discussed below demonstrated results that were within 30 percent accuracy for capital costs. Therefore, as discussed in Section 10.2.6, model-mill costing was used for estimating compliance costs for the two TCF options EPA considered.

Model mill costing was not performed for PS mills. Because this subcategory consists of only 11 mills, compliance costs for this subcategory were estimated using mill-by-mill costing, as described below (Section 10.1.1.2).

10.1.1.2 Mill-by-Mill Costing

Four information sources were used to determine each mill's status from which mill-by-mill costs were estimated:

- BAT Baseline Database;
- Mill cost estimates from proposal;
- BMPs status file; and
- Recovery boiler questionnaire.

The BAT Baseline Database (3) was the main source of updated information for direct- and indirect-discharging mills for both subcategories. Inputs to the BAT Baseline Database include the 1990 census questionnaire information (and subsequent 1991 and 1992 letter updates); industry comments on the proposed rule; industry-supplied data; site visit reports; sampling episodes; meetings and telephone conversations EPA had with industry, environmental groups, and public; and technical articles and conference proceedings.

Mill-by-mill costing proceeded in Quattro™Pro for Windows. One electronic file, or "millsheet," was created for each mill. Once mill-by-mill costing was completed, the results for BPK and PS mills were compiled using macros (a series of command statements that perform compilation tasks) created in Quattro™Pro for Windows. The macros were used to tally the baseline technology in place at the mills, the estimated compliance costs (capital and operating) for each mill, and the mill technology installations or upgrades necessary to meet a particular cost option's requirements. EPA evaluated total costs, annualized costs, and individual technology costs for each option for each subcategory.

10.1.1.3 Final Mill-by-Mill Costing

EPA made minor revisions to the costs presented in the July 1996 Notice in response to comments. EPA made additional changes to the cost model and corrected mill-specific information to estimate final costs for the BPK and PS subcategories (see Section 10.2.2 and Section 10.3.2).

EPA also created modified versions of the cost model to analyze on a model-mill basis the costs of two TCF options and EPA's Incentives Program. Sections 10.2.6 and 10.2.7 contain a discussion of these analyses, including a comparison of the final mill-by-mill cost estimates of BAT, PSES, and BMPs for all options.

10.1.1.4 Final Compliance Cost Estimates

Since the 1993 proposed rule, AF&PA and other commenters submitted compliance cost estimates for BMPs, effluent limitations guidelines (BPT, BCT, and BAT), and standards (NSPS, PSES, and PSNS) that widely diverged from EPA's compliance cost estimates. A number of factors were responsible for those differing cost estimates, but they were primarily driven by differences in costs for BAT process technologies (e.g., brown stock washing, screen

rooms, oxygen delignification, etc.), costs for upgrading chemical recovery systems (most notably recovery boilers) to accommodate BAT process technologies and BMPs, and costs for BMPs and wastewater treatment system upgrades.

EPA's cost bases for BAT/PSES process technologies and BMPs are described in the BAT Cost Model Support Document (4) and accompanying memorandum, "Memorandum: Costing Revisions Made Since the Publication of July 15, 1996 Notice of Data Availability (61 FR 3687)" (5). EPA believes that it has adequately addressed site-specific factors such as site preparation, piping, power requirements, and overhead costs such as project management, insurance, and taxes in estimating compliance costs for BAT technologies, BMPs, and affected process units (i.e., recovery systems) because the costs are based on mill projects supplied by industry that account for such factors.

EPA continues to disagree with industry claims about the extent to which recovery systems will require upgrades as a result of the options considered for the final rule. This is discussed more fully in the Analysis of Impacts of BAT Options on the Kraft Recovery Cycle (6), and Comment Response Document, Volume I, "Issues Concerning EPA's Estimate of the Effect of BAT Options on Recovery Boilers" (7).

Because EPA is not revising conventional pollutant limitations in the final rule and existing treatment systems are generally believed to be adequately designed to comply with the toxic and nonconventional pollutant limitations promulgated by this rule (assuming BAT/PSES process changes are implemented), mills are no longer expected to incur significant treatment system upgrade costs attributable to this rule. As a result, EPA refined its baseline analysis of the existing spill controls already in place at mills and revised its BMP compliance cost estimates based on cost data provided by industry.

10.2 Compliance Cost Estimates for the Bleached Papergrade Kraft and Soda Subcategory

The derivation of compliance cost estimates for the BPK Subcategory is described in the following sections.

10.2.1 Technology Options

EPA's final analysis of BAT and PSES for the BPK subcategory focused on two ECF technology options identified as Option A and Option B. These two options have nine common elements. Sections 8.2.1.1 and 8.2.1.2 detail the technology elements associated with Options A and B, respectively.

10.2.1.1 Process Technologies Costed

Table 10-2 lists the BAT technologies for which EPA estimated costs for each option. EPA also evaluated the impacts to each incidentally affected process unit (i.e.,

evaporators, recovery boilers, and recausticizing systems) to determine the total costs a mill would incur to implement each option. EPA evaluated process technologies in place as of mid-1995 on a mill-specific basis to determine which mills require costs for new or upgraded process unit(s) as a result of implementing BAT technologies. Because EPA regulations require bleach plant and final effluent monitoring, the costs for monitoring equipment are also included in the estimates.

Kappa number targets used for estimating costs were lower than the kappa numbers used to define Option B (see Section 8.2.1.2). The costing targets reflect the fact that current pulping practice produces softwood at kappa number 30 and hardwood at kappa number 20-25, and that modern OD systems achieve approximately 50 percent delignification. Therefore, for costing, the targets were 15 for softwood and 10 for hardwood because a mill intending to achieve limitations based on OD would likely purchase a modern OD system, which is capable of achieving those targets (even though its performance would exceed the delignification achieved by the OD systems used at mills supplying the data EPA used to represent the performance of Option B).

10.2.1.2 BAT Technology Processes Not Costed

EPA considers the use of precursor-free defoamers as part of current baseline technology used today at BPK mills. Defoamers are mineral oil- or water-based products used to break and inhibit the formation of black liquor surface foam. Unchlorinated dioxin precursors are particularly prevalent in certain mineral oils used in these defoamers, but the precursors can be removed by a process called hydrotreating. As evidenced by the drop in measured TCDD and TCDF discharges from bleaching pulp mills, it became known that the use of either water-based defoamers or defoamers made with precursor-free mineral oils in the brown stock or bleach plant areas substantially reduces the dioxin formed in bleaching. Accordingly, most mills began to employ these types of defoamers (8). Consequently, EPA assumes use of precursor-free defoamers to be part of industry's process baseline. Further, any mill not currently using such defoamers can use them without incurring significant cost.

EPA considers chip quality control part of the BAT technology basis because it is an important component of improving yield, reducing bleaching chemical requirements, and optimizing pulp quality. EPA has in fact found that mills can attain adequate control of chip thickness by either the use of thickness screens or by "upstream" controls such as improving the mill's on-site chip-making processes (i.e., maintaining better tolerances on equipment) and imposing tighter quality control standards on chips delivered by off-site sources. Thus, it is possible for mills to achieve adequate chip size control through low or negligible cost beyond current practices to improve quality and uniformity without the need to purchase chip thickness screens (9). Alternatively, mills with poor chip thickness control may choose to install thickness screens, which will pay for themselves by improving yield and reducing bleaching chemical requirements.

Similarly, EPA considers the use of efficient biological wastewater treatment to be part of baseline technology used today at BPK mills. With the exception of one mill that discharges to territorial waters of the United States, wastewater from all mills in the subcategory is treated by biological wastewater treatment. These treatment systems are typically operated to remove in excess of 90 percent of the influent BOD₅ load (1), and are also capable of substantial reductions in COD and AOX. Therefore, EPA did not estimate costs for improving wastewater treatment systems to this level of efficiency.

In addition, implementation of BAT options typically reduce wastewater treatment load (see Section 11.0). EPA, however, did not calculate the savings in operating costs attributable to reduced wastewater treatment system influent BOD₅ load, such as aerator horsepower and electrical use, in estimating the costs of BAT. EPA assumed that operating cost savings at least offset any capital investments in the treatment system required to achieve the reduction in energy consumption. Where a substantial reduction in effluent flow is realized by the BAT technologies in the mill, minor modifications to the effluent treatment systems may be required so that the mill could take advantage of the energy savings mentioned above. These changes might involve installing partitions or baffles to direct flow of effluent in an aerated stabilization basin, or bypassing part of parallel sets of equipment.

10.2.1.3 Basis for Costing Technology Options that also Incidentally Achieve COD Control

EPA's cost estimates include technologies that capture spent pulping liquors and return them to the recovery process. Recovery of spent pulping liquors also incidentally achieve effective COD control. These technologies include:

- Spent pulping liquor spill control (i.e., BMPs, discussed in 2.4.4);
- Effective brown stock washing; and
- Closed brown stock screening.

EPA estimated the cost impact of returning captured spill material to the recovery process under the promulgated BMP program (see Section 10.2.4.4 for details). While the BMP requirements do not mandate the degree to which captured spill material is recovered, EPA has determined that good engineering practice is to recover the material to the maximum degree possible. Such an approach maximizes the value of recovered chemicals and energy (steam), and minimizes the discharge load to the wastewater treatment system, including the COD load. EPA will develop and promulgate COD limitations and standards in a future rulemaking. These limitations and standards will have the effect of reflecting substantial reductions in COD discharges achieved by BMPs for pulping liquor spills and leaks.

Costs for effective brown stock washing are included in the BAT and PSES cost estimate. This technology is used to produce pulp with little black liquor carry-over and is part of the strategy for reducing AOX and dioxin generation. EPA notes that wastewater from upgraded or new washing systems installed to comply with BAT and PSES limitations may be recycled to

the recovery system. While recovery of the washwater does not enhance a mill's ability to comply with the limitations and standards being promulgated at this time, doing so is considered good, and a common pollution prevention practice. As a result, EPA accounted for any increase in the recovery of black liquor from improved washing in the BAT cost model.

Closed screening was also included in EPA's cost estimate for the BAT and PSES options. EPA determined that closed screening, which may be designed to operate as a washing stage, could be implemented under either Option A or Option B at the same cost at mills that require improved washing instead of additional brown stock washers (the supporting information on cost comparison, although protected as CBI, can be found in Table 1 in DCN 145008 (10)). In addition, closed screening is critical for the efficient operation of oxygen delignification, an Option B BAT element. Use of closed screening lowers the overall waste load on the mill wastewater treatment system, including COD load, and is becoming common industry practice.

In order to determine the appropriate costs for Option A, EPA compared the cost of closed screening plus any additional brown stock washing to the cost of improved brown stock washing only. The results were not clear cut. Although the total capital costs for closed screening were less, the annual operating costs for closed screening were somewhat higher. Implementing closed screening allows the decker to be used as an extra, "free" stage of washing, resulting in lower capital costs at mills that require a washing upgrade. To determine the least cost alternative, EPA compared the pre-tax and post-tax present value of Option A with open screening to Option A with closed screening. In several different scenarios, closed brown stock screening was slightly (1 percent or less) less expensive than open screening. As a result, closed screening was retained as a component of Option A.

10.2.2 Costing Revisions

The following section details changes to the cost estimation methodology made since the proposed regulations in 1993.

10.2.2.1 Costing Revisions as a Result of Comments on the Proposal

In response to comments on the proposed rule and as a result of additional information about the industry collected after proposal, EPA modified several assumptions used in estimating costs. A description of the changes that affected costs are summarized below:

- 1) EPA incorporated the costs for BMPs and closed screening into the model. Costs for these elements were estimated separately at proposal, using very limited data. EPA received a substantial amount of new data voluntarily submitted by NCASI on BMPs. EPA also collected the data necessary to determine the capital and operating costs for the technologies and for the combined impacts to the recovery system. As described in Section 10.2.1.3, EPA determined that closed screening, which is standard equipment for water balance at mills operating OD, may be implemented to

essentially act as an additional brown stock washer stage at an equivalent cost at mills that do not use OD (although protected as CBI, this information can be found on Table 1 of DCN 14508 (10)). As a result, the total number of new or upgraded brown stock washers for which EPA estimated final compliance costs is less than the number at proposal.

- 2) EPA accounted for evaporator modifications when improved brown stock washing and BMP modifications resulted in additional process wastewater (i.e., hydraulic load) sent to the recovery area, thus increasing the capital and operating costs for mills that at baseline operated this affected process unit at capacity.
- 3) EPA accounted for increased heat load to the recovery boiler from additional black liquor recovered by BMPs, screen room closure, and improved brown stock washing (heat load from OD was accounted for at proposal). The cost model was revised to estimate the increased capital cost for mills currently operating recovery boilers at capacity and the operating cost savings for reduced fuel requirements as a result of additional steam generation.
- 4) EPA provided an allowance to increase the capacity of the recausticizing system which may require as much as 7 percent increase (refer to Chapter 8 of the Analysis of Impacts of BAT Options on the Kraft Recovery Cycle (6)) due to implementation of OD, if the mill had reported to EPA that they operated their recausticizing system at capacity. EPA determined from the NCASI Recovery Furnace Survey that 20 percent of BPK mills do not have spare capacity. The cost model was revised to estimate additional capital and operating costs associated with a recausticizing system upgrade at these mills.
- 5) EPA revised the assumption that certain continuous cooking digesters could be modified to extended cooking and achieve the costing target kappa into bleaching. EPA notes that some mills use certain continuous cooking digesters for purposes other than kappa reduction (e.g., some mills use partial extended cooking to affect pulp quality characteristics). These mills cannot retrofit the digesters to achieve the target kappa number for the purpose of complying with BAT and PSES limitations without loss of yield. As a result, EPA estimated the costs for new OD systems that achieve the costing target kappa number at the affected mills (this revised assumption resulted in the apparent decrease in the baseline number of mills and lines using extended cooking presented in Table 10-7).

- 6) EPA adjusted equations used to predict the caustic application rate for modified bleaching using data provided by one commenter. This revision increased caustic demand, which, in turn, increased operating costs.
- 7) EPA revised cost curves for most equipment items in accordance with the data collected by voluntarily submitted surveys and comments from industry (see BAT Cost Model Support Document (4)). All cost curves were adjusted for inflation from a 1993 to a 1995 basis, increasing capital costs slightly.
- 8) EPA revised estimates of costs for compliance monitoring, energy, wood, and chemicals.
- 9) EPA estimated costs a mill would incur to accommodate any increased thermal load to individual recovery boilers by estimating costs for addition of anthraquinone to the pulping digester or oxygen-based black liquor oxidation. EPA assumed that mills would most likely reduce the load on the recovery boiler rather than to increase the capacity of an existing boiler for the incremental increase associated with BAT and BMPs (see Section 6 of the Analysis of Impacts of BAT Options on the Kraft Recovery Cycle (6)). To obtain realistic costs, EPA assumed mills would use the most economically feasible upgrade for reducing thermal load.

10.2.2.2 Costing Revisions as a Result of Comments on the Notice

In response to comments on the July 15, 1996 Notice, EPA corrected mill-specific information and made additional changes to assumptions to estimate final costs. These changes were not major revisions to the model. A description of the changes and the effect on costs are summarized below. For a complete description of the following changes, refer to "Memorandum: Costing Revisions Made Since Publication of July 15, 1996 Notice of Data Availability (61 FR 36837)" (5).

- 1) EPA corrected errors in the application of climate factor. If mills require installation of peroxide storage facilities, chlorine dioxide storage facilities, or new or greenfield chlorine dioxide generators, the capital costs were revised to include the climate factor (i.e., an allowance for enclosing these facilities in a building in cold climates). The changes to capital costs were minor and varied depending on mill location.
- 2) EPA revised the assumption that an increase in chlorine dioxide use of one kkg per day would require cost for a chlorine dioxide generator conversion or installation. Instead, EPA assumed that an increase of one kkg per day would trigger an upgrade to the existing generator (i.e., an allowance for minor generator upgrades), while an increase in chlorine dioxide use of

greater than 20 percent above current capacity would trigger either a generator conversion or installation of a new chlorine dioxide generator, which is a more capital-intensive improvement. EPA revised the assumption because several mills operating large generators are capable of upgrading them to expand capacity at a lower cost than installing a new generator to accommodate the amount of chlorine dioxide necessary for ECF bleaching. This revision decreased the capital cost for several mills.

- 3) EPA corrected the errors in the unit costs of caustic and hydrogen peroxide that resulted from a unit conversion error (this error carried through the proposal and the notice cost estimates). The correct unit costs for caustic and hydrogen peroxide are \$0.29/kg and \$0.62/kg, respectively, which are approximately half as much as the erroneous costs of \$0.54/kg and \$1.15/kg, respectively. Although the chemical costs decreased by approximately one half, the effect on overall operation costs (and, likewise, on individual mill operating costs) was a net increase. The reason for this apparent discrepancy is because both ECF technology options result in less chemical consumption overall; therefore, the Notice estimate of net savings from reduced chemical use when using high chemical costs was unreasonably high. Once the correct, lower chemical costs were used, the chemical cost savings decreased, resulting in an overall slight increase in operating costs. Therefore, compared to the costs presented in the Notice, fewer mills now demonstrate overall operating cost savings. This error particularly affected the Option B operating cost estimate, which still displays significant reduction of chemical reduction compared to Option A because of implementation of OD (e.g., operating costs were erroneously estimated as a \$7 million savings at the time of the Notice versus a \$2 million cost for final estimates presented in 10.1.4).
- 4) EPA corrected the double counting of taxes and insurance by adjusting the factor used to calculate the cost of maintenance and repair from 4 percent of capital to 2 percent. Taxes and insurance are accounted for in an additional economic analysis described in Economic Analysis for the National Emissions Standards for Hazardous Air Pollutants for Source Category: Pulp and Paper production; Effluent Limitations Guidelines, Pretreatment Standards, and New Source Performance Standards: Pulp, Paper, and Paperboard Category—Phase 1 (11). As a result, operating cost estimates presented in this section decreased slightly compared to the cost estimates at the time of the Notice.
- 5) EPA revised the assumption that all softwood lines with OD in place could operate them to achieve a kappa number less than 20 by providing costs for an upgraded OD system when a mill's baseline kappa number was greater than 19. EPA revised this assumption based on mill data, demonstrating

that mills not currently pulping to an unbleached kappa number of less than 20 are not capable of achieving the promulgated limitations and standards without incurring costs. As a result, several mills received capital cost allowances to upgrade OD systems.

- 6) EPA revised the assumptions that all hardwood lines that operate OD to achieve kappa numbers of 11 or 12 would incur an operating cost savings in complying with BAT. Previously, EPA assumed these mills could optimize OD to achieve an unbleached kappa number of 10 without incurring capital costs and receiving operating cost savings. Instead, EPA is now assuming that these mills could continue to operate at their current unbleached pulp kappa number without necessarily experiencing any operating cost savings. EPA revised this assumption because mill data demonstrate that these mills are capable of meeting BAT limitations at kappa numbers of 11 or 12.

10.2.3 Baseline Status

At proposal, EPA evaluated BAT, PSES, and BMPs for 88 mills in the BPK subcategory. Since proposal, the total number of mills in the subcategory has decreased from 88 to 86 because one mill closed and another was reclassified as unbleached kraft. Two other mills informed EPA that they would cease bleached kraft production, rather than invest in any new bleaching technology after promulgation of this rule, opting to produce unbleached kraft pulp. As a result, EPA used the cost model to analyze the costs of BAT, PSES, and BMPs for 84 mills (refer to Section 4). However, for EPA's economic analysis (11), these two mills are included in the subcategory profile because mills that produce kraft pulps are subject to MACT I and MACT II. In EPA's economic analysis, EPA estimated MACT I and MACT II costs for these two mills and assumed that they would not incur BAT, PSES, and BMPs costs to determine the economic achievability of the Cluster Rules.

The baseline status of BPK mills both at the time of proposal and in mid-1995 is shown in Table 10-3. The table presents the number of mills and lines that use certain elements of the BAT options at proposal and mid-1995. The table also lists the associated percentage of the total pulp production of the mills using these technologies at proposal and mid-1995. In general, the number of mills and lines and the production percentages have increased, indicating many mills have incorporated elements of the proposed BAT options in this time period. An exception is the number of mills and lines using extended cooking, which is an artifact of overcounting those lines at proposal (see Section 10.2.2.1). Table 10-3 shows the percentage of ECF production has increased by a factor of five while the percent of production using hypochlorite has been cut in half.

10.2.4 Compliance Cost Estimates

The following section presents the compliance cost estimates used in this rulemaking.

10.2.4.1 Total Capital and Operating Compliance Cost Estimates

After revising the model as described in Section 10.2.2, EPA used mill-by-mill costing to obtain final compliance cost estimates for Option A and Option B. Table 10-4 compares the final compliance costs for Option A and B to the costs of the proposed BAT/PSES option. The cost components reported in this section are engineering estimates of the cost of purchasing and installing equipment and the annual operating and maintenance costs associated with that equipment. Proposal costs have been adjusted from 1993 to 1995 dollars to facilitate comparison.

EPA also calculated the annualized costs of Options A and B to facilitate a preliminary comparison of the options prior to performing the economic impact analysis. All cost estimates in this section are expressed in 1995 dollars. Annualized costs, which were calculated on a “per year” and “per ton” basis, are also shown Table 10-4. EPA estimated engineering annualized costs based on a 13 percent nominal (9 percent real) interest rate over 15 years that accounts for tax/depreciation shield using the following equations:

$$\text{Annualized Cost/yr} = I \times ((C \times \text{Capital Cost}) + (P \times O \times \text{Operating Cost}))$$

where:

I	=	Interest factor = 0.1241
C	=	Capital tax/shield depreciation = 0.792
P	=	Present value for operating and maintenance = 9.823
O	=	Operating and maintenance tax shield = 0.593
Capital cost	=	Final capital compliance cost
Operating cost	=	Final operating compliance cost

$$\frac{\text{Annualized Cost}}{t} \quad \frac{\text{Annualized Cost/yr}}{t/\text{yr}}$$

where:

$$t/\text{yr} = \text{kgg/yr} = \text{metric tons (kgg) of unbleached pulp produced by BPK subcategory in 1995} = 29,200,000 \text{ kgg}$$

Table 10-5 presents the final Option A and Option B capital and operating cost estimates broken down to distinguish between direct- and indirect-discharging mills. Nine BPK mills discharge to a POTW (i.e., discharge indirectly) and are subject to PSES, while 75 direct-discharging BPK mills are subject to BAT. Table 10-6 shows the capital and operating cost

ranges for all 84 mills for which costs were developed and the average cost per mill by option (as mentioned previously, two mills in the subcategory were estimated to incur no BAT, PSES, or BMPs costs).

EPA notes that the engineering cost estimates presented in this section, specifically the operating and maintenance costs and annualized costs, differ slightly from the estimates used to calculate this rule's economic achievability. In EPA's economic analysis, operating and maintenance costs include an additional four percent of capital to account for non-plant overhead costs that are not accounted for in the engineering cost estimates. Annualized costs differ slightly because the variables used to calculate the rules economic achievability are more detailed (11). Capital costs in both analyses are equivalent.

10.2.4.2 Technology Components Costs

Tables 10-7 and 10-8 illustrate the cost breakdown for Options A and B, listing the capital and operating contribution of each costed BAT element and each affected process unit to total capital and operating costs, respectively. Table 10-7 shows the capital cost of Option B is approximately twice that of Option A, while Table 10-8 shows the total operating cost for Option B is a fraction of the Option A costs. The total capital costs presented in Table 10-7 do not match the costs presented in Section 10.2.4.1 because the costs in Table 10-7 do not include regional cost factors. Regional cost factors adjust capital costs to account for a mill's geographical location (i.e., rural locations adjusted for lower cost of capital). These factors were applied to the total mill cost after summing all component capital costs and had the net effect of lowering total subcategory capital compliance costs.

The capital and operating costs for several BAT elements and affected process units differ between Option A and B for several reasons. First, Option B includes extended delignification to reduce kappa number prior to bleaching. This, in turn, decreases the amount of chemical required for bleaching to achieve equivalent brightness; therefore, the capital costs for chlorine dioxide generators and the operating costs for chemical demand are considerably lower. The capital and operating costs for hypochlorite elimination are also lower because the decreased chemical demand for Option B enables some mills to avoid replacing hypochlorite stages with a new D-stage. Second, operating oxygen delignification generates more black liquor, which is sent to the recovery system, leading to increased costs for evaporator and recovery boiler upgrades for Option B. Increased black liquor recovery, however, also leads to additional steam generation which reduces operating costs for some mills by decreasing fuel requirements. Lastly, oxygen delignification also consumes more white liquor, creating increased demand on recausticizing systems; therefore, additional recausticizing upgrade costs are associated for Option B and not Option A.

10.2.4.3 Mill Cost Breakdown

Even mills that use Option B technologies (or better) were estimated to incur some costs to comply with BMPs as well as bleach plant and final effluent monitoring costs (although

protected as CBI, Table II itemizes capital and operating costs for each mill, cost group, and the BPK subcategory as a whole in DCN 14508 (10)).

The estimated capital costs are much higher for some mills than others within the same cost group. Many of these high-cost mills require installation of new chlorine dioxide generators and, for Option B, new oxygen delignification systems, which impact capital costs significantly. But, in almost all cases, high costs are attributable to baseline use of hypochlorite. The installation of new D-towers for the elimination of hypochlorite results in high capital costs to comply with either option compared to other mills in the same cost group, although it reduces operating costs by lowering chemical costs.

For both Option A and Option B, EPA's mill-by-mill costing resulted in some mills incurring a net savings in operating and maintenance costs compared to their current status. Three main reasons are responsible for this net savings:

- 1) Bleaching chemical costs are the most influential factor determining whether or not individual mill(s) would achieve a net savings for operating costs. Most mills for which EPA estimated operating cost savings, for either option, are estimated to save significantly on chemical costs compared to their mid-1995 operations. Furthermore, as a result of pre-bleaching lignin reduction, the bleaching chemical requirements are less for Option B than Option A. Hence, the opportunity for savings is greater for Option B.
- 2) EPA's mill-by-mill costing resulted in a net decrease in evaporator hydraulic load for some mills. Because improving brown stock washing decreases the hydraulic load on evaporators and implementation of BMPs increases the weak black liquor (includes process wastewater) hydraulic load on evaporators, if the reduction in hydraulic load due to improved brown stock washing is greater than the increase in hydraulic load due to implementation of BMPs, an operating cost savings will occur at the evaporator because less steam is required to evaporate a smaller total volume of weak black liquor.
- 3) Improving brown stock washing, closing the screen room, and implementing BMPs increases the black liquor recovered per ton of pulp. Burning the additional recovered black liquor in the recovery boiler generates steam, thereby decreasing the amount of steam the mill must generate using supplemental fuel, a net savings.

10.2.4.4 Costs for BMPs

Rationale for Including BMPs - EPA included costs for BMPs as part of the BAT costs for several reasons. First, a portion of the BAT and BMPs compliance costs are

largely inseparable because improved pulping liquor controls can trigger replacement, upgrade, or modification of process units that are also affected by the BAT limitations (e.g., depending on choices made in implementing BAT and BMPs requirements, a mill may determine that the requirements, either singly or together, result in a need to increase evaporator capacity). Incorporating BMPs costs in the BAT estimate recognizes the degree to which BAT and BMPs compliance decision-making is intertwined at mills.

BMPs Cost Estimate - The output of the cost model is an estimate of the cost of complying with BAT or PSES while complying with BMPs. The associated costs of BMPs were removed from the original cost estimates in order to reassess evaporator upgrade costs and recovery boiler capacity adjustment costs, (i.e., anthraquinone pulping or black-liquor oxidation), if such costs would be necessary to comply with BAT or PSES. The "associated costs" incurred through implementation of BMPs include evaporator upgrade costs due to an increased amount of wastewater to evaporate and higher recovery boiler costs due to capacity adjustments to accommodate the incremental increases in thermal load from the recovered black liquor (see Recovery Impacts Document). After removing the impacts of BMPs, recovery boiler costs that may be necessary for the implementation of BAT technologies (e.g., closed screening, new or improved brown stock washing, and extended delignification (Option B only)) were reassessed. The resulting "BAT\PSES-only" capital and operating cost estimates were subtracted from the original cost model output to estimate the BMPs costs for each mill (Table III lists the BAT\PSES-only; BMPs-only; and BAT, PSES, and BMPs capital and operating cost estimates by mill for each option in DCN 14508 (10)).

The total estimated cost of BMP implementation under Option A is slightly greater than BMP implementation cost under Option B (see Table 10-5). This difference lies in the number of mills that would experience the need for recovery capacity adjustment as a result of the two BAT options. Because Option B includes extended delignification, a greater amount of black liquor (albeit of lower heat content) is sent to recovery as compared to Option A. Of the population of mills that currently operate near the maximum thermal capacity of their recovery boilers, a greater number would require capacity increases under Option B than under Option A. When the cost of BMP implementation is examined as an addition to BAT implementation, the added recovery capacity required by BMP implementation is, in the case of a number of mills under Option B, simply an incremental increase on a capacity adjustment that is already needed. In those cases where BAT implementation, rather than BMP implementation, is the "trigger" for recovery capacity adjustment, the cost burden attributable to BMPs is reduced by economy-of-scale and initial cost considerations. In spite of the fact that equivalent thermal load increases are assumed for BMP application to both BAT options, the result is a somewhat reduced BMP implementation cost for Option B when total costs for the BPK subcategory are calculated. The fact that the difference in the calculated total cost for the two options is small demonstrates that this reduced cost of BMP implementation is confined to just a few mills in the subcategory.

10.2.4.5 Total Number of New, Upgraded, or Modified Pulping and Bleaching Technologies

Table 10-9 shows the number of mills for which EPA costed new, upgraded, or modified BAT technologies and other process units (i.e., evaporators, recovery boilers, and recausticizing systems) that are incidentally affected by each option on at least one fiberline. As described in Section 10.2.3, many mills have implemented elements of the BAT options between proposal and mid-1995. As a result, the total that EPA assumes will be necessary for several of these elements has decreased. Several numbers changed (i.e., extended cooking and brown stock washers) because EPA revised costing assumptions (see Section 10.2.2).

10.2.5 Corporate Commitments to Install BAT Elements

After proposal of BAT and PSES in 1993, a number of pulp mill owners and operators announced plans to install new technologies at their facilities. EPA excluded the incurred costs of process changes that were already implemented as of mid-1995 in the cost estimates used to analyze the economic achievability of the rules. However, EPA included the costs of the announced process changes not underway as of July 1, 1995 in the cost estimates used to analyze the economic achievability of the rule. Although EPA included the costs of the process changes announced but not yet underway as of mid-1995 in its final cost estimates, EPA nevertheless evaluated the impact of these costs in an alternative analysis reflecting announced corporate commitments that were not underway as of mid-1995.

Six corporations announced plans to install new technologies at their facilities after proposal of BAT and PSES in 1993. The announced plans involved a total of 24 mills. The process changes were implemented at 12 of these mills by mid-1995, and the costs for these changes were excluded from EPA's analysis of the economic achievability of this rule. Process changes at the other 12 mills were not underway as of July 1, 1995. The costs anticipated for these 12 mills were included in EPA's economic achievability analysis and were also subject to the alternative analysis described below. Table 10-10 lists the corporations announcing commitments for those 12 mills, the process change planned, the number of mills affected by corporate plans, and the reference that contains the corporation decision.

10.2.5.1 Alternative Analysis Reflecting Corporate Commitments

In its alternative analysis, EPA evaluated the impact of corporate commitments by assuming that mills had incurred the costs of the projects that were announced. EPA, therefore, revised a mill's "baseline" technology status to include corporate decisions to install a technology by the end of 1995 if the commitment was confirmed by a corporate statement. EPA performed this alternative analysis in order to determine whether the lower estimated capital costs and operating costs would change EPA's economic impact projections for Options A and B. EPA found that even under the alternative analysis, EPA's projected economic impacts did not change for the two options (12).

Of the 86 mills in the BPK subcategory, corporate commitments were announced but not underway as of July 1, 1995 for process changes at 12 mills. Under this alternative analysis, these mills were credited for operating the announced equipment to implement either ECF bleaching or oxygen delignification followed by ECF bleaching.

The revised "baseline" status of the entire BPK subcategory reflecting this alternative analysis is shown in Table 10-11. The baseline status during proposal and mid-1995 are included for comparison. Assuming all planned process changes are made, the percentage of ECF production will represent approximately half of the total production in the BPK subcategory by the end of 1995.

10.2.5.2 Option A Commitments - ECF Bleaching

Process changes to operate ECF bleaching were announced for 10 mills that operated at less than 100 percent chlorine dioxide substitution as of mid-1995. Under the alternative analysis, the baseline status of each of the 10 affected mills was modified to credit these mills for using 100 percent chlorine dioxide substitution while ensuring other operating conditions remained equivalent (i.e., equivalent chemical charge during each step of the bleach sequence). Other elements of Option A that were not in operation at the affected mills, such as closed screening room, improved brown stock washing, sufficient peroxide or oxygen use for extraction, or elimination of hypochlorite, were not assumed to be instituted as a result of a corporate-level decision to implement ECF bleaching; therefore, costs for these upgrades were included in the alternative analysis cost estimates.

10.2.5.3 Option B Commitments - Oxygen Delignification and ECF Bleaching

Process changes to operate extended delignification followed by ECF bleaching were announced for two mills that did not operate these technologies as of mid-1995. Under the alternative analysis, the baseline status of the two affected mills was modified to credit these mills for using extended delignification with 100 percent chlorine dioxide substitution while ensuring other operating conditions remained equivalent. This alternative analysis did not assume that other elements of Option B that were not in operation during mid-1995 would be implemented as a result of a corporate commitment to implement oxygen delignification and ECF bleaching (i.e., EPA estimated costs for those other elements to calculate the total alternative analysis compliance costs).

10.2.5.4 Compliance Cost Estimates with Corporate Commitments

Overall, under the alternative analysis, adjusting the baseline of the 12 mills affected by corporate commitments resulted in lower estimated capital and operating compliance costs for each option because these mills were credited for already installing the announced BAT elements. Table 10-12 presents a comparison of the final compliance cost estimates of BAT, PSES, and BMPs (from Section 10.2.4.1) and the alternative analysis costs (although protected as CBI, Table IV lists the corporations announcing commitments, the process change planned, the

specific mills affected by corporate plans, and the reestimated compliance cost of each mill in DCN 14508 (10)).

EPA did not use the alternative analysis cost estimates to determine the economic impacts presented in Economic Analysis for the National Emission Standards for Hazardous Air Pollutants for Source Category: Pulp and Paper Production; Effluent Limitations Guidelines, Pretreatment Standards, and New Source Performance Standards: Pulp, Paper, and Paperboard Category—Phase I (11) because the mill-specific baseline data used by EPA reflected technologies in place prior to July 1, 1995. Rather, EPA used the final compliance cost estimates presented in Section 10.2.4.1 to determine the economic impacts of this rule.

10.2.6 Estimated Costs of TCF Bleaching Options

The data available to EPA at promulgation of this rule were insufficient to confirm that TCF processes were technically available for the full range of market products currently served by ECF processes. EPA nevertheless evaluated the costs of retrofitting the U.S. bleached papergrade kraft and soda mills to TCF bleaching to provide perspective on the likelihood of TCF processes being found to be economically achievable when they are shown to be technically available.

10.2.6.1 TCF Options

EPA investigated the costs of two TCF bleach sequences, listed in Table 10-13. TCF bleaching, because it eliminates all use of chlorine-containing compounds, also eliminates the possibility for the formation of TCDD, TCDF, or other chlorinated pollutants. Thus the TCF options do not require the elements of Options A and B that minimize the likelihood of generating TCDD/F during bleaching, i.e., use of dioxin- and furan-precursor free defoamers, and strategies to minimize kappa factor and TCDD- and TCDF-precursors in brown stock pulp. The other common elements of Option A and Option B (adequate chip thickness control, closed brown stock pulp screen room operation, effective brown stock washing, elimination of hypochlorite, oxygen and peroxide enhanced extraction, adequate mixing, and efficient biological wastewater treatment) are necessary for successful operation of a TCF bleach sequence and/or for the control of COD discharges. The TCF bleaching sequences also include medium consistency oxygen delignification. The first TCF bleach sequence, identified in this document as Option C, was based on ozone and peroxide bleaching (OZE_{op}QPZP); the second TCF-bleaching sequence, hereafter called Option D, was based primarily on peroxide bleaching (OQPP).

10.2.6.2 TCF Costing Methodology

Compliance costs for TCF Option C and Option D were estimated by using the model-mill costing approach (as described in Section 10.1.1.1). EPA used a modified version of the cost model to estimate the costs for the 10 model mills to implement the two TCF options. The costs for each model mill were extrapolated for the entire group. The sum of all the groups provided total compliance cost estimates.

10.2.6.3 TCF Estimated Capital, Operating, and Annualized Costs

The capital and operating costs of the two TCF options differ significantly. Option C is characterized by high capital costs and low operating costs. Conversely, Option D is less capital cost intensive and more operating cost intensive. For Option C, an expensive capital cost technology (ozone delignification) is offset with a decrease in peroxide consumption, thereby decreasing operating costs. Option D incurs high operating costs resulting from increased peroxide consumption. In general, the same mill would need at least twice as much peroxide for Option D as for Option C.

Table 10-14 compares the costs of the TCF options to the final costs of Option A and Option B (although protected as CBI, Table V lists the model-mill costing estimates of each mill for Option C and D and the mill-by-mill cost estimates of each mill for Option A and B in DCN 14508 (10).

10.2.7 Voluntary Advanced Technology Incentives Program Costing

To encourage mills to implement and develop more environmentally beneficial technologies, EPA established the Voluntary Advanced Technology Incentives Program to afford direct-discharging mills an opportunity to comply with more stringent regulations in return for regulatory- and enforcement-related incentives, as well as public recognition. The technology bases for the stringent limitations established for this multiple-tier program include elements of BAT Option B, other advanced technologies, and not-yet-developed processes and technologies that will challenge the industry in the future. The Technical Support Document for the Voluntary Advanced Technology Incentives Program (13) provides a detailed description of this program, including the methodology used to estimate costs.

10.2.7.1 Description of Tiers

EPA's program establishes three sets of Advanced Technology BAT limitations for the voluntary program. Each successive tier is characterized by decreased pollutant discharge and effluent flow. Like the baseline BAT regulation, mills entering this program may implement any technology or process change to achieve the Advanced Technology BAT limitations; however, for costing purposes, EPA has identified specific technologies for each tier that would assist mills in achieving the limitations. The first tier, Tier I, employs the same technologies proposed for Option B; therefore, the costs for this tier are assumed to equal the estimates for Option B. Tiers II and III limitations may be achieved by implementing advanced technologies and flow reduction measures using either an ECF or TCF bleaching process (see Technical Support Document for the Voluntary Advanced Technology Incentives Program (13)).

10.2.7.2 Case-Study Mill

The cost estimates for this program are based on a case-study mill. This mill represents a typical Group C mill (see Table 10-1) that produces approximately 1,000 UBMT/d of pulp using a CDE_{op}D bleach sequence. The case-study mill is representative of the type of mill that may commit to this program. Mills of this size benefit from the economy of scale associated with implementing advanced technologies (e.g., two-stage oxygen delignification and ozone delignification that are more costly than either Option A or Option B).

10.2.7.3 Compliance Costs for the Voluntary Advanced Technology Incentives Program

Table 10-15 shows the approximate costs for the case-study mill to achieve each incentive tier. These costs represent maximum estimates since many mills will likely combine elements of the Voluntary Advanced Technology Incentives Program with other modernization projects, thereby reducing actual costs. Since undeveloped technologies and processes may be used in the future to achieve the Advanced Technology BAT limitations, EPA expects these approximate cost projections will be reduced over time. Estimated Option A costs for the case-study mill are included in the table for comparison.

10.3 Compliance Cost Estimates for the Papergrade Sulfite Subcategory

In response to comments received after Proposal, EPA divided the 11 mills in the PS subcategory into three segments:

Segment A: Calcium-, magnesium-, or sodium-based sulfite pulping;

Segment B: Ammonium-based sulfite pulping; and

Segment C: Production of pulp and paper at specialty-grade sulfite mills.

10.3.1 Technology Options

EPA's final analysis of BAT and PSES focused on ECF and TCF technology-based options for three different segments. EPA analyzed one BAT and PSES option for each of the three segments. The BAT option for Segment A (calcium, magnesium, or sodium sulfite) is based on TCF bleaching. The BAT and PSES options for Segment B (ammonium sulfite) and Segment C are based on ECF bleaching. Section 8.2.2 details the technology elements associated with each PS segment.

10.3.1.1 Technology Processes Costed

Table 10-16 lists the process technologies for which EPA estimated costs for each option. EPA also evaluated the costs to upgrade incidentally affected process units (i.e., evaporators for PS mills). For the reasons discussed in Section 10.2.1.2, EPA excluded the costs for the use of precursor-free defoamers. Similarly, EPA considers the use of efficient biological wastewater treatment to be part of baseline technology used today at PS mills. Wastewater from all mills in the subcategory is treated by biological wastewater treatment. These treatment systems are typically operated to remove most of the influent BOD₅ load (see Proposal TDD (1)), and are also capable of substantial reductions in COD and AOX. Therefore, EPA did not include costs for improving wastewater treatment systems to this level of efficiency in its BAT cost estimates.

10.3.2 Cost Model Revisions

EPA used a modified version of the cost model developed for the BPK Subcategory to estimate the costs for the PS mills to implement the BAT and PSES options and BMPs. EPA's proposed BAT and PSES for the PS Subcategory was based on TCF bleaching and oxygen delignification. In response to comments on the proposed rule, EPA eliminated oxygen delignification from the final options. Based on information from PS mills employing TCF bleaching, EPA has determined that oxygen delignification is not necessary for TCF bleaching of papergrade sulfite pulp.

In response to comments on the July 1996 Notice, EPA increased the unit cost of caustic and peroxide (detailed in Section 10.2.2 because this change affected BPK mills as well), leading to increased operating cost estimates for PS mills. In addition, the capital costs for the PS subcategory were recalculated to include regional climate factors for the installation of peroxide storage facilities, chlorine dioxide storage facilities, and new or greenfield chlorine dioxide generators (also detailed in Section 10.2.2).

10.3.3 Compliance Cost Estimates

The following sections detail the results of EPA's compliance cost estimates.

10.3.3.1 Total Costs

EPA used the cost model to estimate BAT compliance costs for each segment with a few exceptions. For one hardwood ammonium sulfite mill, the cost of conversion to TCF bleaching was used to estimate the cost of compliance with the revised BAT/PSES rather than the cost of conversion to ECF bleaching. EPA did so because this mill commented that it could feasibly convert to TCF bleaching without altering its product line. (EPA rejected TCF as a viable BAT option for Segments B and C because it was not shown to provide the full range of products made by all mills in these segments including softwood.) Another hardwood ammonium sulfite mill currently employs TCF bleaching. Mills already operating at TCF were estimated for BMPs

capital costs only. Although protected as CBI, Table VI in DCN 14508 (10) lists the 11 PS mills by segment and the type of bleaching employed at each mill (one PS mill does not employ bleaching). Table 10-17 presents a breakdown of the number of mills costed for each BAT option for each segment.

The cost model was not used to estimate total BAT costs for Segment C. The one mill in this segment provided EPA with an estimate of its cost to convert to ECF bleaching (EPA notes that at the time of promulgation, one Segment A mill prepared business plans to produce specialty-grade pulp; however, EPA estimated its compliance costs as a Segment A mill because that was the mill's status as of mid-1995). EPA reviewed this estimate and determined it was reasonable. All cost information associated with the Segment C mill, including a description and a cost breakdown, is CBI; however, this information is listed in located in Table IX in DCN 14508 (10).

Table 10-18 compares EPA's final BAT costs for all three segments to the estimated costs of the proposed BAT option. EPA estimated that all 11 PS mills will incur costs to comply with BAT, PSES, and BMPs. Proposal costs have been adjusted from 1993 to 1995 dollars to facilitate comparison.

EPA also calculated the annualized costs for the PS subcategory, as discussed in Section 10.2.4.1. Annualized costs, which were calculated on a “per year” and “per ton” basis, are also shown Table 10-18. EPA estimated annualized costs based on a 13 percent nominal (9 percent real) interest rate over 15 years that accounts for tax/depreciation shield using the same equations used to calculate costs for the BPK subcategory (see Section 10.2.4.1) except the total of unbleached pulp production equals 1,280,000 kkg the PS subcategory.

10.3.3.2 Technology Component Costs

EPA estimated capital and operating costs for all mills in the PS subcategory. (Table VII presents the technology component costs and the component costs as a percentage of total costs in DCN 14508 (10)).

10.3.3.3 Mill Cost Breakdown

The final capital and operating costs for each of the 11 to comply with BAT, PSES, and BMPs, although protected as CBI, are listed in Table VIII of DCN 14508 (10).

10.3.3.4 Costs for BMPs

Unlike BPK mills, the BMPs cost estimates for PS mills can be easily separated from the BAT costs. For PS mills, the BAT options had no cost impact on recovery systems. The only estimated recovery system costs result from the impact of BMPs on evaporators. EPA assumed implementation of BMPs does not significantly affect recovery boilers for those mills that operate a recovery boiler. Therefore, no costs for recovery boiler capacity adjustments were

estimated. As a result, estimated cost of implementing BMPs include only the capital and operating costs of BMPs and evaporator upgrades. (The BMPs cost estimates for Segment A and Segment B (without regional factors) and the BMPs cost estimate for Segment C, although protected as CBI, are shown in Tables VIII and IX, respectively, in DCN 14508 (10)).

10.3.3.5 Total Number of New or Upgraded Pulping and Bleaching Technologies

EPA estimated the costs of installing technology options. Table 10-19 shows the number of installations of new or upgraded BAT technologies and affected process units necessary for each PS mills to comply with BAT, PSES, and BMPs for Segment A and Segment B. Segment C is excluded to protect CBI; however, a cost breakdown is located in Table IX in DCN 14508 (10).

10.4 NSPS Compliance Costs

EPA evaluated compliance costs for new sources covered under NSPS limitations. In 40 CFR Part 430.01(j), EPA has set forth a definition of “new source” for the BPK and PS and subcategories. In tailoring a “new source” definition specifically for these subcategories, EPA considered what type of fiber line modifications should be subject to NSPS. A fiber line is a series of operations employed to convert wood or other fibrous raw material into pulp. For the BPK and PS subcategories, the fiber line encompasses pulping, deknottling, brown stock washing, pulp screening, centrifugal cleaning, and multiple bleaching and washing stages. EPA has defined a BPK or PS source as a new source if:

- 1) It is constructed at a site at which no other source is located (i.e., a greenfield mill).
- 2) It completely replaces an existing source. For example, if a fiber line completely replaces an existing fiber line. This definition *does not* include fiber lines enrolled in the Voluntary Advanced Technology Incentives Program (13) or fiber lines modified to comply with baseline BAT.

EPA notes that the following changes *do not* cause an existing fiber line to be considered a new source:

Upgrades of existing pulping operations;

Upgrades or replacement of pulp screening and brown stock pulp washing operations;

Installation of extended cooking and/or oxygen delignification systems or other post-digester, pre-bleaching delignification systems;

Changes in methods or amounts of bleaching chemical applications;

Changes in the types of bleaching chemicals used;

Installation of new bleaching towers to facilitate replacement of sodium or calcium hypochlorite; and

Installation of new bleached pulp washing systems.

- 3) It is substantially independent of an existing source at the same site (i.e., if an existing mill builds and operates an entirely new fiber line that supplements the capacity of an existing fiber line).

10.4.1 NSPS Compliance Costs for the BPK Subcategory

EPA analyzed the costs of two NSPS options for the control of toxic and nonconventional pollutants: Option B and a TCF option (the latter is discussed in Section 10.4.1.1). Option A costs are also presented for comparison. EPA estimated NSPS capital and operating compliance costs using a modified version of the cost model. EPA's costs are for the complete replacement of a fiber line at a case study mill from Group C (see Table 10-1) that produces approximately 1000 UBAD kkg/day of fully bleached pulp using two lines. (EPA notes that the compliance costs estimated for this fiber line replacement would be the same for a fiber line built at a greenfield mill.) EPA estimated compliance costs assuming most of the recovery process units (i.e., recovery boilers and evaporators) are already in place and capable of accommodating the pollutant load contributed from NSPS technologies (except for recausticizing upgrades for which costs were estimated to account for the increased oxidized white liquor requirement of OD, which is part of both Option B and the TCF option).

Table 10-20 presents EPA's estimated capital and operating costs. Unlike the situation for retrofitting existing sources, Option B capital costs are very close to Option A capital costs (i.e., \$202 million versus \$201 million) because the capital cost required for installation of oxygen delignification for Option B at new sources is only slightly greater than the capital cost required for a larger (and, thus, more costly) chlorine dioxide generator for Option A. However, the reduced chemical demand for Option B results in lower operating costs and leads to lower overall annualized cost compared to Option A.

For the BPK subcategory, EPA is also promulgating NSPS for the conventional pollutants BOD₅ and TSS based on the performance of a secondary wastewater treatment system as characterized by the average performance of the best 50 percent of the existing mills in the subcategory using the appropriate level of control (see Section 8.7). EPA estimated the increased capital cost required to comply with the promulgated NSPS for Subpart B rather than the old NSPS discharge limitations. The new BPK subcategory encompasses four old subcategories (former Subparts G, H, I, and P). Table 10-21 compares the old NSPS discharge limitations for two of the former subcategories to the promulgated NSPS BOD₅ discharge limitations. The two

former subparts shown, Subparts I and G, had the lowest and highest BOD₅ limitations of the four subparts that EPA combined into the new Subpart B. EPA estimated additional cost of compliance with the promulgated NSPS over the cost of compliance with the former NSPS for Subparts I and G, in order to estimate the range of increased cost the promulgated NSPS would require.

As discussed in Section 11 of this report, compared to Option A, implementation of Option B technology will reduce the discharge of BOD₅ from the pulping and bleaching processes. EPA accounted for this BOD₅ reduction when estimating the incremental cost of the promulgated NSPS for BOD₅.

EPA determined that the incremental capital cost of complying with the selected NSPS for all pollutants (i.e., Option B plus conventional pollutant control) is 0.50 to 2.0 percent greater than the capital cost of a new fiber line using Option A that complies with the previous NSPS limitations for conventional pollutants.

10.4.1.1 TCF Technology as the Basis of NSPS for the BPK Subcategory

While Section 10.2.5 shows that retrofitting TCF technology is much more costly than retrofitting ECF technologies, EPA notes that recent data from the construction of greenfield TCF mills outside the U.S. suggest that the costs of such a fiber line may be less than that of a greenfield ECF fiber line.

Table 10-20 includes the capital and operating costs required for a case-study mill to install a greenfield fiber line using TCF technologies as the basis for minimizing new source toxic and nonconventional pollutants. EPA notes that greenfield TCF fiber lines are less expensive because they:

- Obviate the costs required for chlorine dioxide manufacturing;

- Require less physical space; and

- Use bleaching towers that may be constructed of more inexpensive grades of stainless steel compared to ECF bleaching towers which require more expensive alloys and plastics to resist the corrosive action of chlorine dioxide (and degradation products).

TCF technologies, however, are not demonstrated for the full range of bleached kraft pulp production at this time. As a result, EPA intends to gather additional data to determine whether TCF technologies may be available for the full range of market products subsequent to this rulemaking. EPA will determine whether to propose revisions to NSPS based upon TCF and, if appropriate, flow reduction technologies.

10.4.1.2 NSPS Compliance Costs for PS Subcategory

The technology basis of NSPS for the three segments of the PS subcategory are the same as the model BAT for those segments. At this time, EPA *is not* promulgating NSPS for the control of conventional pollutants. As presented in Section 10.4.1 above, EPA found that for the BPK subcategory the cost of NSPS technology is an insignificant fraction of the capital cost of a new fiber line (i.e., 0.50 to 2.0 percent). Although EPA had no data specific to papergrade sulfite mills with which to estimate the costs of a new fiber line for a PS mill, based on the analysis of NSPS costs for the BPK subcategory, EPA expects that the NSPS costs for a PS fiber line would also be an insignificant fraction of the capital costs.

EPA also notes that typical costs of including NSPS technology at a new source mill are substantially less than the costs of retrofitting existing mills. Moreover, the reduced operating costs for the NSPS option allow firms to recover the capital cost associated with the NSPS technology.

10.5 References

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3. BAT Baseline Database. Data on mill characteristics and operations collected by EPA through the 1990 census questionnaire, subsequent contacts with mills by phone, fax, and site visits. Record Section 21.10, DCN 13590.
4. BAT Cost Model Support Document. Report prepared by Radian Corporation for EPA. Pulp, Paper, and Paperboard Rulemaking, Record Section 23.1.2, DCN 13953, 1996.
5. Cartwright, G. Memorandum: Costing Revisions Made Since Publication of July 15, 1996 Notice of Data Availability (61 FR 3687). Prepared by ERG for EPA. Record Section 23.1.2, DCN 14493, 1997.
6. Analysis of Impacts of BAT Options on the Kraft Recovery Cycle (Recovery Impacts Document). Report prepared by ERG and N. McCubbin for EPA. Record Section 23.1.2, DCN 14490, 1997.
7. Comment Response Document. EPA, Washington DC, Record Section 30.11, DCN 14497, 1997.

8. Telephone conversation with Mr. W. Gillespie of NCASI. Record Section 23.1.1, DCN 14651, May 5, 1997.
9. EPA Site Visit Report. Prepared by Radian Corporation for EPA. Record Section 7.4, DCN 7654.
10. Classified Appendix for Section 10 of the Supplemental Development Document (Costs). Prepared by ERG for EPA. Record Section 23.1.3, DCN 14508.
11. Economic Analysis for the National Emissions Standards for Hazardous Air Pollutants for Source Category: Pulp and Paper Production; Effluent Limitations Guidelines, Pretreatment Standards, and New Source Performance Standards: Pulp, Paper, and Paperboard Category - Phase I. Prepared by ERG for EPA. Record Section 30.5, DCN 14649, 1997.
12. Kaplan, M. Effects of Reductions in Costs from Corporate Commitments. Prepared by ERG for EPA. Record Section 27.4.4, DCN 14375, January 1997.
13. Technical Support Document for the Voluntary Advanced Technology Incentives Program. EPA, Washington DC, Record Section 22.8, DCN 14488, 1997.

Table 10-1**Baseline Technology Groups for BPK Mills**

Group ^(a)	Number of Mills	Example Bleaching Sequences	Costing Criteria			
			EC or OD? ^(b)	Chlorine Used?	Hypo-chlorite Used?	Percent of ClO ₂ Used
A	3	CEH ^(c)	No	Yes	Yes	none on site
B	5	CEHD, CED	No	Yes	Maybe	0 in first stage
C	32	C/DEH, C/DEHDED, C/DED, C/DEDED	No	Yes	Maybe	< 70
D	8	D/CEDED, D/CEopDEpD	No	Yes	Maybe	70 to 100
E	12	DEDED, DEopDD	No	No	No	100
G	9	EC or OD with C/DEDED, D/CEDED	Yes	Yes	Maybe	< 100
H	7	EC or OD with DEDED, DEopDD	Yes	No	No	100
I	3	EC and OD with C/DEDED, D/CEDED	Both	Yes	Maybe	< 100
J	4	EC and OD with DEDED, DEopDD	Both	No	No	100
K	1	TCF ^(c)	Maybe	No	No	none

^(a)Group E = BPK BAT Option A, Group H = BPK BAT Option B. Group F was eliminated because no mills belong to the group.

^(b)EC is extended cooking (e.g., MCC, EMCC, RDH, or SuperBatch) and OD is oxygen delignification.

^(c)Mills using this bleaching sequence do not usually bleach to full brightness.

Table 10-2**Bleached Papergrade Kraft and Soda Process Technologies Costed**

Mid-1995 Costing Effort Option Number	Process Technologies Costed ^(a)
A	<ul style="list-style-type: none"> ∩ Improved brown stock washing ∩ Closed brown stock screening ∩ Hypochlorite elimination ∩ Oxygen and peroxide enhanced caustic extraction (Eop) ∩ 100% chlorine dioxide substitution^(b) (ECF bleaching) ∩ Implementing strategies to minimize kappa factor and brown stock precursors^(c)
B	<ul style="list-style-type: none"> ∩ Improved brown stock washing ∩ Closed brown stock screening ∩ Hypochlorite elimination ∩ Oxygen and peroxide enhanced caustic extraction (Eop) ∩ 100% Chlorine Dioxide Substitution^(b) (ECF bleaching) ∩ Implementing strategies to minimize kappa factor and brown stock precursors^(c) ∩ Kappa number of 15 for softwood and 10 for hardwood entering the first bleaching stage through addition of oxygen delignification and/or extended cooking^(d)

^(a)BAT/PSES technology options also include use of TCDD and TCDF precursor free defoamers, adequate chip thickness control, and efficient biological wastewater treatment; however, costs were not included (see Section 10.2.1.2).

^(b)The costs for high shear mixing are included in the capital costs for increased chlorine dioxide substitution.

^(c)Mills may use many strategies to achieve this technology element. EPA estimates include oxygen and peroxide reinforced extraction; improved brown stock washing; closed screening; and high shear mixing and control, which are technologies integral for implementing strategies for minimizing kappa factor and brown stock precursors.

^(d)Option B is defined as extended delignification resulting in a kappa number below 20 for softwood and below 13 for hardwood. Lower targets were used for costing to reflect the capability of modern OD systems (refer to Section 8.2.1.2).

Table 10-3**Baseline Status of Bleached Papergrade Kraft and Soda Mills**

	Percent of Total Kraft Production at Proposal (%)	Percent of Total Kraft Production at Mid-1995 (%)	Baseline Estimate at Proposal		Mid-1995 ^(a)
			# Mills	# Lines	
100% Substitution Option A (w/o OD or EC)	NC	17.6	# Mills	NC	14
			# Line	NC	24.5
100% Substitution Option B (w/ OD and/or EC) ^(b)	NC	15.6	# Mills	NC	14
			# Lines	NC	16.5
Total ECF Production (100% Substitution) ^(b)	6.6	33.2	# Mills	6	27 ^(c)
			# Lines	9	41
Hypochlorite on Site (on at least one line)	37.2	17.6	# Mills	37	20
Oxygen Delignification Only (OD) ^(b)	11.7	17.3	# Mills	9	14
			# Lines	13	20
Extended Cooking Only (EC) ^(d)	17.3	5.2	# Mills	12	6
			# Lines	22	6.75
OD and EC	10.7	9.4	# Mills	8	7
			# Lines	10	8
Total Extended Delignification (OD, EC, or OD and EC) ^(e)	NC	32.6	# Mills	NC	28
			# Lines	NC	35.75
			Total Mills ^(f)	87	84

NC = not counted.

^(a)Fractions denote the amount of time a technology is used on a swing line.

^(b)Includes ozone-ECF production.

^(c)Because one mill has a line at Option A and one line at Option B, the number of mills at Option A plus the number of mills at Option B does not equal the total number of mills with ECF production.

^(d)As noted in Section 10.2.2, the number of mills and lines using EC was overcounted at proposal.

^(e)Includes ozone-ECF and TCF production.

^(f)Refer to Section 4 for a description of the subcategory profile (i.e., total number of mills) at proposal and mid-1995.

Table 10-4**Comparison of Bleached Papergrade Kraft and Soda BAT, PSES, and BMPs Compliance Cost Estimates**

Cost	BAT, PSES, BMPs, and Closed Screening Cost Estimated at Proposal^(a)	Option A (BAT, PSES, and BMPs)	Option B (BAT, PSES, and BMPs)
Capital [\$ million]	2,160	966	2,130
Engineering O&M [\$ million/yr] ^(b)	10.6	113	2.02
Annualized Cost [\$ million/yr]	223	176	211
Annualized Cost [\$ /UBMT] ^(c)	7.50	6.04	7.22

^(a)See discussion of BMP proposal cost estimate in Section 10.2.4.4.

^(b)The engineering operating and maintenance costs presented in this table differ from the annual costs presented in EPA's economic analysis (10) because the annual costs include an additional four percent of engineering capital cost to account for non-plant overhead costs.

^(c)Using 29.2 million UBMT/yr for Options A and B, which is the mid-1995 total production for 84 BPK mills.

Table 10-5**BAT, PSES, and BMPs Compliance Cost Estimates for Direct and Indirect Discharging BPK Mills**

	Option A				Option B			
	Capital [\$ million]	O&M [\$ million/yr]	Annualized Cost [\$ /yr]	Annualized Cost [\$/t] ^(b)	Capital [\$ million]	O&M [\$ million/yr]	Annualized Cost [\$ /yr]	Annualized Cost [\$/t] ^(b)
PSES	85.5	4.56	137.6	4.71	255	(7.87)	173	5.92
BAT	697	79.3			1,690	(18.1)		
BMPs ^(a) - direct discharging mills	162	26.9	38.9	1.33	159	26.0	38.0	1.30
BMPs ^(a) - indirect discharging mills	21.1	2.05			21.2	2.0		
Total^(c)	966	113	176	6.04	2,130	2.02	211	7.22

() Represents cost savings.

^(a)BMPs cost estimates for Option A and Option B differ. Refer to Section 10.2.4.4 for explanation.

^(b)Using 29.2 million UBMT/yr for Options A and B, which is the total mid-1995 production for the BPK Subcategory.

^(c)Total may not equal sum of column costs due to rounding.

Table 10-6**Range of Estimated BAT, PSES, and BMPs Costs for the 84 Bleached Kraft Mills**

	Option A		Option B	
	Capital [\$ million]	O&M [\$ million/yr]	Capital [\$ million]	O&M [\$ million/yr]
Range (\$/mill)	0.380 to 67.7	(2.75) to 8.31	0.380 to 95.8	(6.08) to 6.70
Total Cost	966	113	2,130	2.02
Average Cost Per Mill	11.5	1.35	25.3	0.02

() Represents cost savings.

Table 10-7**Component Capital Costs as Percentage of Total Capital Cost for the Bleached Papergrade Kraft and Soda Mills**

Capital Cost Component	Total Capital Cost for Component [\$]		Percent of Overall Capital Cost	
	Option A	Option B	Option A	Option B
Kappa Reduction (OD/EC)	NA	1,514,011,241	NA	61.9
BMPs ^(a)	151,230,000	151,230,000	13.6	6.2
Recovery Boiler	8,688,694	10,638,969	0.8	0.4
Evaporator	53,588,584	53,588,584	4.8	2.2
Closed Screening/Brown Stock Washing	199,812,266	199,812,266	17.9	8.2
ClO ₂ Generator	429,048,659	262,360,284	38.5	10.7
Adding Eop	35,765,522	35,765,522	3.2	1.5
Adding D-Towers (Eliminate Hypochlorite)	220,220,635	164,556,880	19.8	6.7
Recausticizing	NA	37,824,295	NA	1.5
Monitoring	16,008,404	16,008,404	1.4	0.7
Total Capital Cost^(b)	1,114,362,762	2,445,796,444	100	100

NA = Not applicable to option.

^(a)See Section 10.2.4.4 for BMPs cost estimate discussion. The BMPs line item costs only reflect capital and operating costs for implementing spill prevention and control systems. The cost impact on the recovery boiler or the evaporator set from implementing BMPs is included in the line items for those areas.

^(b)Because the regional cost factor is not applied at the component cost level, to estimate component costs as a percentage of total cost the total capital cost estimates are shown without the regional cost factor. As a result, the total capital cost estimates shown above appear higher than the BAT, PSES, and BMPs final compliance cost estimates shown throughout this section. In addition, totals may not equal the sum of component costs due to rounding.

Table 10-8**Component Operating Costs as Percentage of Total Operating Cost for the Bleached Papergrade Kraft and Soda Mills**

Operating Cost Component	Total Operating Cost Component [\$/yr]				Percent of Overall Operating Cost (%)			
	Option A		Option B		Option A		Option B	
	Cost	Savings	Cost	Savings	Cost	Savings	Cost	Savings
Kappa Reduction (OD/EC)	NA	NA	\$95,782,769	---	NA	NA	65.2	---
BMPs	\$6,384,600	---	\$6,384,600	---	5.3	---	4.3	---
Recovery Boiler	---	\$8,461,087	---	\$9,702,373	---	100.0	---	6.7
Evaporator	\$9,416,761	---	\$9,416,761	---	7.8	---	6.4	---
Closed Screening/Brown Stock Washing	\$2,021,791	---	\$2,021,791	---	1.7	---	1.4	---
ClO ₂ Generator	\$10,538,157	---	\$7,204,390	---	8.7	---	4.9	---
Adding Eop	\$1,822,350	---	\$1,851,941	---	1.5	---	1.3	---
Adding D-Towers (Eliminate Hypochlorite)	\$4,764,793	---	\$3,482,789	---	3.9	---	2.4	---
Recausticizing	NA	NA	\$756,486	---	0.0	---	0.5	---
Monitoring (Bleach Plant and Final Effluent)	\$9,421,664	---	\$9,421,664	---	7.8	---	6.4	---
Additional Chemical Cost Over Base	\$72,059,428	---	---	\$135,243,178	59.4	---	---	93.3
Supervision and Technical Support	\$4,828,048	---	\$10,645,282	---	4.0	---	7.2	---

Table 10-8 (Continued)

Operating Cost Component	Total Operating Cost Component [\$/yr]				Percent of Overall Operating Cost (%)			
	Option A		Option B		Option A		Option B	
	Cost	Savings	Cost	Savings	Cost	Savings	Cost	Savings
Subtotal for Operating Costs	\$121,257,592	---	\$146,968,473	---	100	---	100	---
Subtotal for Operating Savings	---	\$8,461,087	---	\$144,945,551	---	100	---	100
Total Operating Cost and Percentages^(b)	\$112,796,505		\$2,022,922		100.0	100.0	100.0	100.0

NA = Not applicable for the option.

^(a)See Section 10.2.4.4 for BMPs cost estimate discussion. The BMPs line item costs only reflect capital and operating costs for implementing spill prevention and control systems. The cost impact on the recovery boiler or the evaporator from implementing BMPs is included in the line items for those areas.

^(b)Totals may not equal the sum of component costs due to rounding.

Table 10-9**Bleached Papergrade Kraft and Soda Mill Technology Upgrades Costed**

		Proposal^(a) (number costed)	Final (number costed)
Screen Room Upgrades (Number of Mills)			
Option A		CS	40
Option B		CS	40
Brown Stock Washer Upgrades (Number of Mills)			
Option A	Add'l Stages	37	22
	New Washers	5	1
Option B	Add'l Stages	37	22
	New Washers	5	1
Evaporator Upgrades (Number of Mills)			
Option A		NC	20
Option B		NC	20
Chlorine Dioxide Generator Upgrades (Number of Mills)			
Option A	Greenfield	6	5
	New	56	40
	Upgrade	NC	8
	Conversion	18	5
Option B	Greenfield	6	5
	New	48	28
	Upgrade	NC	3
	Conversion	17	4
Oxygen Delignification Installations			
Option A	# Mills	NA	NA
	# Lines	NA	NA
Option B	# Mills	56	65
	# Lines	96	96
Extended Cooking Installations (All Retrofits)			
Option A	# Mills	NA	NA
	# Lines	NA	NA
Option B	# Mills	3	3
	# Lines	3	3

Table 10-9 (Continued)

		Proposal^(a) (number costed)	Final (number costed)
Recovery Boiler Capacity Adjustments (Number of Mills)^(b)			
Option A	Anthraquinone	0	9
	O ₂ Black Liquor Oxid.	NC	13
	Upgrade	0	1
	Total Number of Capacity Adjustments	0	23
Option B	Anthraquinone	55	10
	O ₂ Black Liquor Oxid.	NC	16
	Upgrade	55	1
	Total Number of Capacity Adjustments	55	27
Mills Adding Eop (Number of Mills for at Least One Line)			
Option A		64	49
Option B		64	49
Mills Adding New D-Stage to Eliminate Hypochlorite Bleaching (Number of Mills)			
Option A		32	12
Option B		27	9
Recausticizing Upgrades (Number of Mills)			
Option A		NA	NA
Option B		NC	15

^(a)Proposal Option 2A = Final Option A, Proposal Option 3A or 4 = Final Option B.

^(b)EPA revised costing methodology after proposal for estimating recovery boiler costs (see BAT Cost Model Support Document) based on data presented in RID.

CS = costed separately. Model included closed screening for mid-1995 analysis. Refer to Section 10.2.2 for affect on brown stock washer estimate.

NA = not applicable for option

NC = not costed at proposal or notice. Refer to Section 10.2.2 for explanation.

Table 10-10

Corporations Announcing Commitments to Upgrade Process Technologies to Include BAT Elements After July 1, 1995

Corporation	Number of Affected Mills	Announced Commitment	Reference
International Paper	8	100% ClO ₂	DCN 14326 Section 23.1.1
Champion International	1	OD/100% ClO ₂	DCN 13632 Section 23.1.1
Georgia-Pacific	1	OD/100% ClO ₂	DCN 13102 Section 23.1.1
Westvaco	1	100% ClO ₂	DCN 13600 Section 23.1.1
Willamette Industries	1	100% ClO ₂	DCN 13641 Section 23.1.1

Table 10-11**Baseline Status of Bleached Papergrade Kraft and Soda Mills Including Adjustment for Corporate Commitments to Install BAT Elements**

	Percent of Production (%)			Baseline Estimate at Proposal		Mid-1995 ^(a)	Mid-1995 w/ Commitments ^(a)
	At Proposal	Mid-1995	After Commitments				
100% Substitution Option A (w/o OD or EC)	NC	17.6	25.5	# Mills	NC	14	22
				# Line	NC	24.5	38.75
100% Substitution Option B (w/ OD and/or EC) ^(b)	NC	15.6	21.4	# Mills	NC	14	17
				# Lines	NC	16.5	22.5
Total ECF Production (100% Substitution) ^(b)	6.6	33.2	46.9	# Mills	6	27 ^(c)	38
				# Lines	9	41	61
Hypochlorite on Site (on at least one line)	37.2	17.6	17.6	# Mills	37	20	20
Oxygen Delignification Only (OD)	11.7	17.3	18.8	# Mills	9	14	15
				# Lines	13	20	21
Extended Cooking Only (EC) ^(d)	17.3	5.2	5.2	# Mills	12	6	6
				# Lines	22	6.75	6.75
OD and EC	10.7	9.4	9.4	# Mills	8	7	7
				# Lines	10	8	8
Total Extended Delignification (OD, EC, or OD and EC) ^(e)	NC	32.6	34.1	# Mills	NC	28	29
				# Lines	NC	35.75	36.75
				Total Mills ^(f)	87	84	84

NC = Not counted.

^(a)Fractions denote the amount of time a technology is used on a swing line.

^(b)This includes ozone-ECF bleaching mill.

^(c)Because one mill has a line at Option A and one line at Option B, the number of mills at Option A plus the number of mills at Option B does not equal the total number of mills with ECF production.

^(d)As noted in Section 10.2.2, the number of mills and lines using EC was overcounted at proposal.

^(e)This includes ozone-ECF and TCF production.

^(f)Refer to Section 4 for a description of the subcategory profile (i.e., total number of mills) at proposal and mid-1995.

Table 10-12

**Bleached Papergrade Kraft and Soda Total BAT, PSES, and BMPs Cost Estimates with Process Upgrades
Announced but not Underway by Mid-1995**

	Option A				Option B			
	Capital [\$ million]	O&M [\$ million/yr]	Annualized Cost [\$ /yr]	Annualized Cost [\$/t] ^(a)	Capital [\$ million]	O&M [\$ million/yr]	Annualized Cost [\$ /yr]	Annualized Cost [\$/t] ^(a)
Mid-1995 Baseline	966	113	176	6.04	2,130	2.02	210	7.22
Baseline Adjusted for Alternative Analysis	882	74.1	140	4.80	2,050	(31.4)	179	6.14

() Represents cost savings.

^(a)Using 29.2 million UBMT per year for Options A and B, which is the mid-1995 total production for the Bleached Papergrade Kraft and Soda Subcategory.

Table 10-13**TCF Process Technologies Costed**

TCF Option	Process Technologies Costed
Ozone-based (Option C)	<ul style="list-style-type: none"> ∩ Improved brown stock washing ∩ Closed brown stock screening ∩ Kappa number of 10 for softwood and 6 for hardwood entering the first bleaching stage though oxygen delignification AND anthraquinone addition to the digester ∩ Ozone bleaching (delignification) ∩ Oxygen and peroxide enhanced caustic extraction ∩ Substitution of peroxide bleaching for all chlorinated bleaching compounds (TCF bleaching)^(a) ∩ Chelant addition ∩ Bleach Sequence: OZEopQPZP
Peroxide-based (Option D)	<ul style="list-style-type: none"> ∩ Improved brown stock washing ∩ Closed brown stock screening ∩ Kappa number of 10 for softwood and 6 for hardwood entering the first bleaching stage though addition of oxygen delignification AND anthraquinone addition to the digester ∩ Substitution of peroxide bleaching for all chlorinated bleaching compounds (TCF bleaching)^(a) ∩ Chelant addition ∩ Bleach sequence: OQPP

^(a)The costs for mixing are included in the capital costs for totally free chlorine bleaching.

Table 10-14

Comparison of BAT and PSES Option Costs for the Bleached Papergrade Kraft and Soda Subcategory

	Option A^(a) (ECF)	Option B^(a) (OD- ECF)	Option C^(b) (Ozone-TCF)	Option D^(b) (Peroxide-TCF)
Capital Cost [\$ million]	966	2,130	5,630	3,090
Operating Costs [\$ million/yr]	113	2.02	849	660
Annualized Cost [\$ million/yr]	176	211	1,170	780
Annualized Cost [\$ /UBMT]	6.04	7.22	40.0	26.7

^(a)Estimated using mill-by-mill costing approach.

^(b)Estimated using the model-mill costing approach detailed in Section 10.1.1.1.

Table 10-15**Case Study Mill Incentive Tier Costs**

	Option A	Tier I	Tier II	Tier III
TCF Alternative				
Capital Cost [\$ million]	NA	NA	88.0	108
O&M [\$ million/yr]	NA	NA	0.56	2.65
Annualized Cost [\$/UBMT]	NA	NA	23.9	33.8
ECF Alternative				
Capital Cost [\$ million]	18.5	44.0	51.6	70.9
O&M [\$ million/yr]	3.34	0.876	(0.682)	(0.134)
Annualized Cost [\$/UBMT]	11.5	13.4	12.4	19.1

() Represents a savings.

NA = Not applicable because option/tier is not based on this type of bleaching process. However, EPA expects that mills employing a TCF bleaching process will be able to achieve at least the Tier I Advanced Technology BAT limitation for AOX and may be able to achieve the other ultimate Tier I limitations as well.

Table 10-16**Papergrade Sulfite Technology Process Technologies Costed**

Segment	Bleaching Option	Process Technologies Costed
A - Calcium-, Magnesium-, or Sodium-Based Sulfite Pulping	TCF	<ul style="list-style-type: none"> ˘ Totally chlorine free bleaching (bleaching with peroxide) ˘ Elimination of hypochlorite ˘ Oxygen and peroxide enhanced extraction ˘ Improved pulp cleaning
B - Ammonium-Based Sulfite Pulping	ECF	<ul style="list-style-type: none"> ˘ 100% chlorine dioxide substitution (ECF bleaching)^(a) ˘ Hypochlorite elimination ˘ Peroxide enhanced extraction
C - Specialty-Grade Sulfite Pulping	ECF	<ul style="list-style-type: none"> ˘ 100% chlorine dioxide substitution (ECF bleaching)^(a) ˘ Hypochlorite elimination ˘ Oxygen and peroxide enhanced extraction

^(a)The costs for high shear mixing are included in the capital costs for increased chlorine dioxide substitution.

Table 10-17**ECF Versus TCF Costing for the Papergrade Sulfite Mills**

Segment A - Calcium, Magnesium, or Sodium Sulfite BAT Option = TCF	
Total Mills	6 ^(a)
Number of mills costed for conversion to TCF	4
Number of mills currently bleaching at TCF (estimated costs for BMPs, evaporator, monitoring)	1
Number of mills producing papergrade sulfite pulp, without bleaching (estimated costs for BMPs, monitoring)	1
Segment B - Ammonium Sulfite BAT Option = ECF	
Total mills	4 ^(b)
Number of mills costed for conversion to ECF	1
Number of mills costed for conversion to TCF (one mill commented they could feasibly convert to TCF bleaching with lower cost)	1
Number of mills currently bleaching at or committed to ECF (estimated costs for BMPs, monitoring)	1
Number of mills currently bleaching at TCF (estimated costs for BMPs, monitoring)	1
Segment C BAT Option = ECF	
Total mills	1
Number of mills costed for conversion to ECF	1

^(a)One mill currently producing papergrade sulfite pulp has prepared business plans to produce specialty-grade pulp but was costed as a Segment A mill because that was the mill's status as of mid-1995.

^(b)One mill recently ceased papergrade sulfite operations; however, EPA includes the costs of this mill because as of mid-1995 the mill was producing papergrade sulfite pulp. EPA also estimated the costs for the nine direct discharging PS mills that are subject to BAT, which are CBI; however, this information is listed in Table VIII in DCN 14508 (8)).

Table 10-18**Total BAT, PSES, and BMPs Papergrade Sulfite Compliance Cost Estimates
(All Segments)**

	BAT, PSES, and BMPs Compliance Cost Estimates			
	Capital [\$ million]	O&M [\$ million/yr]	Annualized Cost [\$ million/yr]	Annualized Cost [\$/t]
Cost Estimated at Proposal	88.3	17.8	21.5	19.06
Cost Estimates for Mid-1995 ^(a)	73.8	4.59	10.6	8.24

^(a)Although a cost breakdown for each segment is not presented because this information is CBI, this information is listed on Table VIII in DCN 14508 (8).

Table 10-19**Papergrade Sulfite Technology Upgrades**

	Segment A (Calcium, magnesium, or sodium sulfite) BAT Option = TCF	Segment B (Ammonium sulfite) BAT Option = ECF	Segment C (Specialty Grade)
Installation of Final P-Stage	4	1	ND
Chlorine Dioxide Generator Upgrades	0	1	ND
Add New D-Tower (Eliminate Hypochlorite)	0	1	ND
Add Eop	3	2	ND
Evaporator Upgrades	3	3	ND

ND = Not disclosed to protect confidential business information. The technologies for the Segment C mill are identified in Table IX in DCN 14508 (8).

Note: Technology upgrades included in proposal cost estimates are not presented because the proposed option is not comparable to the revised options.

Table 10-20**NSPS Compliance Costs**

Toxic and Conventional Pollutant Control			
	Option A	Option B	TCF
Typical Bleach Sequence	DE _{op} DnD	OODE _{op} D	OO(Q _w)OP(ZQ)(PO)
Capital Costs (\$ million)			
Unbleached Pulp Mill			
New Continuous Digester	53.0	53.0	53.0
New Brown Stock Washing Line	19.4	19.4	19.4
New Closed Screening System	5.94	5.94	5.94
Building and Infrastructure	6.00	6.00	6.00
Bleach Plant			
OD System	--	29.4	29.4
New D-Stage Tower and Washer	15.5	15.5	--
New Eop Stage with Washer	11.3	11.3	--
New D-Stage Tower and Washer	15.5	15.5	--
New E2 Stage with Washer	10.2	--	--
New D-Stage Tower and Washer	15.5	--	--
Chelant Stage with Press Washer	--	--	4.77
Pressurized PO stage with Washer	--	--	9.55
High Consistency Ozone System	--	--	25.7
Pressurized PO Stage with Washer	--	--	9.55
Chelant Supply System	--	--	0.200
Peroxide Unloading and Storage	0.125	0.125	0.125
Monitoring	0.124	0.124	--
Buildings	12.0	12.0	6.00
Miscellaneous Infrastructure	13.6	14.4	15.9
Greenfield ClO2 Generator	21.6	16.2	--
ClO2 Storage	1.47	1.06	--
Upgrade Reausticizing	--	3.10	4.65
Total Capital Cost	201	202	190
Operating Costs			
Annualized Costs (\$/t of pulp)	112	102	96.9
Annual Cost (\$/year)	39,200,000	35,600,000	33,900,000
Conventional Pollutant Control (\$)			
Capital Cost (\$)	162,000 to 3,400,000		

Table 10-21**NSPS Limitations**

NSPS	Former NSPS Limitations (kg/kkg)		Promulgated NSPS (kg/kkg)	
	BOD5	TSS	BOD5	TSS
Old Subpart I - Fine Bleached Kraft ^(a)	2.22	---	---	---
Old Subpart G- Market Bleached Kraft ^(a)	4.02	---	---	---
New Subpart B - Bleached Papergrade Kraft	---	---	1.73	---

^(a)These subcategories were distinct in the previous rulemaking; however, all previous bleached kraft subcategories have been reorganized in one subcategory, Subpart B, by this rulemaking. These two former subcategories represent the range of limitations that are being revised by the promulgation of the limitation for Subpart B in this rulemaking.

SECTION 11

NON-WATER QUALITY ENVIRONMENTAL IMPACTS

11.1 Impacts of BAT, PSES, and BMPs on the Bleached Papergrade Kraft and Soda Subcategory

This section describes EPA's estimate of the water quality environmental impacts of the final options considered for effluent limitations guidelines and standards for the bleached papergrade kraft and soda subcategory of the pulp and paper industry. The non-water quality environmental impacts for the incentives tiers are presented in detail in the Technical Support Document for the Voluntary Advanced Technology Incentives Program (1). Major impacts are summarized in Table 11-1 and discussed further below.

The estimated effects of BAT, PSES, and BMPs on mill effluents, atmospheric discharges, and energy consumption discussed in this section are based on the assumption that all mills adopt the Option A or Option B process technologies described in Sections 8.2.1.1 and 8.2.1.2, respectively. This section also presents EPA's analysis of non-water quality environmental impacts for TCF bleaching processes.

11.1.1 Summary of Impacts on Wood Consumption

As discussed in detail in Section 11.2, EPA estimates wood consumption could be reduced by up to 0.3 percent by the implementation of either Option A or Option B and BMPs. The reduction in wood consumption is a result of the reduction in losses of useful fiber associated with the recovery of spills (BMPs) and improvements in washing and screening of pulp.

11.1.2 Summary of Impacts on Wastewater Flow, BOD₅, and Solid Waste Generation

As discussed in detail in Section 11.3, the BAT, PSES, and BMP options analyzed by EPA will result in progressive reductions in process wastewater flows and pollutant loadings. Generally, the reductions for Option B are greater than Option A.

The average US bleached kraft and soda mill discharges approximately 95 m³/kkg of treated effluent. EPA estimated that Option A could result in process wastewater flow reductions ranging from 10 to 50 m³/kkg. The greater reductions would be realized in mills presently discharging the highest flows. Option B would result in an additional process wastewater reduction of up to 15 m³/kkg at mills with the highest effluent flows. See Section 11.3 for a detailed discussion.

EPA also estimates that raw (untreated) BOD₅ loads would be reduced by 21 percent through implementation of Option A, and further (31 percent) by Option B. This

reduction would have only a modest effect on treated effluent discharges, but would reduce energy consumption and solid waste generation. Energy equivalent to approximately 680,000 bbls oil would be saved in the waste treatment plants by Option A and 1,000,000 bbls oil by Option B (see Section 11.4.2.2).

EPA estimates that the reduction in BOD₅ load to activated sludge wastewater treatment plants (WWTP) will result in a 2 percent reduction in the generation of secondary wastewater treatment sludge for Option A. Option B will result in a 3 percent reduction.

11.1.3 Summary of Impacts on Energy Consumption

Section 11.4 of this report provides the results of EPA's detailed analysis of the energy requirements of BMPs combined with Option A and Option B. As detailed in Section 11.4, bleached kraft mills generate a significant proportion of the energy necessary to operate pulping and bleaching processes through the chemical recovery process. Implementation of Option A or Option B in combination with BMPs would increase recovery of organic material with a resulting increase in energy generated at the mill.

The most useful measures of kraft mill energy performance are the quantity of energy purchased, including energy associated with off-site manufacturing of bleaching chemicals, and energy needed for mill effluent treatment. Implementing Option A would increase purchased energy consumption by approximately one percent, while implementing Option B would reduce it by one percent.

11.1.4 Summary of Impacts on Atmospheric Emissions

Section 11.5 of this report provides the results of EPA's detailed analysis of the air pollution impacts of Option A and Option B. The process changes related to these options decrease the emissions of some HAPs but have little impact on others. Overall, the emission of total HAPs from the sources controlled by MACT I decrease by 7 percent compared to baseline for BAT Option A.

Implementation of Option A may marginally increase the emission of HAPs from the recovery furnace by up to 1.5 percent, while Option B may result in a marginal increase of up to about 2.2 percent. However, capacity adjustments and upgrades¹ to recovery boilers as part of mill modernization programs could also result in reduction of emissions below current levels.

¹Capacity adjustments and upgrades that would generally reduce emissions of some or most pollutants include raising the solids concentration of the black liquor fired, improved turbulence and control of air system, improved boiler instrumentation, automatic port rodding, extraction of lignin from black liquor, heat treatment of black liquor, and improvement of pulping yield. However, EPA estimates that only one recovery boiler would require an air system and control upgrade in order to achieve the effluent limitations guidelines and standards promulgated for Subpart B. See Analysis of Impacts of BAT Options on the Kraft Recovery Cycle (DCN 14490) (2).

As explained in Section 11.5.4, the pollution prevention measures implemented at mills in response to BAT and PSES would have no direct effect on emissions of carbon dioxide, the greenhouse gas of concern in this analysis. However, emissions of carbon dioxide will change approximately in proportion to the changes in energy consumption mentioned above due to the secondary effects of modifying the quantity of fossil fuel burned to serve the pulp industry. EPA concludes that the increased CO₂ emission attributable to Option A pose no unacceptable non-water quality environmental impact.

Sections 11.5.5 and 11.5.6 present EPA's analysis of carbon monoxide emissions related to effluent limitations guidelines. Emissions of carbon monoxide will increase from bleach plants (1,500 kkg/yr over 1995 status) and from combustion of black liquor solids will increase (1,440 kkg/yr over 1995 status, for a total increase of 2,940 kkg/yr over 1995 status) if Option A technologies are implemented. If all mills implement Option B technologies, the increase in carbon monoxide emissions would be approximately 240 kkg/yr and 2,120 kkg/yr over 1995 status, respectively.

11.2 Wood Consumption

This section describes the effect this rulemaking will have on wood consumption at pulp mills.

11.2.1 BAT and PSES Option A

EPA analyzed the impact of Option A on wood consumption. The effluent flow from a typical open screening system ranges from 10 to 25 m³/kkg pulp, as discussed below in Section 11.3. This screen room effluent normally contains 20 to 50 mg/l wood fibers, in addition to whatever screen rejects are discharged with the water. The quantity of fiber lost continuously will therefore range from 0.2 to 1.25 kg/kkg pulp or approximately 0.1 percent of production. When converting a screen room to closed operation, this loss to effluent discharge is eliminated by capture and recycle to the brown stock washers.

In any mill, incidents occur from time to time that result in all of the production being dumped on the floor for a short period. The most common reason is an overflow of a vacuum drum washer, but any pipe can burst or tank overflow. Operators react quickly to such significant malfunctions, but 5 to 30 minutes is often necessary to stop the discharge. Assuming a typical tank overflow lasts 15 minutes, one percent of one day's production would be lost. Traditionally, the pulp and associated black liquor lost in this way is washed down the sewer, and ultimately lost from the process. With the implementation of BMPs, however, most of the material which escapes the production equipment will be recovered. Sufficient data are not available to quantify such losses, but losses of 2 kg/kkg would not be unusual, so it can be assumed that implementation of BMPs will result in a small improvement in wood yield due to recovery of this pulp.

Thus, mills with open screening at baseline that implement Option A technology (including closing the screen room) after the implementation of BMPs, would experience at least 0.1 percent reduction in wood consumption and more likely up to 0.3 percent while maintaining current production.

11.2.2 Option B

EPA estimated that Option B would also result in up to 0.3 percent reduction in baseline wood consumption. Option B differs from Option A only by the inclusion of extended delignification (oxygen delignification or extended cooking). EPA concluded that the installation of oxygen delignification without changing pulping conditions (EPA Option B) would not incrementally affect overall process yield when compared to Option A (3).

11.3 Effluents and Solid Waste

Implementation of BAT, PSES, and BMPs will reduce effluent flow, as well as the load of organic substances and suspended solids discharged to the mills' effluent treatment systems. The reduction in BOD₅ and suspended solids discharges will lower energy consumption and sludge generation in mill wastewater treatment systems and POTWs receiving mill wastewater, as discussed below.

11.3.1 Effluent Flows

The total effluent flow from an integrated bleached papergrade kraft and soda mill is normally between about 50 and 150 m³/kgg pulp produced, although a few mills discharge significantly lower or higher flows (4). The average US bleached kraft and soda mill discharges approximately 95 m³/kgg (5), which corroborates Mannisto's graphs (4). For a 1,000 kkg/day mill, the average effluent flow is similar to that from a city of 250,000 people.

EPA found that bleach plant flows differ by furnish. The average flow for a hardwood line, not employing extended delignification, was 25 m³/kgg pulp. The flow for a comparable softwood line was 37 m³/kgg pulp. Bleach plant flows differ because the quantity of organic material removed from the pulp in bleaching hardwoods is approximately 50 percent less than that removed from bleaching softwoods. Thus, hardwood bleaching lines often use a smaller number of stages than softwood lines use and generate less wastewater.

11.3.1.1 Flow Reduction Resulting from Screen System Closure

The BAT element that has the largest affect on effluent flows is closure of the brown stock screening systems ("closure" eliminates all planned effluent discharges from the screen room). EPA's records show that approximately half the bleached kraft mills still operated open screen rooms in 1995 (EPA BAT Baseline Database) (6). EPA does not have data tabulating the effluent discharges from these screen rooms. Therefore, EPA estimated flow from open screen rooms using a mass balance assuming normal pulp consistencies. Results show that

an open screening system could contribute up to 70 m³/kgg pulp, if all dilution is by fresh water. EPA ultimately rejected this mass balance analysis, however, because it concluded that screening systems were unlikely to operate with such high discharges today.

Springer (1986) states that a poorly designed and operated open screen room could require up to 150 m³/kgg fresh water, thus causing a similar amount of effluent to be discharged (7). He also states that an older open screen room can be operated with 20 to 25 m³/kgg discharge. In the TDD, EPA showed that the average effluent flow from the pulping area of a group of mills that included both mills with open screening and mills with closed screening systems was 16.4 m³/kgg pulp. This amount includes the unbleached white water from the screen room, digester condensates, and miscellaneous flows. Based on these data, EPA concluded that discharges typical for open screen rooms could range from 10 to 25 m³/kgg pulp. Thus, the conversion of a screen room from open to closed will typically reduce mill effluent flow by 10 to 25 m³/kgg pulp, or approximately 10 to 20 percent from the average mill flow (95 m³/kgg).

11.3.1.2 Flow Reduction Resulting from BMPs

BMP implementation will reduce effluent flow in three ways:

- \setminus The recovered black liquor will likely be reused instead of discharged to the mill effluent treatment system. The objective of BMPs is to reduce discharge of organic substances by improving the degree of process closure of the mill. Although up to 34 kg black liquor solids per ton pulp may be recovered as a result of BMPs, the effects on flow are modest. The quantities have been estimated for each mill and are generally in the order of 1 m³/kgg pulp.
- \setminus The attention paid to miscellaneous discharges and the efforts that will be made to avoid clean water discharges diluting the recovered spills will result in a further reduction, as estimated by EPA, in effluent discharges of 1 to 2 m³/kgg in most mills.
- \setminus Since mills are expected to segregate clean cooling water to avoid dilution of spilled black liquor, it will be possible to either discharge these clean waters separately from contaminated wastewater, or to reuse the clean water. Reuse of clean water could result in about 2 percent reduction in effluent flow from mills that choose to make use of this potential benefit of BMPs.

11.3.1.3 General Effects of BAT on Effluent Flows

Other than closing screen rooms and BMPs described above, no elements of the two BAT options will reduce effluent flows directly. However, the application of current

engineering practices to the design of new systems and equipment will result in conservation of water. The greatest improvements are likely to be seen in mills currently using relatively high quantities of water.

Retrofitting an oxygen delignification system (which would be a practical necessity for compliance with Option B) has no direct effect on effluent flows by itself. Some mills have reported reductions in effluent flow in oxygen delignification projects because it is normal practice to close the screen room process by recycling the screen decker filtrate to brown stock washing when oxygen delignification is installed. In some cases, as noted in the TDD, when the unbleached pulp kappa number into bleaching is reduced, one or two complete bleaching stages can be retired (e.g., convert a CD Eo DED bleach plant to an O D EopD). Such action could reduce effluent flows by about 15 m³/kgg pulp. In rare cases, oxygen delignification will result in some water conservation if lower unbleached pulp kappa number into bleaching allows the use of reduced wash water flow in the first bleaching stage.

Mills reduce the kappa number of unbleached pulp entering the bleach plant by two types of extended delignification: extended cooking and oxygen delignification. EPA's data, presented in Table 11-2, show lower bleach plant effluent flows in mills with extended cooking or oxygen delignification.

When upgrading the first chlorine/chlorine dioxide stage to high or 100 percent chlorine dioxide substitution for chlorine, low consistency operations are usually converted to medium consistency, or increase the use of recycled bleach filtrates for pulp dilution to raise the temperature without incurring the cost of direct steam heating. These changes can lead to a reduction in bleach plant effluent flows of about 12 m³/kgg pulp in softwood mills and 5 m³/kgg in hardwood mills. Such improvements are most likely to be made in mills which have high effluent flows.

During mill renovation, new equipment is not installed in isolation. Instead, it is common practice to modernize the mill area involved, at least to some extent. Modern equipment is generally designed to conserve water more effectively than older designs. Many details can be involved, such as the replacement of packing on shafts with modern mechanical seals that use little or no water, or reduction in cooling water requirements by more efficient design. These modifications will generally reduce effluent discharges modestly, but it is difficult to provide realistic numeric estimates.

11.3.2 Solid Wastes

EPA estimates that implementation of Option A and Option B would result in a reduction in the generation of sludge in the effluent treatment systems. The reduction in generation of wastewater treatment sludge results from the decrease in organic load discharged to the effluent treatment system.

Commenters have expressed concerns that modifying mills to approach closure of the water cycle would result in large increases in solid waste requiring disposal. This issue always requires careful consideration, since improving effluent discharges by simply transferring wastes to another medium is clearly undesirable. The only available study supported by detailed engineering analysis and mill experience which considers the technologies involved in the present discussion shows that the rate of solid waste generation for a closed cycle mill would be lower than the current industry average by a factor of about three (8).

EPA has not found any detailed analysis in the literature which would suggest that solid waste generation would increase as a result of partial mill closure. The process changes that are elements of Options A and B are not expected to cause the generation of additional quantities of solid waste. None of the “very low effluent” mills discussed in the Technical Support Document for the Voluntary Advanced Technology Incentives Program generates large quantities of solid waste (1). Review of the pollution prevention technologies being developed for flow reduction for the pulp and paper industry suggests that increased solid waste generation can be readily avoided.

Because of impacts on energy use, implementation of BAT would cause some small change in solid waste generation at utility power stations burning coal. Option A would increase generation of solid waste, while Option B would cause a reduction. EPA has considered these changes to be negligible and has not attempted to estimate quantities of this material.

11.3.2.1 Current Sludge Disposal

An analysis of sludge disposal practices in the late 1980s showed that mills bleaching chemical pulp were disposing of 2.5 million dry kkg/year (9). Since the bleached papergrade kraft subcategory makes up about 90 percent of the bleached chemical pulp production, for this analysis, EPA assumed that this subcategory also contributes approximately 90 percent of the sludge. The sludge generation rate is equivalent to approximately 80 kg/kkg pulp produced.

As reported in 1991, approximately 52 percent of the sludge was being landfilled, 20 percent stored in surface impoundments, 9 percent incinerated, and 7 percent applied (presumably beneficially) to land. The rest was disposed of by various means including ocean outfall, selling, and mixtures of two or more of the above.

11.3.2.2 Primary Sludge

The overall tightening of mill systems due to closing screen rooms, BMPs, and the improvement of washing systems will reduce fiber losses. The reduction in fiber discharges will vary, and will be the greatest in mills presently discharging relatively large amounts of fiber. As discussed in Section 11.2.1, fiber losses of 0.1 to 0.3 percent would be eliminated. Assuming, on average, that 0.2 percent fiber is eliminated, approximately 140,000 kkg/yr fiber would be recovered if all screen rooms previously open were closed. This figure includes the general

tightening up that would be associated with implementation of BAT, PSES, and BMPs due to reductions of spills and also reductions in flows of the weak white water and filtrates that typically contain 20 to 100 mg/L fiber.

NCASI estimated that the average bleached kraft mill generated 57 kg of sludge per ton product in 1989, on the basis of an industry survey (10). Consideration of mill practices suggest that this quantity has been reduced somewhat since 1989, but EPA has no definitive data. The average reduction of 0.2 percent (2 kg/kg) derived from above sources would represent a reduction in primary sludge discharges of 4 percent from the 1989 discharges. Because closed screen rooms, BMPs, and effective brown stock washing are common to both Option A and Option B (and because the extended delignification process unique to Option B does not affect fiber losses), EPA estimates no difference of primary sludge between the options.

11.3.2.3 Secondary Sludge and BAT

All but one of the bleached papergrade kraft mills in the US employ secondary wastewater treatment either on site or through a POTW. (The mill without secondary treatment discharges to the ocean.) Mills either have activated sludge treatment systems (AST), aerated stabilization basins (ASB), or some combination of these types. In order to consider the effects of Options A and B on secondary sludge, EPA considered not only secondary wastewater treatment systems at direct-discharging mills with ASTs, but also POTWs with ASTs receiving predominantly bleached papergrade kraft and soda effluent. All secondary treatment systems create sludge by converting dissolved organic material (BOD_5) into biomass. However, much more sludge is generated by AST than by ASB. In addition, sludge is routinely wasted from AST while it is typically left to degrade biologically in an ASB. Therefore, the estimate of the reduction in solid waste generation resulting from BAT focused on mills employing AST.

The quantity of solid waste produced by activated sludge or similar wastewater treatment processes is proportional to the BOD_5 load on the treatment system. Secondary wastewater treatment sludge can be the major source of solid waste in a mill. Four of the nine POTWs that process wastewater from indirect-discharging bleached kraft mills use aerated stabilization basins, and, therefore, generate little sludge for disposal. The other five POTWs use AST (11). Totaling direct and indirect dischargers that use AST, about 30 percent of the bleached papergrade kraft mills use AST and produce secondary wastewater treatment sludge.

Black liquor solids have a BOD_5 of approximately 0.3 kg BOD_5 /kg BLS. Approximately 0.6 kg of biological (secondary) sludge is generated in an activated sludge system for each kg BOD_5 applied (12). This relationship was used along with an estimate of the reduction in BLS that would result from implementation of Option A and Option B and 1995 baseline sludge generation estimates to calculate the associated changes in sludge generation (13). Additional BLS combusted and decreases in BOD_5 and sludge generation are shown in Table 11-3.

In 1991, EPA determined that the 104 bleached chemical pulp mills discharged approximately 2.5 million dry tons per year of sludge from wastewater treatment plants (14). No reason exists to suppose that a large change has taken place since that time. The bleached papergrade kraft subcategory produces approximately 90 percent of the pulp produced by bleached chemical pulp mills, and consideration of the processes generally used indicates that the quantity of sludge discharged will be approximately in proportion to production.

The foregoing quantities of solid waste include only the dry material. If the sludge is landfilled, it will probably be about 40 percent dry concentration, so the total weight basis requiring disposal will be about 2.5 times the dry quantity.

11.3.2.4 Dioxin and Furan in Sludge

Sludge generated at bleached papergrade kraft and soda mills may contain dioxin and furan if these pollutants are found in wastewater treated at these mills. At proposal, the Agency estimated that the mills in these two subcategories generated 177 g/yr toxic equivalent (TEQ) dioxin in their wastewater treatment sludge. Since the proposal, industry has significantly reduced the level of dioxin and furan in its wastewater. The Agency estimates that the dioxin and furan content of the sludge has decreased similarly, to approximately 50 g/yr TEQ.

The control technologies that form the basis of the BAT limitations and PSES promulgated today limit the concentration of dioxin and furan allowed to be discharged. As a result, the Agency estimates that when fully implemented, the combined application of BAT limitations and PSES will reduce the present sludge loading of dioxin TEQ by 43 g/yr, approximately an 85 percent reduction from current levels.

11.3.2.5 Aerated Stabilization Basins

Approximately 70 percent of mills in the bleached papergrade kraft subcategory use ASBs, some in combination with activated sludge treatment (6). Though ASBs generate much less sludge than activated sludge treatment, they often become partially filled with sludge after a number of years of operation, and require dredging. Lightly loaded ASBs have the ability to mineralize organic sludge, and operate for many years without cleanout. As discussed above, the BAT options will reduce the discharge of BOD₅ and suspended solids to treatment and thus reduce ASB dredging frequencies.

11.3.2.6 Potassium and Chloride Purges

In a conventional, relatively “open” kraft mill, non-process elements such as potassium and chloride are eliminated from the system by discharge in the mill’s wastewater. Many authors, including Tran (1990) (15), have shown that as mills approach process closure, the concentrations of chloride and potassium throughout the liquor system rise, and can cause plugging on the surfaces of the chemical recovery boilers exposed to the products of combustion (i.e., fireside).

Potassium and chloride concentrate in the dust caught in the electrostatic precipitator of the kraft mill recovery boiler. To control the concentrations of potassium and chloride in the mill's cooking cycle, some mills with excellent BMPs and operating practices which minimize losses from the green/white/black liquor cycle have to remove and discharge a portion of the precipitator dust, which is a mixture of inorganic salts of sodium and potassium. The total quantities of these substances discharged with the precipitator dust is identical to the quantity previously discharged with the pulp mill and bleach plant effluents. The point of discharge from the cycle has simply moved.

The precipitator dust discharge, which may be up to 20 kg/kkg pulp, has been described as a solid waste discharge in some documents. However, in many mills, the dust never exists in dry form except between the plates of the precipitator, and is normally discharged as a solution in the effluent². Today, mills commonly discharge this material with the effluent.

Most of the potassium in a mill system enters with the wood and purchased chemicals (15). The potassium entering with the wood will be discharged by any mill, whether operating like a pre-1970 mill, or in accordance with the most advanced BAT criteria. The quantity of potassium entering with the chemicals, and hence discharged, will be less in the more advanced mills, since the quantity of chemicals purchased will drop due to recycle. The mill operator is also likely to avoid purchasing contaminated chemicals to minimize the problems caused by potassium in the mill.

11.4 Energy Impacts

11.4.1 Overview of Energy Impacts

Sections 304(b) and 306 of the Clean Water Act specifically direct EPA to consider the energy requirements of effluent limitations guidelines and standards it establishes. EPA estimated the impacts of BAT, PSES, and BMPs on the energy use of the 86 mills with production in the bleached papergrade kraft and soda subcategory. For Option A and Option B, combined with BMPs, EPA analyzed the following changes in energy use:

- ∨ On-site electrical demand within the mill;
- ∨ Electrical demand for wastewater treatment;
- ∨ Pulp mill and bleach plant process steam demand; and
- ∨ Off-site electrical demand resulting from manufacture of bleaching chemicals (primarily raw materials for on-site ClO₂ generation).

²Quantities are small. The BFR process at Canton, NC, which is the largest chloride removal system operating in the US, discharges approximately 30 m³/day, or 0.03% of total mill discharge flow.

Table 11-4 presents EPA's estimate of the effect of Option A and Option B on energy consumption relative to consumption in 1995. The estimated energy impacts were converted to an "oil equivalent," to conveniently present the combined changes in thermal energy and electric power. As depicted in Figure 11-1, EPA estimated that Option A would result in an increase in oil consumption of 840,700 bbl/year while Option B would result in a decrease in oil consumption of approximately 1,535,000 bbl/year. The energy savings demonstrated by Option B is primarily due to replacement of a portion of chlorine dioxide bleaching chemicals by oxygen (in oxygen delignification). Manufacture of oxygen requires substantially less electrical energy than the manufacture of chlorine dioxide of equivalent bleaching power.

11.4.2 Estimation of Energy Impacts

Estimates of the energy impacts of implementing the technology required to meet Option A and Option B are discussed in this section.

11.4.2.1 Calculation Methodology of Energy Impacts for Option A and Option B Process Changes and BMPs

EPA evaluated the effect of each process change element of Option A and Option B in each mill on demand for steam and electrical energy. The process changes which have a significant effect are listed in Table 11-5. Items described as "insignificant" or "minor" were excluded from calculations of changes in energy consumption because they have no discernible impact within the accuracy of the estimate. In addition to the explicit process changes, the consequential effects of reducing effluent flow and BOD load have an effect on energy consumption in the mills' wastewater treatment plants.

EPA estimated, on a mill-specific basis, the process changes that each BPK mill would need to make in order to implement Option A and, separately, Option B. Based on these estimates, EPA calculated the mill-specific electricity involved. Details of the assumptions and associated equations are defined in the BAT Cost Model Support Document (16). The cost model equations used for the calculations in the report reflect comments received by EPA from the pulp and paper industry and the public on the 1993 and 1996 versions of the cost model. The calculations included changes in power demand for both the mill site and for the manufacture of the principal bleaching chemicals used for each process variation.

The manufacture of sodium chlorate for mill-site chlorine dioxide generation is a major factor in off-site electrical energy demand. Production of chlorine dioxide requires approximately 11 kWh/kg, whereas the equivalent quantity of chlorine requires only about 5 kWh/kg, and the equivalent quantity of oxygen about 1 kWh/kg. All of the potential bleach plant modifications will reduce the demand for electrolytically produced caustic, thus reducing demand for off-site electrical energy. The difference in power required for the various alternative bleaching processes are calculated in the cost model, and are included in the data presented in Figure 11-1 and Table 11-4.

For both Option A and Option B, the need to generate steam by burning fossil fuel at the mill site will be reduced by the heat generated from burning black liquor recovered by improved washing, closing the screen rooms, and BMP. For Option B, a small additional increase in recovery of heat energy will occur due to the incorporation of oxygen delignification, which recovers organic material otherwise discharged to the effluent treatment system in mills that do not use oxygen delignification. EPA estimated that the recovered heat would be approximately one percent of the base case heating value of the black liquor burned at the mill. Heat energy is also consumed in evaporating the recovered black liquor and providing heat to oxygen delignification systems. The net effect was calculated for each mill, and the industry-wide total is shown in Figure 11-1 and Table 11-4.

11.4.2.2 Calculation of Energy Impacts from Effluent Treatment System Operation

Wastewater from all but one US bleached kraft mill is treated in a biological wastewater treatment system prior to discharge to the environment. These treatment systems are equipped with aerators to facilitate biochemical oxidation of the wastewater BOD₅ load. As described in Section 11.3.2.3, implementation of BAT or further pollution prevention technology will reduce the BOD₅ load requiring treatment.

Biodegradation of BOD₅ requires approximately 1.25 kWh per kg BOD₅ to adequately aerate the wastewater (derived from Kocurek, 1992; also a widely accepted value) (12). As described in Section 11.3.2.3, the effects of Option A and Option B on BOD₅ loads to the effluent treatment systems were calculated mill by mill on the basis of the quantity of recovered organic material (black liquor solids). EPA assumed that each kg of black liquor solids would exert 0.3 kg BOD₅ and the reduction in BOD₅ load was calculated for each mill. Where the BOD₅ load is reduced, mills can generally reduce the electrical energy used for aeration of the biological treatment systems. This reduction in energy consumption in effluent treatment is included in the total energy impacts for Option A and Option B shown in Figure 11-1 and Table 11-4.

Where a substantial reduction in effluent flow is realized by the pollution prevention measures in the mill, minor modifications to the effluent treatment systems may be required so that the mill could take advantage of the energy savings mentioned above. These modifications might involve baffles to direct flow of effluent in an ASB, or bypassing part of parallel sets of equipment. See Section 10 for further discussion.

11.4.2.3 Equivalence of Various Forms of Energy

EPA calculated an “oil equivalent” to conveniently present the combined effects of the changes in thermal energy and electric power. The oil equivalent is based on the assumption that all nuclear, hydro-electric, waste fuel, natural gas, coal, co-generation, and wind power systems across the country are operated at their maximum capacity, and that any increase or decrease in fuel electric power demand caused by the effluent guidelines regulations is supplied by conventional condensing-type oil fired power stations. (If EPA assumed that

additional electrical demand would be supplied by coal or natural gas burning facilities, then the predicted effect on fossil fuel consumption would be quite similar. It is expressed in terms of oil equivalents here for convenience of the reader. Coal equivalents could also reasonably be used.)

For example, a mill burning all its black liquor and hog fuel would normally also burn some purchased fossil fuel (oil, coal, or natural gas) to generate additional steam not produced by the recovery boiler and power boiler. All the black liquor must be burned, but the mill cannot normally increase the quantity of black liquor generated, since it is directly related to the pulp production rate. The hog fuel is relatively inexpensive, so all available material will be burned at all times, subject to any limitations in wood burning equipment. Any change in the requirement for process steam will be supplied by changing the quantity of fossil fuel purchased and burned.

Many mills also generate some or all of the electric power they require by passing steam through turbines prior to its use as process heat. This power (known as co-generated power) is relatively inexpensive, so mills normally operate their co-generation equipment to its maximum potential. Some generate more power than is required on site, and sell the surplus to the local utility or other customer. Whether the mill is a net buyer or seller of power, any change in on-site power demand will be passed on to the national electrical power grid, reflecting ultimately in the load on utility stations.

The overall efficiency of conversion of thermal energy in fossil fuels to electricity delivered to consumers is approximately 25 percent, because thermal power stations ultimately reject approximately two-thirds of the thermal energy derived from combusted fuel due to the thermodynamic properties of steam. Energy losses to the stack gas and mechanical and electrical losses occur in the turbines, generators, and distribution system. In addition, a small fraction of the power generated is used in the utility plant itself for motors, electrostatic precipitators, and other necessary auxiliary equipment.

To convert the steam demand calculated as tons per day to equivalent barrels of oil, EPA made the following assumptions. EPA assumed a steam plant operating efficiency of 75 percent, a useful enthalpy of one ton of process steam at a typical mill as 2.7 GJ, and a heat content of 1 barrel of oil equal to 6 GJ. The exact values vary up to several percent from those values assumed from mill to mill, but such variations are minor since the actual change in energy consumption which would result from implementation of the effluent guidelines is only a few percent total, as shown in Table 11-4.

11.4.2.4 Changes in Energy Consumption Relative to Industry Total

In order to determine whether the estimated energy requirements of Option A and Option B pose unacceptable impacts, EPA compared them to the total energy consumption of the bleached papergrade kraft and soda subcategory. EPA estimated the total oil equivalent by adding the purchased electricity and fossil fuels reported in AF&PA's 1995 annual report (17) with EPA's estimate of off-site power consumption for chemical manufacturing (DCN 14510).

For the bleached papergrade kraft and soda subcategory, EPA estimated the total oil equivalent energy consumption to be 117 million bbl/year. The fractional change in this total energy consumption for Options A and B are shown in Table 11-4. Option A represents a 1 percent increase, while Option B would result in a 1 percent reduction in subcategory energy consumption.

11.5 Atmospheric Emissions

Sections 304(b) and 306 of the Clean Water Act specifically direct EPA to consider the air pollution impacts of effluent limitations guidelines and standards it establishes. EPA estimated the impacts of BAT, PSES, and BMPs on the generation and emission of air pollutants by the 86 mills with production in the bleached papergrade kraft and soda subcategory. As detailed in this section, EPA analyzed the air emissions impacts of Option A and Option B. These options will affect atmospheric emissions in a number of ways, as follows:

- ∨ Control technologies that form the basis of Option A and Option B involve changes in processes used to produce bleached pulp. As discussed in Section 11.5.1, air emissions decrease for some air pollutants and remain unchanged for others.
- ∨ Mills will be burning material in the recovery boiler that was previously discharged with the effluent because of the substantial improvements in overall mill closure discussed in Section 11.3. This practice will tend to marginally increase emissions of many substances to the atmosphere by up to one to two percent, as discussed in detail in Section 11.5.2.
- ∨ The location of points of emissions of carbon dioxide from mill sites will change, as discussed below, but the total emission will not.
- ∨ The changes in overall energy consumption discussed in Section 11.4 will change atmospheric emissions from on-site and off-site energy production facilities (increase for Option A and decrease for Option B).
- ∨ A localized increase in emissions of carbon monoxide will occur due to increased chlorine dioxide substitution.

11.5.1 Emissions Due to Mill Process Changes

The control technologies that form the basis of the effluent limitations guidelines and standards involve changes in the processes used to produce bleached kraft pulp. These changes affect the rate at which air pollutants, including HAPs, are emitted from pulping and bleaching processes. As shown in Table 11-6, the process changes at bleached papergrade kraft facilities subject to BAT, PSES, and BMPs decrease the emissions of some HAPs but have little impact on others. For example, the elimination of chlorine and hypochlorite from bleaching

processes as part of the basis for BAT and PSES will reduce the emission of chloroform in the bleached papergrade kraft subcategory by 64 percent but will have little impact on the emission of methanol. The application of BAT, PSES, and BMPs for the bleached papergrade kraft and soda subcategory will reduce the emission of total HAPs from 149,000 Mg/year to 139,000 Mg/year (7 percent reduction). The application of BAT, PSES, and BMPs plus MACT I, II, and III for the bleached papergrade kraft and soda subcategory will reduce total HAP emissions from 149,000 Mg/year to 59,200 Mg/year (60 percent reduction).

11.5.2 Emissions Due to Burning Increased Quantities of Black Liquor

Option A or Option B, combined with BMPs, will result in recovery and burning of increased quantities of black liquor, as discussed in Section 11.3.2.2. EPA calculated the changes in quantities of black liquor generated for each mill for Options A and B (16). EPA estimated the change in atmospheric emissions by applying emission factors (18,19,20,21) developed in support of EPA's MACT II NESHAP to these changes in black liquor firing rates. These estimates, before and after MACT II is applied, are presented in Tables 11-7 and 11-8. Emissions after MACT II controls are implemented are only presented in Table 11-8.

The underlying assumption for calculation of the marginal air emission increases presented in Table 11-7 and Table 11-8 is that the emissions from a recovery boiler are proportional to the quantity of fuel fired. EPA believes that this assumption will generally lead to an overestimate of the actual emissions for the reasons discussed below.

Depending on the current status of a mill, three alternative scenarios³ exist:

Recovery Boiler Operating Below Capacity

If the recovery boiler is operating below its maximum capacity, then the introduction of additional black liquor will raise the bed temperature, and the associated increase in feed of combustion air will increase turbulence. As discussed by many authors, increasing boiler load will normally reduce emissions of organic pollutants, provided the proper combustion conditions are maintained.

Particulate emissions would perhaps increase due to the increased gas flow through the precipitator, but increasing the bed temperature in a recovery boiler improves retention of sodium in the bed, thus reducing particulate formation. SO₂ emissions would drop because raising the bed temperature reduces sulfur emission. One characteristic of recovery boiler combustion conditions is that when SO₂ emissions drop, HCl emissions also drop. Many investigations have shown that SO₂ and HCl emissions drop to

³Discussed in detail in the Analysis of Impacts of BAT Options on the Kraft Recovery Cycle (1997) (2) and the BAT Cost Model Support Document (1996) (16).

essentially zero in boilers with hot smelt beds and adequate combustion conditions. While the increased liquor firing rates that result from implementation of Option A and Option B with BMPs, will not necessarily cause sufficient rise in bed temperature to eliminate the SO₂ and HCl emissions, increased rates will present mills with the opportunity to modify recovery boiler operation to reduce emissions. Thus, a simple assumption that emissions are proportional to firing rate results in an apparent overestimate of emissions from boilers currently operating below capacity.

、 **Boiler Operating at Full Capacity: Mill Chooses to Upgrade the Boiler to Accommodate the Additional Black Liquor**

Recovery boilers are typically upgraded by air system modifications and firing higher concentration liquor. Both result in raising the furnace temperature while upgraded air systems also improve turbulence. The results are the same likely reductions in air emissions discussed above (22).

、 **Boiler Operating at Full Capacity: Mill Chooses to Oxidize the Black Liquor to Reduce Its Heating Value**

In this case, the solids feed to the boiler will rise, but the heat input will not since the heating value of the liquor is reduced by oxygen black liquor oxidation. The demand for combustion air will drop (due to less organic feed and since the products of oxidation introduce oxygen to the stream), so the stack gas flow will drop. Because gas flow through the boiler is the key to emissions of several pollutants, emissions will not likely rise in proportion to the fuel feed. Black liquor oxidation can accommodate a thermal load increase of up to 5 percent. Therefore, if a mill's thermal load increases by less than 5 percent, black liquor oxidation can reduce total thermal load below the mill's baseline thermal load.

In all cases, TRS emissions are likely to be reduced by the above-mentioned increases in temperature and upgrades to the boiler. In addition, sulfur dioxide emission increase estimates are likely overstated because they do not account for the fact that some mills in sensitive areas for sulfur dioxides already have sulfur dioxide controls in place or may choose alternative controls available in the final MACT rule that mitigate these increases.

The discharge of carbon dioxide from the recovery boiler stack will increase in all three scenarios, but will be balanced by a corresponding reduction in emissions from the effluent treatment system and receiving water, as discussed in Section 11.5.3.

The increases in discharges of particulate HAPs due to changes in black liquor firing are overshadowed by the effects of changes in quantities of oil fired in power boilers, as shown in Table 11-9.

11.5.3 Emissions Due to Changes in Energy Consumption

As discussed in Section 11.4 and summarized in Table 11-4, Option A and Option B will have an effect on total energy consumption. For the analysis presented here, EPA estimated changes in on-site steam demand, on-site electric power consumption, and off-site electric power consumption for each mill individually. On-site steam demand is met by power boilers that burn black liquor, wood, coal, or oil and by recovery boilers burning black liquor. Electrical demand is typically met by off-site electric power generating stations that burn coal, oil, natural gas, or use nuclear or hydro energy. For the purpose of this analysis, EPA calculated an oil equivalent to combine the effects of all energy changes.

As discussed in Section 11.4 and summarized in Table 11-4, both Option A and Option B, in combination with BMPs, result in a net increase in combustion of black liquor solids and a corresponding fuel benefit. The decrease in steam demand from the fossil fuel fired boilers will result in less combustion in on-site power boilers and lower emissions from those sources that offset the increased emissions from the recovery boilers discussed in Section 11.5.2. Option A results in a net increase in off-site electric power consumption and a net decrease in on-site power consumption. The on-site electrical savings is further decreased by the decrease in steam demand so that, as shown in Table 11-4, the mill realizes a net energy savings. However, the energy demand associated with Option A results in a net global increase.

Combustion of oil causes emissions of SO₂, carbon dioxide, and trace quantities of various metals (particulate HAPs). Particulate HAPs are also associated with combustion of black liquor, as discussed in Section 11.5.2. The changes in air emissions due to estimated changes in energy consumption are shown in Table 11-9. Table 11-9 also presents total emissions for SO₂ and particulate HAPs resulting from BLS combustion (shown in Table 11-7) plus oil combustion. Changes in carbon dioxide emissions are discussed in Section 11.5.4.

11.5.4 Greenhouse Gases

The earth radiates long-wavelength radiation that is absorbed by water vapor and carbon dioxide (CO₂) in the atmosphere near the earth's surface. Because both water vapor and CO₂ are transparent to the incoming, warming, solar radiation but absorb the long-wave radiation from the earth's surface, the net effect of increases in atmospheric CO₂ and water vapor is a warming of the earth's atmosphere. This effect has been termed the "greenhouse effect" and CO₂ and water vapor have been termed "greenhouse gasses." Anthropogenic generation of water vapor is minuscule relative to atmospheric recycling and is normally ignored in greenhouse gas analysis. Therefore, water vapor is ignored here.

CO₂ is an ultimate product of all combustion processes, including the combustion of fossil fuels to generate electricity and the combustion of wood and black liquor at a pulp mill. CO₂ is also the ultimate product of the biodegradation of water-borne organic wastes generated by a pulp mill. This biodegradation occurs in the biological wastewater treatment system, with the ultimate disposal of sludge, and in the receiving stream.

The generation of CO₂ attributable to the production of bleached pulp equals the carbon taken into the mill with the wood and other raw materials, less the carbon that leaves the mill as product plus the CO₂ generated during the production of energy needed to produce the product. Thus, to minimize the generation of greenhouse gasses, yield of product from the wood must be maximized and energy use minimized. As discussed in Section 11.4, production of bleached pulp consumes energy not just at the pulp mill, but also during the production of bleaching chemicals, with chlorine dioxide requiring the most energy.

EPA examined the effect of Options A and B combined with BMPs on the generation of CO₂ by considering the overall mill carbon balance and the energy balance. As discussed below, EPA concluded that neither option would have an impact on the total emission of greenhouse gasses from mills due to pulp processing. However, the changes in energy consumption will have the effect of increasing CO₂ emissions for Option A while they will be reduced for Option B. EPA concludes that the increased CO₂ emissions attributable to Option A pose no unacceptable non-water quality environmental impact.

11.5.4.1 Mill Carbon Balance

In this context, the mill carbon balance includes all pulping, bleaching, recovery cycle, effluent treatment, and residual effects on the final receiving water. The effects of fuel burned for energy production are discussed separately below.

All carbon that enters the mill as a component of raw material, wood, or purchased chemicals leaves by one of the following paths:

As part of the product	Will not be affected by either option.
As CO ₂ from combustion of black liquor or recalcination of lime in the recovery cycle	Will be slightly increased by both options but offset by reduction in organic load in mill effluents and in energy demand on power boilers.
As organic material in mill effluents	Oxidized to CO ₂ in biological treatment systems and by subsequent biological action in the receiving waters. Some of the material may be recovered as sludge from waste treatment plants, and ultimately converted to CO ₂ by incineration or degradation in landfills.
As organic gases from digester	Will be in the order of 1 kg/kkg pulp. MACT I combustion control devices will reduce these emissions by approximately 98 percent. The rest will oxidize to CO ₂ in time in the atmosphere.

Thus, nearly all the carbon entering the mill eventually reaches the atmosphere as carbon dioxide, except for the carbon component of the product.

The quantity of carbon entering the mill will not be modified significantly by implementation of BMPs and Option A or Option B, because pulp yield is not affected by these technologies (see Section 11.2.2). However, as discussed in Section 11.2, mills may experience decreased wood consumption up to 0.3 percent for both options. Minor changes in carbon entering the mill will include increased use of methanol as a reductant for manufacture of chlorine dioxide. The recausticizing cycle will have to process additional quantities of lime mud (calcium carbonate) because more black liquor will have to be processed as a result of the implementation of BAT. The additional carbon dioxide released in the calcination reaction in the lime kiln has its origin in the wood used in the digester, and is balanced by a reduction in carbon dioxide released by biological oxidation of the mill's waste waters.

To put these assumptions in perspective, the quantity of carbon entering the mill with the wood should be compared with the above-mentioned minor sources.

The worst case for increased carbon input with methanol would be conversion of a softwood mill using no chlorine dioxide in the first bleaching stage to 100 percent substitution, and installing one of the methanol reduction processes to produce chlorine dioxide. Total chlorine dioxide consumption would be approximately 40 kg ClO₂/kkg pulp which would require a feed of 150 kg methanol per ton ClO₂ (equivalent to 6 kg/kkg pulp). The methanol would be discharged to the effluent as an organic by-product of ClO₂ manufacture and would be oxidized

to carbon dioxide in the biological treatment system, producing approximately 8 kg carbon dioxide/kg pulp. The end result would be under 0.3 percent of the total mill emission. The incremental emission of CO₂ would be less for mills that currently operate methanol reduction ClO₂ plants and for mills already using high ClO₂ substitution. If a mill uses extended cooking or oxygen delignification then the amount would be cut further because of reduced chlorine dioxide consumption.

11.5.4.2 Effect of Energy Production and Carbon Sequestration on Carbon Dioxide Emissions

Fossil Fuel Consumption - As discussed in Section 11.4 and summarized in Table 11-4, both Option A and Option B will have an effect on total energy consumption that can be represented as a quantity of oil burned for electric power generation. The carbon content of fuel oil is typically in the range of 83 percent to 88 percent. EPA assumed that the average carbon content of fuel oil burned is 85 percent, and calculated the effect of changes in energy consumption on carbon dioxide emissions. These changes, presented in Table 11-10, would occur primarily at electric utility stations remote from the pulp mills.

Assuming 85 percent carbon, and a typical heating value of 42 MJ/kg, fuel oil contains approximately 20 grams carbon per MJ. In the case of a boiler firing coal, the fuel would typically contain approximately 60 percent carbon, and have a heating value of approximately 28 MJ/kg. The carbon content of the coal is therefore approximately 21 g/MJ. Therefore, the carbon dioxide generation for production of a given amount of electricity varies little, regardless of the fuel used.

Carbon Sequestration - Mills may reduce wood consumption by up to 0.3 percent for both options, as discussed in Section 11.2. Approximately 2,500 kg wood is consumed to manufacture 1,000 kg of fully bleached kraft pulp (oven dry basis). Wood contains approximately 50 percent carbon, so that about 1,250 kg carbon are fed to a mill per ton product. Some of this carbon is incorporated into the product, while the remainder as carbon dioxide (approximately 760 kg carbon/kg pulp (61 percent) or 2,800 kg ClO₂/kg pulp) is emitted to the atmosphere by the pulping and bleaching process, including stack emissions (the majority) and biodegradation of effluents.

If a mill reduces wood consumption by 0.3 percent, carbon input to the mill is reduced by 3.75 kg carbon per ton product (13.75 kg CO₂ per ton product). With a yearly bleached papergrade kraft production of 29.2 million tons per year, 401,500 tons CO₂ per year is sequestered by decreased wood use. Sixty-one percent of the sequestered CO₂ would have been emitted to the atmosphere. Therefore, the net reduction in CO₂ emissions is 245,000 tons CO₂ per year.

Carbon sequestration lessens the impact of fossil fuel consumption on CO₂ emissions for Option A and further reduces CO₂ emissions for Option B. EPA concludes the increased CO₂ emissions pose no unacceptable environmental impacts.

11.5.5 Carbon Monoxide Emissions from Oxygen Delignification

Someshwar (1997) presented data on numerous tests of emissions from four full-scale oxygen delignification systems showing that they generated from 25 to 200 grams CO per ton pulp processed (23). The quantity of CO generated correlated loosely with the oxygen charge.

The proposed air emission control regulations under MACT I require that the vents from oxygen delignification system be incinerated, so that the rate of emission to the atmosphere will be substantially below the rate of generation of CO. Because such an incinerator would be burning various organic gases including methanol, the CO emission to the atmosphere will depend on the design and operation of the incinerator rather than the rate of formation of CO in the oxygen delignification system.

MACT I requirements will ensure efficient oxidation of CO from this source. Keeley (1997) suggests that at least 95 percent conversion of CO to carbon dioxide would be attained (24). Consequently, EPA does not consider that the exact rate of CO emission from the oxygen delignification reactors is important.

11.5.6 Carbon Monoxide from Chlorine Dioxide Bleaching

Downe (1996) expressed concerns that the increase in emissions of carbon monoxide (CO) associated with increases in use of chlorine dioxide (as would be encouraged by guidelines based on either option) would create difficulties for mills requesting permits under air emission control regulations (25).

11.5.6.1 Information Available Prior to 1996

Traditionally, carbon monoxide emissions from bleaching have not been considered significant relative to combustion sources in a pulp mill. However, Van der Merwe (1980) reported that bleaching with chlorine dioxide generated sufficient CO to kill a maintenance worker inside a bleaching vessel (26). Van der Merwe's supposition was subsequently discussed and confirmed by other authors in the context of being an occupational safety issue. As a common practice today, mills test vessels associated with chlorine dioxide bleaching for carbon monoxide prior to entry for maintenance and inspection.

Van der Merwe concluded:

- ∨ Chlorine bleaching of unbleached softwood did not generate CO;
- ∨ Sodium hypochlorite bleaching of softwood generated trace amounts of CO⁴;

⁴Elimination of hypochlorite bleaching is a process technology component of both Option A and Option B.

- ∨ Chlorine dioxide delignification⁵ of oxygen delignified hardwood and softwood pulp generated a concentration of CO of up to 3.2 percent in head space of a laboratory reactor; and
- ∨ Chlorine dioxide delignification of softwood pulp that had not been previously delignified with oxygen generated much higher levels of CO than oxygen delignified pulp.

Van der Merwe also found that CO was generated when unbleached pulp (kappa 32) was bleached with hydrogen peroxide. However, unbleached pulp is never processed with hydrogen peroxide on an industrial scale unless the kappa number is first reduced to well below 20.

In independent work associated with investigations of bleach process yields, Kutney (1983) showed that CO is formed in bleaching, and that the formation is approximately proportional to the extent to which chlorine dioxide is substituted for chlorine (27). He confirmed the trends noted by Van der Merwe.

11.5.6.2 Recent NCASI Study of CO Emissions from Bleaching

Someshwar (1997) reviewed the literature on emissions for CO from chlorine dioxide bleaching (23). He also reported on measurements of CO emissions from six full-scale, operating bleach plants carried out by NCASI using Continuous Emission Monitoring (CEM) equipment and reported on various measurements for other operating mills by third parties.

The measurements reported by Someshwar include mass flows of CO per unit pulp production, whereas most other authors report only concentrations of CO generated.

Someshwar concluded:

- ∨ The major contributors to CO emissions from the bleach plants were the chlorine dioxide bleach towers;
- ∨ Emissions of CO from bleach plants were from 90 to 750 g/kg pulp processed, with an overall average of 390 g/kg;
- ∨ Emissions of CO are roughly proportional to the ClO₂ charge applied to the entire bleach plant; and
- ∨ Contributions to total CO emission from the bleach plant by hydrogen peroxide and extraction stages were small.

⁵The term “chlorine dioxide delignification” is often used to refer to the first chlorine dioxide stage of a modern bleach plant.

The data reported by Someshwar are summarized in Table 11-11. EPA analyzed these data to determine which of the known variables in the bleaching process correlate best with the measured emissions of CO. Correlation with unbleached kappa number, wood type (softwood or hardwood), and level of chlorine dioxide substitution were examined. EPA attempted to discern a relationship between CO emissions and chlorine dioxide charge. The two sets of data which form a coordinated series of experiments (mill AA and mill SG) were examined separately and found to exhibit poor linear regression coefficients relative to equation (1). The best linear regression equation found for CO emission rate vs. total chlorine dioxide charge is:

$$\text{CO emission g/kg pulp} = 7,780 \times \% \text{ClO}_2 + 220 \quad (1)$$

Equation (1) is shown in Figure 11-2. An alternative regression line which is forced to pass through the origin is also shown in Figure 11-2.

$$\text{CO emission g/kg pulp} = 1,637 \times \% \text{ClO}_2 \quad (2)$$

The regression coefficient (0.146) is clearly poor. Although a definite trend toward increasing CO emissions with increasing use of chlorine dioxide exists, the relationship is loose, and not necessarily linear.

Increased use of chlorine dioxide results from mills electing to operate with high substitution rates (an element of both Option A and Option B) and by bleaching high kappa pulp. One could therefore expect mills using oxygen delignification to emit less CO than similar mills without oxygen delignification, as suggested by Van der Merwe (1980) (26). Someshwar does not indicate which mills in Table 11-11 use oxygen delignification (23). EPA assumed that mills showing unbleached kappa numbers which corresponded to the use of oxygen delignification or extended cooking are operating one (or both) of these processes.

EPA assumptions for individual data sets are shown in Table 11-11. On this basis, EPA calculated average carbon monoxide emissions for softwood mills with and without oxygen delignification as follows:

Mills with traditional cooking	439 g/kg pulp
Mills with oxygen delignification or extended cooking	352 g/kg pulp

The few data on hardwood bleaching showed no significant difference between mills with or without oxygen delignification.

11.5.6.3 Effect of BAT on Total Emission of CO

To assist in estimating the costs for Options A and B, EPA calculated the chlorine dioxide consumption for each mill. The total is shown in Table 11-12.

Based on the equations presented in Figure 11-2 and the 1995 bleached kraft subcategory production, the total estimated emissions of carbon monoxide from bleaching for 1995 baseline conditions, Option A, and Option B were calculated as shown in Table 11-12. The values shown in Table 11-12 for CO emissions per ton pulp differ from the values above because they refer to the total of hardwood and softwood pulp.

11.5.6.4 Carbon Monoxide Emissions from Bleach Plants vs. Total Mill Emissions

The total CO emissions from combustion of pulping liquors in bleached, unbleached, sulfite, and semi-chemical pulping mills is 274,000 tons of carbon monoxide per year. Approximately half the total production of chemical/semi-chemical pulp is bleached papergrade kraft.

Assuming that approximately half of the above-mentioned carbon monoxide emissions are from bleached papergrade kraft, the bleach plant emissions for Option A would represent approximately 9 percent of the total carbon monoxide emission from the liquor burning sources in the bleached papergrade kraft subcategory.

EPA concluded that implementation of Option A would increase emissions of CO from bleach plants by approximately 50 g/kg pulp (about 30 kkg/yr for a typical mill), while Option B would cause an increase of approximately 7 g/kg pulp. The emission increase due to Option A is approximately 10 percent of the average emission of CO from combustion sources in a mill. Emission control technology to reduce CO from boilers is well known and available. So, wherever "Prevention of Significant Deterioration" concerns exist, it would be feasible to reduce CO emissions from combustion sources to counter the increase in emissions from the bleach plant.

11.6 Impacts of New Source Performance Standards and Pretreatment Standards for New Sources (NSPS and PSNS) on the Bleached Papergrade Kraft and Soda Subcategory

EPA analyzed the projected non-water quality environmental impacts of Option A for the bleached papergrade kraft and soda subcategory for BAT, PSES, and BMPs based on complete substitution of chlorine dioxide for chlorine and other technology elements (see Section 8.2.1.1 for Option A technology description) in Sections 11.1 through 11.5 above. This section presents the non-water quality environmental impacts of a second technology configuration (NSPS and PSNS) which is equivalent to BAT, PSES, and BMPs with the addition of extended delignification (oxygen delignification or extended cooking) on a new 1000 kkg/d bleached papergrade kraft fiber line (See Section 8.2.1.2 for Option B technology description).

Table 11-13 presents the non-water quality environmental impacts of the selected technology basis for NSPS and PSNS, compared to conventional pulping and bleaching technology. These estimates are based on the same calculation methodology described under BAT and PSES, applied to a 1000 tpd model mill. Based on these estimates, EPA concludes that the process technologies that form the basis for NSPS and PSNS for the bleached papergrade kraft and soda subcategory pose no unacceptable non-water quality environmental impacts.

11.7 Impacts of Totally Chlorine Free (TCF) Technology on the Bleached Papergrade Kraft and Soda Subcategory

EPA analyzed the projected non-water quality environmental impacts of Option A for the bleached papergrade kraft and soda subcategory for BAT, PSES, and BMPs based on complete substitution of chlorine dioxide for chlorine and other technology elements (see Section 8.2.1.1 for Option A technology description) in Sections 11.1 through 11.5. This section presents the non-water quality environmental impacts of two TCF options, TCF-Peroxide and TCF-Ozone described in Section 8 of this document.

Table 11-14 presents the non-water quality environmental impacts of the two TCF options, compared to conventional pulping and ECF bleaching technology (Option A). These estimates are based on the same calculational methodology described under BAT. Based on these estimates, EPA concludes that TCF process technologies for the bleached papergrade kraft and soda subcategory pose no unacceptable non-water quality environmental impacts.

11.8 Impacts of BAT, PSES, and BMPs on the Papergrade Sulfite Subcategory

EPA analyzed the non-water quality impacts that result from implementing BAT, PSES, and BMPs at the 11 papergrade sulfite mills. Because the number of mills in this subcategory is significantly fewer and the size of these mills is generally smaller than the bleached papergrade kraft and soda subcategory, the non-water quality impacts are lesser in magnitude in the papergrade sulfite subcategory compared to the bleached papergrade kraft and soda subcategory.

11.8.1 Wood Consumption

EPA notes that the impacts of BAT, PSES, and BMPs results in up to 0.3 percent decrease in wood consumption for the bleach papergrade kraft and soda subcategory. Approximately two-thirds of this decreased demand, or 0.2 percent, can be attributed to reduced fiber loss due to the implementation of BMPs. The remaining 0.1 percent of decreased demand can be attributed to closed screening. EPA assumes that the demand for wood at papergrade sulfite mills will decrease up to 0.2 percent due to the implementation of BMPs. Closed screening is not a BAT, PSES, and BMPs technology element of papergrade sulfite subcategory and therefore will not result in decreased wood consumption.

11.8.2 Solid Waste and Effluents

The effects of this rulemaking on solid waste and effluents are discussed below.

11.8.2.1 BOD₅ and Sludge Generation

Implementation of BMPs will result in decreased solid waste generation from the recovery and rerouting of an incremental amount of red liquor to other processes that was once sent to wastewater treatment. Eight of the 11 mills can use a recovery furnace or incinerator to combust the recovered red liquor which was previously sent to wastewater treatment. The other three mills use other proprietary processes to recover chemicals and/or byproducts which are assumed to be able to accommodate the incremental red liquor that was previously sent to wastewater treatment. For estimation of solid waste impacts, EPA assumed that all 11 mills would be able to reduce the total organic load sent to wastewater treatment resulting from additional recovered red liquor by an amount equivalent to that achieved by mills employing a recovery furnace or incinerator. This assumption is reasonable because the three mills that do not use a recovery furnace or incinerator do employ various techniques to convert the organic load in the red liquor to a usable byproduct.

EPA estimates BOD₅ in untreated wastewater will decrease by 26,700 kg/d through the implementation of BMPs for the papergrade sulfite subcategory. EPA calculated an associated decrease in sludge generation of 2,470 kkg/yr for papergrade sulfite mills that use activated sludge treatment (several mills use aerated stabilization basins which do not produce sludge) based on the same calculation methodology described above for the bleached papergrade kraft and soda subcategory. EPA is projecting no change in BOD₅ and sludge generation as a result of implementation of BAT and PSES in the papergrade sulfite subcategory.

Since proposal, the dioxin and furan content of sludge at papergrade sulfite facilities has decreased significantly. As discussed in Section 11.3.2.4 for the bleached papergrade kraft and soda subcategory, the control technologies that form the basis of the BAT limitations and PSES promulgated today limit the concentration of dioxin and furan allowed to be discharged. As a result, these limitations will also reduce the sludge loading of dioxin at papergrade sulfite facilities by approximately 85 percent.

11.8.2.2 Effluent Flows

EPA assumed the reduction of effluent flow for papergrade sulfite mills will be comparable to the reductions achieved by bleached papergrade kraft and soda mills from the implementation of BMPs. EPA, therefore, estimates papergrade sulfite mills may achieve an effluent flow reduction of approximately 1 m³/kkg pulp. EPA is projecting no additional change in effluent flows as a result of implementation of BAT and PSES in the papergrade sulfite subcategory.

11.8.3 Energy Impacts

As a result of implementation of BAT, PSES, and BMPs, EPA estimates off-site electrical energy consumption will decrease by 38,100 MMBTU/yr, primarily because of reduced bleaching chemical requirement. EPA estimates on-site electrical energy consumption will decrease by 1,050,000 MMBTU/yr, primarily because of decreased demand for operating wastewater treatment.

EPA estimates the change in on-site steam demand for the papergrade sulfite subcategory to be 10,300 MMBTU/yr. EPA calculated the change in steam demand by calculating the increase in steam demand required for the evaporation of the recovered red liquor at all 11 mills minus the additional steam that could be generated from the combustion of red liquor recovered at the seven mills that use recovery boilers. (Ingruber, Kocurek, and Wong (1985) report a range of red liquor heating values that average 14.9 MJ/kg. This value was used to estimate the amount of steam generated (28)).

The total impact of BAT, PSES, and BMPs for the papergrade sulfite subcategory decreases energy consumption by 1,080,000 MMBTU/yr.

11.8.4 Atmospheric Emissions

EPA estimates emissions of HAPs from papergrade sulfite mills will increase by 2.6 percent as a result of implementation of BAT, PSES, and BMPs. This increase in HAPs is projected to occur from implementation of BMPs that will capture of additional red liquor that was previously discharged, and burning of that red liquor in a chemical recovery boiler or incineration device at 8 of the 11 mills. The other three mills do not use a combustion-based process unit and therefore the capture of additional red liquor at these mills is assumed to not result in increased HAP emissions. The increased air emissions from the recovery of additional pulping liquor are based on the same calculation methodology described for the bleached papergrade kraft and soda subcategory with emission factors changed to reflect sulfite operation. The estimated emission does not represent a significant increase.

11.9 Impacts of New Source Performance Standards and Pretreatment Standards for New Sources (NSPS and PSNS) for the Papergrade Sulfite Subcategory

NSPS and PSNS that EPA is promulgating for the papergrade sulfite subcategory are equivalent to BAT and PSES, respectively. Therefore, EPA projects no non-water quality environmental difference between NSPS/PSNS technology and BAT technology.

11.10 References

A number of EPA documents involved in the development of the effluent guidelines are referred to herein. They are available in the public docket, except for portions

claimed as Confidential Business Information. This list includes documents prepared by the EPA and its contractors, as well as comments submitted to EPA concerning the rulemaking.

All other references listed below can be found in the open literature of the pulp and paper industry. Copies of the smaller documents are also in the public docket.

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Table 11-1

**Summary of Impacts of Options A and B Relative to Baseline^a
for the Bleached Papergrade Kraft and Soda Subcategory**

	Option A^b	Option B^b
Reduction in Wood Consumption	Up to 0.3% Marginal reduction from screen room closure and spill recovery	Up to 0.3% Marginal reduction from screen room closure and spill recovery
Water Conservation	Typically 5 to 10% due to closed screening, better spill collection	Typically 10 to 15% due to closed screening, better spill collection, other mill modernization
Solid Waste Generation^c		
Primary sludge	About 4% reduction due to fiber recovery	About 4% reduction due to fiber recovery
Secondary sludge at mills with activated sludge treatment	2% reduction due to reduced BOD ₅ to treatment	3% reduction due to reduced BOD ₅ to treatment
Energy Consumption (as change in bbls of oil)	Increase 1% due to energy for off-site chemical manufacture, with offsets in mill.	Decrease 1% due to replacement of Cl ₂ and ClO ₂ with O ₂ ; reduction in WWTP power
Air Emissions From burning increased quantities of black liquor		
Total gaseous HAPs, kkg/yr	Increase 220 (1.1%)	Increase 308 (1.6%)
Total particulate HAPs, kkg/yr	Increase 0.71 (1.1%)	Increase 1.03 (1.6%)
Carbon monoxide, kkg/yr	Increase 1,440 (1.2%)	Increase 2,120 (1.7%)
Sulfur dioxide, kkg/yr	Increase 784 (1.2%)	Increase 1,150 (1.7%)
From changes in energy consumption		
Carbon dioxide, kkg/yr	Increase 154,000	Decrease 1,650,000
Sulfur dioxide, kkg/yr	Increase 1,800	Decrease 6,300
Total particulate HAPs, kkg/yr	Increase 4.64	Decrease 16.3
From changes in chlorine dioxide bleaching		
Carbon monoxide, kkg/yr	Increase 1500	Increase 220

^aBaseline is technology in place as of mid-1995.

^bData presented are simplified. Refer to detailed discussion in body of report. Individual mills vary.

^cPercentage reductions for solid waste are all shown relative to total solid waste discharge from same source in late 1980s.

Table 11-2

**Bleach Plant Effluent Flow for Bleached Papergrade Kraft and
Soda Mills With and Without Extended Delignification**

	Hardwood^a	Softwood^a
Mills without oxygen delignification or extended cooking	24.7 m ³ /kgg	37.1 m ³ /kgg
Mills with oxygen delignification or extended cooking	19.7 m ³ /kgg	24.7 m ³ /kgg
Reduction in effluent flow	5 m ³ /kgg	12.4 m ³ /kgg

^aDCN 13952, Section 24.

Table 11-3**Black Liquor Solids, BOD₅, and Sludge Generation for Option A and Option B for the Bleached Papergrade Kraft and Soda Subcategory**

	Option A	% Change from Baseline Option A	Option B^a	% Change from Baseline Option B
Additional heat from black liquor solids combustion ^b (GJ/d)	29,600	NC	45,600	NC
Additional BLS to combustion resulting from process changes ^c (kkg/d)	2,160	1.5	3,260	2.2
Decreased BOD ₅ to treatment (kg/d)	649,000	21	979,000	31
Decreased sludge generation in ASTs (kkg/yr)	36,000	2	62,000	3

^aHeat in BLS from extended delignification assumed to have HHV of 14.5 MJ/kg.

^bSee BAT Cost Model Support Document (4).

^cIncrease over baseline estimated assuming 1,750 kg BLS/kkg pulp for baseline.

NC = Not calculated.

Table 11-4**Effect of Options A and B on Energy Consumption Relative to 1995 Base Case for the Bleached Papergrade Kraft and Soda Subcategory**

		Option A	Option B	Note
Electrical Power Consumption				
Increase (decrease) in off-site power consumption	MW	87	(161)	^a
Increase (decrease) in on-site power consumption	MW	(21)	66	
Total increase (decrease) in power consumption	MW	67	(95)	
Total increase (decrease) in power consumption	kWh/kgg	19	(27)	
Increase (decrease) in thermal energy to generate power	GJ/d	23,100	(32,800)	^b
Increase (decrease) in thermal energy to generate power	GJ/kgg	0.28	(0.39)	
Increase (decrease) in oil equivalent to generate power	trillion BTU/yr	7.666	(10.88)	
Increase (decrease) in oil equivalent to generate power	bbl/yr	1,347,000	(1,911,000)	
Steam Consumption				
Net steam requirements (savings)	kgg/d	(2,410)	1,790	
Fossil fuel requirement (savings) from steam demand (generation)	bbl/yr	(506,200)	376,400	^c
Total Energy Consumption				
Total increase (decrease) in fuel consumed	trillion BTU/yr	4.785	(8.734)	e
Total increase (decrease) in fuel consumed	bbl/yr	840,700	(1,535,000)	e
Total increase (decrease) in fuel consumed	number of households	46,100	(84,300)	d
Increase (decrease) in fuel consumed relative to total energy consumption by bleached kraft subcategory in 1995		1%	(1%)	e

^aOff-site power consumption is for manufacture of bleaching chemicals.

^bEstimate of thermal energy required assumes overall efficiency of condensing power station and distribution system of 25 percent.

^cConversion of fuel oil to useful steam assumes overall steam plant efficiency of 75 percent.

^dAssumes 103.6 million Btu/household/yr (Energy Information Administration (DOE) 1993)

^eSee DCN 14510 for baseline energy calculations of 116 million bbl/yr.

Table 11-5

**Process Changes Affecting Energy Consumption at
Bleached Papergrade Kraft and Soda Mills**

Process modification	Steam demand	Electrical demand
Improve brown stock washing and screen room closure	Reduced demand for fossil fuel corresponding to fuel value of recovered black liquor. Reduced demand from reduction in water to evaporate.	Minor, may be plus or minus.
Extended cooking	Reduced demand for fossil fuel corresponding to fuel value of recovered black liquor.	Insignificant in fiber line. Net reduction in off-site power for bleach chemical manufacture.
Oxygen delignification	Reduced demand for fossil fuel corresponding to fuel value of recovered black liquor. Heat demand for oxygen reactor.	Additional mixing energy in fiberline. Net reduction in power for bleach chemical manufacture.
High chlorine dioxide substitution	Minor increase	Increased energy for pulp mixing. Increased energy off site for bleach chemical manufacture.
Best Management Practices	Reduced demand for fossil fuel corresponding to fuel value of recovered black liquor. Steam demand to evaporate recovered water.	Insignificant
Evaporator upgrade	Steam demand increase	Insignificant
Evaporator load reduction	Steam demand decrease	Insignificant
Measures to compensate for increased load on recovery boiler:		
` Recovery boiler upgrade	Steam generated from above mentioned black liquor replaces some steam from fossil fuel.	Minor change
` Anthraquinone pulping additive	None	None
` Black liquor oxidation	Reduction in net demand since steam generated in reaction is used for evaporator.	Increase
Recausticizing upgrade	Insignificant	Minor change
Reduction in effluent flow due to above	None	Minor reduction in pumping energy.
Reduction in effluent BOD ₅ due to above	None	Reduction in WWTP power.

Table 11-6

**Impact of BAT, PSES, and BMPs:
Bleached Papergrade Kraft and Soda Subcategory Air Emissions**

Air Pollutants	Bleached Papergrade Kraft BAT Baseline Emissions and Reductions (Mg/yr)		
	Baseline Emissions	Emission Reductions from BAT/PSES/BMPs	Emission Reductions from BAT/PSES/BMPs Plus MACT I, II, and III
Hazardous air pollutants (HAP)	149,000	10,000	89,800
Chloroform ^a	9,510	6,060	6,240
Methanol ^a	96,400	3,100	66,080
Volatile organic compounds	569,000	11,000	301,200
Total reduced sulfur	100,000	1,300	59,800

^aBaseline emission is a subset of baseline HAP emissions (149,000 Mg/yr).

Table 11-7**Atmospheric Emission Changes Due to Burning Recovered Black Liquor, Bleached Papergrade Kraft and Soda Subcategory Before MACT II is Applied**

Pollutant	Emissions, Mg/yr ^a			Change from Baseline	
	Before MACT II Baseline	Increase from Option A	Increase from Option B	Option A	Option B
Total Reduced Sulfur (TRS)	2,650	27.4	36.0	1.03%	1.36%
Criteria Pollutants					
Carbon Monoxide	123,700	1,440	2,120	1.17%	1.71%
Particulate Matter	31,370	356	514	1.14%	1.64%
Nitrogen Oxides	36,120	423	623	1.17%	1.73%
Sulfur Dioxides	67,770	784	1,150	1.16%	1.69%
Volatile Organic Compounds	19,500	213	295	1.09%	1.51%
Gaseous HAPs					
Acetaldehyde	1,150	12.5	17.0	1.08%	1.48%
Benzene	580	6.43	9.10	1.11%	1.57%
Formaldehyde	421	4.99	7.43	1.19%	1.76%
Hydrochloric Acid	6,890	79.1	115	1.15%	1.67%
Methanol	6,810	72.5	95.9	1.06%	1.41%
Methyl Ethyl Ketone	469	5.26	7.45	1.12%	1.59%
Methyl Isobutyl Ketone	556	6.26	8.91	1.13%	1.60%
Phenol	1,330	14.6	20.4	1.09%	1.53%
Toluene	482	5.45	7.79	1.13%	1.62%
Xylenes	1,159	13.0	18.5	1.12%	1.60%
Total Gaseous HAPs	19,860	220	308	1.11%	1.55%

Table 11-7 (Continued)

Pollutant	Emissions, Mg/yr ^a			Change from Baseline	
	Before MACT II Baseline	Increase from Option A	Increase from Option B	Option A	Option B
Particulate HAPs					
Antimony	2.72	0.02	0.03	0.89%	1.29%
Arsenic	8.16	0.10	0.14	1.17%	1.69%
Beryllium	0	0.00	0.00	0.00%	0.00%
Cadmium	1.81	0.02	0.02	0.86%	1.25%
Chromium	2.72	0.02	0.03	0.89%	1.29%
Cobalt	1.81	0.02	0.03	1.14%	1.65%
Lead	20.0	0.22	0.32	1.13%	1.62%
Manganese	11.8	0.14	0.20	1.16%	1.67%
Mercury	0.907	0.01	0.02	1.49%	2.15%
Nickel	5.44	0.06	0.08	1.05%	1.51%
Selenium	8.16	0.10	0.14	1.20%	1.73%
Total Particulate HAPs	62.6	0.71	1.03	1.14%	1.64%
Total HAPs^b	19,920	220	308	1.11%	1.55%

^aAll nationwide baseline emissions estimates received from MRI (MRI July 1996, October 1996) (21,29)

^bTotal HAPs include gaseous HAPs and particulate HAPs.

Table 11-8**Atmospheric Emission Changes Due to Burning Recovered Black Liquor, Bleached Papergrade Kraft and Soda Subcategory After MACT II is Applied**

Pollutant	Emissions, Mg/yr ^a			Change from Baseline	
	After MACT II Baseline	Increase from Option A	Increase from Option B	Option A	Option B
Total Reduced Sulfur (TRS)	2,650	27.4	36.0	1.03%	1.36%
Criteria Pollutants					
Carbon Monoxide	123,700	1,440	2,120	1.17%	1.71%
Particulate Matter	18,500	209	301	1.13%	1.62%
Nitrogen Oxides	36,120	423	623	1.17%	1.73%
Sulfur Dioxides	67,770	784	1,150	1.16%	1.69%
Volatile Organic Compounds	19,500	213	295	1.09%	1.51%
Gaseous HAPs					
Acetaldehyde	1,150	12.5	17.0	1.08%	1.48%
Benzene	580	6.43	9.10	1.11%	1.57%
Formaldehyde	421	4.99	7.43	1.19%	1.76%
Hydrochloric Acid	6,890	79.1	115	1.15%	1.67%
Methanol	6,810	72.5	95.9	1.06%	1.41%
Methyl Ethyl Ketone	469	5.26	7.45	1.12%	1.59%
Methyl Isobutyl Ketone	556	6.26	8.91	1.13%	1.60%
Phenol	1,330	14.6	20.4	1.09%	1.53%
Toluene	482	5.45	7.79	1.13%	1.62%
Xylenes	1,159	13.0	18.5	1.12%	1.60%
Total Gaseous HAPs	19,860	220	308	1.11%	1.55%

Table 11-8 (Continued)

Pollutant	Emissions, Mg/yr ^a			Change from Baseline	
	After MACT II Baseline	Increase from Option A	Increase from Option B	Option A	Option B
Particulate HAPs					
Antimony	0.91	0.01	0.02	1.57%	2.25%
Arsenic	5.44	0.06	0.08	1.03%	1.48%
Beryllium	0.00	0.00	0.00	0.00%	0.00%
Cadmium	0.91	0.01	0.01	1.02%	1.46%
Chromium	0.91	0.01	0.02	1.57%	2.25%
Cobalt	0.91	0.01	0.02	1.34%	1.92%
Lead	11.8	0.13	0.19	1.12%	1.61%
Manganese	7.3	0.08	0.12	1.11%	1.59%
Mercury	0.00	0.01	0.01	0.00%	0.00%
Nickel	2.72	0.03	0.05	1.23%	1.77%
Selenium	5.44	0.06	0.08	1.05%	1.51%
Total Particulate HAPs	37.2	0.42	0.60	1.13%	1.62%
Total HAPs^b	19,890	220	308	1.11%	1.55%

^aAll nationwide baseline emissions estimates received from MRI (MRI July 1996, October 1996) (21,29)

^bTotal HAPs include gaseous HAPs and particulate HAPs.

Table 11-9**Atmospheric Emissions: Oil Combustion and Oil Combustion Plus BLS Combustion (Before MACT II is Applied) (Mg/yr)**

Pollutant ^a	Oil Combustion ^b		Combustion: Total Oil Plus BLS	
	Increase for Option A	Decrease for Option B	Increase for Option A	Decrease for Option B
Criteria Pollutants				
Sulfur Dioxides ^c	1,794	6,312	2,578	5,166
Particulate HAPs				
Antimony	0.08	0.27	0.10	0.24
Arsenic	0.14	0.51	0.24	0.37
Beryllium	0.009	0.032	0.009	0.03
Cadmium	0.25	0.87	0.27	0.85
Chromium	0.16	0.57	0.18	0.54
Cobalt	0.21	0.74	0.23	0.71
Lead	0.23	0.82	0.45	0.50
Manganese	0.10	0.36	0.24	0.16
Mercury	0.04	0.13	0.05	0.11
Nickel	3.3	11.8	3.36	11.7
Selenium	0.08	0.28	0.18	0.14
Total Particulate HAPs	4.64	16.32	5.35	15.29

^aEmissions based on energy consumption in Figure 11-1, Values shown are total kkg/yr for the bleached papergrade kraft and soda subcategory.

^bEmission factors from AP-42, Section 1.3, 5th Edition, 1995.

^cAssumes that the average sulfur content of residual oil burned in the US is 0.7 percent (or where high sulfur oil is used, SO₂ emission control equipment is installed to reduce emissions to the equivalent of 0.7 percent sulfur oil).

Table 11-10

**Changes to Carbon Dioxide Emissions Resulting From Changes in
Consumption of Fossil Fuel and Wood Consumption for Option A and Option
B for the Bleached Papergrade Kraft and Soda Subcategory**

	Fossil Fuel Consumption	Wood Consumption	Net Change
Option A	Increase by 399,000 kkg/yr	Reduce by 245,000 kkg/yr	Increase by 154,000 kkg/yr
Option B	Reduce by 1,405,000 kkg/yr	Reduce by 245,000 kkg/yr	Reduce by 1,650,000 kkg/yr

Table 11-11**Average CO Emissions From Kraft Bleaching With Chlorine Dioxide**

Mill Code	Bleaching Sequence	Wood Type	% Sub.	Total ClO ₂ charge	Bleach Plant Inlet Kappa	OD or EC	Total CO Emissions g/kgg			Source of Data
							Avg.	Min.	Max.	
SF1	Cd (Eop)DEpD	Hwd	6%	0.74%	8.0	y	268	250	295	Mill
SD2	CD(Eo) DP	Swd	15%	1.08%	11.3	y	264	241	282	Mill
SE1	D(Eop)DP	Swd	100%	1.12%	13.3	y	295	214	345	Mill
C	D(Eop)D	Swd	100%	1.18%	15.0	y	282	136	395	NCASI
C	D(Eop)D	Hwd	100%	1.20%	10.0	y	400	309	550	NCASI
AA	CdEDED	Swd	0%	1.30%	30.0	n	332			Lab
SE2	D(Eo)DP	Hwd	100%	1.32%	8.2	y	286	264	309	Mill
C	D(Eop)D	Swd	100%	1.43%	12.5	y	423	327	495	NCASI
AA	CdEDED	Swd	10%	1.53%	30.0	n	314			Lab
SF2	Cd (Eop)DEpD	Swd	13%	1.58%	13.0	y	586	550	623	Mill
SA1	Cd(Eo) D	Hwd	35%	1.65%	9.0	y	245		295	Mill
SA2	CD(Eo)D	Swd	55%	1.66%	11.3	y	195		218	Mill
SD1	Cd(Eo) D	Swd	50%	1.97%	10.9	y	355	350	364	Mill
AA	CdEDED	Swd	30%	1.98%	30.0	n	323			Lab
SG2	CEDED	Swd	30%	2.02%	nk	n	532	459	564	Mill
E	Cd(Eop)DED	Swd	60%	2.14%	27.5	n	323	264	409	NCASI
E	Cd(Eop)DED	Swd	60%	2.19%	27.5	n	309	218	414	NCASI
AA	CdEDED	Swd	50%	2.44%	30.0	n	364			Lab
SG1	CEDED	Swd	15%	2.49%	nk	n	650	641	236	Mill
B	D(Eop)D	Swd	100%	2.67%	27.0	n	386	223	614	NCASI
G	D(Eop) PD	H/S/Swdust	100%	2.77%	22.5	n	423	245	527	NCASI
B	D(Eop)D	Swd	100%	2.82%	27.0	n	432	91	750	NCASI
AA	CdEDED	Swd	70%	2.90%	30.0	n	441			Lab
F	Cd(Eop) D	Swd	85%	3.06%	27.0	n	455	286	627	NCASI

Table 11-11 (Continued)

Mill Code	Bleaching Sequence	Wood Type	% Sub.	Total ClO ₂ charge	Bleach Plant Inlet Kappa	OD or EC	Total CO Emissions g/kg			Source of Data	
							Avg.	Min.	Max.		
B	D(Eop)D	Hwd	100%	3.07%	17.0	n	295	195	423	NCASI	
G	D(Eop) PD	Swd	100%	3.39%	30.0	n	464	414	550	NCASI	
SB	D Eop DD	Swd	100%	3.41%	13.0	y	414	409	418	Mill	
AA	DEDED	Swd	100%	3.58%	30.0	n	527			Lab	
SG3	CEDED	Swd	70%	3.63%	nk	n	614	577	650	Mill	
SG4	CEDED	Swd	100%	3.98%	nk	n	568	568	568	Mill	
							Maximum	650	641	750	
							Minimum	195	91	218	
							Average	392	329	455	

Data in column "OD or EC" were inferred by EPA from bleaching conditions. All other data after Someshwar (1997) (23).

Table 11-12**Carbon Monoxide Emissions from Bleach Plants for Option A and Option B
for Bleached Papergrade Kraft and Soda Subcategory**

	Baseline	Option A	Option B
Chlorine dioxide use, kkg/day	1,660	2,200	1,740
Carbon monoxide emissions, kkg/yr	10,900	12,400	11,200
Carbon monoxide emissions, g/kg pulp	374	425	381

Table 11-13**Comparison of NSPS/PSNS to Conventional Technology**

	1000 tpd Fiber Line
Wood Consumption	No Difference
Effluent Flow	Moderate Decrease ^a
BOD₅ to Treatment	Decrease by 11,300 kg/day
Sludge Generation	Decrease by 890 kg/day
Carbon Dioxide Emissions	Decrease by 21,700 Mg/yr
Energy Impacts:	
Total Electricity Demand	Decrease by 222,600 million BTU/yr in oil equivalent
Total Steam Demand	Increase by 60,180 million BTU/yr in oil equivalent
Total Energy Demand	Decrease by 162,400 million BTU/yr in oil equivalent
Air Emissions:	
Hazardous Air Pollutants	Increase by 407 Mg/yr
Chloroform	No Difference
Volatile Organic Compounds	Increase by 707 Mg/yr
Total Reduced Sulfur	Increase by 28 Mg/yr
Particulate Matter	Decrease by 12 kg/yr
Carbon Monoxide	Decrease by 3 Mg/yr
Nitrogen Oxides	Decrease by 28 Mg/yr
Sulfur Dioxides	Decrease by 56 Mg/yr

^aSee Section 11.4.1.3

Table 11-14
Comparison of Two TCF Technologies to Conventional Technology
(Option A) for the Bleached Papergrade Kraft and Soda Subcategory

	TCF-Peroxide	TCF-Ozone
Wood Consumption	No Difference	No Difference
Final Effluent Flow	Decrease by approximately 90 percent (a)	Decrease by approximately 90 percent (a)
BOD₅ to Treatment	Decrease by approximately 90 percent (a)	Decrease by approximately 90 percent (a)
Sludge Generation from BOD₅	Decrease by approximately 90 percent (a)	Decrease by approximately 90 percent (a)
Carbon Dioxide Emissions	Moderate Decrease	Moderate Decrease
Energy Impacts:		
Total Electricity	Decrease by 4.73 trillion BTU/yr in oil equivalent	Decrease by 7.11 trillion BTU/yr in oil equivalent
Total Steam Demand	Decrease by 35.1 trillion BTU/yr in oil equivalent	Decrease by 83.8 trillion BTU/yr in oil equivalent
Total Energy Demand	Decrease by 39.9 trillion BTU/yr in oil equivalent	Decrease by 90.9 trillion BTU/yr in oil equivalent
Air Emissions:		
Hazardous Air Pollutants - Chlorinated	Elimination (b)	Elimination (b)
Hazardous Air Pollutants - Non-Chlorinated	No Difference (c)	No Difference (c)
Chloroform	Elimination (b)	Elimination (b)
Volatile Organic Compounds - Chlorinated	Elimination (b)	Elimination (b)
Volatile Organic Compounds - Non-Chlorinated	No Difference (c)	No Difference (c)
Total Reduced Sulfur	No Difference	No Difference
Particulate Matter	No Difference	No Difference
Carbon Monoxide from ClO ₂ Application	Elimination	Elimination

Table 11-14 (Continued)

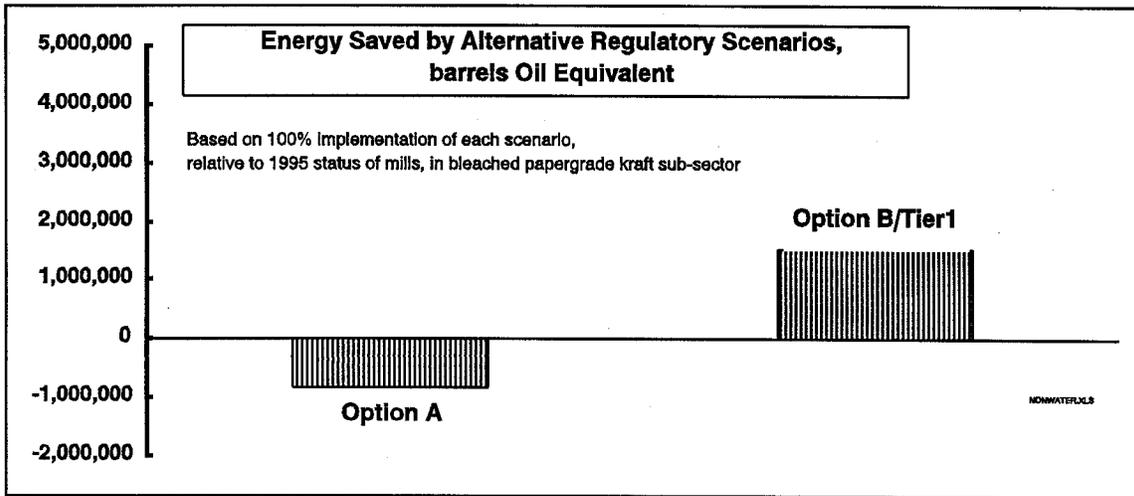
	TCF-Peroxide	TCF-Ozone
Nitrogen Oxides	Slight Decrease (d)	Slight Decrease (d)
Sulfur Dioxides	Slight Decrease (d)	Slight Decrease (d)

(a) Final effluent flow rates are typically 95 m³/kkg (see Section 11.3), of which 25 to 60 m³/kkg typically come from bleach plant effluents. While TCF operation itself does not require recycling of bleach plant effluents, TCF facilities operating today typically have bleach plant effluent discharges of 5 to 15 m³/kkg, a bleach plant reduction of approximately 30 m³/kkg (30). TCF facilities recycle bleach plant effluents to recover bleaching chemicals and to reduce BOD₅ load to and sludge generation in secondary treatment. Industry practice in mills using TCF technology is to reduce effluent flow throughout the mill. For example, the Metsa-Rauma mill at Rauma, Finland discharges 9 m³/kkg effluent, of which 5 m³/kkg is from the bleach plant (31). 90 percent final effluent flow reduction is attainable but actual reduction at each mill depends on local site constraints and the priority given to flow reduction. It is reasonable to assume that comparable decreases would occur for BOD₅ and sludge generation from BOD₅.

(b) Any emission results from process water chlorination.

(c) See Revised Draft Chemical Pulping Emission Factor Development Document, DCN A9240IVA8.

(d) Due to decrease in fossil fuel consumption.



**Figure 11-1. Energy Impacts of Proposed Regulations,
Bleached Papergrade Kraft and Soda Subcategory**

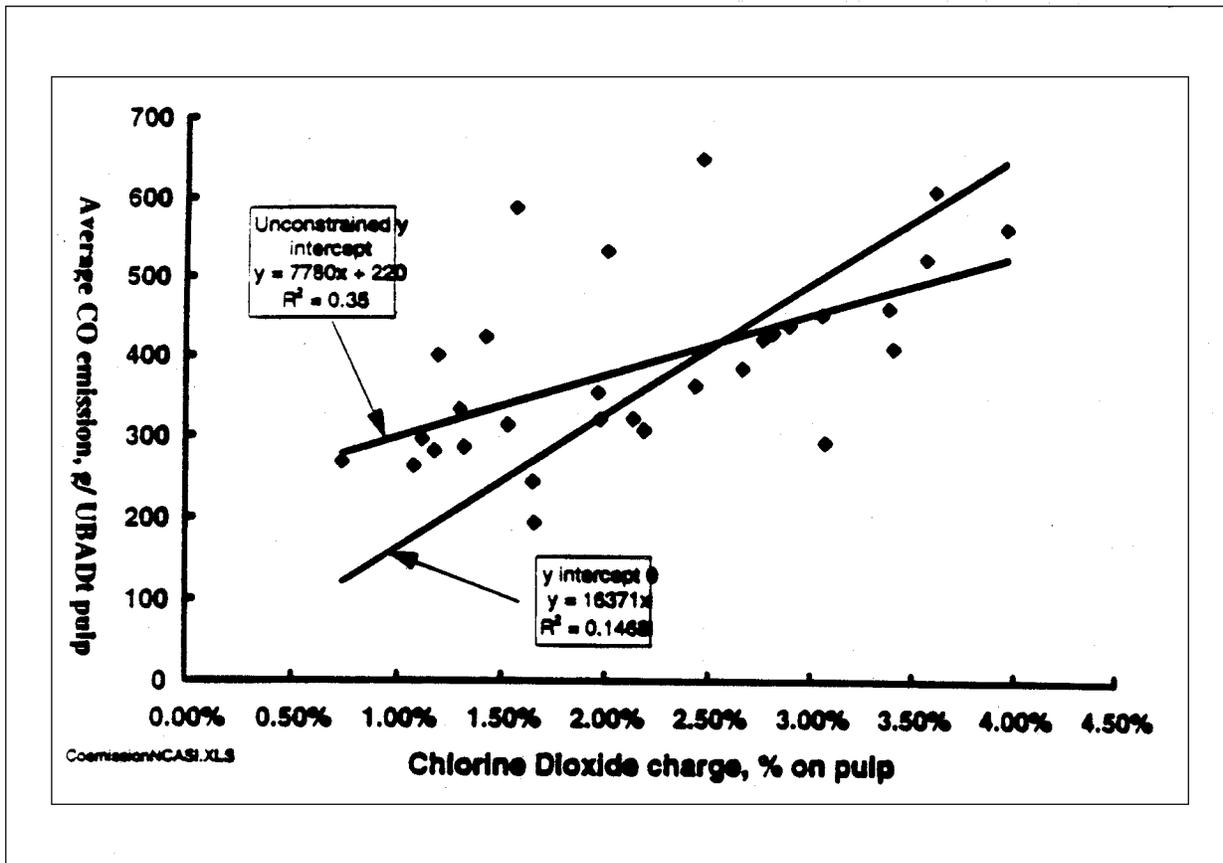


Figure 11-2. Emissions of CO Measured by NCASI

SECTION 12

BEST CONVENTIONAL POLLUTANT CONTROL TECHNOLOGY

12.1 Introduction

The 1977 amendments to the Clean Water Act established BCT for discharges of conventional pollutants from existing industrial point sources. BCT is not an additional limitation, but replaces BAT for the control of conventional pollutants.

This section presents a summary of the final BCT methodology, describes the revisions made to the BCT technology options and cost estimates for the end-of-pipe treatment technologies, and discusses the results of the final BCT cost test. This section does not represent the methodology used to estimate end-of-pipe treatment costs since it has not changed since proposal. This methodology is described in the Proposed Technical Development Document (EPA 821-R-93-019) (TDD).

12.2 Summary of the Final BCT Methodology

In considering whether to promulgate revised BCT limits for the Bleached Papergrade Kraft and Soda (Subpart B) and the Papergrade Sulfite (Subpart E) subcategories, EPA considered whether technologies are available that achieve greater removals of conventional pollutants than the current BPT effluent limitations guidelines. EPA also considered whether those technologies are cost-reasonable according to the BCT cost test, which compares the incremental removals and costs associated with BCT limitations to a baseline associated with BPT.

For the final rule, EPA chose to conduct the BCT analysis using estimates of industry's 1989 discharge of conventional pollutants (based on data from the 1990 industry census) as the BPT baseline against which BCT technology options are analyzed. EPA evaluated the candidate BCT technologies and concluded that none of the options passed the BCT cost test. Therefore, at this time, EPA is not promulgating more stringent BCT limitations for Subparts B and E of this industry category. BCT limitations for former Subparts G, H, I, and P (now Subpart B) and former Subparts J and U (now Subpart E) remain in effect.

12.3 Revisions to the Proposed BCT Technology Options and Cost Estimates

Based on comments received on the proposed rule and the July 15, 1996 Notice of Data Availability (61 FR 36835) and correction of double-counting some costs, EPA revised the inputs to the BCT cost test related to BCT option performance, the costs to install or upgrade end-of-pipe treatment systems, and the annual operating costs for end-of-pipe treatment systems. This section describes only these revisions (see also Comment Response Document, DCN 14497, Volume IV, "BCT Cost Test").

12.3.1 Conventional Pollutant Control Option Performance

At proposal, EPA developed four candidate BCT options:

- (1) Option A.1 - Performance level of the best-performing mill in each subcategory assuming the baseline performance is equal to the proposed BPT Option 2;
- (2) Option A.2 - Multimedia filtration assuming the baseline performance is equal to the proposed BPT Option 2;
- (3) Option B.1 - Performance level representing the average of the best 90 percent of mills in each subcategory assuming the baseline performance is equal to current industry performance;
- (4) Option B.2 - Performance level representing the average of the best 50 percent of mills in each subcategory assuming the baseline performance is equal to current industry performance.

Two of these options, Options A.1 and A.2, assumed the baseline performance to be equal to the proposed BPT Option 2. Because EPA has decided not to revise BPT limitations for conventional pollutants, EPA chose not to evaluate these two options. For the final rule for the Bleached Papergrade Kraft and Soda Subcategory, EPA only considered Options B.1 and B.2, known now simply as BCT Options 1 and 2.

EPA identified a new BCT option for the Papergrade Sulfite Subcategory, which is the average performance level achieved by the three mills with at least 85 percent of their production in the subcategory whose wastewater treatment performance reflects BCT candidate level performance. Final production of most mills in the Papergrade Sulfite Subcategory is comprised of a large portion of purchased pulp. For the proposed rule, BCT option performance levels for this subcategory were calculated using data from mills with 37 to 96 percent of their final production in the subcategory. After proposal, EPA reassessed the impact of purchased pulp on the final effluent BOD₅ load and determined that four mills with 85 percent or more of final off-machine production derived from sulfite pulp produced on site discharged substantially higher BOD₅ loads from secondary biological wastewater treatment. EPA determined that effluent from these few mills more appropriately represented wastewater from the subcategory. EPA used data from three of these mills to characterize BCT, because EPA did not consider the treatment performance of the fourth mill to be representative of the subcategory as a whole. This fourth mill treats wastewater from liquor by-products manufactured on site, which is unique among papergrade sulfite mills.

Section 8.3 of this document presents a detailed discussion of the development of options for the control of conventional pollutant discharges.

12.3.2 Accounting for Cluster Rules Impacts on BCT Costs

In order to conduct the BCT cost test, discussed in Section 12.4.4. EPA estimated the pollutant removals achieved by the industry in upgrading from BPT to BCT. EPA also estimated the cost for upgrading from BPT to BCT.

EPA estimated the pollutant removals achieved by the BCT Options by calculating the reduction in each mill's discharged pollutant load at Options 1 and 2, relative to the baseline (pollutant load discharged in 1989, as reported in the 1990 industry census). At proposal, EPA attributed the entire increment to BCT, even though some conventional pollutant removals result from other components of the Cluster Rules.

EPA estimated the cost for each mill to upgrade its treatment system from the baseline 1989 performance to the Option 1 and Option 2 level of performance. Before EPA estimated the costs of BPT at proposal it accounted for the pollutant load reduction that will result from implementation of the cluster rules (i.e., BAT, BMP, and NESHAP). Applying these load reductions reduced the load of BOD₅ requiring treatment, and therefore also reduced the costs associated with end-of-pipe treatment system upgrades. At proposal, EPA used these BPT costs to represent the costs of BCT Options B.1 and B.2.

EPA received comments questioning this approach. When EPA revised the inputs to the BCT cost test, it reevaluated this approach and, for the final rule, decided not to account for cluster rule impacts on costs because they were not also taken into account when estimating loads.

12.3.3 Engineering Cost Estimates

EPA received several comments pertaining to the estimate of costs to install and/or upgrade end-of-pipe treatment systems for the removal of conventional pollutants. The Agency has not changed its approach to designing end-of-pipe treatment systems, but has revised certain unit costs which comprise the capital and annual operating and maintenance costs for end-of-pipe treatment and some assumptions based on comments received on the proposed rule. This section presents a summary of the individual unit costs and assumptions that were revised or reevaluated prior to their inclusion in the final BCT cost test, including aerated stabilization basin liner costs, activated sludge aeration and sludge handling costs, flow reduction costs, indirect cost factors, land costs, and polymer addition. All other costs that comprise end-of-pipe treatment system installation and operation have been described previously in the TDD supporting the proposed rule.

12.3.3.1 Aerated Stabilization Basin Liner Costs

Based on comments received on the proposed rule, EPA reevaluated the unit cost to install liners for aerated stabilization basins. At proposal, EPA estimated clay liner costs to be \$0.37 per square foot (1991 dollars). Commenters questioned whether these costs accounted for

transportation of the clay to mills that were not located near a vendor. Therefore, EPA reevaluated the transportation costs associated with installing clay liners and found that, in some cases, transportation would add over \$2.00 per square foot to the cost of installing clay liners.

Because of the relatively high clay transportation costs, EPA investigated alternative materials for use as aerated stabilization basin liners, including plastic (HDPE) liners and geosynthetic liners. Based on the information provided by vendors, HDPE liners would cost approximately \$0.35 per square foot, including transportation and installation, while geosynthetic liners would cost \$0.57 per square foot, including transportation and installation. EPA chose to estimate basin costs assuming installation of a geosynthetic liner, which includes excavating the lagoon, laying the liner, and covering the liner with 6 to 8 inches of backfill from the original excavation.

12.3.3.2 Activated Sludge Aeration Costs

EPA reevaluated aeration costs for mills with existing activated sludge systems. When designing upgrades to achieve the target BOD₅ and TSS loads, EPA considered additional aeration tank volume and/or aeration, as well as operational modifications. In some cases, EPA determined that the mill has sufficient existing aeration capacity, but requires additional retention time to meet the target long-term average conventional pollutant concentrations. In these cases, additional aeration costs were eliminated from the compliance cost estimates.

12.3.3.3 Activated Sludge Handling Costs

As described in the TDD, EPA estimated costs for the management and disposal of sludge from new or upgraded activated sludge units. These incremental costs were based on the increased amounts of sludge resulting from upgrades as determined by the activated sludge design model.

At proposal, the Agency calculated mill-specific unit costs to estimate the capital and annual operating and maintenance (O&M) costs for sludge handling and disposal. EPA assumed that sludge increases of 5 percent or less could be handled with no additional cost. Following proposal, EPA determined that sludge increases up to 15 percent could be handled with no additional cost. However, EPA also determined that, for mills that required increased sludge handling capacity, a minimum capital cost would be incurred that was greater, in some cases, than the incremental capital cost that was previously estimated.

12.3.3.4 Flow Reduction Costs

As described in Section 11.6.1.1 of the TDD, some mills could not achieve target BOD₅ or TSS loads for the candidate BCT options with end-of-pipe treatment alone because their target BOD₅ and TSS concentrations were lower than the lowest currently demonstrated concentrations. Therefore, as at proposal, these mills required flow reduction to increase their

target concentrations. The technologies that reduce flow also reduce BOD₅ and TSS loads. Flow reduction, if required, was applied to a mill first; the revised final effluent flow rates, BOD₅ load, and TSS load achieved with flow reduction were entered into models to design and cost end-of-pipe wastewater treatment upgrades that would enable the mill to achieve the target loads.

For some mills, the cost to meet the more stringent candidate BCT option (Option 2) was lower than the cost to meet Option 1 because Option 1 costs were based on end-of-pipe treatment upgrades only and not on flow reduction. For these mills, EPA decided for the final rule to cost flow reduction for both candidate BCT options, which resulted in a lower cost to comply with BCT Option 1.

12.3.3.5 Indirect Cost Factors

In response to comments, EPA reviewed the indirect cost factors used to estimate overhead and profit, engineering, and contingency costs. The indirect cost factors used at proposal totaled 30 percent of the total direct capital costs. Commenters believed that indirect costs could range from 39 percent to 85 percent of the total direct capital costs. EPA reviewed data submitted by commenters and consulted a standard chemical engineering design text. (1) EPA found that an indirect cost factor of 30 percent was reasonable for the final design stage; however, an indirect cost factor of 45 percent was more appropriate for cost estimates at the conceptual stage. Therefore, because EPA's costs are "conceptual design" not "final design" EPA revised the end-of-pipe compliance costs using an indirect cost factor of 45 percent.

12.3.3.6 Land Costs

While in the process of revising end-of-pipe cost estimates, EPA considered whether certain mills actually required additional capital costs to purchase land on which to build or expand end-of-pipe treatment systems. For certain mills for which EPA had estimated land purchase costs at proposal, EPA reviewed information collected during recent site visits. Although this information suggested these mills may have sufficient room to accommodate the estimated treatment upgrades, because this information contradicted information reported in the 1990 Census Questionnaire and similar information was not available for all mills, for the final rule, EPA chose not to revise (i.e., reduce) land purchase costs. The result is more conservative (i.e., higher) compliance cost estimates.

12.3.3.7 Polymer Addition

At proposal, the polymer addition upgrade was developed based on best professional judgment. As discussed in the Proposed TDD, polymer addition was costed at a rate of 5 mg/L based on final effluent flow rate. Comments received on the proposal from pulp mills stated that EPA had overcosted polymer addition by using too high a rate of addition. EPA contacted additional pulp mills and determined that a polymer addition rate of 1.1 mg/L was more appropriate. Therefore, EPA revised the cost of polymer addition, which resulted in lower compliance costs.

12.3.3.8 Calculation of Total Annualized Costs

One of the components of total annualized costs for both the proposed and final rulemakings is annual general and administrative costs (GAC), such as insurance, which is included in annual O&M costs. For proposal, EPA estimated GAC as 4 percent of capital costs plus 60 percent of O&M costs for purposes of determining BCT-candidate option costs. After proposal, EPA determined that the 60 percent component was already included in the engineering estimates. For the final rule, therefore, EPA estimated GAC for BCT-candidate option costs as only 4 percent of capital. (For more discussion of their impact on this change see, Comment Response Document, DCN 14497, Volume IV, "BCT Cost Test.")

12.4 Final BCT Methodology

Components of the BCT methodology used for EPA's final evaluation of BCT Options 1 and 2 are described in the following sections.

12.4.1 BCT Technology Basis

As discussed in Section 12.2.1, EPA identified two final candidate BCT options for the Bleached Papergrade Kraft and Soda Subcategory and one final candidate BCT option for the Papergrade Sulfite Subcategory. As at proposal, EPA calculated the BCT performance levels as a function of effluent pollutant concentration, mill production, and effluent flow rate. Both in-process flow reduction technologies and end-of-pipe wastewater treatment can be combined to achieve the BCT performance levels.

The technologies used to estimate the cost to comply with BCT Options 1 and 2 are the same technologies used at proposal. Technologies were selected based on the operations present at each mill, as reported in the 1990 census questionnaire. Costed technologies include:

Flow reduction technologies

- \ Paper machine vacuum pump seal water recycle;
- \ Screen room closure; and/or
- \ Reuse of deinking washwater after flotation clarification.

End-of-pipe wastewater treatment

- \ Primary clarification;
- \ Aerated stabilization basins; and/or
- \ Activated sludge systems.

12.4.2 End-of-Pipe Treatment Costs

The final BCT compliance cost estimates for the Bleached Papergrade Kraft and Soda (BPK) and the Papergrade Sulfite (PS) subcategories are shown in Table 12-1. EPA estimated that BPK mills would incur an average capital cost of \$1.2 million (and a maximum cost of \$14.5 million) for Option 1 and an average capital cost of \$2 million (and a maximum cost of \$17.4 million) for Option 2. Annual O&M costs for the two options ranged from zero to \$3.5 million. PS mills would incur an average capital cost of \$1.2 million (and a maximum cost of \$3.9 million). Annual O&M costs ranged from zero to \$0.3 million.

12.4.3 Conventional Pollutant Removals

The final BCT option conventional pollutant removals for the Bleached Papergrade Kraft and Soda and the Papergrade Sulfite subcategories are shown in Table 12-2. EPA estimated that BPK mills would remove an average of 1.6 million pounds of BOD₅ and TSS from pulp mill effluents for Option 1 and an average of 2.5 million pounds of BOD₅ and TSS for Option 2. PS mills would remove an average of 57,000 pounds of BOD₅ and TSS under the candidate option.

12.4.4 BCT Cost Test Results

The background, application, and results of the BCT cost test are discussed in the following sections.

12.4.4.1 Background

The 1977 Clean Water Act amendments added Section 304(b)(4), which established BCT for direct discharges of conventional pollutants from existing industrial point sources. Effluent limitations based on BCT may not be less stringent than the limitations based on BPT. Thus, BPT effluent limitations are a “floor” below which BCT effluent limitations cannot be established.

The Clean Water Act amendments that created BCT also specify that the cost associated with BCT effluent limitations be “reasonable” with respect to the effluent reductions. Accordingly, the BCT methodology was developed to answer the question of whether it is “cost-reasonable” for industry to control conventional pollutants at a level more stringent than that already required by BPT effluent limitations.

As promulgated in July 1986 (51 FR 24974), the first step in establishing BCT effluent limitations for an industry (or a subcategory within an industry) is to identify candidate technologies that provide conventional pollutant control beyond the level achieved by the BPT effluent limitations. The next step is to evaluate these technology options by applying the two-part BCT cost test. To “pass” the POTW test (the first part of the test), the cost per pound of conventional pollutant removed by industrial dischargers in upgrading from BPT to BCT must be

less than the cost per pound of conventional pollutant removed in upgrading POTWs from secondary treatment to advanced secondary treatment. The POTW upgrade cost is referred to as the POTW benchmark; its derivation is described in the 1986 final BCT methodology notice.

The second part of the test that the BCT technology must pass is the industry cost-effectiveness test. This test is actually a ratio of two incremental costs: (1) the cost per pound removed by the BCT technology relative to BPT; and (2) the cost per pound removed by BPT relative to no treatment (i.e., “raw” waste load or “baseline”). The ratio of these two costs is a measure of the BCT technology’s cost effectiveness. As in the POTW test, this ratio is compared to a calculated industry cost benchmark. If the industry ratio is lower than the benchmark, the BCT technology passes the cost test.

EPA evaluates both tests as measures of reasonableness. As such, if the BCT technology passes both the POTW and industry cost test, then the most stringent technology option among them becomes the basis for setting BCT effluent limitations. Alternately, if no candidate technology more stringent than BPT passes, then BCT effluent limitations are set equal to BPT effluent limitations.

12.4.4.2 Application of the Final BCT Cost Test

EPA reviewed the control and treatment technology alternatives available for application in the pulp, paper, and paperboard industry for the control of conventional pollutants. As mentioned in Section 12.2.1, the result was to define two final candidate technologies for BPK mills and one final candidate technology for PS mills.

The BCT cost test calculations rely on cost and performance data from the 1990 industry census questionnaire and on results from the wastewater treatment model used at proposal (with the changes noted in Section 12.2.3). Since no information is available that accurately depicts the costs for the removal of conventional pollutants from raw waste load (RWL) to the current BPT regulation, the BCT cost test was performed using the LTA as derived from the 1989 performance data collected in the 1990 industry census questionnaire to represent BPT level of performance of biological treatment (biological treatment constitutes the basis of the current BPT). The source of cost estimates for wastewater treatment upgrades to achieve BCT was the end-of-pipe treatment system cost model used at proposal, which estimates capital and operating engineering costs. These costs were annualized using a cost annualization model that estimates the cost actually incurred by the mill to upgrade its pollution controls. This model takes into account tax savings the business accrues through depreciation and other tax shields.

Given these inputs, the BCT cost test was performed for two option for BPK mills and one option for PS mills:

- BPK - Option 1 - Current LTA to the average of the best performing 90 percent of BPK mills;

BPK - Option 2 - Current LTA to the average of the best performing 50 percent of BPK mills; and

PS Option - Current LTA to the average of PS mills.

For each option, the pounds of pollutant removed and cost incurred for the POTW cost test are the incremental pounds and costs associated with secondary wastewater treatment upgrades and necessary flow reduction. The ratio of incremental costs compared to incremental pounds constitutes the first part of the BCT cost test.

The second part, the industry cost-effectiveness test, requires the computation of a ratio of two incremental costs. The first incremental cost is the cost per pound for the removal of conventional pollutants incurred by industry in upgrading from BPT to BCT (i.e., the ratio from the first part of the cost test). The second incremental cost is the cost per pound for the removal of conventional pollutants incurred by industry to meet BPT relative to no treatment (i.e., RWL to current LTA). The ratio of the first cost to the second cost is the measure of the BCT technology's cost effectiveness.

The next step in the BCT cost test is to compare the two tests' results (or ratios) to the POTW and industry benchmarks. As explained above, the ratios calculated for the BCT cost test must be less than the POTW and industry benchmarks, respectively, to pass the BCT cost test. For a more detailed explanation of the benchmarks, refer to the 1986 notice of final regulation for the BCT methodology. In this analysis, the benchmarks are as defined in that notice, but indexed to comparable year data as the costs of treatment. As at proposal, EPA has indexed all costs to 4th quarter 1991 dollars.

Finally, the costs and pollutant removals for each mill were apportioned according to subcategory production. Baseline (RWL to current LTA) costs and pollutant removals are apportioned because mills are meeting their current limits based on all production at the facility, not just BPK and PS production. BCT option costs and pollutant removals are apportioned because the mill LTAs are calculated using proposed LTAs for all subcategories, not just the new LTAs for the BPK and PS subcategories. Mill LTAs for each option were calculated by multiplying the mill's percent production for each subcategory by the subcategory proposed LTA and then summing. Therefore, the calculations for both baseline and BCT option costs and pollutant removals are:

$$\text{Costs} = \text{Total annualized cost} \times \text{percent production in BPK (or PS)}$$

$$\text{Removals} = \text{Total pollutant removals (BOD}_5 + \text{TSS)} \times \text{percent production in BPK (or PS)}$$

12.4.4.3 Cost Test Results

The final BCT cost test results for the Bleached Papergrade Kraft and Soda and the Papergrade Sulfite Subcategories are shown in Table 12-3. None of the candidate technology options passed the BCT cost test. Therefore, EPA is not promulgating more stringent BCT effluent limitations guidelines for Subparts B and E at this time. Rather, the BCT limitations promulgated for former Subparts G, H, I, and P (now Subpart B) and former Subparts J and U (now Subpart E) remain in effect.

12.5 References

1. Means. Building Construction Cost Data. 54th Annual Edition, 1996.

Table 12-1**Best Conventional Pollutant Control Technology (BCT) Costs**

Subcategory¹	BCT Option	Capital (\$)	Engineering O&M (\$/yr)	Total Annualized Costs (1995 \$)
Bleached Papergrade Kraft and Soda	Option 1 (best 90%)	102,006,505	12,059,708	17,181,639
	Option 2 (best 50%)	172,405,961	18,724,362	28,092,172
Papergrade Sulfite	Option 1 (average)	11,030,865	593,202	1,451,886

¹Costs for mills with operations in more than one subcategory have been apportioned based upon annual production.

Table 12-2**Conventional Pollutant Reductions Associated With BCT**

Subcategory¹	BCT Option	BOD₅ Reductions (lb/yr)	TSS Reductions (lb/yr)
Bleached Papergrade Kraft and Soda	Option 1 (best 90%)	47,108,171	73,738,529
	Option 2 (best 50%)	74,873,613	118,476,733
Papergrade Sulfite	Option 1 (average)	3,115,156	4,065,428

Table 12-3**Results of the Final BCT Cost Test**

	Bleached Papergrade Kraft and Soda - Option 2 (best 50%)	Bleached Papergrade Kraft and Soda - Option 1 (best 90%)	Papergrade Sulfite - Option 1 (average)
A. POTW Test			
Total Annualized BCT Costs (1995 \$)	\$28,092,172	\$17,181,639	\$1,451,886
Pounds Removed by BCT	193,350,346	120,846,700	7,180,583
Industry BCT Benchmark (cost per pound removed relative to current LTA)	0.15	0.14	0.20
POTW Benchmark (cost per pound to upgrade to advanced secondary treatment)	0.48	0.48	0.48
Is BCT cost < POTW cost?	YES	YES	YES
Pass/Fail Test	PASS	PASS	PASS
B. Industry Cost Test			
RATIO 1			
Total Annualized Costs (RWL to Current LTA)	\$241,694,766	\$241,694,766	\$19,439,167
Pounds Removed (RWL to Current LTA)	3,375,724,754	3,375,724,754	277,287,784
B1. Industry BCT Cost (from Part A)	0.15	0.14	0.20
B2. Industry Current Cost (RWL to Current LTA)	0.07	0.07	0.07
RATIO1: Ratio of B1 to B2	2.03	1.99	2.88
RATIO 2			
C1. POTW Benchmark	0.48	0.48	0.48
C2. POTW Cost to upgrade from no treatment to secondary	0.37	0.37	0.37
RATIO2: Ratio of C1 to C2	1.29	1.29	1.29
Is Ratio 1 < Ratio 2?	NO	NO	NO
Pass/Fail Test	FAIL	FAIL	FAIL

SECTION 13

ABBREVIATIONS AND CONVERSIONS

13.1 Abbreviations

2,3,7,8-TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin
2,3,7,8-TCDF	2,3,7,8-tetrachlorodibenzofuran
ACM	active chlorine multiple
AF&PA	American Forest and Paper Association
AOX	Adsorbable organic halides. A bulk parameter which measures the total chlorinated organic matter in wastewater.
ASB	aerated stabilization basin
AST	activated sludge treatment
BAT	Best Available Technology Economically Achievable
BCT	Best Conventional Pollutant Control Technology
BID	Background Information Document: Pulp, Paper, and Paperboard Industry--Background Information for Proposed Air Emission Standards (October, 1993)
BFR	bleach filtrate recycle
BLS	black liquor solids
BMP	Best Management Practices
BOD ₅	Five-day biochemical oxygen demand
BPK	bleached papergrade kraft and soda mills
BPT	Best Practicable Control Technology
C	bleach sequence symbol for chlorine stage
CAA	Clean Air Act
CBI	confidential business information
CDD	chlorinated dibenzo-p-dioxin
CDF	chlorinated dibenzofuran
CEK	target kappa number
CEM	continuous emission monitor
CFR	Code of Federal Regulations

ClO ₂	chlorine dioxide
CMN	corrugated, molded and newsprint
CO ₂	carbon dioxide
COD	chemical oxygen demand
CTMP	chemi-thermo-mechanical pulp
CWA	Clean Water Act
D	bleach sequence symbol for chlorine dioxide stage
DBD	dibenzo-p-dioxin
DBF	dibenzofuran
DCN	document control number
E	bleach sequence symbol for extraction stage
EA	Economic Analysis for the National Emission Standards for Hazardous Air Pollutants for Source Category: Pulp and Paper Production; Effluent Limitations Guidelines, Pretreatment Standards, and New Source Performance Standards: Pulp, Paper, and Paperboard Category - Phase I, Record Section 30.5, DCN 14649.
EAD	Engineering and Analysis Division
EC	extended cooking
ECF	elemental chlorine-free
EMCC [®]	extended modified continuous cooking, a registered trademark of Kamyr, Inc.
EPA	U.S. Environmental Protection Agency
FR	Federal Register
GAC	general and administrative costs
H	bleach sequence symbol for hypochlorite stage
HAP	hazardous air pollutant
HVLC	high concentration low volume
HW	hardwood
ISO	International Organization for Standardization
ITC [®]	Iso Thermal Cooking, a registered trademark of Kvaerner

LTA	long-term average
LTS	long-term study
MACT	Maximum Achievable Control Technology
MCC®	Modified Continuous Cooking, a registered trademark of Kamyr, Inc.
ML	minimum level
N	bleach sequence symbol indicating the absence of a washing stage
NA	not applicable
Na ₂ SO ₄	sodium sulfate
NAICS	North American Industry Classification System
NC	not costed
NC	not counted
NCASI	National Council of the Paper Industry for Air and Stream Improvement, Inc.
ND	not detected
ND	not disclosed to prevent compromising confidential business information
NESHAP	National Emission Standards for Hazardous Air Pollutants
NPDES	National Pollutant Discharge Elimination System
NRDC	Natural Resources Defense Council
NSPS	New Source Performance Standards
O	bleach sequence symbol for oxygen stage
O&M	operating and maintenance
OAR	Office of Air and Radiation
OD	oxygen delignification
P	bleach sequence symbol for peroxide stage
PCS	permit compliance system
pH	negative logarithm of the effective hydrogen-ion concentration in moles per liter, a measure of acidity
PMP	pollutant minimization program

POTW	publicly owned treatment works
PS	papergrade sulfite mills
PSES	Pretreatment Standards for Existing Sources
PSNS	Pretreatment Standards for New Sources
Q	bleach sequence symbol for acid chelant stage
QA	quality assurance
QC	quality control
RDH [®]	Rapid-Displacement Heating, a registered trademark of Beloit Corp.
RWL	raw waste load
S	bleach sequence symbol for sodium bisulfite
SCC	Sample Control Center
SIC	Standard Industrial Classification
STDD	Supplemental Technical Development Document for Effluent Limitations Guidelines and Standards, for the Pulp, Paper, and Paperboard Category Subpart B (Bleached Papergrade Kraft and Soda) and Subpart E (Papergrade Sulfite), October 1997
STFI	Swedish Forest Products Research Institute
SW	softwood
TCF	totally chlorine-free
TDD	Technical Development Document for Proposed Effluent Limitations Guidelines and Standards for the Pulp, Paper, and Paperboard Point Source Category, October 1993
TEQ	toxic equivalent
TRS	total reduced sulfur
TSS	total suspended solids
UBK	unbleached kraft mills
Z	bleach sequence symbol for ozone stage

13.2 Units of Measure

ADMT	air dry metric ton
ADT	air dry (short) ton
atm	atmosphere
bbbl	barrel
BTU	British Thermal Unit
d	day
g	gram
G	giga
kg	kilogram
kgg	1,000 kilograms = 1 metric ton = 1 mega gram
kPa	kilopascal
kWh	kilo Watt hour
J	joule
L	liter
m ³	cubic meter
mg	milligram
M	mega
MGD	million gallons per day
ng	nanogram
OMMT	off-machine metric ton
OMT	off-machine (short) ton
pg	picogram
ppb	part per billion
ppm	part per million
ppq	part per quadrillion
ppt	part per trillion
psi	pounds per square inch
	microgram

UBADt	unbleached air dry ton
UBMt	unbleached metric ton
W	watt
yr	year

13.3 Unit Conversions

Table 13-1 presents mass and concentration unit conversions used throughout this document.

Table 13-1
Units of Measurement

Mass Units		
Unit	Unit Abbreviation	Equivalent Mass in Grams
Gigagram	Gg	1,000,000,0000
Megagram or Metric ton	Mg or kkg	1,000,000
Kilogram	kg	1,000
Gram	g	1
Milligram	mg	0.001
Microgram		0.000001
Nanogram	ng	0.000000001
Picogram	pg	0.000000000001
Femtogram	fg	0.000000000000001
Concentration Units		
Unit Abbreviation	Liquids	Solids
ppm (10^{-6})	mg/L	mg/kg =
ppb (10^{-9})		
ppt (10^{-12})	ng/L	ng/kg = pg/g
ppq (10^{-15})	pg/L	pg/kg = fg/g

- Notes:
- (1) For liquids, conversions from metric concentration unit to ppm, ppb, ppt, and ppq are approximate.
 - (2) 1.0 kg = 2.2046 lbs.

Source: American Petroleum Institute
Publication No. 4506, March 1990