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Economic and Environmental Benefits Analysis Document For The Final Effluent Limitations Guidelines and Standards For The Metal Products & Machinery Point Source Category

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Christine Todd Whitman
Administrator

G. Tracy Mehan, III
Assistant Administrator, Office of Water

Geoffrey H. Grubbs
Director, Office of Science and Technology

Sheila E. Frace
Director, Engineering and Analysis Division

Nicolaas Bouwes
Chief, Economic and Environmental Assessment Branch

William Anderson
Technical Coordinator

Lynne Tudor
Economist

James C. Covington, III
Economist

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U.S. Environmental Protection Agency
Office of Water
Washington, DC 20460

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Questions or comments regarding this economic document should be addressed to:

Mr. James C. Covington, III.
Economist
Engineering and Analysis Division (4303T)
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, N.W.
Washington, DC 20460
(202) 566 - 1034
covington.james@epa.gov

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Executive Summary

INTRODUCTION

EPA is promulgating effluent limitations guidelines and standards for the Metal Products and Machinery (MP&M) industry. This document presents EPA's economic and environmental analyses supporting the final rule. The Executive Summary provides an overview of the costs and benefits of the regulation.

Overall, EPA finds that the final rule has modest economic impacts and benefits. The estimated social cost of the final rule is $13.8 million annually (2001$). The total benefits that can be valued in dollar terms in the categories traditionally analyzed for effluent guidelines range from around $1.0 to $1.5 million annually (2001$), based on alternative extrapolation methods.

EPA recognizes that estimates of both costs and benefits are uncertain. To supplement the national level analysis performed for the final MP&M regulation, EPA conducted a more detailed case study of the expected State-level costs and benefits of the MP&M rule in Ohio. In contrast to the national-level analysis, the more detailed case study analysis finds that the final regulation would achieve benefits substantially exceeding estimated social costs. Comparing the midpoint estimate of social costs ($62,232) with the midpoint estimate of monetizable benefits ($930,408) for Ohio, EPA estimates a net benefit of the final MP&M rule for Ohio is $868,178 (2001$).

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EPA notes that effluent limitations guidelines for the MP&M industry are technology-based. EPA is neither required to demonstrate environmental benefits of its technology-based rules, nor is it required to consider receiving water quality in setting technology-based effluent limitations guidelines and standards. EPA considers benefits as one of the factors that the Agency evaluates.

Detailed descriptions of the analytic methodologies and results are presented in the Economic, Environmental, and Benefits Assessment for the Final Metal Products and Machinery Rule (EEBA). In addition, the EEBA presents costs, benefits, and economic impacts for alternatives to the final rule that were considered by EPA.

ES.1 OVERVIEW OF FACILITIES EVALUATED FOR REGULATION UNDER THE MP&M POINT SOURCE CATEGORY AND ITS EFFLUENT DISCHARGES

The MP&M Point Source Category regulates oily operations process wastewater discharges to surface waters from existing or new industrial facilities (including facilities owned and operated by federal, state, or local governments) engaged in manufacturing, rebuilding, or maintenance of metal parts, products, or machines for use in the sixteen Metal Product & Machinery (MP&M) industrial sectors. Please note the underlined language in the previous sentence as a facility may be subject to the MP&M effluent guidelines even if it is not in one of the MP&M industrial sectors. For example, EPA considers a facility performing machining part of the "Bus & Truck" MP&M industrial sector if it manufactures metal parts for truck trailers. Process wastewater means wastewater as defined at 40 CFR parts 122 and 401, and includes wastewater from air pollution control devices (see 40 CFR 438.2(g)). Oily operations are listed at 40 CFR 438.2(g) and defined in Appendix B to Part 438 (see also Section 4 of the TDD).

According to Statistics of U.S. Business, 1996, approximately 638,696 establishments operate in the MP&M industry sectors. Based on information in the MP&M survey database, approximately 44,000 facilities meet the definition of an MP&M facility. These 44,000 facilities include approximately 41,000 indirect dischargers (i.e., facilities discharging effluent to a publicly-owned sewage treatment works or POTWs) and 3,000 direct dischargers (i.e., facilities discharging effluent directly to a waterway under a NPDES permit).

Table ES.1 reports the estimated number of MP&M facilities and total discharge flow (before final rule implementation) by type of facility. The largest number of sites, approximately 22,000, perform "rebuilding/maintenance only" and account for approximately 6 percent of the total estimated discharge flow for the industry. "Manufacturing only" contains the next largest number of facilities (15,400) and accounts, by far, for the largest percentage of the total estimated discharge flow for the industry (82 percent).

Table ES.1: Number of MP&M Facilities and Total Discharge Flow by Type of Facility

Type of Facility	Number of Facilities	Total Estimated Discharge Flow (million gal/yr)	Percent of Facilities	Percent of Total Discharge Flow
Manufacturing & Rebuilding/Maintenance	6,600	9,400	15.0%	12.0%
Manufacturing only	15,400	64,100	35.0%	82.0%
Rebuilding/Maintenance only	22,000	4,700	50.0%	6.0%
Total	44,000	78,200	100.0%	100.0%

Source: U.S. EPA analysis. See Section 4 of the Technical Development Document for the final rule.

Of the 43,858 water discharging facilities, 3,593 are predicted to close in the baseline, leaving 40,265 existing MP&M facilities that EPA estimates could be regulated.[1] After accounting for subcategory and discharger class exclusions, EPA estimates that the final rule will regulate 2,382 of these facilities, all of which are direct dischargers. These regulated facilities represent 5.9 percent of the 40,265 facilities that could be potentially regulated.

Table ES.2 summarizes information on the total number of MP&M facilities that were evaluated for the final rule, the number operating in the baseline, and the number and percent of facilities that will be regulated under the final rule. As reported in Table ES.2, no indirect dischargers are subject to the final regulation. The rule will regulate 2,382 direct dischargers in the Oily Wastes subcategory.

Table ES.2: Number of MP&M Facilities Evaluated for the Final Rule and Regulated under the Final Rule

Discharge Status	MP&M Facilities	Operating in the Baseline	Regulated under the Final Rule	Percent of Facilities Operating in the Baseline that are Regulated
Direct dischargers	2,739	2,641	2,382	90%
Indirect dischargers	41,162	37,652	0	0%
All dischargers	43,858	40,265	2,382	6%

Source: U.S. EPA analysis.

[1] These are facilities that are predicted to close due to weak financial performance under baseline conditions, i.e., in the absence of the final rule. EPA does not attribute the costs or the reduced discharges resulting from these baseline closures to the final rule, and therefore excludes these facilities from its analyses of the rule's impacts. Baseline closures account for differences between the universe of facilities discussed in this report and the universe discussed in the *Technical Development Document.*

Several aspects of the MP&M industries as a whole and part of those industries evaluated for regulation under the final rule are important in understanding the need for the regulation, the likely distribution and occurrence of benefits, and the framework of the economic analysis for the regulation.

Facilities in the relevant MP&M industries are located in every state, with a particular concentration in the heavy industrial regions along the Gulf Coast, both East and West Coasts and the Great Lakes Region. Moreover, MP&M facilities are frequently located in highly populated regions. Based on an analysis of in-scope sample facilities, around 35% of these facilities discharge to reaches located adjacent to counties with populations of at least 500 thousand people.[2]

Discharges of these pollutants to surface waters and POTWs have a number of adverse effects, including degradation of aquatic habitats, reduced survivability and diversity of native aquatic life, and increased human health risk through the consumption of contaminated fish and water.

Many MP&M facilities evaluated for the final regulation produce goods and services that serve multiple market sectors. It is not possible to associate regulatory costs and benefits to particular sectors, because EPA is not able to link regulated processes to specific sectors for facilities operating in multiple sectors. As a result, EPA's cost and economic impact analyses are disaggregated by type of facility but not by sector.

ES.2 Description of the Final Rule

In order to address variations between products, raw materials processed, and other factors that result in distinctly different effluent characteristics, EPA proposed eight groupings called "subcategories" for the January 2001 proposal and June 2002 Notice of Data Availability (NODA). EPA retained this subcategory structure for evaluating options for the final rule. Regulation of a category using subcategories allows each subcategory to have a uniform set of effluent limitations that take into account technological achievability and economic impacts unique to that subcategory (see Section 6 of the TDD). For the final rule, EPA is establishing limitations and standards only for direct dischargers in the Oily Wastes subcategory. The other seven subcategories (General Metals, Metal Finishing Job Shops, Non Chromium Anodizing, Printed Wiring Board, Railroad Line Maintenance, Shipbuilding Dry Docks, and Steel Forming & Finishing) were considered for regulation at proposal and for some of the alternative regulatory options, but are not further regulated under the final rule.

EPA is establishing BPT pH limitations and daily maximum limitations for two pollutants, oil and grease as hexane extractable material (O&G (as HEM)) and total suspended solids (TSS), for direct dischargers in the Oily Wastes subcategory based on the proposed technology option (Option 6). The technology requirements include the following treatment measures: (1) in-process flow control and pollution prevention; and (2) oil-water separation by chemical emulsion breaking and skimming (see Section 9 of the TDD). This technology is available technology readily applicable to all facilities in the Oily Wastes subcategory. Approximately 42% of the direct discharging facilities in the Oily Wastes subcategory currently employ this technology already.

EPA is promulgating BCT equivalent to BPT for facilities in the Oily Wastes subcategory and has decided not to establish BAT limitations. EPA is promulgating NSPS for new direct dischargers in the Oily Wastes subcategory at the BPT and BCT levels.

ES.3 Economic Impacts and Social Costs of the Final Rule

EPA assessed the economic impacts and social costs of the final rule using detailed financial and technical data from the MP&M surveys (see Section 3 of the TDD). Engineering analyses of these facilities identified the pollution prevention and treatment systems needed to comply with the final rule and other regulatory alternatives. The estimated capital and annual operating and maintenance costs of these systems, incremental to the costs of systems already in place, represent the

[2] EPA is not able to characterize the location characteristics of all potentially-regulated MP&M facilities at the national level precisely, because the MP&M survey design was not intended to provide national results by location characteristics.

compliance costs of the rule.[3] EPA analyzed the financial performance of the facilities evaluated for regulation under pre-regulation conditions (the baseline) and as subject to regulatory requirements. The Agency used a variety of measures to assess the economic impacts resulting from the final rule, both for the regulated MP&M facilities and for the firms and governments that own the facilities. The economic impact analysis also considered impacts for small entities in particular, and impacts on employment, foreign trade and communities. The results of the analyses for sample facilities were extrapolated using survey sample weights for each facility, to provide national-level results.

ES.3.1 Economic Impacts

Overall, EPA found the economic impact of the final rule to be modest. The following are EPA's findings for different categories of impacts.

a. Facility impacts

The facility impact analysis assesses how facilities will be affected financially by the final rule. Key outputs of the facility impact analysis include expected facility closures in the MP&M industries, associated losses in employment, and the number of facilities experiencing financial stress short of closure ("moderate impacts"). EPA performed economic impact analyses for three categories of facilities, using different methodologies to evaluate each of the groups. The three groups are:

- Private MP&M Facilities. This group includes privately-owned facilities that do not perform railroad line maintenance and are not owned by governments. This major category includes private businesses in a wide range of sectors or industries, including facilities that manufacture and rebuild railroad equipment. Only facilities that repair railroad track and equipment along the railroad line are not included.

- Railroad line maintenance facilities maintain and repair railroad track, equipment and vehicles.

- Government-owned facilities include MP&M facilities operated by municipalities, State agencies and other public sector entities such as State universities. Many of these facilities repair, rebuild, and maintain buses, trucks, cars, utility vehicles (e.g., snow plows and street cleaners), and light machinery.

The specific methodology used to assess impacts differed for each of the three types of MP&M facilities. For private MP&M facilities, EPA established thresholds for measures of financial performance and compared the facilities' performance before and after compliance with each regulatory option with these thresholds. Impacts were measured at the operating company level for railroad line maintenance facilities, since firms are unlikely to keep track of financial performance at the facility level for these sites. For governments, EPA compared compliance costs with facilities' baseline costs of service, and assessed the impact of the compliance costs on the government's taxpayers and on its ability to finance compliance costs by issuing debt.

EPA identified facilities that are financially weak and might be expected to close under baseline conditions. Of the estimated 43,858 discharging facilities, 8.2 percent or 3,593 facilities were assessed as baseline closures. The 3,593 baseline closures include 3,511 indirect dischargers, or 8.5 percent of indirect dischargers, and 98 direct dischargers, or 3.6 percent of direct dischargers. These facilities were excluded from the post-compliance analysis of regulatory impacts.

Table ES.3 summarizes the facility-level economic impact of the final rule. EPA estimates that the final rule will cause no facilities to close or to incur moderate financial stress short of closure. The final rule excludes all indirect discharging facilities and two percent of the direct discharging facilities from requirements.

[3] The annual equivalent of capital and other one-time costs is calculated by annualizing costs at a seven percent discount rate over an estimated 15 year equipment life. Annual compliance costs are annualized capital costs plus annual operating and maintenance (O&M) costs.

Table ES.3: Regulatory Impacts for All Facilities, Final Rule, National Estimates			
	Total[a]	Direct	Indirect
Number of facilities operating in the baseline: total	40,265	2,641	37,652
private MP&M and railroad line maintenance	*36,480*	*2,183*	*34,325*
government-owned	*3,785*	*458*	*3,327*
Number of facilities with subcategory exclusions	37,883	259	37,652
Percent of facilities operating in the baseline excluded or below cutoffs	94.1%	9.8%	100.0%
Number of facilities operating subject to regulatory requirements	2,382	2,382	0
Number of regulatory closures	0	0	0
Percent of facilities operating in the baseline that are regulatory closures	0.0%	0.0%	0.0%
Number of facilities experiencing moderate impacts	0	0	0
Percent of facilities operating in the baseline that experience moderate impacts	0.0%	0.0%	0.0%

[a] The total number of facilities does not sum to the number of facilities by subcategory because some facilities have an indirect and direct discharging operation within the same facility.

Source: U.S. EPA analysis.

Table ES.4 summarizes impacts for government-owned facilities in particular. Under the final rule, 88 percent of the government-owned facilities are excluded from requirements by subcategory exclusions. The compliance costs of the final rule do not result in significant budgetary impacts for any of the governments that operate MP&M facilities.

Table ES.4: Regulatory Impacts for Government-Owned Facilities, Final Rule, National Estimates	
Number of government-owned facilities operating in the baseline	3,785
Number of facilities with subcategory exclusions	3,327
Percent of facilities operating in the baseline excluded	88%
Number of facilities operating subject to regulatory requirements	458
Number of facilities experiencing significant budgetary impacts[a]	0
Percent of facilities operating in the baseline that experience significant budgetary impacts	0%

[a] A government is judged to experience major budgetary impacts if (1) any of its MP&M facilities incur compliance costs exceeding 1% of baseline cost of service and (2) the government fails both the taxpayer impact and debt impact tests.

Source: U.S. EPA analysis.

b. Firm-level impacts

EPA examined the impacts of the final rule on firms that own MP&M facilities, as well as on the financial condition of the facilities themselves. A firm that owns multiple MP&M facilities could experience adverse financial impacts at the firm level if its facilities are among those that incur significant impacts at the facility level. The firm-level analysis is also used to assess impacts on small firms, as required by the Regulatory Flexibility Act.

EPA compared compliance costs with revenue at the firm level as a measure of the relative burden of compliance costs. EPA applied this analysis only to MP&M facilities owned by private entities. EPA estimated firm-level compliance costs by summing costs for all facilities owned by the same firm that responded to the survey plus estimated compliance costs for additional facilities for which respondents submitted voluntary information. The Agency was not able to estimate the national numbers of firms that own MP&M facilities precisely, because the sample weights based on the survey design represent numbers of facilities rather than firms. Most MP&M facilities (26,472 of 36,480, or 73 percent) are single-facility firms, however. These firms can be analyzed using the survey weights. In addition, from survey responses, EPA identified 389 sample facilities that are owned by 276 multi-facility firms. It is not known how many multi-facility firms exist at the national level, so EPA included these 276 firms in the firm-level analysis without extrapolation to the national level.

Table ES.5 shows the results of the firm-level analysis. The results represent a total of 26,748 MP&M firms (26,472 + 276), owning 26,861 facilities (26,472 owned by single-facility firms + 389 owned by multi-facility firms).

Table ES.5: Firm Level Before-Tax Annual Compliance Costs as a Percent of Annual Revenues

Number of Firms in the Analysis[a]	Number and Percent with Before-Tax Annual Compliance Costs/Annual Revenues Equal to:					
	0%		>0% and <1%		Over 1%	
	Number	%	Number	%	Number	%
26,748	25,722	96.2%	1,027	3.8%	0	0%

[a] Firms whose only MP&M facilities close in the baseline are excluded.

Source: U.S. EPA analysis.

None of the firms in the analysis incur after-tax costs of greater than 1 percent of their annual revenues. Of the 1,027 firms that incur any costs at all, none own facilities that close or experience moderate impacts as a results of the final rule.

This analysis is likely to overstate costs at the firm level because it does not consider the actions a multi-facility firm might take to reduce its compliance costs under the final rule, such as transferring functions among facilities to consolidate wet processes and to take advantage of scale economies in wastewater treatment.

c. Employment effects

Potential changes in employment from the rule include: (1) job losses that occur when facilities close and (2) job gains resulting from facilities' compliance activities. EPA estimates that the final rule will cause no facilities to close and therefore the final rule will cause no job losses. EPA estimates that the regulation will increase employment, with the manufacture and installation of compliance equipment causing a short-term gain in direct employment of 20 FTEs. In addition, EPA estimates that operation and maintenance of compliance equipment will cause a continuing direct requirement for 2 FTEs per year. The net effect on direct employment of the regulation is an estimated increase in 47 FTE-years, a measure that reflects both the number and duration of jobs gained. Over the 15 year analysis period, the employment gain averages 3 FTEs per year.

d. Community impacts

EPA also considered the potential impacts of changes in employment due to the regulation on the communities where MP&M facilities are located. Given that no closures are predicted due to the final rule, EPA does not expect the rule to have significant impacts at the community level.

e. Foreign trade impacts

The foreign trade impacts analysis allocates the value of changes in output for each facility that is projected to close to exports, imports, or domestic sales, based on the dominant source of competition in each market as reported in the surveys. EPA does not expect any foreign trade impacts as a result of the final rule because no facility closures are expected.

f. Impacts on new facilities

The new facility analysis assessed whether revised or new discharge limits for newly constructed sources would create a barrier to entry by new businesses and new facilities. To assess the potential for barrier to entry, EPA compared, by subcategory and discharger status, the estimated annual incremental costs of meeting revised new source limits with the estimated annual revenue of new facilities. EPA based the estimates of annual revenue and incremental costs of meeting revised new source limits on information from the existing facility database. EPA used the findings from this analysis, in terms of the estimated percentages of new facilities that would incur costs exceeding specified revenue thresholds, to decide whether to issue revised new source limits for the various industry subcategories and discharger classes. From this analysis, EPA concluded that the promulgation of revised new source limits for the Oily Wastes direct discharger subcategory would not create a barrier to entry and this information, in part, underlies EPA's decision to promulgate new source limits for this subcategory as part of the final regulation.

g. Impacts on small entities

Table ES.6 shows the total number of facilities operating in the baseline and the number owned by small entities. Overall, approximately 73 percent of all MP&M facilities are owned by small entities. However, subcategory exclusions in the final rule will exclude approximately 95 percent of the facilities owned by small entities.

Table ES.6: Number and Percent of MP&M Facilities Owned by Small Entities

Type of Facility	Number of Facilities of all Sizes Operating in the Baseline	Number of Facilities Owned by Small Entities	Percent of Facilities Owned by Small Entities
Private MP&M[a]	36,480	27,418	75%
Government-owned	3,785	1,962	52%
Total[a]	40,265	29,380	73%

[a] Excludes baseline closures

Source: U.S. EPA analysis.

EPA assessed impacts on small entities by comparing compliance costs to revenues for the small entities at the firm level and by analyzing the facility impact analysis results for facilities owned by small firms. These analyses indicate that no facilities will incur costs exceeding 1% of revenues, and only 1,019 facilities owned by small firms will incur any costs at all. None of these facilities incur moderate impacts or close as a result of the final rule.

EPA estimates that 1,962 facilities are owned by small governments (those with populations less than 50,000). The subcategory exclusions in the final rule exclude 1,682 of these small government-owned MP&M facilities. Thus, the final rule covers 280 small government-owned facilities. Of these facilities, only 140 incur costs, and the average annual cost per facility is less than $30,000. All of the 140 facilities have costs less than 3 percent of baseline cost of service. EPA estimated no significant impacts for any of these facilities or the governments that own them, based on the analysis of change in site cost of service, impact on taxpayers, and impact on government debt levels. The total compliance cost for all the small government-owned facilities incurring costs under the final rule is $3.5 million.

ES.3.2 Social Costs

The social costs of the final rule represent the value of society's resources used to comply with and administer the rule. EPA estimated three categories of social cost for the final regulation:

- the cost of society's economic resources used to comply with the final regulation,
- the cost to governments of administering the final regulation, and
- the social costs of unemployment resulting from the regulation.

Resource costs of compliance are the value of society's productive resources including labor, equipment, and materials expended to achieve the reductions in effluent discharges required by the final rule. The social costs of these resources are generally higher than the cost burden to facilities because facilities are able to deduct the costs from their taxable income and may offset some of the costs through increased prices to customers. The costs to society, however, are the full value of the resources used, whether they are paid for by the regulated facilities, by all taxpayers in the form of lost tax revenues, or passed on to customers through increased prices.

The main cost to government from administering the regulation is the cost to POTWs for writing permits, and for compliance monitoring and enforcement activities. POTWs could incur costs in writing new permits for previously unpermitted facilities, and writing revised permits for some facilities earlier than would otherwise be required. Because the final regulation excludes all indirect dischargers from coverage, EPA expects that the final rule will not increase POTW administrative costs.

The loss of jobs from facility closures would represent a social cost of the regulation. From its facility impact analysis, EPA estimates that no facilities will close as a result of the regulation. Accordingly, EPA estimates a zero cost of unemployment for the final rule. EPA did not recognize possible savings in unemployment-related costs from jobs created by the rule as a negative cost (benefit) of the regulation.

From this analysis EPA estimated a total annual social cost of $13.8 million annually (2001$) for the final rule (see Table ES.7). All of this cost results from the estimated resource cost of compliance.

Table ES.7: Total Social Cost: Final Rule (millions, 2001$)

Social Cost Categories	Final Rule
Resource cost of compliance expenditures	$13.8
Costs to POTWs of administering the rule	$0.0
Social costs of unemployment	$0.0
Total Social Cost	$13.8

Source: U.S. EPA analysis.

ES.4 National Benefits of the Final Rule

The final regulation will reduce MP&M industry pollutant discharges to the nation's surface waters with a number of consequent benefits to society, including:

- improved quality of freshwater, estuarine, and marine ecosystems;
- increased survivability and diversity of aquatic and terrestrial wildlife; and
- reduced risks to human health through consumption of fish or water taken from affected waterways.

Table ES.8 shows EPA estimates for reduction in pollutant discharges to U.S. waters under the final rule. Loadings are shown both in pounds of pollutant and in toxic-weighted pound equivalents. The latter measure reflects the relative toxicity of the various toxic pollutants. The regulation would result in a 80 percent reduction in total toxic-weighted pollutant lbs. equivalent per year. The estimated toxic weighted pollutant reductions range from 87 percent for priority metal pollutants to 1 percent for arsenic. Reductions in pounds of pollutants (not toxic-weighted) range from 93 percent for oil and grease (O&G) to 5 percent for arsenic. As shown in Table ES.8, the final rule achieves modest reductions for arsenic, organics, biological oxygen demand (BOD), and chemical oxygen demand (COD), and significant reductions for toxic metals, other inorganics, bulk pollutants, and oil and grease.

Table ES.8: Summary of Discharges by Pollutant Type for Regulated MP&M Facilities[a]						
Pollutant Category	**Current Releases**		**Releases under the Final Rule**		**Percent Reduction Due to the Final Rule**	
	Pounds	**Pounds Eq.**	**Pounds**	**Pounds Eq.**	**Pounds**	**Pounds Eq.**
Priority Pollutants						
Metals	794	2,756	153	351	80.7%	87.3%
Organics	336	58	268	45	20.2%	22.4%
Arsenic	22	75	21	74	4.5%	1.3%
Cyanide (CN)	0	0	0	0	-	-
Nonconventional Pollutants						
Metals	25,863	417	16,428	158	36.5%	62.1%
Organics	2,159	45	1,038	39	51.9%	13.3%
Other inorganics	2,334	0.2	1,301	0.1	44.3%	50.0%
Bulk pollutants	335,679		167,295		50.2%	
Conventional Pollutants						
BOD	263,419		165,567		37.1%	
COD	523,440		488,697		6.6%	
O&G	428,137		28,955		93.2%	
TSS	160,695		73,769		54.1%	
Total		3,351		667		80.1%

[a] Includes only direct discharging facilities in the Oily Wastes subcategory that continue to operate in the baseline and that are subject to the final rule.

Source: U.S. EPA analysis.

EPA assessed the benefits from the expected pollutant reductions in three broad classes: human health, ecological, and productivity benefits.[4] EPA was able to assess benefits within these three classes with varying degrees of completeness and rigor. Where possible, EPA quantified the expected effects and estimated monetary values. Some benefit categories could not be monetized because of data limitations and a limited understanding of how society values certain water quality changes.

EPA used sample facility data to estimate national benefits from the regulation. The Agency extrapolated findings from the sample facility analyses to the national level using two extrapolation methods: (1) traditional extrapolation and (2) post-stratification extrapolation. EPA traditionally uses a standard linear weighting technique (i.e., traditional extrapolation) to estimate national compliance costs, changes in pollutant removals, and national-level benefits of environmental regulations. However, using sample weights that are based only on facility-specific (e.g., engineering) characteristics without including non-facility factors can lead to a conditional bias in the estimation of national-level benefits. In particular, this approach omits consideration of important non-facility factors that influence the occurrence and size of benefits. Non-facility factors that are likely to affect the occurrence and size of benefits from reduced sample facility discharges and that are not reflected in the standard stratification and sample-weighting approach include the receiving water body type and size and the size of population residing in the vicinity of a sample facility. To address omission of these important non-facility factors (i.e., water body type and size, affected population, and co-occurrence MP&M discharges) in designing the MP&M facilities sample, EPA adjusted sampling weights through post-stratification using two variables: (1) receiving water body type and size and (2) the size of the population residing in the vicinity of the sample facility. The Agency used a commonly used post-

[4] EPA evaluated two productivity measures: (1) the reduction in pollutant interference at POTWs, and (2) pass-through of pollutants into the sludge, which limits options for POTW disposal of sewage sludge. Because the final rule only regulates direct discharges and thus does not affect POTW operations, productivity benefits were evaluated for alternative options only.

stratification method called "raking" to adjust original sample weights to reflect these benefits characteristics. Appendix G of this report provides detail on extrapolation methods used in this analysis.

To supplement the national-level analysis performed for the final MP&M regulation, EPA also conducted a detailed case study of the expected state-level costs and benefits of the MP&M rule in Ohio. For several reasons, EPA judges that the Ohio case study is more robust than the national benefit analyses that EPA undertakes in support of effluent guideline development. These reasons include: (1) use of more detailed data on MP&M facilities than is possible at the national level; (2) use of more detailed and accurate water quality data than are usually available; (3) more accurate accounting for the presence and effect of multiple discharges to the same reach; (4) inclusion of data on non-MP&M discharges in the baseline and post compliance; (5) use of a first-order decay model to estimate in-stream concentrations in downstream water bodies; and (6) inclusion of an additional recreational benefit category (swimming) in the analysis. The Ohio case study analysis is presented in Chapters 20, 21, and 22 of this report.

ES.4.1 Reduced Human Health Risk

EPA estimates that the final rule will prevent discharge of 18 pounds per year of carcinogens and 119 pounds per year of lead. Also, the final rule will prevent discharge of an additional 6,900 pounds of 76 pollutants of concern that are known to cause adverse human health effects. These reduced pollutant discharges from MP&M facilities are expected to result in reduced risk of illness from consumption of contaminated fish, shellfish, and water.

EPA analyzed the following measures of health-related benefits: reduced cancer risk from fish and water consumption; reduced risk of non-cancer toxic effects from fish and water consumption; lead-related health effects to children and adults; and reduced occurrence of in-waterway pollutant concentrations in excess of levels of concern. The levels of concern include human health-based ambient water quality criteria (AWQC) or documented toxic effect levels for those chemicals not covered by water quality criteria. Although some health effects are relatively well understood and can be quantified and monetized in a benefits analysis (e.g., cancer), others are less well understood, and may not be assessed with the same rigor or at all (e.g., systemic health effects). The Agency therefore monetized only two of these health benefits: (1) changes in the incidence of cancer from fish and water consumption, and (2) changes in adverse health effects in children and adults from reduced lead exposure.

The national-level analysis of human health benefits finds negligible monetized benefits from the final rule. However, because of significant simplifications in the national level analysis, this finding should be recognized as potentially having substantial error and should therefore be interpreted with caution. In particular, the national-level analysis: (1) is based only on limited information on MP&M facilities at the national level; (2) accounts in only a very limited way for the presence and effect of joint discharges on the same reach; (3) omits data on non-MP&M discharges in the baseline and post compliance; and (4) omits consideration of the downstream effects of pollutant discharges.

In contrast to the national-level analysis, the methods and data used for the Ohio case study address a number of these analytic weaknesses. This more rigorous analysis finds that the final regulation would achieve $0.5 million (2001$) in health-related benefits in the state of Ohio alone. EPA estimates that this analysis provides a more accurate, albeit lower-bound, estimate of health-related benefits than indicated by the simpler national-level analysis. Moreover, given (1) that Ohio represents only about 6 percent of the total MP&M facility population and (2) that a substantial share of the total MP&M facility population is located in other states with similar water body and population characteristics (e.g., the states of Illinois, Indiana, Michigan, Pennsylvania), it is reasonable to expect that additional human health benefits would be estimated for the remainder of the country if EPA were able to apply this more rigorous approach at the national level. Accordingly, EPA judges that the final rule's human health benefits are higher than its social costs.

a. Benefits from reduced incidence of cancer cases

EPA assessed changes in the incidence of cancer cases from consumption of MP&M pollutants in fish tissue and drinking water. The methodology for assessing human health benefits from reduced cancer incidence is presented in Chapter 13 of this report. The Agency valued changes in incidence of cancer cases using a willingness-to-pay (WTP) of $6.5 million (2001$) for avoiding premature mortality. This estimate of the value of a statistical life saved is recommended in EPA's Guidelines for Preparing Economic Analysis. This estimate does not include estimates of WTP to avoid morbidity prior to death.

EPA estimated aggregate cancer risk from contaminated drinking water for populations served by drinking water intakes on water bodies to which MP&M facilities discharge. EPA based this analysis on six carcinogenic pollutants for which drinking water criteria have not been published.[5] This analysis excludes seven carcinogens for which drinking water criteria have been published. EPA assumed that public drinking water treatment systems will remove these pollutants from the public water supply. To the extent that treatment for these seven pollutants may cause incidental removals of the chemicals without criteria, the analysis may overstate cancer-related benefits.

Calculated in-stream concentrations provide the basis for estimating changes in cancer risk for populations served by affected drinking water intakes. EPA estimates that baseline MP&M discharges from in-scope facilities are associated with virtually zero annual cancer cases. The national-level analysis finds that the final regulation would lead to a marginal reduction in these cancer cases resulting from consumption of contaminated drinking water; correspondingly, monetary benefits estimated from reduced consumption of contaminated drinking water are essentially zero.

EPA also estimated cancer risk from the consumption of contaminated fish for recreational and subsistence anglers and their families. EPA based this analysis on thirteen carcinogenic pollutants found in MP&M effluent discharges. Estimated contaminant concentrations in fish tissue are a function of predicted in-stream pollutant concentrations and pollutant bioconcentration factors. EPA used data on numbers of licensed fishermen by state and county, presence of fish consumption advisories, number of fishing trips per person per year, and average household size to estimate the affected population of recreational and subsistence anglers and their families. The analysis uses different fish consumption rates for recreational and subsistence anglers to estimate the change in cancer risk among these populations.

EPA estimated that baseline MP&M discharges from in-scope facilities are associated with 0.03 annual cancer cases. The national-level analysis shows that the final option would lead to a marginal reduction in cancer cases among recreational and subsistence angler populations. The monetary benefits estimated from consumption of less contaminated fish by these populations are essentially negligible.

The findings from the national analysis of changes in cancer risk for the final rule differ from the Ohio case study results. Based on the Ohio case study, the final option is expected to eliminate 0.01 cancer cases annually in the State of Ohio alone. This reduction translates into $14,500 (2001$) in annual benefits due to reduced cancer risk from consumption of contaminated fish tissue and drinking water (see Chapter 22 of this report for detail).

The difference in the findings of the national and Ohio analyses results primarily from more comprehensive information on MP&M and non-MP&M facility discharges used in the Ohio case study analysis. The national-level analysis accounts only for the pollutant exposures from MP&M sample facilities. In contrast, the Ohio case study approach accounts for a broader baseline of pollutant exposure, including more thorough and detailed coverage of discharges from MP&M facilities and also estimated exposures from non-MP&M sources. As a result, the Ohio case study analysis more accurately reflects baseline health risk conditions.

b. Reductions in systemic health effects

The final rule can potentially achieve a wide range of non-cancer human health benefits (e.g., systemic effects, reproductive toxicity, and developmental toxicity) from reduced contamination of fish tissue and drinking water sources. The common approach for assessing the risk of non-cancer health effects from the ingestion of a pollutant is to calculate a hazard quotient by dividing an individual's oral exposure to the pollutant, expressed as a pollutant dose in milligrams per kilogram body weight per day (mg/kg-day), by the pollutant's oral reference dose (RfD). An RfD is defined as an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily oral exposure that likely would not result in the occurrence of adverse health effects in humans, including sensitive individuals, during a lifetime. A hazard quotient less than one means that the pollutant dose to which an individual is exposed is less than the RfD, and, therefore, presumed to be without appreciable risk of adverse human health effects. EPA guidance for assessing exposures to mixtures of pollutants recommends calculating a hazard index (HI) by summing the individual hazard quotients for those pollutants in the mixture that affect the same target organ or system (e.g., the kidneys, the respiratory system). HI values are interpreted similarly to hazard quotients; values below one are generally considered to suggest that exposures are not likely to result in appreciable risk of adverse health effects during a lifetime, and values above one are generally cause for concern, although an HI greater than one does not necessarily suggest a likelihood of adverse effects. Chapter 13 of this report provides a detailed discussion of the methodology for assessing changes in systemic health effects associated with this rule.

[5] EPA included n-nitrosodimethylamine (NDMA) in its assessment of the baseline incidence of cancer cases. However, the Agency did not consider NDMA pollutant reductions in its benefits analysis due to limited wastewater sampling for that pollutant.

To evaluate the potential benefits of reducing the in-stream concentrations of 76 pollutants that cause non-cancer health effects, EPA estimated target organ-specific HIs for drinking water and fish ingestion exposures in both the baseline and post-compliance scenarios. Specifically, EPA calculated target-organ specific HIs for pollutants predicted in each MP&M discharge reach; as a result, a separate HI was calculated for each target organ/exposure pathway (fish consumption and drinking water)/reach combination. EPA then combined estimates of the numbers of individuals in the exposed populations with the HIs for the populations to determine how many individuals might be expected to realize reduced risk of non-cancer health effects in the post-compliance scenario.

The results of EPA's analysis suggest that hazard indices for individuals in the exposed populations may decrease after facilities comply with today's rule. Increases in the percentage of exposed populations that would be exposed to no risk of non-cancer adverse human health effects due to the MP&M discharges occur in both the fish and drinking water analyses. The shift to lower hazard indices should be considered in conjunction with the finding that the hazard indices for incremental exposures to pollutants discharged by MP&M facilities (for which reference doses are available) are less than one in the baseline analysis for the entire population associated with sample facilities. Whether the incremental shifts in hazard indices are significant in reducing absolute risks of non-cancer adverse human health effects is uncertain and will depend on the magnitude of contaminant exposures for a given population from risk sources not accounted for in this analysis.

c. Benefits from reduced exposure to lead

EPA performed a separate analysis of benefits from reduced exposure to lead. This analysis differs from the analysis of non-cancer adverse human health effects from exposure to other MP&M pollutants because it is based on dose-response functions tied to specific health endpoints to which monetary values can be applied. Chapter 14 of this report presents the methodology for assessing benefits from reduced exposure to lead.

Many lead-related adverse health effects are relatively common and are chronic in nature. These effects include, but are not limited to, hypertension, coronary heart disease, and impaired cognitive function. Lead is harmful to individuals of all ages, but the effects of lead on children are of particular concern. Children's rapid rate of development makes them more susceptible to neurobehavioral effects from lead exposure. The neurobehavioral effects on children from lead exposure include hyperactivity, behavioral and attention difficulties, delayed mental development, and motor and perceptual skill deficits.

This analysis assessed benefits of reduced lead exposure from consumption of contaminated fish tissue to three sensitive populations: (1) preschool age children; (2) pregnant women; and (3) adult men and women. This analysis uses blood-lead levels as a biomarker of lead exposure. EPA estimated baseline and post-compliance blood lead levels in the exposed populations and then used changes in these levels to estimate benefits in the form of avoided health damages.

EPA assessed neurobehavioral effects on children based on a dose response relationship for IQ decrements. Avoided neurological and cognitive damages are expressed as changes in overall IQ levels, including reduced incidence of extremely low IQ scores (<70, or two standard deviations below the mean) and reduced incidence of blood-lead levels above 20 mg/dL. The analysis uses the value of compensatory education that an individual would otherwise need and the impact of an additional IQ point on individuals' future earnings to value the avoided neurological and cognitive damages. The national-level analyses shows that implementation of the final option would not result in any changes in IQ loss across all exposed children. The final option does not reduce occurrences of extremely low IQ scores (<70) or incidences of blood-lead levels above 20 mg/dL.

Prenatal exposure to lead is an important route of exposure. Fetal exposure to lead in utero due to maternal blood-lead levels may result in several adverse health effects, including decreased gestational age, reduced birth weight, late fetal death, neurobehavioral deficits in infants, and increased infant mortality. To assess benefits to pregnant women, EPA estimated changes in the risk of infant mortality due to changes in maternal blood-lead levels during pregnancy. The national-level analysis shows that the final option does not result in changes in maternal blood lead levels during pregnancy and as a result does not reduce neonatal mortality.

The national-level analysis finds no benefits to children from reduced exposure to lead. However, as for the cancer risk analysis previously discussed, these findings differ from the more comprehensive analysis used in the Ohio case study. Using the more rigorous case study approach, EPA estimates that the final regulation will yield annual lead-related benefits for children in Ohio of $422,113 (2001$). This benefit value includes three components. First, reduced lead exposure is estimated to reduce neonatal mortality by 0.024 cases annually with an annual value of $162,094 (2001$). Second, reduced lead exposure will avoid the loss of an estimated 26.96 IQ points among preschool children in Ohio, which translates into

$253,934 (2001$) per year in benefits. Third, the annually avoided costs of compensatory education from incidence of IQ below 70 and blood-lead levels above 20 g/dL among children amounts to approximately $5,345 (2001$).

Lead exposure has been shown to have adverse effects on the health of adults as well as children. The health effects in adults that EPA quantified all derive from lead's effects on blood pressure. Quantified health effects include increased incidence of hypertension (estimated for males only), initial coronary heart disease (CHD), strokes (initial cerebrovascular accidents and atherothrombotic brain infarctions), and premature mortality. This analysis does not include other health effects associated with elevated blood pressure and other adult health effects of lead, including nervous system disorders, anemia, and possible cancer effects. EPA used cost of illness estimates (i.e., medical costs and lost work time) to estimate monetary value of reduced incidence of hypertension, initial CHD, and strokes. EPA then used the value of a statistical life saved to value changes in risk of premature mortality. The national-level analysis finds that the final rule will achieve no lead-related health benefits among adults.

Again, the national analysis results differ from the Ohio case study results. Using the case study approach, EPA estimates that the final regulation will achieve total lead-related benefits among Ohio adults of $117,393 (2001$). This value includes benefits from reduced hypertension among adult males: a reduction of an estimated 9.4 cases annually, with benefits of approximately $10,670 (2001$). In addition, reducing the incidence of initial CHD, strokes, and premature mortality among adult males and females in Ohio would result in estimated benefits of $963, $2,115, and $103,645, respectively (see Chapter 22 of this report for detail).

Based on the national-level benefits analysis, EPA found that total benefits from reduced exposure to lead, for both children and adults, are negligible under the final rule. However, based on the Ohio case study findings, benefits for children and adults from reduced lead-related health effects of the final rule are estimated to total approximately $0.5 million (2001$) annually in the state of Ohio alone (see Section H of today's final rule for detail). As in the cancer risk analysis, the difference in the national and Ohio-based findings stems primarily from more comprehensive information on MP&M and non-MP&M facility discharges used in Ohio.

d. Exceedances of human health-based AWQC

EPA also estimated the effect of MP&M facility discharges on the occurrence of pollutant concentrations in affected waterways that exceed human health-based AWQCs. In a conceptual sense, this analysis and its findings are not additive to the preceding analyses of change in cancer or lead-related health risks but are another way of quantitatively characterizing the same possible benefit categories. This analysis compares the estimated baseline and post-compliance in-stream pollutant concentrations in affected waterways to ambient water criteria for protection of human health. The comparison included AWQC for protection of human health through consumption of organisms and consumption of water and organisms. Pollutant concentrations in excess of these values indicate potential risks to human health.

EPA estimates that in-stream concentrations of 4 pollutants (i.e., arsenic, iron, manganese, and n-nitrosodimethylamine) will exceed human health criteria for consumption of water and organisms in 78 receiving reaches nationwide as the result of baseline MP&M pollutant discharges. EPA estimates that 23% of human health AWQC exceedances are caused by n-nitrosodimethylamine (NDMA). EPA did not consider NDMA pollutant reductions in its benefits analyses due to limited wastewater sampling data for that pollutant. EPA estimates that the final rule will not eliminate the occurrence of concentrations in excess of human health criteria for consumption of water and organisms and for consumption of organisms on any of the reaches on which baseline discharges are estimated to cause concentrations in excess of AWQC values.

ES.4.2 Ecological, Recreational, and Nonuser Benefits

EPA expects the MP&M rule to improve aquatic species habitats by reducing concentrations of toxic contaminants such as aluminum, cadmium, copper, lead, mercury, silver, and zinc in water. These improvements should enhance the quality and value of water-based recreation, such as fishing, swimming, wildlife viewing, camping, waterfowl hunting, and boating. The benefits from improved water-based recreation would be seen as increases in the increased value participants derive from a day of recreation and the increased number of days that consumers of water-based recreation choose to visit the cleaner waterways. This analysis measures the economic benefit to society from water quality improvements based on the increased monetary value of recreational opportunities resulting from those improvements

a. Reduced aquatic life impacts

EPA quantified the ecological improvements of the final regulation by comparing estimates of in-waterway concentrations of pollutants discharged by MP&M facilites with AWQC values for protection of aquatic species. Pollutant concentrations in excess of acute and/or chronic AWQC limits for protection of aquatic life indicate potential adverse impacts to aquatic species. EPA estimates that baseline in-stream concentrations of 9 pollutants (i.e., aluminum, cadmium, copper, lead, manganese, mercury, nickel, silver, and zinc) will exceed the acute and chronic criterion for aquatic life in 353 reaches nationwide. The final rule eliminates concentrations in excess of aquatic life AWQCs on nine of these reaches. EPA's analysis shows that none of the receiving reaches exceeding chronic or acute aquatic life AWQC at the baseline discharge level will experience partial water quality improvements from reduced occurrence of AWQC exceedances for some pollutants.

b. Recreational benefits

EPA assessed the recreational benefits from reduced occurrence of pollutant concentrations exceeding aquatic life and/or human health AWQC values. Combining its findings from both the aquatic life and human health AWQC exceedance analyses, EPA found that 394 stream reaches exceed chronic or acute aquatic life AWQC and/or human health AWQC values at baseline discharge levels. The Agency estimates that the final rule will eliminate exceedances on nine of these discharge reaches, leaving 384 reaches with concentrations of one or more pollutants exceeding AWQC limits. None of these 384 reaches will experience partial water quality improvements from reduced occurrence of some pollutant concentrations in excess of AWQC limits.

EPA attached a monetary value to reduced exceedances based on increased values for three water-based recreation activities (fishing, wildlife viewing, and boating) and on nonuser values. EPA applied a benefits transfer approach to estimate the total WTP, including both use and nonuse values, for improvements in surface water quality. This approach builds upon a review and analysis of the surface water valuation literature.

EPA first estimated the baseline value of water-based recreation for benefiting reaches, based on per-reach estimates of:

- annual person-days of water-based recreation, and
- per-day values of water-based recreation.

The baseline per-day values of water-based recreation are based on studies by Walsh et. al (1992) and Bergstrom and Cordell (1991). The studies provide values per recreation day for a wide range of water-based activities, including fishing, boating, wildlife viewing, waterfowl hunting, camping, and picnicking. The mean values per recreational fishing, boating, and wildlife viewing day used in this analysis are $42.12, $48.30 and $26.28 (2001$), respectively. Applying facility weights and summing over all benefiting reaches provides a total baseline value for a given recreational activity for MP&M reaches expected to benefit from the elimination of pollutant concentrations in excess of AWQC limits.

EPA then applied the percentage change in the recreational value of water resources implied by surface water valuation studies to estimate changes in values for all MP&M reaches in which the regulation eliminates AWQC exceedances by one or more MP&M pollutants. The Agency selected eight of the most comparable studies and calculated the changes in recreation values from water quality improvements (as percentage of the baseline) implied by those studies. Sources of estimates included Lyke (1993), Jakus et al. (1997), Montgomery and Needleman (1997), Paneuf et al. (1998), Desvousges et al. (1987), Lant and Roberts (1990), Farber and Griner (2000), and Tudor et al. (2002). EPA's reasoning for selecting each study is discussed in detail in Chapter 15 of this report. EPA took a simple mean of point estimates from all applicable studies to derive a central tendency value for percentage change in the water resource values due to water quality improvements. These studies yielded estimates of increased recreational value from water quality improvements expected from reduced MP&M

discharges of 12, 9, and 18 percent for fishing, boating, and wildlife viewing respectively. Using all possible applicable valuation studies in developing a benefits transfer approach to valuing changes in the recreational value of water resources from reduced MP&M discharges, makes unit values more likely to be nationally representative, and avoids the potential bias inherent in using a single study to make estimates at the national level.

Table ES.9 presents the estimated national recreational benefits of the final rule (2001$). The estimated increased value of recreational activities to users of water-based recreation is $537,197, $202,691, and $259,949 annually for fishing, boating, and wildlife viewing, respectively. The recreational activities considered in this analysis are stochastically independent; EPA calculated the total user value of enhanced water-based recreation opportunities by summing over the three recreation categories. The estimated increase in the total user value is $999,838 annually.

EPA also estimated non-market nonuser benefits. These non-market nonuser benefits are not associated with current use of the affected ecosystem or habitat; instead, they arise from the value society places on improved water quality independent of planned uses or based on expected future use. Past studies have shown that nonuser values are a sizable component of the total economic value of water resources. EPA estimated average changes in nonuser value to equal one-half of the recreational use benefits based on study by A. Fisher and R. Raucher (1984). The estimated increase in nonuse value is $499,919 (2001$).

A recent literature review finds that nonuse benefits are, on average, 1.9 to 2.5 times all use values, rather than 0.5 times recreational benefits alone as EPA has traditionally assumed for its nonuse benefit estimates (T. Brown, 1993). EPA's method for estimating nonuse benefits from water quality improvements resulting from reduced MP&M discharges is therefore likely to understate the true value of nonuse benefits.

Table ES.9: Estimated Recreational Benefits from Reduced MP&M Discharges (thousands, 2001$)

Recreational Activity	Traditional Extrapolation	Post-Stratification Extrapolation
Recreational fishing	$537	$350
Recreational boating	$203	$132
Wildlife viewing and near-water recreation	$260	$169
Total recreational use benefits (fishing + boating + wildlife viewing)	$1,000	$651
Nonuser benefits (½ of total recreational use)	$500	$326
Total Recreational Benefits (2001$)	**$1,500**	**$977**

Source: U.S. EPA analysis.

The recreational trips corresponding to the three activities considered in this analysis are stochastically independent; EPA calculated the total value of enhanced water-based recreation opportunities by summing the three recreation categories and nonuser value. The resulting increase in the value of water resources to consumers of water-based recreation and nonusers is $1,500 thousand (2001$) annually under the traditional extrapolation method and $977 thousand (2001$) annually under the post-stratification extrapolation method.

ES.4.3 POTW Impacts

The final rule only regulates direct dischargers. Therefore, the selected option does not affect POTW operation. For the alternative policy options that consider both direct and indirect dischargers, EPA evaluated two productivity measures associated with MP&M pollutants. The first measure is the reduction in pollutant interference at publicly-owned treatment works (POTWs). The second measure is pass-through of pollutants into the sludge, which limits options for POTW disposal of sewage sludge. These analyses are presented in Chapter 16 of this report.

ES.4.4 Total Estimated Benefits of the Final MP&M Rule

Using the traditional extrapolation method, EPA estimates total benefits for the five monetized categories of approximately $1,500,000 (2001$) annually. This value understates the total benefits of the rule because the benefits analysis omits significant sources of benefits to society. Examples of benefit categories not reflected in this estimate include non-cancer health benefits other than benefits from reduced exposure to lead; other water-dependent recreational benefits, such as swimming and waterskiing benefits to recreational users from reduced concentration of conventional pollutants and nonconventional pollutants such as TKN; and reduced cost of drinking water treatment for the pollutants with drinking water criteria. In addition, as noted in the prior discussion, although the national-level benefits analysis finds negligible benefits from reduced health risk, the more rigorous analytic approach used for the Ohio case study found material health-related benefits approximately $0.5 million in the state of Ohio alone.

ES.5 National Benefits-Costs Comparison

The comparison of benefits and for the final rule is inevitably incomplete because EPA cannot value all of the benefits resulting from the final rule in dollar terms. A comparison of benefits and costs is thus limited by the lack of a comprehensive benefits valuation and also by uncertainties in the estimates. Bearing these limitations in mind, EPA presents a summary comparison of benefits and costs for the final rule in Table ES.10. The estimated social cost of the final rule is $13.8 million annually (2001$). The total benefits that can be valued in dollar terms in the categories traditionally analyzed for effluent guidelines range from $977,000 to $1,500,000 annually (2001$), based on the alternative extrapolation methods.

As previously noted, EPA used more detailed information and a more comprehensive analytic method to estimate expected benefits of the final rule for the state of Ohio. This more rigorous analysis was undertaken to address certain issues in the national-level analysis and to supplement the national-level analysis performed for the final rule. The following section presents this analysis. The Ohio case study showed that the more rigorous analytic approach leads to a different conclusion from that found in the simpler, national-level analysis approach in particular, that the estimated state-level benefits exceed the estimated state-level cost. As previously discussed, given (1) that Ohio accounts for only about 6 percent of total MP&M facilities, and (2) that other states with substantial numbers of MP&M facilities have similar population and water body characteristics to Ohio, EPA estimates that use of the more rigorous approach nationally would yield a higher estimate of national benefits. On this basis, the Agency estimates that national benefits from the final rule may be comparable to its social costs.

Table ES.10: Comparison of National Annual Monetizable Benefits to Social Costs (thousands, 2001$)

Benefit and Cost Categories	Traditional Extrapolation	Post-Stratification Extrapolation
Benefit Categories		
Reduced Cancer Risk from Fish Consumption	$0	$0
Reduced Cancer Risk from Water Consumption	$0	$0
Reduced Risk from Exposure to Lead	$0	$0
Enhanced Water-Based Recreation	$1,000	$651
Nonuse Benefits	$500	$326
Total Monetized Benefits	**$1,500**	**$977**
Cost Categories		
Resource Costs of Compliance	$13,825	$13,825
Costs of Administering the Final Regulation	$0	$0
Social Costs of Unemployment	$0	$0
Total Monetized Costs	**$13,825**	**$13,825**
Net Monetized Benefits (Benefits Minus Costs)	**($12,325)**	**($12,847)**

Source: U.S. EPA analysis.

ES.6 OHIO CASE STUDY

Part V of this report presents a detailed case study of the expected state-level costs and benefits of the MP&M rule in Ohio. The case study assesses the costs and benefits of the final rule for facilities and water bodies located in Ohio. Ohio is among the ten states with the largest numbers of MP&M facilities. The state has a diverse water resource base and a more extensive water quality ecological database than many other states. EPA gathered data on MP&M facilities and on Ohio's baseline water quality conditions and water-based recreation activities to support the case study analysis. These data characterize current water quality conditions, water quality changes expected from the regulation, and the expected welfare changes from water quality improvements at water bodies affected by MP&M discharges. The case study also estimates the social costs of the final rule for facilities in Ohio and compares estimated social costs and benefits for the state.

The case study analysis supplements the national-level analysis performed for the final MP&M regulation in two important ways. First, the analysis used improved data and methods to determine MP&M pollutant discharges from both MP&M facilities and other sources. In particular, EPA administered 1,600 screener questionnaires to augment information on the Ohio's MP&M facilities. The Agency also used information from the sampled MP&M facilities to estimate discharge characteristics of non-sampled MP&M facilities, as described in Appendix H of the EEBA report. The Agency assigned discharge characteristics to all non-MP&M industrial direct discharges based on the information provided in the EPA's Permit Compliance System (PCS) database. Second, the analysis used an original travel cost study to value four recreational uses of water resources affected by the regulation: swimming, fishing, boating, and near-water activities. The added detail provides a more complete and reliable analysis of water quality changes from reduced MP&M discharges. The study provides more complete estimates of changes in human welfare resulting from reduced health risk, enhanced recreational opportunities, and improved economic productivity.

EPA estimated human health benefits from reduced MP&M dischargers in Ohio using similar methodologies to those used for the national-level analysis. These methodologies are presented in Chapter 13 and 14 of the EEBA report.

The case study analysis of recreational benefits combines water quality modeling with a random utility model (RUM) to assess how changes in water quality from the regulation will affect consumers' valuation of water resources. The RUM analysis addresses a wide range of pollutant types and effects, including water quality measures not often addressed in past recreational benefits studies. In particular, the model supports a more complete analysis of recreational benefits from reductions in nutrients and toxic pollutants (i.e., priority pollutants and nonconventional pollutants with toxic effects).

EPA subjected this study to a formal peer review by experts in the natural resource valuation field. The peer review concluded that EPA had done a competent job, especially given the available data. As requested by the Agency, peer reviewers provided suggestions for further improvements in the analysis. Since the proposed rule analysis, the Agency made changes to the Ohio model and conducted additional sensitivity analyses suggested by the reviewers. The peer review report and EPA's response to peer reviewers' comments, along with the revised model, are in the docket for the rule.

ES.6.1 Benefits

The use of an original RUM in this case study allows the Agency to address limitations inherent in benefits transfer used in the analysis of recreational benefits at the national level. The use of benefits transfer often requires additional assumptions because water quality changes evaluated in the available recreation demand studies are only roughly comparable with the water quality measures evaluated for a particular rule. The RUM model estimates the effects of the specific water quality characteristics analyzed for the final MP&M regulation, such as presence of AWQC exceedances and concentrations of the nonconventional pollutant Total Kjeldahl Nitrogen (TKN). EPA estimates that this direct link between the water quality characteristics analyzed for the rule and the characteristics valued in the RUM analysis reduces uncertainty in benefit estimates and makes the analysis of recreational benefits more robust.

The final MP&M regulation affects a broad range of pollutants, some of which are toxic to human and aquatic life but are not directly observable (i.e., priority and nonconventional pollutants). These unobservable toxic pollutants degrade aquatic habitats, decrease the size and abundance of fish and other aquatic species, increase fish deformities, and change watershed species composition. Changes in toxic pollutant concentrations may therefore affect recreationists' valuation of water resources, even if consumers are unaware of changes in ambient pollutant concentrations.

The study used data from the National Demand Survey for Water-Based Recreation (NDS), conducted by U.S. EPA and the

National Forest Service, to examine the effects of in-stream pollutant concentrations on consumers' decisions to visit a particular water body. The analysis estimated baseline and post-compliance water quality at recreation sites actually visited by the surveyed consumers and at all other sites within the consumers' choice set, visited or not. The RUM analysis of consumer behavior then estimated the effect of ambient water quality and other site characteristics on the total number of trips taken for different water-based recreation activities and the allocation of these trips among particular recreational sites. The RUM analysis is a travel cost model, in which the cost to travel to a particular recreational site represents the "price" of a visit.

EPA modeled two consumer decisions: (1) how many water-based recreational trips to take during the recreational season (the trip participation model); and (2) which recreation site to choose (the site choice model). Combining the trip participation model's prediction of trips under the baseline and post-compliance scenarios and the site choice model's per-trip welfare measure provides a measure of total welfare. EPA calculated each individual's seasonal welfare gain for each recreation activity from post-compliance water quality changes, and then used Census data to aggregate the estimated welfare change to the State level. The sum of estimated welfare changes over the four recreation activities yielded estimates of total welfare gain.

EPA estimated other components of benefits in Ohio using similar methodologies to those used for the national-level analysis. In addition to the RUM study of recreational benefits, other analytical improvements included the following: (1) use of more detailed data on MP&M facilities, obtained from the 1,600 additional surveys; (2) use of data on non-MP&M discharges to estimate current baseline conditions in the state, and (3) use of a first-order decay model to estimate in-stream concentrations in the Ohio water bodies in the baseline and post-compliance.

Appendix H of this report describes the water quality model used in this analysis and the approach and data sources used to estimate total pollutant loadings from all industrial and municipal sources to Ohio's water bodies. The Agency has concluded that the added level of detail results in more robust benefit estimates.

Summing the monetary values over all benefit categories yields total monetized benefits of $930,408 (2001$) annually for the final rule, as shown in Table ES.11. Although more comprehensive than the national benefits analysis, the case study benefit estimates still omit important mechanisms by which society is likely to benefit from the final rule. Examples of benefit categories not reflected in the monetized benefits include non-cancer health benefits (other than lead-related benefits) and reduced costs of drinking water treatment.

Table ES.11: Annual Benefits from Reduced MP&M Discharges in Ohio (thousands, 2001$)

Benefit Category	Mean Annual Benefits
1. Reduced cancer risk:	
Fish consumption	$15
Water consumption	$0
2. Reduced risk from exposure to lead:	
Children	$422
Adults	$117
3. Enhanced fishing	$153
4. Enhanced swimming	$10
5. Enhanced boating	$0
4. Enhanced wildlife viewing	$88
5. Nonuse benefits (½ recreational use benefits)	$125
Total Monetized Benefits	**$930**

Source: U.S. EPA analysis.

ES.6.2 Social Costs

EPA also estimated the social costs of the final rule for MP&M facilities in Ohio. EPA developed engineering estimates of compliance costs for each Ohio facility, and annualized costs using a seven percent discount rate over a 15-year period.

Estimating the frequency of baseline closures is necessary to assess the costs of regulation. Facilities assessed as baseline closures are not expected to incur compliance costs under the final MP&M regulation. The screener data collected for Ohio facilities did not provide financial data to perform an after-tax cash flow or net present value test, as done in the national analysis. EPA therefore used data from the national analysis to estimate the percentage of facilities assessed as baseline closures. EPA assumed that the frequency of baseline closures among Ohio facilities would be the same as that estimated in the national analysis for facilities with the same discharge status, subcategory, and flow category. For example, two percent of direct Oily Wastes facilities discharging less than one million gallons per year close in the baseline in the national data set; this same percentage is assumed for Ohio screener indirect dischargers in that flow and size category. EPA reduced the total estimated costs for screener facilities, by analysis category, based on the fraction of facilities assessed as baseline closures.

EPA used the same methods as used in the national social cost analysis to estimate other components of social costs for the Ohio case study. Table ES.12 shows the total estimated social costs of the final rule for Ohio facilities.

Table ES.12: Annual Social Costs for Ohio Facilities: Final Option (thousands, 2001$, costs annualized at 7%)

Component of Social Costs	Final Rule
Resource value of compliance costs	$62
Government administrative costs	$0
Social cost of unemployment	$0
Total Social Cost	$62

Source: U.S. EPA analysis.

ES.6.3 Comparing Monetized Benefits and Costs

The Ohio case study shows substantial net positive benefits associated with the MP&M regulation. EPA estimates the social cost in Ohio of the final regulation to be $62 thousand annually ($2001). The sum total of benefits that can be valued in dollar terms is $930 thousand annually ($2001). Comparing the midpoint estimate of social costs ($62 thousand) with the midpoint estimate of monetizable benefits ($930 thousand) results in a net social benefit of $868 thousand. This represents a partial cost-benefit comparison because not all of the benefits resulting from the regulation can be valued in dollar terms (e.g., changes in systemic health risk).

For the reasons previously discussed, EPA judges that the analytic approach and detailed data used for the Ohio case study provide a more robust and accurate benefits estimate than the data and approach used for the national-level analysis.

Chapter 1: Introduction

INTRODUCTION

CHAPTER CONTENTS

The U.S. Environmental Protection Agency (EPA) is promulgating effluent limitations guidelines and standards for the Metal Products and Machinery (MP&M) Point Source Category, under Sections 301, 304, 306, 307 and 501 of the Clean Water Act. EPA has determined that the final rule is not likely to result in aggregate costs to the economy that exceed $100 million annually. The Agency therefore found that the final regulation is not a "significant regulatory action" as defined by Executive Order 12866 (58 FR 51735, October 4, 1993).

1.1 PURPOSE

This Economic, Environmental, and Benefits Analysis report (EEBA) presents EPA's economic and benefits analyses for the final MP&M regulation. These analyses supported EPA in developing the final regulation and in meeting the requirements of the following statutes and executive orders:

- Executive Order 12866 "Regulatory Planning and Review", which requires analysis of costs, benefits, and economic impacts of the final rule and regulatory alternatives;
- Unfunded Mandates Reform Act (UMRA), which requires evaluation of impacts on governments, among other requirements;
- Regulatory Flexibility Act as amended by the Small Business Regulatory Enforcement Fairness Act of 1996 (RFA/SBREFA), which requires consideration of the rule's impact on small firms and governments;
- Executive Order 12898 "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations"; and
- Executive Order 13084 " Protection of Children from Environmental Health Risks and Safety Risks".

1.2 ORGANIZATION

This report is organized in five major parts, 22 chapters, and 14 appendices, as follows:

Part I "Introduction and Background Information" (Chapters 1 though 4) describes the need for the regulation, provides a profile of the MP&M industry, and describes regulatory options evaluated and selected by the Agency for the final rule.

Part II "Costs and Economic Impacts" (Chapters 5 through 11) presents EPA's analysis of the economic impacts and social costs of the final rule. Chapter 5 presents the analysis of costs and impacts at the facility level. Chapters 6 through 9 present analyses of other types of economic impacts that derive from the facility-level analysis, including impacts on employment, governments (for EPA's analyses under UMRA), communities, foreign trade, firms, and new facilities. Chapter 10 provides an analysis of impacts on small firms and governments, as required by RFA/SBREFA. Finally, Chapter 11 presents the social costs of the final rule.

Part III "Benefits" (Chapters 12 through 17) provides EPA's analysis of the environmental impacts and benefits of the final rule. Chapter 12 provides an overview of the benefits expected from the rule. Chapters 13 through 16 present EPA's analyses of different components of the benefits analysis. These include human health benefits (except for lead-related) (Chapter 13), lead-related benefits (Chapter 14), recreational benefits (Chapter 15), and benefits to POTWs (Chapter 16). Chapter 17 presents an analysis of the environmental justice effects of the final rule, as required by Executive Order 12898.

Part IV "Comparison of Costs and Benefits" (Chapters 18 and 19) compares the social costs and benefits for the final rule (Chapter 18) and for other regulatory alternatives evaluated by the Agency for the final rule (Chapter 19).

Part V " Ohio Case Study" (Chapters 20 through 22) provides a detailed case study of the final rule's costs and benefits for the State of Ohio. This case study includes a more detailed and complete analysis of benefits, based on more complete information on the number and location of MP&M facilities and the characteristics of affected waters than was available for the national analyses. The case study also includes an original travel cost study to value recreational uses affected by the final rule. EPA believes that the case study provides more robust results because it avoids the uncertainties that result from the need to extrapolate sample facility results to the national level. The results of the case study generally confirm the overall results of the national analysis.

Appendices to this report provide additional material in support of the analyses described in the chapters, including the following:

- Appendix A: supporting material for the profile of the MP&M industries in Chapter 3;
- Appendix B: description of the cost pass-through analysis;
- Appendix C: description of the moderate impact analysis;
- Appendix D: description of the methodology used to estimate capital outlays as part of the facility impact analysis;
- Appendix E: description of the calculation of capital cost components;
- Appendix F: description of the methodology used to estimate POTW administrative costs;
- Appendix G: summary of the method used to extrapolate sample facility results to the national level;
- Appendix H: description of fate and transport model for drinking water and Ohio analyses;
- Appendix I: discussion of methodologies and results of the environmental assessment analysis;
- Appendix J: analyses of spatial distribution of MP&M facility location and benefiting population;
- Appendix K: description of the surface water valuation studies and specific values selected for assessing recreational benefits from the final regulation;
- Appendix L: description of parameters in the IEUBK lead model;
- Appendix M: sensitivity analysis of lead related benefits; and
- Appendix N: analysis of the national demand for water-based recreation survey (NDS).

The docket for the final rule, located at U.S. EPA Headquarters, provides additional supporting documentation, including:

- copies of the literature cited in the report;
- documentation of the financial and economic portions of the MP&M Section 308 surveys;
- memorandums documenting supplementary analyses undertaken in support of regulation development, but that are not included in the EEBA; and
- datasets, spreadsheets, and programs used to perform the analyses.

1.3 READERS' AIDS

Each chapter includes a chapter-specific table of contents. A list of references is provided at the end of each chapter. Glossaries and lists of acronyms are also provided at the end of the chapters, and the first usage of items listed in them are denoted in the text with the following formats:

- ***Glossary*** indicates that a term is defined in the chapter glossary, and
- **Acronym** indicates that the acronym is included in the chapter list of acronyms.

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Chapter 2: The MP&M Industry and the Need for Regulation

INTRODUCTION

The Metal Products and Machinery **(MP&M)** effluent guidelines establish limitations and standards only for direct dischargers in the Oily Wastes subcategory (40 CFR 438, Subpart A). EPA establishes industrial subcategories based on a number of considerations (see Chapter 4 and Section 6 of the TDD). EPA evaluated seven other subcategories for the final rule: general metals, metal finishing job shops, non chromium anodizing, printed wiring board, railroad line maintenance, shipbuilding dry docks, and steel forming and finishing. EPA evaluated a number of options for these seven subcategories. Based on these analyses, EPA did not establish or revise limitations or standards for facilities in these seven subcategories.

CHAPTER CONTENTS

The facilities regulated under this rule produce, manufacture, rebuild, or maintain metal parts, products, or machines for use in sixteen different industrial sectors. These industrial sectors include: hardware, aircraft, aerospace, ordnance, electronic equipment, stationary industrial equipment, mobile industrial equipment, buses and trucks, motor vehicles, household equipment, instruments, office machines, railroads, ships and boats, precious metals and jewelry, and miscellaneous metal products. Most of the subcategories above serve multiple markets. EPA evaluated options that would have covered facilities in three additional industrial sectors: printed wiring boards, metal finishing job shops, and iron and steel. The final regulation does not cover facilities in these sectors.

This chapter provides an overview of the ***MP&M industry*** evaluated for the final rule and presents the pollutant discharges from ***MP&M facilities*** subject to the final regulation. The chapter also reviews the reasons why EPA is regulating the industry's effluent discharges including the need to reduce pollutant discharges from the MP&M industry, the issue of addressing market imperfections, other effluent guidelines that may overlap in coverage of the MP&M industry sectors evaluated for the final rule, and requirements that stem from the ***Clean Water Act*** **(CWA)** and litigation.

2.1 OVERVIEW OF FACILITIES EVALUATED FOR REGULATION UNDER THE MP&M POINT SOURCE CATEGORY

The MP&M Point Source Category regulates oily operations process wastewater discharges to surface waters from existing or new industrial facilities (including facilities owned and operated by Federal, State, or local governments) engaged in manufacturing, rebuilding, or maintenance of metal parts, products, or machines for use in the sixteen Metal Product & Machinery (MP&M) industrial sectors listed above. Please note the underlined language in the previous sentence as a facility may be subject to the MP&M effluent guidelines even if it is not in one of the MP&M industry sectors. For example, EPA considers a facility performing machining part of the "Bus & Truck" MP&M industry sector if it manufactures metal parts for truck trailers. Process wastewater means wastewater as defined at 40 CFR parts 122 and 401, and includes wastewater from air pollution control devices (see 40 CFR 438.2(g)). Oily operations are listed at 40 CFR 438.2(g) and defined in Appendix B to Part 438 (see also Section 4 of the TDD).

As defined for this document, MP&M facilities: (1) produce metal parts, products, or machines for use in one of the 19 industry sectors evaluated for coverage in the MP&M point source category; (2) use operations in one of the eight regulatory subcategories evaluated for coverage in the MP&M point source category; and (3) discharge process wastewater, either directly or indirectly, to surface waters. MP&M facilities frequently produce products for multiple sectors and subcategories. As referred to in this document, MP&M facilities represent only a portion of all facilities in the industry sectors, since some facilities may perform operations that are not covered by one of the subcategories (i.e., part assembly or plastic molding), and some may not generate or discharge process wastewater.

According to *Statistics of U.S. Business*, 1996, approximately 638,696 establishments operate in the MP&M industry sectors. Based on information in the MP&M survey database, approximately 44,000 facilities meet the definition of an MP&M facility. These 44,000 facilities include approximately 41,000 indirect dischargers (i.e., facilities discharging effluent to a ***publicly-owned sewage treatment works*** or **POTW**s) that would be subject to ***Pretreatment Standards for Existing Sources* (PSES)**. The remaining 3,000 direct dischargers (i.e., they discharge effluent directly to a waterway under a National Pollutant Discharge Elimination System **(NPDES)** permit) and would thus be subject to ***Best Available Technology Economically Achievable* (BAT)** and ***Best Practicable Control Technology Currently Available* (BPT)** requirements.

Table 2.1 reports the estimated number of MP&M facilities and total discharge flow (before final rule implementation) by type of facility. The largest number of sites, approximately 22,000, perform "rebuilding/maintenance only" and account for approximately 6 percent of the total estimated discharge flow for the industry. "Manufacturing only" contains the next largest number of facilities (15,400) and accounts, by far, for the largest percentage of the total estimated discharge flow for the industry (82 percent).

Table 2.1: Number of MP&M Facilities and Total Discharge Flow by Type of Facility

Type of Facility	Number of Facilities	Total Estimated Discharge Flow (million gal/yr)	Percent of Facilities	Percent of Total Discharge Flow
Manufacturing & Rebuilding/Maintenance	6,600	9,400	15.0%	12.0%
Manufacturing Only	15,400	64,100	35.0%	82.0%
Rebuilding/Maintenance Only	22,000	4,700	50.0%	6.0%
Total	44,000	78,200	100.0%	100.0%

Source: U.S. EPA analysis. See Section 4 of the Technical Development Document for the final rule.

Of the 43,858 water discharging facilities, 3,593 are predicted to close in the baseline, leaving 40,265 existing MP&M facilities that EPA estimates could be regulated.[1] After accounting for subcategory and discharger class exclusions, EPA estimates that the final rule will regulate 2,382 of these facilities, all of which are direct dischargers. These regulated facilities represent 5.9 percent of the 40,265 facilities that could be potentially regulated.

Table 2.2 summarizes information on the total number of MP&M facilities that were evaluated for the final rule, and the number that will be regulated under the final rule. As reported in Table 2.2, no indirect dischargers are subject to the final regulation. The rule will regulate 2,382 direct dischargers in the Oily Wastes subcategory. The rule excludes direct dischargers in the General Metals, Metal Finishing Job Shops, Non -Chromium Anodizing, Printed Wiring Board, Railroad Line Maintenance, Shipbuilding Dry Docks, and Steel Forming and Finishing subcategories (214 facilities, 12 facilities, 0 facilities, 8 facilities, 6 facilities, 6 facilities, and 13 facilities, respectively)[2].

[1] These are facilities that are predicted to close due to weak financial performance under baseline conditions, i.e., in the absence of the final rule. EPA does not attribute the costs or the reduced discharges resulting from these baseline closures to the final rule, and therefore excludes these facilities from its analyses of the rule's impacts. Baseline closures account for differences between the universe of facilities discussed in this report and the universe discussed in the *Technical Development Document.*

[2] EPA excluded 3,511 indirect and 98 direct dischargers predicted to close in the baseline.

Table 2.2: MP&M Facilities by Subcategory and Discharger Class, and Facilities Regulated Under the Final Rule[a]

Subcategory	Indirect Dischargers		Direct Dischargers	
	Evaluated for Regulation (# of facilities)	Regulated under Final Rule (# of facilities)	Evaluated for Regulation (# of facilities)	Regulated under Final Rule (# of facilities)
General Metals	10,244	0	214	0
Metal Finishing Job Shop	1,479	0	12	0
Non-Chromium Anodizing	93	0	0	0
Printed Wiring Board	600	0	8	0
Steel Forming & Finishing	12	0	13	0
Oily Waste	24,394	0	2,382	2,382
Railroad Line Maintenance	820	0	6	0
Shipbuilding Dry Dock	9	0	6	0
All Categories	37,652	0	2,641	2,382

[a] Excludes facilities that close in the baseline.

Source: U.S. EPA analysis.

2.2 MP&M Discharges and the Need For Regulation

EPA is regulating the MP&M industry because the industry releases substantial quantities of pollutants, including toxic pollutant compounds (priority and nonconventional metals and organics) and ***conventional pollutants*** such as ***total suspended solids*** (TSS) and ***oil and grease*** (O&G). These MP&M industry pollutants are generally controlled by straightforward and widely-used treatment system technologies such as chemical precipitation and clarification (frequently referred to as the "lime and settle" process).[3]

Discharges of these pollutants to surface waters and POTWs have a number of adverse effects, including degradation of aquatic habitats, reduced survivability and diversity of native aquatic life, and increased human health risk through the consumption of contaminated fish and water. In addition, many of these pollutants volatilize into the air, disrupt biological wastewater treatment systems, and contaminate sewage sludge.

Metal constituents are of particular concern because of the large amounts present in MP&M effluents. Unlike some organic compounds and other wastes that are metabolized in activated sludge systems to relatively innocuous constituents, metals are chemical elements and cannot be eliminated. Moreover, in solution, some metals have a high affinity for biological uptake. Depending on site-specific conditions, metals form insoluble inorganic and organic complexes that partition to sewage sludge at POTWs or underlying sediment in aquatic ecosystems. The accumulated metal constituents can return to a ***bioavailable*** form upon land application of sewage sludge; dredging and resuspension of sediment; or as a result of seasonal, natural, or induced alteration of sediment chemistry.

Benefits of reducing metal and other pollutant loads to the environment from MP&M facilities include reduced risk of cancer and systemic human health risks, improved recreation opportunities (e.g., fishing , swimming, boating, and other near-water recreational activities), improved aquatic and benthic habitats, and less costly sewage sludge disposal and increased beneficial use of the sludge.[4]

[3] See Chapter 12 and Appendix I for more detailed information on the pollutants of concern in the MP&M industry.

[4] Sewage sludge is also called biosolids.

The goal of the MP&M regulation is to reduce pollutant discharges and to eliminate or reduce the level of risk and harm caused by them. These pollutant discharges and their harmful consequences are the ***externalities*** that the MP&M regulation addresses, as discussed in Section 2.3.

2.2.1 Baseline MP&M Discharges for Regulated Facilities

Table 2.3 provides an overview of the discharges from MP&M facilities that are regulated under the final rule. Loadings are defined as ***toxic-weighted*** loadings. This measure weights quantities of different pollutants by a measure of their relative toxicity. Toxic-weighted loadings measures the relative toxic effects of discharges containing different mixtures of pollutants. MP&M discharges also contain conventional pollutants with little or no toxic effects but that can have substantial adverse environmental impacts, such as O&G and some components of TSS.

Table 2.3: Toxic-Weighted Discharges for Direct Discharging Facilities in the Oily Wastes Subcategory (Pounds Equivalent)[a]

# of Regulated Facilities	2,382
Baseline Discharges	3,351
Average Baseline Loadings per Facility	1.41
Remaining Discharges Under Final Rule	668
Average Discharges Under Final Rule per Facility	0.28
Discharge Reductions Achieved by Final Rule	2,683

[a] Discharges discussed in this table are total discharges from the facility, and do not reflect POTW pollutant removals. EPA believes it is appropriate to analyze wastewater discharges disregarding POTW removals because indirect discharges present environmental risks that are not fully addressed by POTW treatment. The MP&M industry releases 89 pollutants that cause inhibition problems at POTWs and an additional 35 pollutants that volatilize to form hazardous air pollutants (HAPs) that may present a threat to human health or the environment. Other MP&M pollutants are found in POTW sludge. Only eight of these pollutants have land application pollutant criteria that limit the uses of sludge.

[b] Excludes discharges from facilities that are projected to close in the baseline (327 lbs-equiv., or an average of 4.4 lbs-equiv. per closing facility).

Source: U.S. EPA analysis.

As reported in Table 2.3, direct dischargers in the Oily Wastes subcategory currently release a total of 3,351 toxic weighted pounds per year, an average of 1.41 toxic weighted pounds per facility. After implementation of the final rule, EPA estimates that Oily Wastes direct dischargers will release only 668 toxic weighted pounds per year, an average of 0.28 toxic pounds per facility. EPA estimates that the final rule will reduce pollutant discharges by approximately 2,683 toxic weighted pounds per year.

2.2.2 Discharges under the MP&M Regulation

Reductions in toxic loadings result from treatment of effluents and pollution prevention at facilities that are subject to the regulation. Table 2.4 shows baseline and post-regulation loadings by type of pollutant, both as unweighted pounds and on a toxic-weighted basis, for facilities that are regulated under the final rule. The final rule eliminates 80.1 percent of the baseline toxic-weighted loadings from the facilities that are regulated, including 83.7 percent of the ***priority pollutants*** (87.3 percent of metals, 22.4 percent of organics, and 1.3 percent of arsenic) and 57.4 percent of the ***nonconventional pollutants*** (62.1 percent of metals, 13.3 percent of organics, and 50.0 percent of “other inorganics”). The final rule also eliminates substantial fractions of the baseline discharges of conventional pollutants from the regulated facilities, including 6.6 percent of

***chemical oxygen demand* (COD)**, 37.1 percent of ***biological oxygen demand* (BOD)**, 93.2 percent of oil and grease (O&G), and 54.1 percent of total suspended solids (TSS).[5]

Table 2.4: Summary of Discharges by Pollutant Type for Facilities Regulated under the Final Rule[a]

Pollutant Category	Current Releases		Releases under the Final Rule		Final Rule Reductions	
	Pounds	Pounds Eq.	Pounds	Pounds Eq.	Pounds	Pounds Eq.
Priority Pollutants						
Metals	794	2,756	153	351	641	2,405
Organics	336	58	268	45	68	13
Arsenic	22	75	21	74	1	1
Cyanide (CN)	0	0	0	0	0	0
Nonconventional Pollutants						
Metals	25,863	417	16,428	158	9,435	259
Organics	2,159	45	1,038	39	1,121	6
Other Inorganics	2,334	0.2	1,301	0.1	1,033	0.1
Bulk Pollutants	335,679		167,295		168,384	
Conventional Pollutants						
BOD	263,419		165,567		97,852	
COD	523,440		488,697		34,743	
O&G	428,137		28,955		399,182	
TSS	160,695		73,769		86,926	

[a] Discharges discussed in this table are facility discharges and do not account for POTW removals. EPA believes it is appropriate to analyze wastewater discharges disregarding POTW removals because indirect discharges present environmental risks that are not fully addressed by POTW treatment. The MP&M industry releases 89 pollutants that cause inhibition problems at POTWs and an additional 35 pollutants that volatilize to form hazardous air pollutants (HAPs) that may present a threat to human health or the environment. Other MP&M pollutants released by the industry are found in POTW sludge. Only eight of these pollutants have land application pollutant criteria that limit the uses of sludge.

Source: U.S. EPA analysis.

2.3 Addressing Market Imperfections

Environmental legislation in general, and the CWA and the MP&M regulation in particular, seek to correct imperfections – ***uncompensated*** environmental externalities – in the functioning of the market economy. In manufacturing, rebuilding, and repairing metal products and machinery, MP&M facilities release pollutants that increase risks to human health and aquatic life and cause other environmental harm without accounting for the consequences of these actions on other parties (sometimes referred to as ***third parties***) who do not directly participate in the business transactions of the business entities.

[5] It is not possible to provide an overall estimate of total pollutant pounds removed, because overlap among some of the pollutant categories would result in double-counting if the categories were summed. For example, TSS may include some of the priority pollutant and nonconventional metals discharges. Use of the toxic-weighted loadings avoids this double-counting, but does not include conventional pollutants.

These costs are not borne by the responsible entities and are therefore *external* to the production and pricing decisions of the responsible entity.

A profit-maximizing firm or a cost-minimizing government-owned facility will ignore these costs when deciding how much to produce and how to produce it. In addition, the externality is uncompensated because no party is compensated for the adverse consequences of the pollution releases.

When these external costs are not accounted for in the production and pricing decisions of the responsible entities, their decisions will yield a mix and quantity of goods and services in the economy, and an allocation of economic resources to production activities, that are less than optimal. In particular, the quantity of pollution and related environmental harm caused by the activities of the responsible entities will, in general, exceed ***socially optimal levels***. As a result, society will not maximize total ***social welfare***.

In addition, adverse ***distributional effects*** may accompany the uncompensated environmental externalities. If the distribution of pollution and environmental harm is not random among the U.S. population, but instead is concentrated among certain population subgroups based on socio-economic or other demographic characteristics, then the uncompensated environmental externalities may produce undesirable transfers of economic welfare among subgroups of the population. See *Chapter 17: Environmental Justice and Protection of Children* for more information.

The goal of environmental legislation and implementing regulations, including the final MP&M rule that is the subject of this EEBA, is to correct these environmental externalities by requiring businesses and other polluting entities to reduce their pollution and environmental harm. Congress, in enacting the authorizing legislation, and EPA, in promulgating the implementing regulations, act on behalf of society to achieve a mix of goods and services and a level of pollution that more nearly approximates socially optimal levels. As a result, the mix and quantity of goods and services provided by the economy, the allocation of economic resources to those activities, and *the quantity of pollution and environmental harm accompanying those activities* will yield higher economic welfare to society.

Requiring polluting entities to reduce levels of pollution and environmental harm is one approach to addressing the problem of environmental externalities. This approach imposes costs on the polluting entities in the form of compliance costs incurred to reduce pollution to allowed levels. A polluting entity will either incur the costs of meeting the regulatory limits or will determine that compliance is not in its best financial interest and will cease the pollution-generating activities. This approach to addressing the problem of environmental externalities will generally result in improved economic efficiency and net welfare gains for society if the cost of reducing the pollution and environmental harm activities is less than the value of benefits to society from the reduced pollution and environmental harm.

It is theoretically possible to correct the market imperfection by means other than direct regulation. For example, negotiation and/or litigation could achieve an optimal allocation of economic resources and mix of production activities within the economy. However, the transaction costs of assembling the affected parties and involving them in the negotiation/litigation process, as well as the public goods character of the improvement sought by negotiation or litigation, make this approach impractical.

2.4 Overlap with Other Effluent Guidelines

EPA has previously promulgated effluent guidelines regulations for 13 metals-related industries. In some instances, these industries may perform operations that are found in MP&M facilities. These effluent guidelines are:

- Electroplating (40 CFR Part 413),
- Iron & Steel Manufacturing (40 CFR Part 420),
- Nonferrous Metals Manufacturing (40 CFR Part 421),
- Ferroalloy Manufacturing (40 CFR Part 424),
- Metal Finishing (40 CFR Part 433),
- Battery Manufacturing (40 CFR Part 461),

- Metal Molding & Casting (40 CFR Part 464),
- Coil Coating (40 CFR Part 465),
- Porcelain Enameling (40 CFR Part 466),
- Aluminum Forming (40 CFR Part 467),
- Copper Forming (40 CFR Part 468),
- Electrical & Electronic Components (40 CFR Part 469), and
- Nonferrous Metals Forming & Metal Powders (40 CFR Part 471).

In 1986, the Agency reviewed coverage of these regulations and identified a significant number of metals processing facilities discharging wastewater that these 13 regulations did not cover. From this review, EPA performed a more detailed analysis of these unregulated sites and identified the discharge of significant amounts of pollutants. This analysis resulted in the formation of the "Machinery Manufacturing and Rebuilding" **(MM&R)** point source category. In 1992, EPA changed the name of the category to "Metal Products and Machinery" **(MP&M)** to clarify coverage of the category (57 FR 19748).

Only direct dischargers in the Oily Wastes subcategory will be regulated under the final regulations for 40 CFR Part 38. Table 2.5 shows the MP&M subcategories and the coverages that apply to each. EPA does not intend this table to be exhaustive, but rather to provide a general overview of the applicability of the Electroplating, Metal Finishing, and Metal Products & Machinery effluent guidelines.

Table 2.5: Coverage by MP&M Subcategory

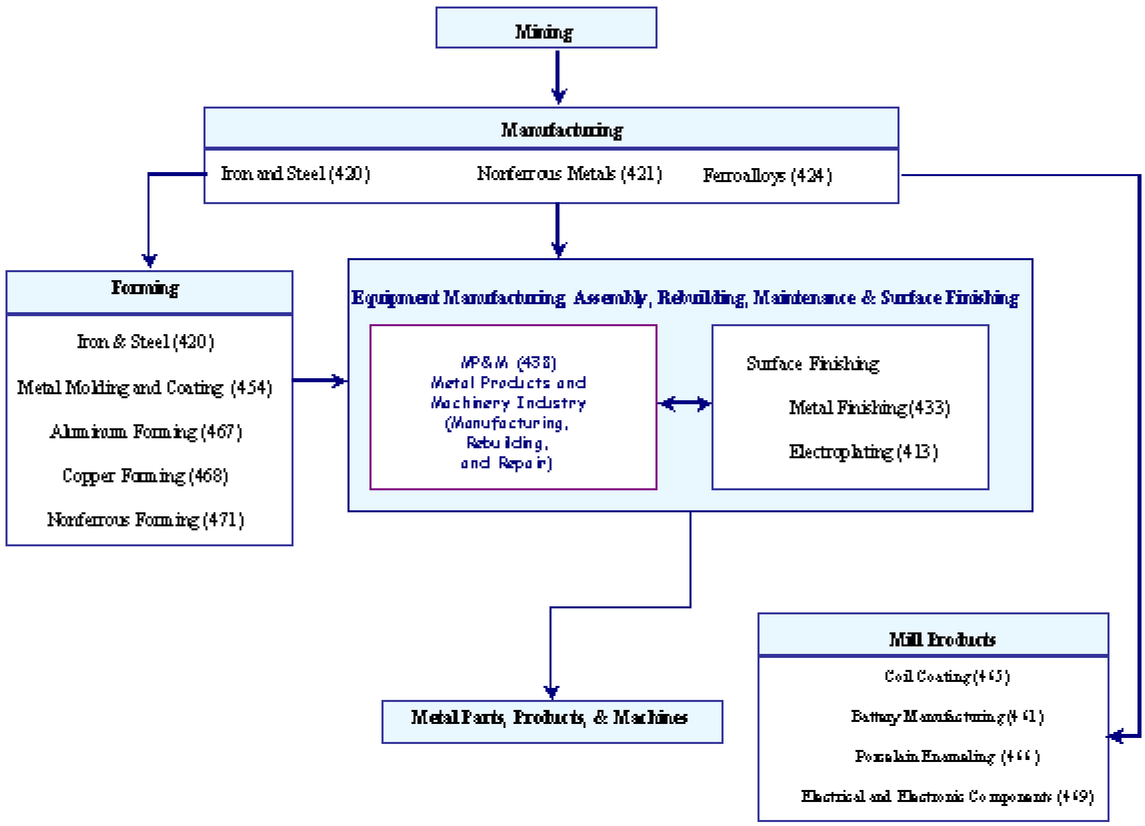
Subcategory	Continue Coverage under 40 CFR Part 413 (Electroplating)	Continue Coverage under 40 CFR Part 433 (Metal Finishing)	Coverage under 40 CFR Part 438 (Metal Products & Machinery)
General Metals (including Continuous Electroplaters)	Existing indirect dischargers currently covered by Part 413.	New and existing direct and indirect dischargers currently covered by Part 433.	None
Metal Finishing Job Shops	Existing indirect dischargers currently covered by Part 413.	New and existing direct and indirect dischargers currently covered by Part 433.	None
Non-Chromium Anodizers[a]	Existing indirect dischargers that are currently covered by 413.	New and existing direct and indirect dischargers currently covered by Part 433.	None
Printed Wiring Board (Printed Circuit Board)	Existing indirect dischargers that are currently covered by 413.	New and existing direct and indirect dischargers currently covered by Part 433.	None
Steel Forming & Finishing Wire Drawing[a]	N/A	N/A	None
Oily Waste[b]	N/A	N/A	All new and existing direct dischargers under this subcategory. (See 438.20)
Railroad Line Maintenance[b]	N/A	N/A	None
Shipbuilding Dry Docks[b]	N/A	N/A	None

[a] These facilities will continue to be subject to Part 420.
[b] There are no national categorical pretreatment standards for these facilities.

Source: U.S. EPA analysis.

Figure 2.1 illustrates the relationship among the various metals industries effluent guidelines.

Figure 2.1: Metals Industries Effluent Guidelines Covered Under 40CFR



Source: U.S. EPA analysis.

2.5 MEETING LEGISLATIVE AND LITIGATION-BASED REQUIREMENTS

EPA's effluent limitations guidelines and standards for the MP&M industry are under authority of the CWA, Sections 301, 304, 306, 307, and 501. These CWA sections require the EPA Administrator to publish limitations and guidelines for controlling industrial effluent discharges consistent with the overall CWA objective to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters." EPA's MP&M industry regulation responds to these requirements.

In addition, the MP&M regulation responds to the requirements of a consent decree entered by the Agency as a result of litigation. Section 304(m) of the CWA (33 U.S.C. 1314(m)), added by the Water Quality Act of 1987, required EPA to establish schedules for (i) reviewing and revising existing effluent limitations guidelines and standards, and (ii) promulgating new effluent guidelines. On January 2, 1990, EPA published an Effluent Guidelines Plan (55 FR 80), in which schedules were established for developing new and revised effluent guidelines for several industry categories. One of the industries for which the Agency established a schedule was the Machinery Manufacturing and Rebuilding Category (MM&R).[6]

[6] The name was changed to Metal Products and Machinery (MP&M) in 1992 to avoid confusion over what was covered by the rule.

The Natural Resources Defense Council, Inc. **(NRDC)** and Public Citizen, Inc. challenged the Effluent Guidelines Plan in a suit filed in U.S. District Court for the District of Columbia (NRDC et al v. Reilly, Civ. No. 89-2980). The plaintiffs charged that EPA's plan did not meet the requirements of Section 304(m). A Consent Decree in this litigation was entered by the Court on January 31, 1992. This plan required, among other things, that EPA propose effluent guidelines for the MP&M category by November, 1994 and take final action on these effluent guidelines by May, 1996. EPA filed a motion with the Court on September 28, 1994, requesting an extension until March 31, 1995, for the EPA Administrator to sign the proposed regulation and a subsequent four month extension for signature of the final regulation in September 1996. EPA published a proposal entitled, "Effluent Limitations Guidelines, Pretreatment Standards, and New Source Performance Standards: Metal Products and Machinery" (60 FR 28210) on May 30, 1995.

EPA initially divided the industry into two phases based on industry sector, as the Agency believed that would make the regulation more manageable. The Phase I proposal included the following industry sectors: Aerospace; Aircraft; Electronic Equipment; Hardware; Mobile Industrial Equipment; Ordnance; and Stationary Industrial Equipment. At that time, EPA planned to propose a rule for the Phase II sectors approximately three years after the MP&M Phase I proposal.

EPA received over 4,000 pages of public comment on the Phase I proposal. One area where commenters from all stakeholder groups (i.e., industry, environmental groups, and regulators) were in agreement was that EPA should not divide the MP&M industry into two separate regulations. Commenters raised concerns regarding the regulation of similar facilities with different compliance schedules and potentially different limitations for similar processes based solely on whether the facilities were in a Phase I or Phase II sector. Furthermore, a large number of facilities performed work in multiple sectors. In such cases, permit writers and control authorities (e.g., POTWs) would need to decide which MP&M rule (Phase I or 2) applied to a facility.

Based on these comments, EPA decided to combine the two phases of the regulation into one proposal. EPA published a proposal entitled, "Effluent Limitations Guidelines, Pretreatment Standards, and New Source Performance Standards for the Metal Products and Machinery Point Source Category" (66 FR 424) on January 3, 2001. The proposal published in January 2001 completely replaced the 1995 proposal.

On June 5, 2002, EPA published a Notice of Data Availability (NODA) (67 FR 38752). In the NODA, EPA discussed major issues raised in comments on the 2001 proposal; suggested revisions to the technical and economic methodologies used to estimate compliance costs, pollutant loadings, and economic and environmental impacts; presented the results of these suggested methodology changes and incorporation of new (or revised) data; and summarized the Agency's thinking on how these results could affect the Agency's final decisions.

This report addresses the 304(m) decree as amended, requiring the MP&M rules to be promulgated by February 14, 2003.

GLOSSARY

Best Available Technology Economically Achievable: Effluent limitations for direct dischargers, addressing priority and nonconventional pollutants. BAT is based on the best existing economically achievable performance of plants in the industrial subcategory or category. Factors considered in assessing BAT include the cost of achieving BAT effluent reductions, the age of equipment and facilities involved, the processes employed, engineering aspects of the control technology, potential process changes, non-water quality environmental impacts (including energy requirements), economic achievability, and such factors as the Administrator deems appropriate. The Agency may base BAT limitations upon effluent reductions attainable through changes in a facility's processes and operations. Where existing performance is uniformly inadequate, EPA may base BAT upon technology transferred from a different subcategory within an industry or from another industrial category.

Best Practicable Control Technology Currently Available: Effluent limitations for direct discharging facilities, addressing conventional, toxic, and nonconventional pollutants. In specifying BPT, EPA considers the cost of achieving effluent reductions in relation to the effluent reduction benefits. The Agency also considers the age of the equipment and facilities, the processes employed and any required process changes, engineering aspects of the control technologies, non-water quality environmental impacts (including energy requirements), and such other factors as the Agency deems appropriate. Limitations are traditionally based on the average of the best performances of facilities within the industry of various ages, sizes, processes, or other common characteristics. Where existing performance is uniformly inadequate, EPA may require higher levels of control than currently in place in an industrial category if the Agency determines that the technology can be practically applied.

bioavailable: Degree of ability to be absorbed and ready to interact in organism metabolism. (http://www.epa.gov/OCEPAterms)

biological oxygen demand: A measure of the amount of oxygen consumed in the biological processes that break down organic matter in water. The greater the BOD, the greater the degree of pollution. (http://www.epa.gov/OCEPAterms/bterms.html)

chemical oxygen demand: A measure of the oxygen required to oxidize all compounds, both organic and inorganic, in water. (http://www.epa.gov/OCEPAterms/cterms.html)

Clean Water Act: Act passed by the U.S. Congress to control water pollution. Formerly referred to as the Federal Water Pollution Control Act of 1972 or Federal Water Pollution Control Act Amendments of 1972 (Public Law 92-500), 33 U.S.C. 1251 et. seq., as amended by: Public Law 96-483; Public Law 97-117; Public Laws 95-217, 97-117, 97-440, and 100-04.

conventional pollutants: Statutorily listed pollutants understood well by scientists. These may be in the form of organic waste, sediment, acid, bacteria, viruses, nutrients, oil and grease, or heat. (http://www.epa.gov/OCEPAterms)

distributional effects: Occurs when the distribution of pollution and environmental harm is not random among the U.S. population, but instead is concentrated among certain population subgroups based on socio-economic or other demographic characteristics, then the uncompensated environmental externalities may produce undesirable transfers of economic welfare among subgroups of the population.

externalities: Costs or benefits of market transactions that are not reflected in the prices buyers and sellers use to make their decisions. An externality is a by-product of the production or consumption of a good or service that affects someone not immediately involved in the transaction.
(http://www.enmu.edu/users/biced/home/glossary.html)
A type of market failure that causes inefficiency.
(http://www.amosweb.com/cgi-bin/gls_dsp.pl?term=externalities)

MP&M facilities: MP&M facilities are defined on the basis of three considerations: (1) they produce metal parts, products, or machines for use in one of the 19 industry sectors evaluated for coverage in the MP&M point source category; (2) they use operations in one of the eight regulatory subcategories evaluated for coverage in the MP&M point source category; and (3) they discharge process wastewater, either directly or indirectly, to surface waters. In this document, the term "MP&M facilities" refers to all facilities meeting the above definition, regardless of whether a facility's industrial sector, subcategory, or discharger category is covered by the final regulation. If the MP&M facilities are referred to as *"regulated"* facilities or facilities *"subject to the final regulation"*, the use of the qualifier *"regulated"* or *"subject to the final regulation"* restricts the definition to include only those facilities in the industry sectors, subcategory, and discharger category covered by the final regulation.

MP&M industry: The facilities and markets comprising the 19 industry sectors evaluated for coverage in the MP&M point source category. In this document, the term "MP&M industry" refers to the full 19 industry sectors, regardless of whether an industry sector is covered by the final regulation. If the MP&M industry is referred to as the *regulated* MP&M industry, the use of the qualifier "regulated" restricts the definition to only the industry sectors, subcategory, and discharger category covered by the final regulation.

nonconventional pollutants: Any pollutant not statutorily listed or which is poorly understood by the scientific community.
(http://www.epa.gov/OCEPAterms)

oil and grease (O&G): These organic substances may include hydrocarbons, fats, oils, waxes and high-molecular fatty acids. Oil and grease may produce sludge solids that are difficult to process. (http://www.epa.gov/owmitnet/reg.htm)

Pretreatment Standards for Existing Sources (PSES): Categorical pretreatment standards for existing indirect dischargers, designed to prevent the discharge of pollutants that pass through, interfere with, or are otherwise incompatible with the operation of POTWs. Standards are technology-based and analogous to BAT effluent limitations guidelines.

priority pollutants: 126 individual chemicals that EPA routinely analyzes when assessing contaminated surface water, sediment, groundwater or soil samples.

publicly-owned treatment works: A treatment works for municipal sewage or liquid industrial wastes that is owned by a State or municipality.

socially optimal level: Situation in which it is impossible to make any individual better off without making someone else worse off. Also referred to as Pareto optimal.

social welfare: The sum of the welfare of all participants in the society; measured by the sum of consumer surplus --the value consumers derive from goods and services less the price they have to pay for the goods and services -- and producers' surplus -- the revenue received by producers of goods and services less their costs of producing the goods and services.

third parties: Those affected by a by-product of the production or consumption of a good or service that are not immediately involved in the transaction.

total suspended solids: A measure of the suspended solids in wastewater, effluent, or water bodies, determined by tests for "total suspended non-filterable solids."
(http://www.epa.gov/OCEPAterms/tterms.html).

toxic-weighted pollutants: This measure weights quantities of different pollutants in effluents by a measure of their relative toxicity. Toxic-weighted loadings measures the relative toxic effects of discharges containing different mixtures of pollutants.

uncompensated: Where parties damaged by externalities receive no compensation for accepting the damage.

ACRONYMS

BAT: Best Available Technology Economically Achievable
BPT: Best Practicable Control Technology Currently Available
BOD: biological oxygen demand
COD: chemical oxygen demand
CWA: Clean Water Act
MM&R: Machinery Manufacturing and Rebuilding
MP&M: Metal Products and Machinery
NPDES: National Pollutant Discharge Elimination System
NRDC: Natural Resources Defense Council
O&G: oil and grease
POTW: publicly-owned treatment works
PSES: Pretreatment Standards for Existing Sources
TSS: total suspended solids

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Chapter 3: Profile of the MP&M Industry Sectors

Introduction

The final MP&M rule will apply to facilities that manufacture, rebuild, or maintain metal parts, products or machines to be used in a large number of industrial sectors. ***Manufacturing*** is the series of unit operations necessary to produce metal products, and is generally performed in a production environment. ***Rebuilding/maintenance*** is the series of unit operations necessary to disassemble used metal products into components, replace the components or subassemblies or restore them to original function, and reassemble the metal product. These operations are intended to keep metal products in operating condition and can be performed in either a production or a non-production environment. Manufacturing and rebuilding/maintenance activities often occur at the same facilities.

The MP&M industry encompasses a large number of industries that manufacture intermediate and final goods, support transportation and other vehicle services, and repair and maintain products and equipment. The health of the MP&M industry is generally tied to the overall economic performance of the economy. The MP&M industry includes manufacturing and non-manufacturing industries defined by 224 4-digit ***Standard Industrial Classification (SIC)*** codes, which are grouped into nineteen industry sectors.[1] Of the 224 SIC codes, 174 are manufacturing (SICs 20 through 39) and 50 are non-manufacturing. All nineteen sectors include manufacturing industries, and eleven include non-manufacturing industries as well.

Although EPA evaluated regulatory options that would have covered facilities operating in any of the nineteen sectors, the final regulation covers facilities operating only in sixteen of those sectors.

Chapter Contents

This chapter provides a profile of the industry sectors that were evaluated for coverage by the MP&M rule. The profile focuses on the economic characteristics of the sectors and the facilities within the sectors, which may affect the rule's financial and economic impacts. It presents and interprets a wide variety of data associated with production, market structure, and competitiveness, for each sector and for the MP&M industry as a whole.

[1] Appendix A lists the nineteen sectors and their associated 4-digit SIC codes.

3.1 DATA SOURCES

This profile presents data from the *Economic Censuses, Statistics of U.S. Businesses* (SUSB), *Annual Survey of Manufacturers (*ASM*)*, *U.S. Industry and Trade Outlook*, EPA's Sector Notebooks, and other sources, to characterize the MP&M sectors, including both dischargers and non-dischargers.

The years 1988 and 1996 were chosen as the years for which data are presented because these are the base analysis years, respectively, for the MP&M Phase 1 sectors survey and the Phase 2 survey. In the cases when data for those years were not available, data from other years were used.

This profile relies on industries defined by SICs, both because data collection for the MP&M sectors was defined by SICs and to allow use of historical data. The Census Bureau switched to use of the new ***North American Industry Classification System (NAICS)*** codes starting with the 1997 Economic Censuses. Data classified by NAICS code were converted to SIC format before being included in the profile. The conversion used a bridge containing the percentage of each NAICS code that needed to be assigned to each SIC code. For a detailed discussion of the bridge, see Appendix A.

The Agency used survey data to characterize the facilities within the MP&M sectors that are potentially subject to the rule because they discharge process wastewater from MP&M operations. The survey provides data such as discharge type, small business status, sources of revenues, and financial performance.

The survey requested information on the sectors from which each facility derives its revenues. Many facilities derive revenues from more than one sector. It is therefore difficult to link facility characteristics to a specific sector. Data on the potentially-regulated facilities are therefore summarized by the regulatory subcategories rather than by sectors.

All monetary values are shown in real 2001 dollars. EPA used the ***Producer Price Index (PPI)*** for industrial commodities as a conversion tool. A PPI is an index that measures price changes, from the perspective of the seller, of a collection of goods and services that are important inputs for a specific industry or for the economy as a whole. This chapter uses the PPI for industrial commodities to inflate ***nominal values*** to ***real values***. Later chapters include PPI's that are sector specific. These PPI's are derived from the average of the PPI's for each component industry SIC code, weighted by industry output.

Table 3-1 shows the PPI values for the relevant years for which prices were deflated. The PPI for industrial commodities increased slightly every year between 1988 and 1996. Total inflation for industrial commodities from 1988 to 1996 was 19.8%.

Table 3.1: Producer Price Index for Industrial Commodities

Year	Producer Price Index (PPI)	Percent Change
1988	100.0	n/a
1989	105.0	5.0%
1990	108.9	3.8%
1991	109.6	0.6%
1992	110.4	0.8%
1993	111.9	1.4%
1994	113.5	1.4%
1995	118.1	4.0%
1996	119.8	1.4%
1997	120.1	0.3%
1998	117.4	-2.3%
1999	119.0	1.4%
2000	126.8	6.6%
2001	127.7	0.7%

Source: Bureau of Labor Statistics, Producer Price Index.

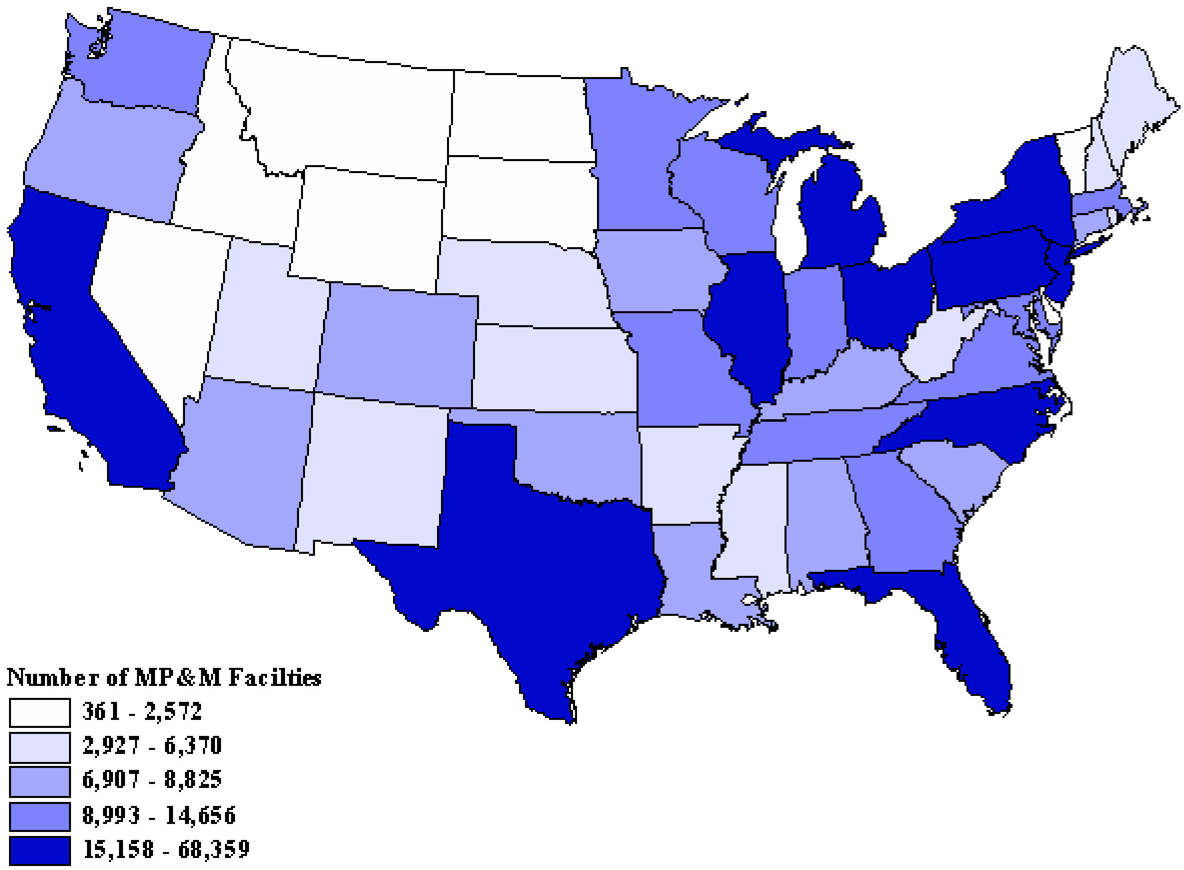
3.2 Overview of the MP&M Industry and Industry Trends

This section provides a general overview of the MP&M industry. It describes the individual MP&M industry sectors, provides basic economic information about MP&M manufacturers, and summarizes recent industry trends.

Figure 3-1 shows that MP&M facilities are located in every state. A few MP&M sectors such as shipbuilding are concentrated geographically. Transportation-related MP&M facilities are found throughout the country. Overall, MP&M

facilities are most concentrated in the heavy industrial regions along the Gulf Coast, both the East and West Coasts, and the Great Lakes Region (New York, Pennsylvania, Ohio, Indiana, Illinois, and Michigan).

Figure 3.1: Number of MP&M Facilities by State in 1992



Source: Department of Commerce, Bureau of the Census, Census of Manufacturers, Census of Transportation, Census of Wholesale Trade, Census of Retail Trade, Census of Service Industries, 1992.

Table 3.2 lists the MP&M sectors and provides a brief description of the products and services produced by each. Appendix A provides a more detailed list of the 4-digit SIC codes in each sector.

Table 3.2: MP&M Sector Definitions

Sector	Sector Description
Aerospace	Metal parts or products such as missiles, space vehicles, satellites and associated launching equipment.
Aircraft	Metal parts or products including all types of aircraft for public, private or commercial use. Includes aircraft parts and equipment as well as aircraft maintenance activities.
Bus and Truck	Metal parts or products including freight trucks and trailers as well as public, private and commercial buses. Includes all associated equipment including equipment specific to truck and bus terminals. Includes bus and truck maintenance activities.
Electronic Equipment	Metal parts or products including general electronic components such as tubes, capacitors, and transformers, as well as finished electronic equipment such as televisions, radios, and telephones.
Hardware	Metal parts or products such as tools, cutlery, valves and tubing, dies, springs, sheet metal, drums, and heat treating equipment.
Household Equipment	Metal parts or products including appliances such as refrigerators, laundry equipment, lighting equipment, cooking equipment, and vacuum cleaners. Non-communication type radios and televisions are included in this sector.
Iron and Steel	Sites engaged in iron or steel manufacturing, forming and finishing.
Instruments	Metal parts or products such as laboratory and medical equipment, measuring devices, environmental and process controls, optical equipment, surgical and dental equipment, and pens.
Metal Finishing Job Shop	Facilities with more than 50 percent of their revenues coming from work on products not owned by the site. While there are SIC codes associated with some Metal Finishing Job Shops, they sell to a variety of markets and are not a market in and of themselves.
Mobile Industrial Equipment	Metal parts or products including tractors and other farm equipment, construction machinery and equipment, mining machinery and equipment, industrial cranes and hoists, and tracked military vehicles.
Motor Vehicle	Metal parts or products including private passenger vehicles and associated parts and accessories such as automobiles, motorcycles, utility trailers and recreational vehicles, and mobile homes.
Office Machines	Metal parts or products including office computer equipment, storage devices, printers, photocopiers and associated parts and accessories.
Ordnance	Metal parts or products including all small arms, artillery, and ammunition with the exception of missiles (aerospace). Does not include the chemical processing or the manufacture of explosives.
Other Metal Products	Metal parts or products including products and machinery not categorized into the other sectors (e.g., sporting goods, musical instruments).
Precious Metals and Jewelry	Metal parts or products including jewelry, silverware, trophies, and clocks as well as all associated parts and accessories.
Printed Wiring Boards	Metal parts or products including printed wiring boards and printed circuit boards.
Railroad	Metal parts or products including railcars, locomotives and associated parts and accessories as well as track, switching and terminal stations.
Ships and Boats	Metal parts or products including ships and boats for military, freight, and private recreation. Includes submarines, ferries, tug boats, barges, yachts, and other recreational boats as well as all parts and accessories. Also includes rebuilding and maintenance activities performed at marinas, dry docks, and other on shore activities specifically related to ships and boats.
Stationary Industrial Equipment	Metal parts or products including all industrial machinery, such as turbines, oil field machinery, elevators and moving stairways, conveying equipment, chemical process industry equipment, pumps, compressors, blowers, industrial ovens, vending machines, commercial laundry equipment, commercial refrigeration and heating equipment, welding apparatus, motors, and generators.

Source: U.S. EPA analysis.

Table 3.3 shows output by sector for manufacturers, non-manufacturers, and all MP&M firms. Output is a good indicator of the overall size of a market. In 1997, MP&M firms accounted for more than $2.8 trillion in output. Motor vehicles were the largest single MP&M sector, accounting for 43 percent of all MP&M output. Ordnance is the smallest sector, with 0.2 percent of MP&M output.

The MP&M manufacturing and non-manufacturing sectors differ in several important ways. The manufacturing sector accounted for $1.6 trillion in output, equal to 57 percent of the total MP&M output. The non-manufacturing sector accounted for $1.2 trillion, or 43 percent of MP&M output. Although MP&M non-manufacturers' revenues were nearly $400 billion smaller than manufacturers' revenues, the MP&M non-manufacturers had three times as many facilities as the MP&M manufacturers. Also, although manufacturing output was relatively evenly divided among the different sectors, more than 86 percent of non-manufacturing output came from the motor vehicle and bus and truck sectors.

Table 3.3: MP&M Output and Share in 1997[a] (millions, 2001$)

Sector	Manufacturers		Non-Manufacturers		Sector Total	
	Output [b]	Share	Output [b]	Share	Output [b]	Share
Aerospace	20,115.1	1.2%			20,115.1	0.7%
Aircraft	105,163.8	6.4%	9,935.9	0.8%	115,099.7	4.0%
Bus & Truck	15,118.4	0.9%	209,316.1	16.7%	224,434.5	7.8%
Electronic Equipment	145,886.9	8.9%			145,886.9	5.1%
Hardware	189,145.5	11.6%			189,145.5	6.6%
Household Equipment	102,242.3	6.3%	2,847.7	0.2%	105,090.0	3.6%
Instruments	141,548.0	8.7%	7,401.9	0.6%	148,949.9	5.2%
Iron and Steel	20,403.0	1.2%			20,403.0	0.7%
Job Shop [c]	15,360.2	0.9%			15,360.2	0.5%
Mobile Industrial Equipment	54,704.7	3.3%			54,704.7	1.9%
Motor Vehicle	366,448.7	22.4%	870,450.5	69.6%	1,236,899.2	42.8%
Office Machine	119,783.0	7.3%	30,929.9	2.5%	150,712.9	5.2%
Ordnance	5,778.8	0.4%			5,778.8	0.2%
Other Metal Products	60,249.6	3.7%	22,040.7	1.8%	82,290.3	2.9%
Precious Metals and Jewelry	9,760.7	0.6%	367.4	0.0%	10,128.1	0.4%
Printed Wiring Boards	10,400.7	0.6%			10,400.7	0.4%
Railroad [d]	8,412.6	0.5%	30,727.9	2.5%	39,140.5	1.4%
Ships and Boats	18,081.1	1.1%	37,383.0	3.0%	55,464.1	1.9%
Stationary Industrial Equipment	227,053.7	13.9%	29,747.1	2.4%	256,800.8	8.9%
Total MP&M	**1,635,656.8**	**100.0%**	**1,251,148.1**	**100.0%**	**2,886,804.9**	**100.0%**
Percent of total	*56.7%*		*43.3%*		*100.0%*	

[a] Data for 1996 were not available, so economic census data from 1997 were used.
[b] Value of shipments for manufacturing industries; total sales for retail and wholesale trade; total receipts for service industries; total revenue for transportation.
[c] Includes facilities in two SICs that are defined specifically as job shops (SICs 3471 and 3479.) Facilities reporting in other sectors may also operate as job shops, so these data are likely to understate the true output of MP&M job shops.
[d] Non-manufacturing railroad data are estimated based on 1992 data.

Source: Department of Commerce, Bureau of the Census, Census of Manufacturers, Census of Transportation, Census of Wholesale Trade, Census of Retail Trade, Census of Service Industries, 1997.

The following sections describe the MP&M sectors and briefly discuss recent industry trends in each sector. The discussion is based on *2001 Value Line Industry Reports, U.S. Industry and Trade Outlook 2000* (DRI-McGraw Hill), EPA's Sector Notebooks, and other sources.

3.2.1 Aerospace

The aerospace industry includes original equipment manufacturers (OEM) and facilities that rebuild and repair aerospace equipment. The industry serves both military and commercial end-uses such as space vehicles for commercial communication satellites, although military applications dominate. Its products include guided missiles, space vehicles, and associated propulsion units and parts. The assembly of aerospace products draws on numerous other industries, including plastics, rubber, fabricated metals, metal casing, glass, textile, and electronic components. Aerospace products are typically produced by a prime contractor and several tiers of subcontractors. Final assembly is performed by relatively few facilities, only a small number compared with the numerous subassembly and parts manufacturers. Aerospace manufacturing is extremely capital intensive.

The U.S. aerospace industry has consolidated substantially in recent years, due to declines in defense spending. The number of facilities and firms as well as sector value of shipments and ***employment*** decreased from 1988 to 1996 in the US.

Growth in the industry is expected to come from lower cost air-to-air missiles, with strong focus on increasing efficiency in production by reducing costs. Consumer demand has also grown for direct-to-home television, voice and data transmission, and other satellite services, which have increased the commercial demand for space vehicles needed to launch satellites.

The aerospace industry exports a substantial share of its output. Many North American and European governments with large defense budgets have been seeking to reduce their military budgets, while governments in South America (with smaller budgets) have been maintaining or increasing their defense spending. Substantial consolidation has occurred in the European aerospace industry, which has become more competitive with U.S. companies (U.S. EPA 1997; DRI/McGraw Hill 2000).

3.2.2 Aircraft

Trends in the aircraft sector are heavily influenced by changes in industry structure and in the international political-economic arena. Although new aircraft production increased substantially in 1998 and 1999, production weakened in 2001 because of the economic slowdown and then plummeted following the September 11th terrorist attacks. Airlines have reacted to falling ticket sales by cutting scheduled flights, reducing personnel, and delaying or cancelling investment in new aircraft.

During the 1990's, there was substantial restructuring through mergers and consolidation in the aircraft manufacturing industry, including producers of both aircraft and aircraft parts nationally and internationally. Firms focused on improving efficiency through cost cutting efforts such as reduced staffing. In addition, there is a growing trend for U.S. producers to outsource many aircraft parts to firms in other nations, in order to bring down costs and compete internationally.

In addition to aircraft manufacturing, this sector includes rebuilding and repair of aircraft at manufacturers' facilities or at airports.[2] The aircraft maintenance and repair industry has slowed with the post 9/11 decline in passenger travel.

3.2.3 Electronic Equipment

The electronic equipment sector can be divided into two general groups of industries: microelectronics manufacturers and telecommunications equipment manufacturers.

Microelectronics industries manufacture a wide range of products, from electronic connectors to integrated circuit panels. These products are used as material inputs in many industries such as automotive, telecommunications, aerospace, computer, and medical equipment. Although the microelectronics industry covers a diverse array of products, producers, and end-uses, some general trends have been evident in the industry. A strong increase in the use of microelectronic products in industries throughout the economy has led to rapid growth in microelectronics manufacturing over the past two decades. Although the US is a major producer of consumer electronics, Japan is the world's leading producer of consumer electronics, and U.S. firms face strong international competition for cutting edge technological advances in their products. Due to the high skill level necessary in the development of products, there is considerable competition for skilled labor. The recent economic slowdown has led to lowered demand for end-products that incorporate microelectronics. In response, the microelectronics

[2] The rule regulates wastewater generated from washing vehicles only when it occurs as a preparatory step prior to performing an MP&M unit operation (e.g., prior to disassembly to perform engine maintenance or rebuilding). The rule does not cover the washing of cars, aircraft, or other vehicles when it is performed only for aesthetic/cosmetic purposes.

industry has reduced capacity and laid off workers to reduce costs. Despite this decline, microelectronics continue to be an increasingly necessary component of the global economy.

Telecommunication industries focus on the production of network equipment, fiber optics, and wireless communication equipment. Much of the growth in the industry has come from the increasing use of fiber optics and wireless end-user devices. The telecommunications industries experienced rapid growth in the nineties; however, industry activity slowed considerably with the collapse of the telecommunications bubble. Telecom firms have reacted by cutting employees, reducing costs, and selling off portions of their firms. Most have continued their R&D efforts.

3.2.4 Hardware

The hardware sector consists of many different industries, which can be generally classified into three groups: building hardware, conventional hardware, and tooling hardware.

Building hardware consists of a group of industries that manufacture metal building products, including fabricated structural metal, sheet metalwork, and architectural metalwork. This group of industries grew rapidly throughout the 1990's. The building products industry as a whole saw record sales in 1998 and again in 1999. Much of this growth is attributed to large highway projects funded by the Transportation Efficiency Act for the 21st Century.

Conventional hardware includes products such as screws, industrial fasteners, and valves and hose fittings. The products produced in this industry are used in the production of manufactured goods. Trends in this industry, therefore, generally reflect trends in other manufacturing industries. One of the most important industries influencing conventional hardware is the auto industry. Hardware producers have experienced pressures from end users such as auto makers to reduce costs. The industry faces a continued trend of consolidation of firms and increasing global pressure from countries with low labor costs. Domestic producers of screws and industrial fasteners saw growth in the real value of shipments due to the strong U.S. economy in the late nineties.

The tooling hardware sector also contains a variety of different industries that produce various types of tools for different uses. Because these industries also face continued globalization, many of them are impacted by changes in the global economy. The decline in Asian markets in 1998 and 1999 resulted in a sharp decline in the value of shipments for the machine tooling industries. Prior to the 1998 financial crisis, value of shipments were increasing annually. The market for the power-driven segment of hand tools has increased, however, despite troubled overseas markets.

3.2.5 Household Equipment

There are three general groups of industries included in the household equipment sector: household furniture, household appliances, and plumbing equipment. Generally speaking, factors that affect this sector are consistent across these three groups. Low unemployment and increased disposable income stimulated growth in each of these industries in the nineties. However, because purchases of household equipment are relatively expensive and discretionary, consumers cut back spending in the recent recession. All three household equipment industries face international competition, as imports account for a substantial share of domestic consumption.

Metal furniture accounts for 20 percent of the household furniture industry. Metal components are increasingly being added to non-metal furniture. For example, there is a trend to increase the functionality of non-metal furniture by equipping recliners with heat and massage. This could increase the industry’s reliance on metal parts. The industry has integrated vertically, as large manufacturers have begun to open their own retail stores in an effort to differentiate their products.

There are two groups of household appliance manufacturers. Major appliances such as washing machines and refrigerators are produced by relatively few firms. Smaller appliances are characterized by little product differentiation but considerable price competition and are manufactured by a larger number of companies.

Finally, a significant characteristic of the plumbing equipment market is the extent of U.S. dependence on foreign imports. While the U.S. construction market has grown at a record pace in the past few years, increasing demand for plumbing equipment, much of the demand has been served by imports and this industry has a trade deficit.

3.2.6 Instruments

The instruments sector is characterized by a diverse array of technologically advanced products and intense global competition among many firms of varying sizes. The sector can be generally divided into industrial measuring and testing instruments, and medical instruments.

In the industrial measuring industry, producers of laboratory instruments are typically integrated firms who have consolidated and reduced costs in response to pressures from medical and pharmaceutical customers. Producers of measuring devices are also facing pressures to consolidate. These firms have been hurt by low commodity prices during the past few years, which have led to reduced investment in measuring equipment by fuel and grain producers. Sales should rebound, however, if Asian economies and fuel prices continue to grow. Small companies still dominate the electronic test equipment industry, which is characterized by a high degree of product differentiation. Most of these firms are not large enough to export products.

Sales for medical devices increased steadily throughout the 1990's, while employment remained relatively constant. The industry has historically been characterized by many small to mid-size firms and intense competition for technological innovation. Efforts to bring down health care costs is one of the primary challenges facing this industry. Pressure to reduce costs has reduced insurance companies' willingness-to-pay for new equipment. As the population ages, however, demand for medical services and devices is expected to grow. The industry will likely continue to grow in the next few years, but at a slower pace than it has grown historically..

3.2.7 Iron and Steel

The basic iron and steel industry is regulated under 40 CFR 420, and primary iron and steel works, blast furnaces and rolling mills are not affected by the MP&M rule. The MP&M rule will regulate facilities that perform MP&M operations or cold forming operations on steel wire, rod, bar, pipe, or tube. This subcategory does not include facilities that perform those operations on base materials other than steel, nor does it include wastewater from cold forming, electroplating or continuous hot dip coating of steel sheet, strip, or plates or wastewater from performing any hot steel forming operations.

Events in the global steel industry in the past few years have had significant and possibly far reaching impacts on domestic producers. In 1998, the industry experienced a global steel crisis. This crisis was caused in part by the Asian financial crisis, which triggered a sharp decline in imports of steel by major steel importing countries of Asia. This led to a flood of steel imports into U.S., and U.S. steel imports rose 33 percent in 1998. The situation was made worse by global overcapacity largely derived from producers in Russia and Latin America.

This flood of steel into the U.S. and Europe led to rapidly declining steel prices in both regions. Excess inventories that accrued during the surge of imports hurt domestic producers. The "unfair" trading prices resulted in over 20 nations taking formal trade protection actions such as import duties and price floors. The US Congress determined that foreign steel was being sold in the US at unfair prices, and reacted by enacting anti-dumping tariffs. The slowdown in the US economy has also negatively affected the steel industry. Most steel firms are being forced to focus on rationalizing capacity and cutting costs.

3.2.8 Job Shops

MP&M metal finishing job shops are defined as those facilities with more than 50 percent of their revenues coming from products not owned by the site. While there are specific SIC codes associated with some Metal Finishing Job Shops, they sell to a variety of markets and are not a market in and of themselves.

3.2.9 Mobile Industrial Equipment

Mobile industrial equipment includes a number of different industries that produce machinery for different purposes, including construction, farming, and mining. Growth in the construction equipment industry is typically tied to economic factors such as housing starts, employment, and consumer confidence. Shipments of construction equipment rose steadily during much of the 1990's. The 1998 Transportation Equity Act for the 21st Century was expected to stimulate further spending by federal, state, and local governments. However, the current recession has forced many industry buyers to cut back or cancel orders.

The farm and mining machinery industries both have been suffering from low commodity prices. Both industries experienced growth in shipments throughout much of the 1990's, but were hit in 1999 by low prices. Farm equipment was hit hardest as the real value of shipments fell by 38 percent in 1999. Output is expected to continue to decrease until grain surpluses decline and agricultural prices rise. However, the consolidation of farms has also had a significant in impact on this industry. With the increase in farm size, there is growing dependence upon mechanization to farm more acres per farm.

3.2.10 Motor Vehicle and Bus & Truck

The major trend in the motor vehicle and bus and truck industries is the continual consolidation of firms into highly capital intensive globalized manufacturers. Motor vehicle manufacturers are no longer constrained within national boundaries, as mergers and joint ventures include some of the largest firms from different countries. Many foreign owned manufacturers have facilities located in the U.S., and relative production costs and exchange rates play a greater role in determining the location of production facilities than the national identity of parent companies.

Manufacturers have increasingly standardized the design of motor vehicles and their parts. These changes have resulted in much less product differentiation among manufacturers, but also in greater product quality. However, greater product quality has resulted in a consistently sharp increase in price over the past three decades. This price increase may have reached its pinnacle in the mid-nineties, since prices declined in 1998 and 1999. Industry output for automobiles increased 1.3 percent between 1996 and 2000. Although the current recession has hurt car prices, manufacturers have used incentives such as zero percent financing to maintain sales volume.

3.2.11 Office Machine

The office machine sector experienced rapid growth in the nineties that reversed itself with the downturn in the economy. The industry experienced 7.8 percent growth in the real value of shipments between 1996 and 2000. While this growth was accomplished with only a 1.3 percent increase in total employment, production employment increased by 5.4 percent. The relative difference between total and production employment can be attributed to increasing reliance on the Internet for sales, thereby reducing the need for non-production sales staff. Despite this increase in production employment, the industry remained extremely capital intensive. The recent weakness of the US economy hit the office machine sector hard with business purchases of computers and computer accessories falling significantly.

Firms in the office machine sector have undergone mergers and acquisitions to bring down costs in order to compete. Firms often rely on joint venturing agreements, and sometimes form alliances with past competitors to produce complementary components of new technologies. Consolidation also allows firms to diversify, providing a range of products such as PCs, software, and information technology to protect against the strong competition in the market for any one product. Firms have also increasingly outsourced production to electronics manufacturers more equipped to increase production and take advantage of economies of size, while the original firms utilize their resources for research and development of new technologies to stay competitive.

Globalization is an important trend in this industry as machine components are produced in different countries. Despite the trend toward a globalized market, the U.S. has held a negative trade balance for over a decade.

3.2.12 Ordnance

The ordnance sector includes firms that manufacture small arms, including grenade launchers and heavy field machine guns; artillery, including naval, aircraft, anti-aircraft, tank, coast, and field artillery; and ammunition, including bullets, bombs, mines, torpedoes, grenades, depth charges, and chemical warfare projectiles. It does not include the chemical processing or manufacture of explosives. Overall, the industry has a high ratio of value added to total sales.

The ordnance sector has contracted significantly since the end of the Cold War. Decreases in US government military spending have caused significant declines in ordnance production, leading to lower industry shipments and cutbacks in employment. Foreign customers, including foreign governments, buy over 80 percent of the ordnance manufactured in the US. Although shipments of military weaponry have declined, sales of small arms have increased in the US over the past few years. Recent military actions by the US will likely result in government weapons purchases that will benefit the industry.

3.2.13 Precious Metals and Jewelry

Domestic production in the precious metals and jewelry industry is dominated by many small firms with low capital intensity, mostly concentrated in the northeast US. It is influenced by trends in consumer behavior, the retail market, and global competition. Devaluation in the price of gold due to declining world prices has benefitted the industry because it reduces the cost of making jewelry. Increased disposable income fueled strong consumer spending on precious metals and costume jewelry in the nineties, but this trend has weakened with the recent economic downturn.

Increases in spending have not always translated into gains for domestic producers. The lowering of tariffs has resulted in a steady increase in imports of costume jewelry, as labor-intensive production is often less expensive in developing countries. Domestic producers have also been hurt by the strong U.S. dollar, which makes U.S. exports more expensive. Another challenge comes from the retail market, which has put strong pressure on producers to bring down prices in order to compete. These challenges include consolidation of retailers, giving them greater purchasing power, increased Internet and television home shopping, and a decrease in the number of wholesalers.

3.2.14 Printed Wiring Boards

Printed wiring boards (also referred to as printed circuit boards) are the physical structures on which electronic components such as semiconductor and capacitors are mounted. Computers and communications are the largest uses for printed wiring boards. In addition, printed wiring boards are used in a wide array of other products, including toys, radios, television sets, electronic wiring in cars, guided-missile and airborne electronic equipment, biotechnology, medical devices, digital imaging equipment, and industrial control equipment. While some producers of PWBs produce them for their own use, most manufacturers are independent firms that sell PWBs to the open market. The majority of PWB manufacturers are small firms.

The domestic PWB industry experienced considerable growth throughout the 1990's. Real industry output grew nine percent from 1996 to 2000. Growth was spurred by continual growth in end-use markets. In addition to the increased in value of shipments, U.S. firms saw a 5.6 percent increase in average hourly earnings and a 16.3 percent increase in ***capital expenditures*** over the same period. However, demand in the PC, telecommunications, and electronics sectors has weakened recently. In parallel, there is growing international competitive pressure for PWB makers to reduce production costs. Consequently, many of the larger PWB firms are looking to relocate offshore.

3.2.15 Railroad

Railroad service consists of both freight and passenger service. In the past few years, railroad companies have been focusing on improving the efficiency of their lines and services. There has been a continued trend toward consolidation of major freight railroads. Consequently, companies have reduced the number of lines and focused attention on increasing the capacity of fewer lines. Railroads have also begun to focus on guaranteeing deliveries at specific times, which will allow them to compete with the trucking industry.

Since the 1980's railroad traffic increased by 50 percent, while the line network decreased by 39 percent. This was accomplished by increasing capital expenditures for equipment such as new locomotives with greater horsepower, installation of double tracks, and increases in the capacity of non-railroad owned freight cars. Consequently, freight service in the nineties saw the first increase in operating revenue since 1984, although this was coupled with sharp decreases in employment. Passenger service has undergone similar changes to increase efficiency by adding new locomotives and beginning a transition to high speed train service. Total industry output increased 7.6 percent per year from 1988 to 1996. Although transportation volume is sensitive to the generally poor macroeconomic situation, railways have succeeded in cutting costs to maintain earnings.

3.2.16 Ships and Boats

Ship manufacturing experienced continual declines throughout the 1990's. Despite efforts by the Federal Government to stimulate investment in converting the industry from production of military ships to merchant ships, the U.S. Navy remains the primary customer of shipbuilders. The U.S. Navy dramatically reduced its orders for new vessels since the end of the Cold War, and has decommissioned many ships and submarines. The Navy decreased its fleet by 208 ships from 1985 to 1998. Although the Navy plans to add 66 new ships through construction and conversion from 2000 through 2004, this represents a decline of over 60 percent in the procurement of new ships since the 1980's. The ship building industry was helped by the Oil Pollution Act of 1990, which required all oil tankers entering U.S. ports to have double hulls. General economic woes and instability in the Middle East are expected to hurt the ships and boats industry.

This sector also manufactures recreational boats, with sales that reflect overall trends in recreational expenditures. The U.S. boat building business is the world's leading supplier of recreational craft. Despite this, rapid growth in the market for smaller personal water craft (e.g., jet skis) has led to an increase in imports of boats.

3.2.17 Stationary Industrial Equipment

The stationary industrial equipment sector includes firms that manufacture machinery and machinery parts used for oil, paper, and food production, printing and packaging, as well as heaters and air conditioners, electric generating equipment, and motor generators. These industries also produce large metal-working machines used in making parts for other industries.

The industries supplying oil and gas production, paper production, and printing machinery were affected by similar global factors, and consequently followed similar trends. Low petroleum prices affected oil production in 1998. Natural gas production was influenced by the low oil prices, which put pressure on the gas industry to reduce costs in order to compete. These factors led to a decline of 38 percent in real value of shipments for oil production equipment manufacturers in 1998 and 1999. The price of petroleum increased in 1999 and 2000 and machinery shipments rebounded by 9.2 percent. However, natural gas prices fell in 2001, hurting the industry.

Paper manufacturing equipment has suffered from events overseas. Although the U.S. has seen a decline in the production of paper throughout the latter half of the 1990's, the U.S. remains the largest producer of paper manufacturing machinery. The industry therefore relies heavily on exports to sustain growth. With struggling economies overseas, the industry saw a decline in value of shipments from 1996 to 2000. Printing machinery manufacturers realized strong growth during the first half of the 1990's due to increased demand for new digital presses, but a decline in exports resulted in slower growth for the later half of the decade. Global events did not have such an impact on manufacturers of packaging machinery, as the U.S. is not only the leading producer of this equipment but also its leading end-user.

A variety of industries manufacture equipment used to produce energy or to power equipment. Refrigeration, air conditioning, and heating equipment sales tend to follow growth in housing starts and construction of new office buildings. A number of factors contributed to strong growth in this industry throughout the 1990's including record housing starts, record heat in the summer of 1999, replacement of chlorofluorocarbon (CFC) air conditioning units, and a large percentage of new homes being built with central air conditioning. With 66 percent of the existing air conditioners containing CFC technology still in operation, replacement of these machines provides an opportunity for growth in this industry in the future.

Manufacturers of turbines, transformers, and switchboards, all of which are used for the production of electricity, saw considerable growth in the late 1990s as the domestic economy grew. This strength has been limited by the recent recession. A number of advanced technologies have been developed to meet the demands of a deregulated industry. These new technologies are capable of producing electricity from smaller facilities at competitive costs. Implementation of these technologies is not expected to take place for a few years, however, until the effects of deregulation become clearer.

3.3 Characteristics of MP&M Manufacturing Sectors

The data in these analyses come primarily from the *Annual Survey of Manufacturers* and the Small Business Administration, although some data from the 1997 Census were used for important economic indicators that were not available in 1996. The multi-year analyses presented in this section cover a nine year period from 1988 to 1996, the base years for the original Phase 1 and Phase 2 survey data. Although ideally data would have been presented for the ten year period from 1987 to 1996, OMB reclassified a number of 4-digit SIC industries in 1987. This made it difficult to compare SIC codes before and after this reclassification and resulted in incomplete data in the *Annual Survey of Manufacturers* for many SIC codes in 1987. Because the data were incomplete in 1987, 1988 was chosen as the first year of the time series. With the exception of data for non-manufacturing sectors, single-year data focus on the year 1996, the base analysis year for the overall MP&M regulatory analysis. Because the *Annual Survey of Manufacturers* does not include data for non-manufacturing sectors, single-year data for these sectors are for 1997, the most recent year of the *Economic Census*.

3.3.1 Domestic Production

a. Output

The two most common measures of manufacturing output are ***value of shipments (VOS)*** and ***value added (VA)***. Historical trends in these measures provide insight into the overall economic health of an industry. Value of shipments is the sum of the receipts a manufacturer earns from the sale of its outputs. It is an indicator of the overall size of a market or the size of a firm in relation to its market or competitors. Value added is the difference between the value of shipments and the value of purchased non-labor inputs used to make the products sold. It is used to measure the value of production activity in a particular industry. The ratio of VA to VOS is an indicator of the importance of the industry's contribution to the total value of the product. A ratio close to zero indicates that the value of the input materials is much more important than the value of industry processing. A ratio close to one indicates that industry processing is the primary source of value in the product.

Table 3.4 presents Department of Commerce data on VOS and VA for the MP&M manufacturing sectors during the period from 1988 to 1996. VOS for the entire MP&M manufacturing sector grew from 1.27 trillion dollars in 1988 to 1.51 trillion dollars in 1996, for an average annual growth rate of 2.1 percent. VA for the entire industry grew at a slower annual rate of 1.5 percent, from 638 billion dollars to 720 billion dollars. In comparison, US GDP grew at 2.6 percent per year over the same period.

Value added as a percent of value of shipments for the MP&M manufacturing industries as a whole was 48 percent in 1996. This indicates that 48 percent of the value of their output was the result of MP&M processing and 52 percent was the cost of purchased inputs. In general, MP&M processing is important to the value of MP&M output products.

Growth in the individual sectors was generally consistent with the overall trend in MP&M manufacturing of slow positive growth. Fourteen of the nineteen sectors had positive growth in VOS, and thirteen had positive growth in VA. Railroad equipment manufacturers enjoyed the largest average annual growth of 7.6 percent in VOS. Electronic equipment experienced the next largest average growth, with annual growth in VOS averaging 5.1 percent. Only the aerospace and ordnance industries experienced a large decline in VOS and VA over this period. Aerospace VOS declined 7.6 percent per year and ordnance VOS declined 7.3 percent per year. Both decreases were attributable to cutbacks in government defense spending at the end of the Cold War.

VA as a percent of VOS for the individual sectors varied substantially from the manufacturing average of 48 percent. The ordnance sector had the highest ratio of VA to VOS, at 67.6 percent, and the instrument and printed wiring board sectors also had high ratios. In these sectors, industry processing is the most important part of the value of the finished product. Sectors with low ratios of VA to VOS included the iron and steel sector, railroad sector, bus and truck sector and especially the motor vehicle sector, for which VA as a percent of VOS was equal to only 33.7 percent. The value of input materials was the most important contributor to the value of products in these sectors.

b. Number of facilities and firms

The number of facilities and firms in an industry is an indicator of industry size and structure. Changes in the number of firms and facilities can indicate whether or not the industry is experiencing growth, and changes in the ratio of facilities to firms can indicate whether an industry is becoming more integrated.

This profile uses SUSB data to assess the number of firms and facilities in the MP&M manufacturing sector. The SUSB did not begin its survey until 1989, and it did not include firms in its survey until a year later. Thus, facilities data are presented in 1989 and firm data are presented in 1990.

Table 3.5 shows the number of MP&M manufacturing facilities in 1989 and 1996 and the number of firms in 1990 and 1996. Overall, the number of firms grew 2.1 percent annually and the number of facilities grew 1.4 percent annually over this period. By 1996, there were 144,603 manufacturing firms and 153,354 facilities. The average number of facilities per firm was relatively constant, with only a minor decrease from 1.07 in 1990 to 1.06 in 1996. Most MP&M manufacturers are single-facility firms.

Trends in the individual manufacturing sectors were generally consistent with overall trends in manufacturing. The aerospace industry was the only MP&M manufacturing sector to experience significant downsizing during this period, with firms and facilities decreasing annually by 4.1 and 4.2 percent, respectively. The iron and steel industry experienced a more modest decrease in number of firms and facilities. The number of firms and facilities in the printed wiring board sector grew the fastest, by a little over five percent annually.

Table 3.4: Real Value of Shipments and Value Added: MP&M Manufacturing Sectors (millions, 2001$)							
Sector	Value of Industry Shipments			Value Added by Manufacture			
	1988	1996	Average Annual Growth Rate	1988	1996	Average Annual Growth Rate	Value Added as a % of Value of Shipments in 1996
Aerospace	35,991	19,111	-7.6%	24,167	10,645	-9.7%	55.7%
Aircraft	101,554	88,897	-1.7%	51,692	48,204	-0.9%	54.2%
Bus & Truck	9,843	14,362	4.8%	3,622	5,513	5.4%	38.4%
Electronic Equipment	85,498	127,347	5.1%	48,862	67,071	4.0%	52.7%
Hardware	152,597	180,756	2.1%	82,644	98,674	2.2%	54.6%
Household Equipment	87,764	98,763	1.5%	42,595	45,551	0.8%	46.1%
Instruments	118,322	136,377	1.8%	78,160	89,052	1.6%	65.3%
Iron and Steel	19,396	19,963	0.4%	7,228	7,103	-0.2%	35.6%
Job Shops	11,733	14,927	3.1%	6,967	8,307	2.2%	55.7%
Mobile Industrial Equipment	45,150	56,159	2.8%	21,356	24,302	1.6%	43.3%
Motor Vehicle	315,641	387,547	2.6%	107,025	130,627	2.5%	33.7%
Office Machine	86,352	110,084	3.1%	43,008	43,849	0.2%	39.8%
Ordnance	10,241	5,567	-7.3%	6,631	3,761	-6.8%	67.6%
Other Metal Products	58,809	63,995	1.1%	36,039	37,431	0.5%	58.5%
Precious Metals and Jewelry	10,790	9,242	-1.9%	5,018	4,403	-1.6%	47.6%
Printed Wiring Boards	10,162	11,408	1.5%	5,927	6,997	2.1%	61.3%
Railroad	4,195	7,533	7.6%	1,893	2,761	4.8%	36.7%
Ships and Boats	18,802	16,666	-1.5%	10,086	8,424	-2.2%	50.5%
Stationary Industrial Equipment	176,961	236,213	3.7%	97,388	125,443	3.2%	53.1%
Total	**1,359,801**	**1,604,916**	**2.1%**	**680,309**	**768,118**	**1.5%**	**47.9%**
US GDP	**7,189,924**	**8,821,069**	**2.6%**	**n/a**	**n/a**	**n/a**	**n/a**

Source: Department of Commerce, Bureau of the Census, Annual Survey of Manufacturers; Economagic

Horizontal integration varied substantially across sectors. The railroad sector, with 1.41 facilities per firm in 1996, was the most horizontally integrated, but the iron and steel and aerospace sectors also had high numbers of facilities per firm. The precious metals and jewelry sector had nearly a one to one ratio between facilities and firms, indicating a very low level of horizontal integration.

Table 3.5: Number of Firms and Facilities: MP&M Manufacturing Sectors

Sector	Number of Firms			Number of Facilities			Facilities per Firm	
	1990	1996	Average Annual Growth Rate	1989	1996	Average Annual Growth Rate	1990[a]	1996
Aerospace	109	85	-4.1%	143	106	-4.2%	1.33	1.25
Aircraft	1,428	1,486	0.7%	1,633	1,691	0.5%	1.16	1.14
Bus & Truck	889	953	1.2%	1,016	1,040	0.3%	1.11	1.09
Electronic Equipment	5,649	6,180	1.5%	6,396	6,693	0.7%	1.08	1.08
Hardware	34,984	37,832	1.3%	37,861	40,044	0.8%	1.06	1.06
Household Equipment	6,787	7,563	1.8%	7,914	8,303	0.7%	1.11	1.10
Instruments	7,963	9,730	3.4%	8,959	10,552	2.4%	1.10	1.08
Iron and Steel	597	583	-0.4%	784	770	-0.3%	1.30	1.32
Job Shop	4,798	5,280	1.6%	5,104	5,549	1.2%	1.04	1.05
Mobile Industrial Equipment	3,318	3,341	0.1%	3,606	3,591	-0.1%	1.07	1.07
Motor Vehicle	4,991	6,044	3.2%	5,977	7,024	2.3%	1.17	1.16
Office Machine	1,828	2,002	1.5%	2,050	2,087	0.3%	1.07	1.04
Ordnance	340	421	3.6%	385	442	2.0%	1.09	1.05
Other Metal Products	11,517	13,819	3.1%	12,069	14,198	2.3%	1.03	1.03
Precious Metals and Jewelry	3,719	3,867	0.7%	3,870	3,892	0.1%	1.01	1.01
Printed Wiring Boards	1,034	1,452	5.8%	1,046	1,530	5.6%	1.06	1.05
Railroad	147	152	0.6%	180	215	2.6%	1.27	1.41
Ships and Boats	2,511	3,195	4.1%	2,708	3,310	2.9%	1.05	1.04
Stationary Industrial Equipment	35,231	40,618	2.4%	37,261	42,317	1.8%	1.04	1.04
Total	**127,840**	**144,603**	**2.1%**	**138,962**	**153,354**	**1.4%**	**1.07**	**1.06**

[a] Calculated using data from 1990 for facilities and firms.

Source: Small Business Administration, Statistics of U.S. Businesses.

c. Employment

Employment is a measure of the level and trend of activity in an industry. While employment growth generally signals economic strength in an industry, strong productivity growth and scale economies can yield growth in revenues that exceeds growth in employment. Changing patterns of labor utilization relative to output are particularly important in understanding how regulatory requirements may translate into job losses both in aggregate and at the community level. This profile presents DOC data on employment for 1988 and 1996.

Table 3.6 shows that employment in the MP&M manufacturing sectors as a whole decreased modestly between 1988 and 1997. Over those years, total employment dropped from 7.98 million to 7.55 million, an average decline of 0.7 percent annually. To put this in perspective, VOS for the entire MP&M manufacturing sector grew about 2.1% annually over the same period of time, signaling that growth in output has been driven by increases in capital expenditures and labor productivity, not by increases in employment.

Although total MP&M industry employment declined over the analysis period, not all sectors experienced employment declines. Employment grew or stayed constant in ten of the nineteen sectors. However, while a number of sectors evidenced large percentage and absolute losses in employment, no sectors showed large percentage gains and only two showed large absolute gains in employment . Employment shrank by 11.6 percent annually in the aerospace sector, 9.1 percent in the ordnance sector, and 5.6 percent in the aircraft sector, due to cutbacks in defense spending following the Cold War. The greatest absolute decline occurred in the aircraft sector, which lost almost 220,000 jobs. The largest percentage increase in employment was in the railroad sector, which gained just 2.1 percent annually. The largest absolute increase in employment over the nine years was in the stationary industrial equipment sector, which gained 127,100 jobs.

Table 3.6: Employment: MP&M Manufacturing Sectors

Sector	Number of Employees		
	1988	1996	Average Annual Growth Rate
Aerospace	223,700	81,000	-11.9%
Aircraft	596,600	376,800	-5.6%
Bus & Truck	63,900	67,700	0.7%
Electronic Equipment	602,500	604,800	0.0%
Hardware	1,246,200	1,307,600	0.6%
Household Equipment	584,900	570,600	-0.3%
Instruments	886,500	753,800	-2.0%
Iron and Steel	65,500	67,900	0.5%
Job Shops	123,300	129,200	0.6%
Mobile Industrial Equipment	232,400	232,600	0.0%
Motor Vehicle	928,000	974,000	0.6%
Office Machine	329,800	259,100	-3.0%
Ordnance	86,500	40,200	-9.1%
Other Metal Products	368,100	361,400	-0.2%
Precious Metals and Jewelry	87,100	65,800	-3.4%
Printed Wiring Boards	80,900	88,300	1.1%
Railroad	25,900	30,600	2.1%
Ships and Boats	182,900	141,300	-3.2%
Stationary Industrial Equipment	1,269,800	1,396,900	1.2%
Total	**7,984,500**	**7,549,600**	**-0.7%**

Source: Department of Commerce, Bureau of the Census, Annual Survey of Manufacturers.

d. Capital expenditures

Capital expenditures are an indicator of production characteristics and market structure. Capital expenditures are the amount of money spent annually on capital, which includes equipment, machinery, vehicles, software, buildings, intellectual rights, or any other permanent addition to a firm. Capital does not refer to input materials that are consumed in the course of production. New capital expenditures are needed to modernize, expand, and replace a firm's existing production capacity to meet growing demand or to stay current with new regulations or changing technology.

An industry with high capital stock compared to its employee payroll is considered capital intensive: its production relies more heavily on machinery, software, and other forms of capital than on labor. An industry with high capital requirements can have significant barriers to entry for new firms, making the market less competitive.

Table 3.7 presents DOC data on new capital expenditures by MP&M manufacturing sector.

Table 3.7: New Capital Expenditures: MP&M Manufacturing Sectors

Sector	Capital Expenditures (millions, 2001$)			Capital Expenditures per Facility (2001$)		
	1988	1996	Average Annual Growth Rate	1988/89	1996	Change from 1988/89 to 1996
Aerospace	1,310	522	-10.9%	9,160,839	4,924,528	-4,236,311
Aircraft	3,015	2,156	-4.1%	1,846,295	1,274,985	-571,310
Bus & Truck	161	213	3.6%	158,465	204,808	46,343
Electronic Equipment	3,118	4,482	4.6%	487,492	669,655	182,163
Hardware	3,517	5,624	6.0%	92,892	140,446	47,553
Household Equipment	2,150	2,616	2.5%	271,670	315,067	43,396
Instruments	4,002	4,832	2.4%	446,702	457,923	11,221
Iron and Steel	420	623	5.0%	535,714	809,091	273,377
Job Shops	353	772	10.3%	69,161	139,124	69,963
Mobile Industrial Equipment	1,121	1,121	0.0%	310,871	312,169	1,299
Motor Vehicle	5,697	12,840	10.7%	953,154	1,828,018	874,864
Office Machine	3,044	3,109	0.3%	1,484,878	1,489,698	4,820
Ordnance	196	91	-9.2%	509,091	205,882	-303,209
Other Metal Products	1,768	1,999	1.5%	146,491	140,794	-5,697
Precious Metals and Jewelry	93	156	6.7%	24,031	40,082	16,051
Printed Wiring Boards	430	624	4.8%	411,090	407,843	-3,247
Railroad	78	103	3.6%	433,333	479,070	45,736
Ships and Boats	483	374	-3.1%	178,360	112,991	-65,369
Stationary Industrial Equipment	4,333	7,222	6.6%	116,288	170,664	54,376
Total	**35,288**	**49,480**	**4.3%**	253,940	322,652	68,712

Source: Department of Commerce, Bureau of the Census, Annual Survey of Manufacturers.

In general, the MP&M manufacturing sector is relatively capital intensive. In 1988, manufacturing capital expenditures were 38.3 billion dollars. They increased by 4.3 percent annually to reach a total yearly investment in capital of 49.5 billion dollars in 1996. Average yearly capital expenditures per firm increased from $254,000 in 1988 to $353,000 in 1996.

For the most part, changes in capital investment from 1988 to 1996 in the individual manufacturing sectors followed the trend for the MP&M manufacturing sectors as a whole. Capital expenditures in the job shop and motor vehicle sectors grew at over

10% annually. The only sectors for which spending on new capital declined were aerospace, aircraft, ordnance, and ships and boats.

There was large variation in capital expenditures across the MP&M sectors. A few industries stood out as being extremely capital intensive. Aerospace firms spent an average of 4.8 million dollars on capital per firm in 1996, and the aircraft, motor vehicle, and office machine sectors each spent more than one million dollars per firm in 1996. The precious metal and jewelry sector had the lowest levels of capital investment, with only $40,000 spent per firm in 1996.

3.3.2 Industry/Market Structure

A number of factors play an important role in determining market structure for an industry, including the barriers that firms face in entering and exiting the market, the degree to which firms in the market are vertically and horizontally integrated, and the extent to which markets have been globalized. The following sections discuss these factors.

a. Facility size

Facility size is an indicator of economies of scale. The presence of many large facilities can indicate that there are advantages to building on a larger scale, such as dividing labor more efficiently, utilizing equipment more effectively, or getting bulk discounts.

Table 3.8 shows 1997 Census data on the distribution of manufacturing facilities and VOS by employment size category and MP&M sector. The MP&M industry is characterized by a large number of small facilities. The Census data indicate that, in 1997, 98.6 percent of all facilities in the MP&M industry employed less than 500 employees. Those facilities, however, accounted for only 59 percent of the total value of shipments from the manufacturing industries. The 1.4 percent of facilities with 500 or more employees generated 41 percent of the total VOS from the manufacturing industries. These large facilities are likely to enjoy substantial economies of scale.

Table 3.8: Number of Facilities and Value of Shipments by Employment Size Category: MP&M Manufacturing Sectors in 1997

Sector	Number of Facilities					Value of Shipments (millions, 2001$)				
	1 to 19	20 to 99	100 to 499	500 to 2,499	2,500 or more	1 to 19	20 to 99	100 to 499	500 to 2,499	2,500 or more
Aerospace	33	23	20	13	10	42	991	15,993	185	2,916
Aircraft	898	441	270	72	32	716	10,087	74,417	2,744	17,913
Bus & Truck	658	335	154	18	1	675	8,013	573	2,366	3,357
Electronic Equipment	3,450	2,086	1,019	205	21	2,945	37,794	37,178	14,258	54,660
Hardware	26,065	11,854	2,686	189	0	20,669	79,456	3	69,005	25,619
Household Equipment	4,958	2,274	1,110	191	11	3,745	40,843	7,314	13,747	37,067
Instruments	6,741	2,667	1,103	253	20	5,592	44,850	21,168	17,124	52,680
Iron and Steel	278	292	205	13	0	528	11,072	0	4,530	4,254
Job Shop	3,701	1,654	199	6	0	2,103	5,610	0	7,273	343
Mobile Industrial Equipment	2,116	990	383	90	9	1,937	17,351	8,913	7,219	26,684
Motor Vehicle	4,004	1,874	1,206	324	79	3,495	54,221	231,896	13,404	119,088
Office Machine	1,408	485	218	73	21	1,553	16,551	59,499	4,842	35,440
Ordnance	298	77	40	17	2	168	1,472	935	522	2,686
Other Metal Products	11,265	2,375	611	68	3	5,382	21,579	7,473	12,511	16,812
Precious Metals and Jewelry	3,250	480	100	12	0	1,777	3,436	0	2,864	1,666
Printed Wiring Boards	801	412	156	20	0	526	4,322	0	2,022	3,334
Railroad	81	71	54	13	1	99	2,659	1,222	678	3,714
Ships and Boats	3,755	469	179	25	6	1,314	5,714	6,414	2,036	2,404
Stationary Industrial Equipment	30,513	8,555	2,344	343	12	18,793	86,348	10,837	50,039	69,921
Total	104,274	37,413	12,056	1,947	227	72,061	452,366	483,834	227,368	480,558

Source: Department of Commerce, Bureau of the Census, Census of Manufacturers, 1997.

Although the majority of MP&M industry facilities are small, the distribution of facilities by employment size category varies substantially among the 19 MP&M sectors. The aerospace, aircraft, motor vehicle, and railroad sectors all had proportionally high numbers of large facilities. The aerospace sector, in particular, had large economies of scale, with 23 percent of its facilities employing 500 or more employees. The hardware, job shop, other metal products, precious metal, and ships and boats sectors had proportionally large numbers of small facilities. At least 93 percent of facilities in each of these sectors had less than 100 employees.

b. Firm size

This profile uses firm employment size as an indicator of market power and barriers to entry. If the largest firms in an industry own disproportionately many facilities or control a large portion of industry output, then they may have significant market power. These firms can use their large production capacities to control and exploit markets. The presence of many large firms in an industry can also indicate that there are barriers to entry into that industry, such as capital requirements or economies of scale, that give existing firms in the industry a competitive advantage. EPA used 1996 SUSB data to assess the competitiveness of the MP&M manufacturing industries.

Table 3.9 presents the distribution of manufacturing firms, facilities, and VOS by firm employment size and MP&M sector. Overall, most MP&M manufacturing firms were small, but the firms that were big owned many facilities and had disproportionately high receipts. In 1996, 138,492 firms, equal to 96 percent of manufacturers, had fewer than 500 employees. These small businesses owned 92 percent of all facilities but had total sales of only 418.3 billion dollars, equal to 28 percent of total estimated receipts. In 1996, 6,111 firms had 500 or more employees. These firms owned eight percent of all facilities but had estimated receipts of 1.08 trillion dollars, equal to 72 percent of the total for manufacturers. It is likely that there are significant economies of scale in the MP&M manufacturing industries.

Although MP&M manufacturing firms tend to be small, firm size varies significantly among individual sectors. The aerospace, iron and job shops, and railroad sectors had proportionally high numbers of large facilities. In the aerospace sector, 50 percent of facilities were owned by firms with 500 or more employees, and 38 percent of firms had 500 or more employees. In contrast, over 98 percent of firms in the job shop, other metal products, precious metals, and ships and boats sectors had less than 500 employees.

Table 3.9: Number of Firms, Facilities, and Estimated Receipts by Firm Employment Size Category, 1996: MP&M Manufacturing Sectors

Sector	Firms			Facilities			Estimated Receipts (millions, 2001$)		
	1 to 99	100 to 499	500 or more	1 to 99	100 to 499	500 or more	1 to 99	100 to 499	500 or more
Aerospace	51	2	32	51	2	53	n/a	n/a	19,029
Aircraft	1,209	135	142	1,212	158	321	2,453	2,840	93,860
Bus & Truck	805	92	56	810	107	123	2,269	2,638	6,702
Electronic Equipment	4,936	681	563	4,977	786	930	12,156	17,353	81,615
Hardware	34,162	2,345	1,325	34,398	2,968	2,678	66,557	42,561	61,295
Household Equipment	6,408	665	490	6,455	791	1,057	12,799	17,412	66,409
Instruments	8,273	727	730	8,320	842	1,390	17,248	16,243	96,894
Iron and Steel	362	108	113	368	153	249	2,015	4,426	12,737
Job Shops	4,945	240	95	5,001	338	210	7,157	3,487	3,097
Mobile Industrial Equipment	2,875	263	203	2,898	319	374	6,668	6,321	32,129
Motor Vehicle	4,950	614	480	4,987	724	1,313	11,314	21,376	366,635
Office Machine	1,662	167	173	1,668	180	239	5,373	7,535	64,424
Ordnance	358	25	38	358	28	56	329	453	4,213
Other Metal Products	13,097	492	230	13,152	602	444	13,568	10,738	30,677
Precious Metals and Jewelry	3,747	86	34	3,753	89	50	3,559	2,019	2,148
Printed Wiring Boards	1,250	137	65	1,258	150	122	2,231	2,402	5,769
Railroad	99	24	29	101	30	84	326	496	6,271
Ships and Boats	3,003	137	55	3,012	165	133	2,699	2,954	11,501
Stationary Industrial Equipment	37,669	1,691	1,258	37,835	2,002	2,480	52,700	35,623	119,210
Total	**129,861**	**8,631**	**6,111**	**130,614**	**10,434**	**12,306**	**221,420**	**196,877**	**1,084,612**

Source: Small Business Administration, Statistics of U.S. Businesses, 1996.

c. Foreign trade

This profile uses two measures of foreign competitiveness: ***export dependence*** and ***import penetration***. Export dependence is the share of value of shipments that is exported. Import penetration is the share of domestic consumption met by imports. For both measures, a high value indicates a relatively high openness to foreign markets and global competition. This openness has benefits, including providing domestic consumers with a wider selection of products and services at lower prices, and allowing domestic producers to make profits in foreign markets. It can have costs, too, if imports to domestic consumers are unreliable or if foreign competition drives down prices for domestic producers. This profile uses 1996 data from the Department of Commerce to illustrate trends in foreign trade.

Table 3.10 shows that overall, the U.S. is an importer of MP&M manufactured goods, with net imports of 75.7 billion dollars in 1996. In general, MP&M industry sectors face global competition, as illustrated by the number of sectors that had both a high export dependence and import penetration. For example, in the precious metals sector, roughly 77 percent of U.S. consumption was met by imports, while almost 23 percent of U.S. production was sold as exports.

Although overall the US has a large trade deficit in MP&M manufactured goods and services, the US was a net exporter in six of the eighteen sectors for which balance of trade data was available. Eighty one percent of production in the ordnance sector and 67 percent of production in the aircraft sector was consumed overseas. The aircraft sector had the highest absolute net exports, valued at 27.26 billion dollars. A few sectors, especially aerospace, ships and boats, iron and steel, and bus and truck, were relatively closed to global competition, with low levels of imports and exports. Foreign imports had the highest relative importance in the precious metals, office machine, and household equipment sectors. The motor vehicle sector had the highest absolute net imports, valued at 63.12 billion dollars.

Table 3.10: Trade Statistics, 1996: MP&M Manufacturing Sectors						
Sector	Value of Imports (millions, 2001$)	Value of Exports (millions, 2001$)	Value of Shipments (millions, 2001$)	Implied Domestic Consumption[a]	Import Penetration[b]	Export Dependence[c]
(a)	(b)	(c)	(d)	(e)	(f)	(g)
Aerospace	143	143	19,111	19,112	0.7%	0.7%
Aircraft	14,015	41,278	88,896	61,633	22.7%	67.0%
Bus & Truck	410	436	14,362	14,335	2.9%	3.0%
Electronic Equipment	31,478	30,615	127,347	128,211	24.6%	23.9%
Hardware	26,753	20,560	180,756	186,949	14.3%	11.0%
Household Equipment	40,697	16,809	98,762	122,650	33.2%	13.7%
Instruments	18,990	31,462	136,376	123,904	15.3%	25.4%
Iron and Steel	937	263	19,963	20,637	4.5%	1.3%
Job Shop[d]	n/a	n/a	14,927	n/a	n/a	n/a
Mobile Industrial Equipment	10,775	16,634	56,159	50,300	21.4%	33.1%
Motor Vehicle	124,203	61,015	387,546	450,735	27.6%	13.5%
Office Machine	67,082	47,783	110,084	129,384	51.8%	36.9%
Ordnance	647	2,792	5,566	3,421	18.9%	81.6%
Other Metal Products	25,282	11,243	63,996	78,035	32.4%	14.4%
Precious Metals and Jewelry	15,839	4,607	9,243	20,474	77.4%	22.5%
Printed Circuit Boards	2,667	1,947	11,408	12,127	22.0%	16.1%
Railroad	1,208	773	7,533	7,969	15.2%	9.7%
Ships and Boats	1,081	1,080	16,666	16,666	6.5%	6.5%
Stationary Industrial Equipment	38,809	55,835	236,213	219,187	17.7%	25.5%
Total[e]	**421,015**	**345,274**	**1,604,915**	**1,680,656**	**25.1%**	**20.5%**

[a] Implied domestic consumption based on value of shipments, imports, and exports [column d + column b - column c].
[b] Import penetration based on implied domestic consumption and imports [column b / column e].
[c] Export dependence based on value of shipments and exports [column c / column d].
[d] As explained in the text, job shops include only two SICs specific to job shops, and not facilities in other SICs that may be operating as job shops.
[e] Components may not sum to totals due to rounding.

Source: Department of Commerce, Bureau of the Census.

d. Establishment births and deaths

The number of firms starting up and closing each year reflects the competitiveness of an industry. Industries with high numbers of these "births" and "deaths" relative to the total number of firms in the industry are likely to have low barriers to entry or exit. These industries are likely to be competitive. Industries with low number of births and deaths are more likely to have significant barriers to entry and exit, such as capital requirements or economies of scale, that make the industries less competitive. As discussed in previous sections, firms in less competitive industries can manipulate prices to generate profits, while firms in more competitive industries have little control over prices. This profile presents SUSB data from 1989 to

1997 on establishment births and deaths. These data are only available by three digit SIC code, making it impossible to calculate sector specific birth and deaths rates. However, data for the MP&M industry as a whole are presented.

The MP&M manufacturing sector has an annual birth rate of 8.1 percent and an annual death rate of 7.8 percent, indicating that in general the MP&M manufacturing sector is relatively competitive. Three digit SIC industry birth and death rates are much more variable, ranging from 4 percent to up to 15 percent. For a more complete discussion, along with the three digit SIC birth and death rates, see Appendix A.

3.3.3 Financial Condition and Performance

Operating margin is a measure of industry financial performance. Operating margin is defined as VOS less annual payroll and cost of materials, as a percent of VOS, and thus measures pre-tax operating profitability before capital- and financing-related charges. Firms with higher operating margins have more cushion against operating losses as a consequence of fluctuating input prices, and thus are likely to be more stable.

Table 3.11 presents DOC data on operating margins for each MP&M manufacturing industry for the years 1988 and 1996, as well as the change in operating margin between the two years. In 1996, the average operating margin for the MP&M sectors was 29.6 percent. This was a slight increase from 1988, when the average operating margin for the MP&M manufacturers was 28.0 percent. Ten MP&M manufacturing sectors experienced increases in their operating margins during this time period, while nine industries experienced decreases.

Instruments, other metal products, and ordnance were the most profitable sectors, according to this measure, with operating margins around 40 percent. The iron and steel, motor vehicle, railroad, and ships and boats sectors had the lowest operating margins, all near 22 percent. The greatest increases in operating margin occurred in the aircraft, ordnance, and bus & truck industries, which all gained between five and six percent. The greatest decrease occurred in the aerospace industry, which lost 3.5 percent.

Table 3.11: Operating Margin[a]: MP&M Manufacturing Sectors in 1988 and 1996			
Sector	**1988**	**1996**	**Change in Operating Margin**
Aerospace	32.4%	28.9%	-3.5%
Aircraft	20.6%	26.7%	6.1%
Bus & Truck	18.5%	24.4%	5.9%
Electronic Equipment	32.0%	33.8%	1.8%
Hardware	27.5%	29.7%	2.2%
Household Equipment	29.7%	29.5%	-0.2%
Instruments	37.1%	41.1%	4.0%
Iron and Steel	23.2%	22.9%	-0.3%
Job Shops	31.8%	30.8%	-1.0%
Mobile Industrial Equipment	27.9%	28.2%	0.3%
Motor Vehicle	20.9%	22.4%	1.5%
Office Machine	31.7%	30.2%	-1.5%
Ordnance	34.3%	39.6%	5.3%
Other Metal Products	41.9%	40.4%	-1.5%
Precious Metals and Jewelry	27.9%	28.2%	0.3%
Printed Wiring Boards	37.2%	36.8%	-0.4%
Railroad	22.4%	22.1%	-0.3%
Ships and Boats	23.2%	22.5%	-0.7%
Stationary Industrial Equipment	29.4%	31.5%	2.1%
All MP&M Manufacturers[b]	**28.0%**	**29.6%**	**1.6%**

[a] Operating Margin is calculated as (value of shipments - cost of materials - payroll)/value of shipments.
[b] Weighted average by VOS.

Source: Department of Commerce, Bureau of the Census, Annual Survey of Manufacturers.

3.4 CHARACTERISTICS OF MP&M NON-MANUFACTURING SECTORS

Eleven of the 18 MP&M sectors include non-manufacturing industries. The non-manufacturing activities are defined by 50 four-digit SIC codes: 26 transportation SIC codes, 18 service SIC codes, five retail trade SIC codes, and one wholesale trade SIC code. MP&M facilities may perform both manufacturing and non-manufacturing activities.

The analyses presented in this section cover 1997 only, because the Census does not collect data annually for non-manufacturing SICs as it does for manufacturers in the Annual Survey of Manufacturers. The profile is based on data from the 1997 Censuses of Transportation, Communications, and Utilities; Service Industries; Retail Trade; and Wholesale Trade.

3.4.1 Domestic Production

a. Output

This profile uses sales and receipts as a measure of output. The sum of the receipts a manufacturer earns from the sale of its outputs is an indicator of the overall size of a market or the size of a firm in relation to its market or competitors. EPA used Department of Commerce data to assess sales and receipts for the MP&M non-manufacturing sectors.

Table 3.12 shows sales and receipts by sector for MP&M non-manufacturers. The MP&M nonmanufacturing sector generated 1.25 trillion dollars in sales and receipts in 1997. Motor vehicle repair and maintenance, with sales and receipts of 870 billion dollars, accounted for almost 70 percent of total sales and receipts. Bus and truck, with sales and receipts of 209 billion dollars, accounted for another 17 percent. These two vehicle sectors made up 87% of total non-manufacturing output. The smallest sector was precious metals and jewelry, which accounted for only 367 million dollars in sales and receipts.

Table 3.12: Sales/Receipts: MP&M Non-Manufacturing Sectors in 1997 (millions, 2001$)

Sector	Output [a]	Share
Aircraft	9,935.9	0.8%
Bus & Truck	209,316.1	16.7%
Household Equipment	2,848	0.2%
Instruments	7,402	0.6%
Motor Vehicle	870,451	69.6%
Office Machine	30,930	2.5%
Other Metal Products	22,041	1.8%
Precious Metals and Jewelry	367	0.029%
Railroad[b]	30,728	2.5%
Ships and Boats	37,383	3.0%
Stationary Industrial Equipment	29,747	2.4%
Total	**1,251,148**	**100.0%**

[a] Total sales for retail and wholesale trade, total receipts for service industries, total revenue for transportation.
[b] Railroad sales/receipts is estimated from 1992 data.

Source: Department of Commerce, Bureau of the Census, Census of Transportation, Census of Wholesale Trade, Census of Retail Trade, Census of Service Industries, 1997.

b. Number of facilities and firms

The number of facilities and firms in an industry is an indicator of the size and structure of an industry. Increases and decreases in the number of firms and facilities can indicate whether an industry is growing or shrinking, and changes in the ratio of facilities and firms can indicate whether an industry is becoming more integrated and concentrated. This profile uses SBA data to assess the number of facilities and firms in the non-manufacturing sector from 1989 to 1996. The SBA changed its survey to include firms in 1990, but data on the number of firms are not available from this source in 1989.

Table 3.13 shows the number of facilities and firms in the MP&M non-manufacturing sectors in 1989/1990 and 1996, with average annual growth rates. The number of firms and facilities grew from 1989 to 1996 in all of the sectors. The average number of facilities per firm shrank slightly over this time period, from 1.13 to 1.11, due to the fact that the number of firms in the non-manufacturing sector grew at 4.5 percent per year while the number of facilities grew at only 3.6 percent per year. In general, most MP&M non-manufacturers are single facility firms.

Although the number of facilities and firms increased for all of the sectors over this time period, not all industries grew at the same rate. The number of facilities in the other metal products sector grew at only 0.6 percent annually, and the number of facilities in the stationary industrial equipment and instruments sectors grew at 1.3 percent annually. In contrast, the number of facilities in the office machine sector grew by 20.2 percent annually and the number of firms in the office machine sector grew by 23.7 percent annually.

Concentration varied across the sectors. Stationary industrial equipment was the most concentrated sector, with an average of 1.45 facilities per firm in 1996. The other metal products, household equipment, and office machine sectors were the least concentrated sectors, with only 1.04, 1.06, and 1.07 facilities per firm, respectively.

Table 3.13: Number of Firms and Facilities: MP&M Non-Manufacturing Sectors

Sector	Number of Firms			Number of Facilities			Facilities per Firm	
	1990	1996	Average Annual Growth Rate	1989	1996	Average Annual Growth Rate	1989/90	1996
Aircraft	2,024	3,281	8.4%	2,463	4,062	7.4%	1.22	1.24
Bus & Truck	74,719	113,840	7.3%	88,128	127,675	5.4%	1.18	1.12
Household Equipment	3,234	3,706	2.3%	3,367	3,935	2.3%	1.04	1.06
Instruments	7,214	7,444	0.5%	8,365	9,185	1.3%	1.16	1.23
Motor Vehicle	183,986	213,355	2.5%	203,592	234,542	2.0%	1.11	1.10
Office Machine	9,206	32,916	23.7%	9,714	35,150	20.2%	1.06	1.07
Other Metal Products	32,865	36,290	1.7%	34,683	37,902	1.3%	1.06	1.04
Precious Metals and Jewelry	1,379	1,625	2.8%	1,535	1,838	2.6%	1.11	1.13
Railroad[a]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Ships and Boats	5,739	8,290	6.3%	6,561	9,262	5.0%	1.14	1.12
Stationary Industrial Equipment	14,672	15,075	0.5%	20,880	21,791	0.6%	1.42	1.45
Total	**335,038**	**435,822**	**4.5%**	**379,288**	**485,342**	**3.6%**	**1.13**	**1.11**

[a] The railroad sector has only two non-manufacturing SIC codes, both of which were excluded from the 1997 Census. Thus no data on railroads is available.

Source: Small Business Administration, Statistics of U.S. Businesses.

c. Employment

Employment is a measure of the level and trend of activity in an industry. Payroll is a measure of the skill level of employees and of their value to the production process. While employment growth is often correlated with economic strength in an industry, strong productivity growth and scale economies can result in growth in revenues that could not be predicted from employment trends alone. Trends in labor utilization relative to output are important in understanding how regulatory requirements may translate into job losses both in aggregate and at the community level.

Table 3.14 shows DOC data on employment and payroll for the non-manufacturing MP&M sectors in 1997. Total employment for the non-manufacturing sector was 5.99 million, and total payroll was $201 billion. Average yearly pay/employee was $33,610.

The majority of total employment came from the motor vehicle and bus and truck sectors. The motor vehicle sector had 2.6 million employees, and the bus and truck sector had 2.1 million employees. Together these two sectors accounted for over 78 percent of total employment in the non-manufacturing sector. The precious metals and jewelry sector had the lowest employment, with only 5,599 employees.

Workers in a few industries were highly compensated. The railroad sector paid its workers $58,851 per year, and the office machine sector paid $56,092 per year. On the other extreme, workers in the precious metals and jewelry sector earned only $20,121 per year.

Table 3.14: Employment and Payroll, 1997: MP&M Non-Manufacturing Sectors

Sector	Employment	Share	Payroll (thousands, 2001$)	Share	Pay/Employee
Aircraft	121,210	2.0%	3,286,985	1.6%	27,118
Bus & Truck	2,106,432	35.1%	65,643,990	32.6%	31,164
Household Equipment	25,455	0.4%	935,661	0.5%	36,757
Instruments	76,970	1.3%	2,530,404	1.3%	32,875
Motor Vehicle	2,622,049	43.7%	83,223,310	41.3%	31,740
Office Machine	235,332	3.9%	13,200,240	6.6%	56,092
Other Metal Products	226,069	3.8%	6,981,264	3.5%	30,881
Precious Metals and Jewelry	5,599	0.1%	112,659	0.1%	20,121
Railroad	197,421	3.3%	11,618,460	5.8%	58,851
Ships and Boats	178,560	3.0%	7,221,006	3.6%	40,440
Stationary Industrial Equipment	198,735	3.3%	6,701,350	3.3%	33,720
Total	**5,993,832**	**100.0%**	**201,455,328.90**	**100.0%**	**33,610.44**

Source: Department of Commerce, Census of Transportation, Census of Wholesale Trade, Census of Retail Trade, Census of Service Industries, 1997.

3.4.2 Industry Structure and Competitiveness

A number of factors play an important role in determining market structure for an industry, including the barriers that firms face in entering and exiting the market, the degree to which firms in the market are vertically and horizontally integrated, and the extent to which markets have been globalized. This profile shows facility size and firm size as measures of industry structure and competitiveness in the MP&M non-manufacturing sector.

a. Facility size

Facility size is an indicator of economies of scale. The presence of many large facilities in an industry can indicate that there are advantages to building on a larger scale, such as dividing labor more efficiently, utilizing equipment more effectively, or getting bulk discounts. EPA used data from the 1997 Census to assess facility size for manufacturing facilities.

Non-manufacturing facilities tend to be small. There were 255,602 non-manufacturing facilities, or 52.9 percent, that employed 4 employees or less. These facilities accounted for 7 percent of sales and receipts in the non-manufacturing MP&M sectors. Facilities with less than 20 employees accounted for 88 percent of all non-manufacturing facilities but generated only 24 percent of non-manufacturing revenues. Facilities with more than 100 employees employed less than one percent of total employees, but generated 17 percent of total revenues. Non-manufacturing MP&M facilities appear to experience significant economies of scale.

Although the individual non-manufacturing sectors tended to have small facilities, there was some variation between sectors in facility size. The aircraft sector and the ships and boats sector had relatively large facilities, probably because these sectors are involved with large-scale transportation. For both sectors, 6.3 percent of facilities had more than 100 employees. In contrast, the other metal products and precious metals and jewelry sectors had mostly small facilities. Ninety four percent of facilities in the other metal products sector and 96 percent of facilities in the precious metals and jewelry sector had less than 20 employees.

Table 3.15 presents the number of facilities and total sales by facility employment size category for each category.

Table 3.15: Number of Facilities and Sales/Receipts by Facility Employment Size Category: MP&M Non-Manufacturing Sectors in 1997

Sector	Number of Facilities					Sales/Receipts (millions, $2001)				
	0 to 4	5 to 9	10 to 19	20 to 99	100 or more	0 to 4	5 to 9	10 to 19	20 to 99	100 or more
Aircraft	1,936	936	720	870	299	381	482	879	2,767	5,433
Bus & Truck	67,959	24,548	19,355	21,294	3,573	15,924	16,044	24,189	75,663	81,036
Household Equipment	1,886	735	456	305	37	358	411	551	1,072	457
Instruments	5,535	1,737	988	711	131	1,017	936	1,064	2,473	1,917
Motor Vehicle	126,505	58,372	28,184	23,021	2,548	41,209	45,438	62,030	388,395	180,200
Office Machine	16,849	3,619	2,186	1,935	408	3,598	2,592	3,327	9,285	12,146
Other Metal Products	21,564	7,585	3,813	2,136	138	3,810	3,856	4,444	7,178	2,118
Precious Metals and Jewelry	790	215	88	41	2	109	81	70	88	19
Railroad[a]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Ships and Boats	2,605	930	848	1,046	366	2,578	1,580	2,161	9,535	19,380
Stationary Industrial Equipment	9,974	7,601	3,601	2,084	134	3,183	5,487	6,000	9,321	3,189
Total	**255,602**	**106,277**	**60,238**	**53,443**	**7,635**	**72,168**	**76,907**	**104,714**	**505,778**	**305,894**

[a] The non-manufacturing railroad sector is comprised of two SIC codes, both of which were excluded from the 1997 Census.

Source: Department of Commerce, Bureau of the Census, Census of Transportation, Census of Wholesale Trade, Census of Retail Trade, Census of Service Industries, 1997.

b. Firm size

This profile uses firm employment size as an indicator of market power and barriers to entry. The distribution of facilities and output by firm size can indicate that the firms in an industry have market power. If the largest firms own disproportionately many facilities, in which case they are considered horizontally integrated, or if the largest firms control a large portion of industry output, then they may have significant market power. These firms can use their large capacities to control and exploit markets. The presence of many large firms in an industry can also indicate that there are barriers to entry into that industry, such as capital requirements or economies of scale, that give existing firms in the industry a competitive advantage.

Table 3.16 presents SUSB data on numbers of firms and facilities with estimated receipts by firm employment size category in 1996 for MP&M non-manufacturers. In general, although the majority of MP&M non-manufacturing firms were small, the larger firms owned many facilities and had disproportionately large market shares. The vast majority of non-manufacturing firms – 427,173 firms or about 98 percent of non-manufacturers – employed fewer than 100 employees. However, these firms owned only 90 percent of all facilities and earned 610 billion dollars, only 58 percent of all revenues. The 2,338 firms with 500 or more employees, equal to 0.54 percent of all non-manufacturers, owned 6.5 percent of all facilities and generated 207 billion dollars, equal to 19.8 percent of total revenue.

Firm size in the individual MP&M non-manufacturing sectors is relatively similar to the trends in the non-manufacturing sector as a whole. At least 94 percent of the firms in every sector had less than 100 employees. Although firm size varies little by sector, there were larger variations in receipts by firm size. The aircraft, instruments, and ships and boats sectors each had a small percentage of firms that controlled a large share of the market. In the aircraft sector, the largest 2.35 percent of firms generated 60.4 percent of total revenues. In the instruments sector, the largest 1.2 percent of firms generated 50.2 percent of total revenues. In the ships and boats sector, the largest 2.6 percent of firms generated 57.4 percent of total revenues.

Table 3.16: Number of Firms, Facilities, and Estimated Receipts by Firm Employment Size Category, 1996: MP&M Non-Manufacturing Sectors

Sector	Firms			Facilities			Estimated Receipts (millions, 2001$)		
	1 to 99	100 to 499	500 or more	1 to 99	100 to 499	500 or more	1 to 99	100 to 499	500 or more
Aircraft	3,124	80	77	3,189	139	734	2,717	1,264	6,071
Bus & Truck	111,038	2,001	801	112,751	4,334	10,590	79,331	23,943	66,113
Household Equipment	3,669	19	18	3,700	23	212	2,032	275	873
Instruments	7,277	76	91	7,536	206	1,443	3,119	562	3,715
Motor Vehicle	209,814	3,010	531	216,707	7,119	10,716	465,989	186,083	87,113
Office Machine	32,428	290	198	32,745	759	1,646	14,787	4,800	10,565
Other Metal Products	35,788	284	218	36,205	567	1,130	16,749	2,308	4,610
Precious Metals and Jewelry	1,615	6	4	1,661	105	72	269	0	0
Railroad	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Ships and Boats	7,833	243	214	8,000	519	743	9,087	6,122	20,493
Stationary Industrial Equipment	14,587	302	186	16,331	1,359	4,101	15,422	4,606	7,739
Total	**427,173**	**6,311**	**2,338**	**438,825**	**15,130**	**31,387**	**609,502**	**229,963**	**207,294**

[a] The non-manufacturing railroad sector is comprised of two SIC codes, both of which were excluded from the 1997 Census.

Source: Small Business Administration, Statistics of U.S. Businesses.

3.5 Characteristics of All MP&M Sectors

This section presents additional market structure data for the MP&M industry as a whole. It includes eight-firm concentration data and risk-normalized ***return on assets*** ***(ROA)*** data as measures of industry competitiveness.

3.5.1 Eight-firm Concentration Ratio

The eight-firm ***concentration ratio*** (8-firm CR) is a measure of the degree to which the largest firms in an industry have market power. It is defined as the percentage of the value of total industry shipments that is produced by the top eight firms of a given industry. In general, an industry with a high 8-firm CR are likely to have larger entry and exit barriers and to be less competitive. Firms in this kind of industry have less incentive to compete and more ability to manipulate prices to increase their profits. It is more difficult for firms in a competitive, less concentrated industry to manipulate prices. This profile presents 8-firm CR data from the 1992 Census.

Table 3.17 shows the 8-firm CR for each sector in 1992. The aerospace and aircraft sectors were particularly concentrated, with the largest eight firms in each sector producing 92 percent and 85 percent of industry shipments, respectively. The motor vehicle, ordnance, and railroad sectors were also relatively concentrated. The job shop and hardware industries were the least concentrated, with only 19 percent and 25 percent of output, respectively, being produced by the eight largest firms.

Table 3.17: Eight-firm Concentration Ratio, 1992

Sector	8-firm Concentration Ratio	
	Value	Rank[a]
Aerospace	92.29	19
Aircraft	85.3	18
Bus & Truck	42.51	7
Electronic Equipment	47.27	9
Hardware	24.52	2
Household Equipment	54.22	10
Instruments	44.2	8
Iron and Steel	41.87	6
Job Shop	19.26	1
Mobile Industrial Equipment	58.56	13
Motor Vehicle	77.30	17
Office Machine	61.38	14
Ordnance	76.90	16
Other Metal Products	54.27	11
Precious Metals and Jewelry	35.0	4
Printed Circuit Boards	35.0	3
Railroad	71.00	15
Ships and Boats	58.20	12
Stationary Industrial Equipment	41.16	5

[a] Rank is a comparison within the MP&M manufacturing sectors only. A rank of 1 indicates the lowest level of concentration.

Source: Department of Commerce, Bureau of the Census.

3.5.2 Risk Normalized Return on Assets

Firms' abilities to enter and exit markets determine, in part, the competitiveness of an industry. If significant barriers to entry exist, potential entrants may be dissuaded and existing firms may enjoy market power. If few barriers to entry exist, existing firms are more likely to face competition for market share via price and other competitive tactics. Some important entry barriers for the MP&M industry are large capital requirements, economies of scale, and brand name recognition. Although data on barriers to entry are limited, the available data show that market power exists in some sectors.

EPA used the risk normalized return on assets as an indicator of the existence of entry or exit barriers for each industry [3]. A firm's return on assets is the profit the firm earns from investing in assets. Normally, firms in riskier industries tend to have higher ROA's. However, barriers to entry or exit can allow firms to achieve higher ROA's than would be predicted from their

[3] The risk normalized ROA only assigns MP&M industry sectors relative rankings and does not imply that they face high or low barriers to competition in absolute terms.

risk level. The risk normalized return on assets measures the additional profit that firms earn above and beyond what their risk level predicts. EPA used data from Marketguide.com to calculate a risk normalized ROA. The agency calculated risk normalized ROA by dividing each firm's ROA by its asset beta (a measure of the relative riskiness of the firm's common stock) and averaging over the five-year period from 1996 to 2000.

The electronic equipment, printed circuit board, and office machine industries had the lowest risk normalized ROA's, indicating relatively weaker barriers to entry or exit for these industries. The instrument, other metal products, mobile industrial equipment, and motor vehicle industries had the highest ROA's. These industries are likely to have significant barriers to entry and exit.

Table 3.18 presents the average risk normalized return on assets for the period from 1996 to 2001, based on data from Marketguide.com.

Table 3.18: Average Risk Normalized Return on Assets, 1996 to 2001

Sector	Risk-Normalized ROA (%)	
	Value	Rank
Aerospace	13.19	8
Aircraft	16.15	13
Bus & Truck	12.31	7
Electronic Equipment	7.21	1
Hardware	17.18	15
Household Equipment	12.02	5
Instruments	19.64	18
Iron and Steel	11.38	4
Job Shop	13.44	9
Mobile Industrial Equipment	18.13	17
Motor Vehicle	18.10	16
Office Machine	9.58	3
Ordnance	12.30	6
Other Metal Products	26.60	19
Precious Metals and Jewelry	14.43	10
Printed Circuit Boards	7.50	2
Railroad	14.62	11
Ships and Boats	16.11	12
Stationary Industrial Equipment	16.78	14

Source: www.marketguide.com

3.6 CHARACTERISTICS OF MP&M FACILITIES

This section uses survey data to characterize MP&M facilities. It includes data on facility revenue sources, discharge type, small business status, market type, and financial performance. These data are organized according to MP&M regulation subcategories based on unit operations performed and the nature of the waste generated. EPA determined that a basis exists for dividing the MP&M category into the following subcategories: General Metals, Non-Chromium Anodizing, Metal Finishing Job Shops, Printed Wiring Boards, Steel Forming and Finishing, Oily Wastes, Railroad Line Maintenance, and Shipbuilding Dry Dock. EPA did not generally define subcategories in terms of industrial sectors because many facilities perform operations covered by multiple sectors and, as a result, the industrial sectors are too broad for subcategorization.

Table 3.19 shows the national number of MP&M facilities that sell products to different combinations of sectors. The table shows that many MP&M facilities operate in multiple market sectors. Almost every combination of sectors shows overlap, and some MP&M facilities report revenues from three or more sectors.

Table 3.19: Overlap of Sectors

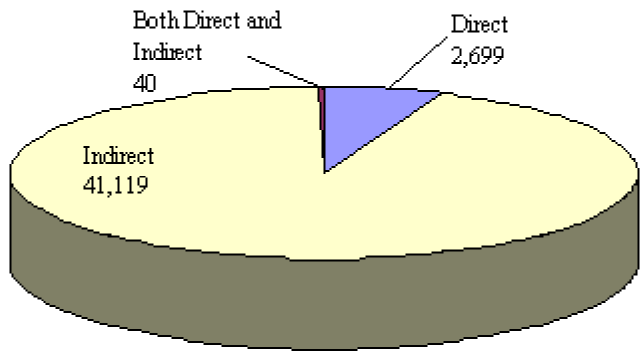
Sector	Aerospace	Aircraft	Bus and Truck	Electronic Equipment	Hardware	Household Equipment	Instrument	Mobile Industrial Equipment	Motor Vehicle	Office Machine	Ordnance	Other Metal Products	Precious Non-Precious Metals	Printed Circuit Boards	Railroad	Ships and Boats	Stationary Industrial Equipment	Unknown
Aerospace	1,828																	
Aircraft	0	2,350																
Bus and Truck	129	169	5,574															
Electronic Equipment	1,327	1,318	824	4,073														
Hardware	345	399	914	1,129	7,075													
Household Equipment	289	317	477	898	1,600	2,635												
Instrument	1,046	1,126	398	1,680	678	610	4,965											
Mobile Industrial Equipment	47	116	1,511	704	738	417	404	2,467										
Motor Vehicle	157	220	1,790	619	823	678	524	1,089	13,853									
Office Machine	265	349	198	622	515	477	356	159	223	1,088								
Ordnance	132	119	52	204	86	77	202	80	153	89	481							
Other Metal Products	289	321	457	850	1,450	1,393	475	438	695	329	36	5,359						
Precious and Non-Precious Metals	47	47	0	36	47	24	47	12	36	36	0	92	1,651					
Printed Circuit Boards	160	164	0	164	160	160	4	0	0	375	0	160	0	1,229				
Railroad	16	61	95	86	143	67	69	124	154	91	58	81	12	26	1,132			
Ship and Boat	102	0	237	146	191	156	104	138	245	138	25	78	12	0	48	1,366		
Stationary Industrial Equipment	1,169	1,255	714	1,818	1,151	687	1,293	688	530	486	130	469	39	164	109	324	4,907	
Unknown																		583

Source: U.S. EPA analysis.

The remainder of this profile focuses on MP&M industry facilities that discharge effluent. Out of a total population of 638,696 MP&M industry establishments reported in the *Statistics of U.S. Businesses* for 1996, approximately seven percent, or 43,858 facilities, are effluent dischargers as identified by the MP&M surveys.

Figure 3.2 shows the breakdown of MP&M facilities by discharge type. Of the effluent dischargers, 41,119 (94 percent) are indirect dischargers, meaning that they discharge into a sewer or a POTW, and 2,699 (6 percent) are direct dischargers that discharge directly into a surface water body. The remaining 40 facilities are both direct and indirect dischargers.

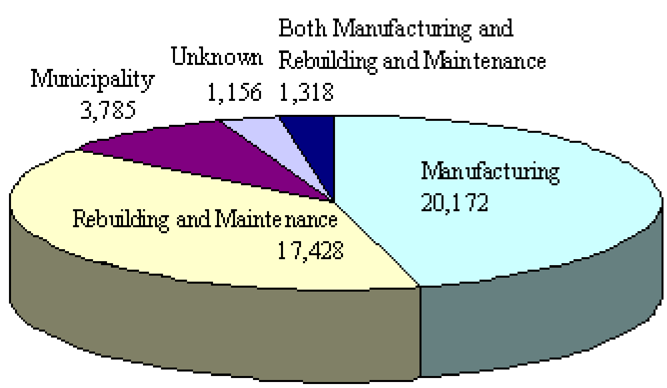
Figure 3.2: Facilities by Discharge Type



Source: U.S. EPA analysis.

Figure 3.3 shows facilities by revenue source. Local governments or municipalities operate 3,785 facilities (9 percent). The remaining 40,073 facilities are privately owned. Of these, 17,428 facilities (40 percent) are rebuilding and maintenance facilities and 20,172 facilities (46 percent) are manufacturing facilities.

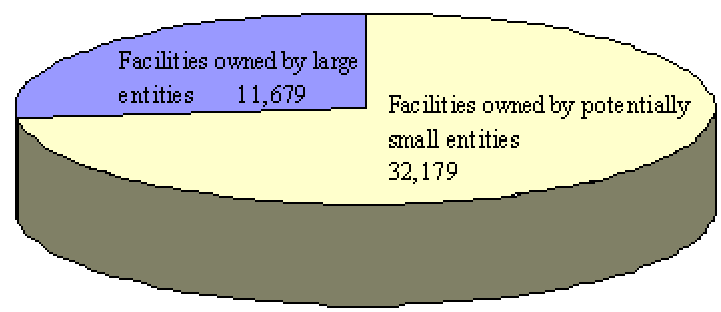
Figure 3.3: Facilities by Revenue Source



Source: U.S. EPA analysis.

Figure 3.4 shows facilities by small entity status. Small Business Administration (SBA) thresholds were used to estimate the number of facilities that are likely to be owned by small businesses, as defined by the SBA. Using the methodology detailed in the Small Entity Impact Analysis (see Chapter 10), EPA determined that 32,179 facilities (73 percent) are owned by small or potentially small entities.

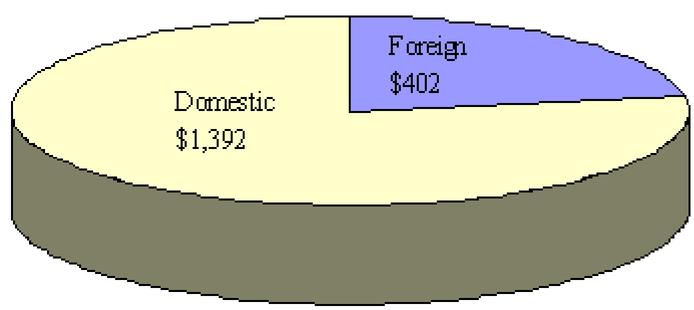
Figure 3.4: Facilities by Small Entity Status



Source: U.S. EPA analysis.

Figure 3.5 indicates that MP&M facilities derive approximately 22 percent of their revenues from export sales. Almost 78 percent of MP&M revenues come from domestic non-government sources. Government purchases account for a very small share of MP&M revenues overall.

Figure 3.5: 1996 Facility Revenues by Market Type (billions, 2001$)



Export data were not available for Iron and Steel surveys.

Source: U.S. EPA analysis.

To characterize baseline financial performance across regulation subcategories, EPA used ***Pre-Tax Return on Assets (PTRA)*** as a measure of industry profitability. PTRA measures the return, before tax, to total capital that company management achieves from its deployed capital assets. Unlike the ROA measure noted above in section 3.5.2, the PTRA reported in this discussion is not adjusted for risk.

Table 3.20 shows that the printed wiring board subcategory has the highest median PTRA (13.4 percent) of all the subcategories. The shipbuilding drydock subcategory has the lowest median PTRA (2.5 percent). The median PTRA for all of the MP&M facilities is 11.1 percent.

Table 3.20: Financial Performance

Subcategory	Median Pre-Tax Return on Assets (PTRA)
Shipbuilding Drydock	2.5%
General Metals	11.5%
Steel Forming & Finishing	9.1%
Metal Finishing Job Shops	9.2%
Non-Chromium Anodizer	9.0%
Oily Wastes	9.6%
Printed Wiring Boards	13.4%
Railroad Line Maintenance[a]	n/a

[a] PTRA data was not available for railroad line maintenance because these facilities were treated as cost-centers in the survey analysis.

Source: U.S. EPA analysis.

GLOSSARY

capital expenditures: expenditures for permanent additions and major alterations to facilities and equipment, as well as replacements and additions to capacity, which are ordinarily depreciated. Reported capital expenditures include work done on contract and expenditures for assets leased from other concerns through capital leases. Expenditures for land and cost of maintenance and repairs charged as current operating expenses are excluded

concentration ratio: the percentage of output from a given industry that is produced by the largest firms in that industry. For example, the eight firm concentration ratio measures the percentage of output that is produced by the eight largest firms in an industry. The concentration ratio is a measure of industry competitiveness.

employment: total number of full-time equivalent employees, including production workers and non-production workers.

export dependence: the share of shipments by domestic producers that is exported; calculated by dividing the value of exports by the value of domestic shipments.

import penetration: the share of all consumption in the U.S. that is provided by imports; calculated by dividing imports by reported or apparent domestic consumption (the latter calculated as domestic value of shipments minus exports plus imports).

manufacturing: series of unit operations necessary to produce metal products; generally performed in a production environment.

North American Industry Classification System: classification system adopted beginning in 1997 to replace SIC codes. NAICS codes will be used throughout North American and allow for greater comparability with the International Standard Industrial Classification System (ISIC), which is developed and maintained by the United Nations. The new system also better reflects the structure of today's economy, including the growth of the service sectors and new technologies.

nominal values: dollar values expressed in current dollars.

operating margin: measure of the relationship between input costs and the value of production, as an indicator of financial performance and condition. Everything else being equal, industries and firms with lower operating margins will generally have less flexibility to absorb the costs associated with a regulation than those with higher operating margins. Operating margins were calculated in this profile by subtracting the cost of materials and total payroll from the value of shipments. Operating margin is only an approximate measure of profitability, since it does not consider capital costs and other costs. It is used to examine trends in revenues compared with production costs within an industry; it should not be used for cross-industry comparisons of financial performance.

pre-tax return on assets (PTRA): the ratio of cash operating income (net income plus depreciation) to the book value of total assets. This ratio is a measure of facility profitability.

producer price index (PPI): a family of indexes that measures the average change over time in selling prices received by domestic producers of goods and services (Bureau of Labor Statistics, PPI Overview). Used in this profile to convert nominal values into real dollar values.

real values: nominal values normalized using a price index to express values in a single year's dollars. Removes the effects of price inflation when evaluating trends in dollar measures.

rebuilding/maintenance: unit operations necessary to disassemble used metal products into components, replace the components or subassemblies or restore them to original function, and reassemble the metal product. These operations are intended to keep metal products in operating condition and can be performed in either a production or a non-production environment.

return on assets: the profit the firm earns from investing in assets. Generally firms in riskier industries have higher returns on assets. A risk normalized return on assets (RNROA) measures the additional profit that firms earn above and beyond what their risk level predicts. The RNROA is a measure of industry competitiveness.

Standard Industrial Classification: classification system used for all establishment-based Federal economic statistics classified by industry. Each establishment is assigned a 4-digit SIC code based on its principal product, or service. Last revised in 1987 and currently being replaced by the NAICS.

value added: measure of manufacturing activity, derived by subtracting the cost of purchased inputs (materials, supplies, containers, fuel, purchased electricity, contract work, and contract labor) from the value of shipments (products manufactured plus receipts for services rendered), and adjusted by the addition of value added by merchandising operations (i.e., the difference between the sales value and the cost of merchandise sold without further manufacture, processing, or assembly) plus the net change in finished goods and work-in-process between the beginning-and end-of-year inventories. Value added avoids the duplication in value of shipments as a measure of economic activity that results from the use of products of some establishments as materials by others. Value added is considered to be the best value measure available for comparing the relative economic importance of manufacturing among industries and geographic areas.

value of shipments: net selling values of all products shipped as well as miscellaneous receipts. Includes all items made by or for an establishment from materials owned by it, whether sold, transferred to other plants of the same company, or shipped on consignment. Value of shipments is a measure of the dollar value of production, and is often used as a proxy for revenues. This profile uses value of shipments to indicate the size of a market and how the size differs from year to year, and to calculate operating margins.

ACRONYMS

NAICS: North American Industry Classification System
PPI: producer price index
PTRA: pre-tax return on assets
ROA: return on assets
SIC: Standard Industrial Classification
VA: value added
VOS: value of shipments

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Chapter 4: Regulatory Options

INTRODUCTION

The preamble for the final rule describes the regulatory options considered by EPA for the final MP&M effluent guidelines. This chapter provides a brief summary of the subcategories and the regulatory options.

CHAPTER CONTENTS

4.1 SUBCATEGORIZATION

EPA may divide a point source category into subcategories to address variations in products, raw materials, processes, and other factors that result in distinctly different effluent characteristics. Defining subcategories makes it possible to establish effluent limitations that take into account technological achievability and economic impacts unique to each subcategory. EPA considered the following factors in defining MP&M subcategories:

- unit operation,
- activity,
- raw materials,
- products,
- size of site,
- location,
- age,
- nature of the waste generated,
- economic impacts,
- treatment costs,
- total energy requirements,
- air pollution control methods,
- solid waste generation and disposal, and
- publicly-owned treatment work ***(POTW)*** burden.

In a way similar to the proposed rule, EPA established subcategories for the final MP&M rule based on unit operations performed. The subcategories are defined in part based on the type of wastewater that facilities discharge, including:

facilities that discharge wastewaters with high metals content, with or without oil and grease ***(O&G)***; and

- facilities that discharge wastewaters containing mainly O&G, with limited metals and other associated organic constituents.

The subcategories identified by EPA in each group are:

Metal-bearing (with or without O&G):

- General Metals,
- Metal Finishing Job Shops,
- Non-Chromium Anodizing,
- Printed Wiring Board,
- Steel Forming & Finishing; and

Oil-bearing only:

- Oily Wastes,
- Railroad Line Maintenance, and
- Shipbuilding Dry Docks.

For the final rule, EPA is establishing limitations and standards only for direct dischargers in the Oily Wastes subcategory. The other subcategories were considered at proposal and for some of the alternative regulatory options but are not further regulated under the final rule. Section VI.B of the preamble accompanying the final rule describes the basis for defining these subcategories. The following are brief summaries of each subcategory:

General Metals: The General Metals subcategory includes facilities that perform operations that generate metal-bearing wastewater.[1] At a minimum, wastewater at these sites requires metals removal and may also require the preliminary treatment steps of oil/water separation, chromium reduction, and cyanide destruction. For example, wastewater generated from most manufacturing operations and heavy rebuilding operations (e.g., aircraft/aerospace, bus/truck, railroad, ship, industrial equipment) would be regulated under the General Metals subcategory as well as sites performing surface finishing operations at a captive shop (i.e., not a metal finishing job shop) including continuous electroplating as defined in today's rule.

Metal Finishing Job Shops: These facilities must perform one or more of the six operations regulated by the existing Metal Finishing (40 CFR 433) and Electroplating (40 CFR 413) effluent guidelines, and must meet the definition of a ***job shop***. The six metal finishing operations are electroplating, electroless plating, anodizing, coating, chemical etching and milling, and printed circuit board manufacture. A job shop is a facility that owns no more than 50 percent of the materials undergoing metal finishing. EPA proposes to regulate Printed Wiring Board facilities that are job shops under this subcategory, but is seeking comment on this proposal.

Non Chromium Anodizing: This subcategory includes facilities that perform aluminum anodizing without the use of chromic acid or dichromate sealants. The wastewater generated at these facilities contains very low levels of metals (except for aluminum) and toxic organic pollutants.

Printed Wiring Board: These facilities manufacture, maintain, and repair printed wiring boards (i.e., circuit boards), not including job shops. They perform some unique operations, including applying, developing, and stripping of photoresist; lead/tin soldering; and wave soldering.

Steel Forming & Finishing: This subcategory applies to facilities that perform MP&M operations or cold forming operations on steel wire, rod, bar, pipe, or tube. Other operations on steel, including any hot forming operations for steel, or cold forming, electroplating, or continuous hot dip coating of other steel products, will be regulated under the revisions to the existing Iron and Steel Manufacturing effluent guidelines (40 CFR 420).

Oily Wastes: The Oily Wastes subcategory is a "catch-all" for sites that discharge wastewater exclusively from oily operations and are not otherwise covered by the Railroad Line Maintenance or Shipbuilding Dry Dock subcategory. Oily operations for the this subcategory are defined in today's final rule as: alkaline cleaning for oil removal, aqueous or solvent degreasing, corrosion preventative coating (as specified in § 438.21(b)); floor cleaning; grinding; heat treating; deformation by impact or pressure; machining; painting (spray or brush); steam cleaning; and testing (such as hydrostatic, dye penetrant, ultrasonic, magnetic flux); iron phosphate conversion coating; abrasive blasting, alkaline treatment without cyanide; assembly/disassembly; tumbling/barrel finishing/mass finishing/vibratory finishing; burnishing; electrical discharge machining; polishing, thermal cutting; washing of final products; welding; wet air pollution control for organic constituents; adhesive bonding; and calibration.

Railroad Line Maintenance: This is one of two specific subcategories that discharge only oil-bearing wastewaters (as defined above for the Oily Wastes subcategory). The Railroad Line Maintenance subcategory includes facilities that discharge from performing routine cleaning and light maintenance on railroad engines, cars, car-wheel trucks, or similar parts or machines. Facilities engaged in the manufacture, overhaul or heavy maintenance of railroad engines, cars, car-wheel

[1] These sites may also perform operations that generate oil-bearing wastewater.

trucks, or similar parts or machines are not covered by this subcategory and depending on the operations performed may be covered by either the General Metals or Oily Wastes subcategory.

Shipbuilding Dry Docks: This is the second of two specific subcategories that discharge only oil-bearing wastewaters (as defined above for the Oily Wastes subcategory). The Shipbuilding Dry Dock subcategory applies to discharges of process wastewater generated in or on dry docks and similar structures, such as graving docks, building ways, marine railways and lift barges at shipbuilding facilities (or shipyards). When generated by operations from within a dry dock or similar structure, this subcategory covers process wastewater generated inside and outside the vessel (including bilge water) and wastewater generated from barnacle removal conducted as preparation for ship maintenance, rebuilding or repair. Wastewaters generated from other operations at shipyards are not included in this subcategory.

4.2 Technology Options

EPA defined specific effluent limitations guidelines and standards for consideration in developing the regulation based on a statistical analysis of the performance of several wastewater treatment technology options. This analysis is described in Section 9 of the *Technical Development Document* and the *Statistical Support Document.*

EPA is establishing BPT pH limitations and daily maximum limitations for two pollutants, oil and grease as hexane extractable material (O&G (as HEM)) and total suspended solids (TSS), for direct dischargers in the Oily Wastes subcategory based on the proposed technology option (Option 6). The technology requirements include the following treatment measures: (1) in-process flow control and pollution prevention; and (2) oil-water separation by chemical emulsion breaking and skimming (see Section 9 of the TDD). This technology is available technology readily applicable to all facilities in the Oily Wastes subcategory. Approximately 42% of the direct discharging facilities in the Oily Wastes subcategory currently employ this technology already.

4.3 BPT/BAT Options for Direct Dischargers

EPA selected the ***Best Practicable Control Technology Currently Available (BPT)*** for direct dischargers in each subcategory based on the average of the best performances within the industry from operations of various ages, sizes, processes, and other characteristics. The Agency considered the cost of these treatment technologies relative to the effluent reductions achieved to assess the cost-reasonableness of these limitations. EPA then considered application of the ***Best Available Technology Economically Achievable (BAT)*** for priority and nonconventional pollutants and ***Best Conventional Pollutant Control Technology (BCT)*** for conventional pollutants. EPA is promulgating BCT equivalent to BPT for facilities in the Oily Wastes subcategory and has decided not to establish BAT limitations.

Table 4.1 shows the technology basis for the selected option for BPT, BCT and BAT for the Oily Wastes subcategory.

Table 4.1: Selected Options For Direct Dischargers: BPT, BCT and BAT

Subcategory	BPT Option	BCT/BAT
For oil-bearing wastes		
Oily Wastes	6	BCT = 6 BAT not promulgated

Source: U.S. EPA analysis.

4.4 PSES Options for Indirect Dischargers

EPA considered ***Pretreatment Standards for Existing Sources (PSES)*** options for regulating existing indirect dischargers under today's final rule. EPA has selected no further regulation for indirect dischargers in all of the defined subcategories.

Wastewater discharges to POTWs from facilities in all subcategories will continue to be regulated by local limits, general pretreatment standards, and 40 CFR 413 or 433, as appropriate.

4.5 NSPS AND PSNS OPTIONS FOR NEW SOURCES

EPA is promulgating ***New Source Performance Standards (NSPS)*** for new direct dischargers in the Oily Wastes subcategory at the BPT and BCT levels. New facilities have the opportunity to incorporate the best available demonstrated technologies, including process changes, in-plant controls, and end-of-pipe treatment technologies, without the cost of retrofitting. EPA considered the same technologies discussed previously for BPT/BAT and PSES as the basis for new source technology. In addition, because new sites may be able to install pollution prevention and pollution control technologies more cost-effectively then existing sources, the Agency strongly considered more advanced treatment options. EPA is not promulgating ***Pretreatment Standards for New Sources (PSNS)*** for new indirect dischargers.

Table 4.2 lists the technology options and exclusions for new direct and indirect dischargers.

Table 4.2: Options For New Direct Dischargers (NSPS) and Indirect Dischargers (PSNS)

Subcategory	NSPS Technology Option	PSNS Technology Option
For oil-bearing wastes		
Oily Wastes	6	No further regulation

Source: U.S. EPA analysis.

4.6 SUMMARY OF THE FINAL RULE AND REGULATORY ALTERNATIVES

The following describes the final rule and the three alternative regulatory options considered by EPA:

- ***Final Rule:*** technology Option 6 applied only to direct dischargers in the Oily Wastes subcategory;

- ***NODA/Proposal Option:*** applies limitations and standards for direct dischargers in all eight MP&M subcategories and pretreatment standards for all indirect dischargers in three subcategories (i.e., Metal Finishing Job Shops, Printed Wiring Board, and Steel Forming & Finishing); pretreatment standards for facilities above a certain wastewater flow volume in two subcategories (i.e., General Metals and Oily Wastes); and no national pretreatment standards for facilities in three subcategories (i.e., Non-Chromium Anodizing, Railroad Line Maintenance, and Shipbuilding Dry Docks);

- ***Direct Dischargers + 413 to 433 Upgrade Option:*** applies the same technology requirements for direct dischargers as the final rule and includes new requirements for indirect dischargers in the General Metals, Printed Wiring Board, and Metal Finishing Job Shops subcategories currently regulated under the Electroplating regulations (40 CFR 413); and

- ***Direct Dischargers + 413 plus 50% Local Limits Upgrade Option:*** applies the same technology requirements for direct dischargers as the final rule and includes new requirements for indirect dischargers in the General Metals, Printed Wiring Board, and Metal Finishing Job Shops subcategories currently regulated under the Electroplating regulations (40 CFR 413) and also includes new requirements for indirect dischargers in the General Metals subcategory that are currently regulated by local limits or general pretreatment standards.

GLOSSARY

Best Practicable Control Technology Currently Available (BPT): effluent limitations for direct discharging facilities, addressing conventional, toxic, and nonconventional pollutants. In specifying BPT, EPA considers the cost of achieving effluent reductions in relation to the effluent reduction benefits. The Agency also considers the age of the equipment and facilities, the processes employed and any required process changes, engineering aspects of the control technologies, non-water quality environmental impacts (including energy requirements), and such other factors as the Agency deems appropriate. Limitations are traditionally based on the average of the best performances of facilities within the industry of various ages, sizes, processes, or other common characteristics. Where existing performance is uniformly inadequate, EPA may require higher levels of control than currently in place in an industrial category if the Agency determines that the technology can be practically applied.

Best Available Technology Economically Achievable (BAT): effluent limitations for direct dischargers, addressing priority and nonconventional pollutants. BAT is based on the best existing economically achievable performance of plants in the industrial subcategory or category. Factors considered in assessing BAT include the cost of achieving BAT effluent reductions, the age of equipment and facilities involved, the processes employed, engineering aspects of the control technology, potential process changes, non-water quality environmental impacts (including energy requirements), economic achievability, and such factors as the Administrator deems appropriate. The Agency may base BAT limitations upon effluent reductions attainable through changes in a facility's processes and operations. Where existing performance is uniformly inadequate, EPA may base BAT upon technology transferred from a different subcategory within an industry or from another industrial category.

Best Conventional Pollutant Control Technology (BCT): effluent limitations for direct discharging facilities, addressing conventional pollutants. Conventional pollutants include biochemical oxygen demand (BOD_5), total suspended solids (TSS), fecal coliform, pH, and O&G. BCT is the equivalent of Best Available Technology (BAT) for control of conventional pollutants. EPA evaluates the reasonableness of BCT candidate technologies by applying a two-part cost test: (1) the POTW test, and (2) the industry cost-effectiveness test. In the POTW test, EPA calculates the cost per pound of conventional pollutant removed by industrial dischargers to upgrade from BPT to a BCT candidate technology, and then compares this cost to the POTW cost per pound for similar pollutant load reductions. The upgrade cost to industry must be less than the POTW benchmark of $0.25 per pound (in 1976 dollars). In the industry cost-effectiveness test, the ratio of the incremental BPT to BCT cost divided by the BPT cost for the industry must be less than 1.29 (i.e., the cost increase must be less than 29 percent).

Job Shop: Facilities with more than 50 percent of their revenues coming from work on products not owned by the site. While there are SIC codes associated with some Metal Finishing Job Shops, they sell to a variety of markets and are not a market in and of themselves.

New Source Performance Standards (NSPS): effluent limitations for new direct dischargers based on the best available demonstrated control technology. NSPS represents the greatest degree of effluent reduction attainable through the application of the best available demonstrated control technology for all pollutants (i.e., conventional, nonconventional, and priority pollutants). In establishing NSPS, EPA considers the cost of achieving the effluent reduction and any non-water quality environmental impacts and energy requirements.

Pretreatment Standards for Existing Sources (PSES): categorical pretreatment standards for existing indirect dischargers, designed to prevent the discharge of pollutants that pass through, interfere with, or are otherwise incompatible with the operation of POTWs. Standards are technology-based and analogous to BAT effluent limitations guidelines.

Pretreatment Standards for New Sources (PSNS): pretreatment standards for new indirect dischargers, designed to prevent discharges of pollutants that pass through, interfere with, or are otherwise incompatible with the operation of POTWs. Addresses all pollutants (i.e., conventional, nonconventional, and priority pollutants). Based on the same factors as are considered in promulgating NSPS.

Acronyms

BAT: Best Available Technology Economically Achievable
BCT: Best Conventional Pollutant Control Technology
BPT: Best Practicable Control Technology Currently Available
NSPS: New Source Performance Standards
O&G: oil and grease
POTW: publicly-owned treatment works
PSES: Pretreatment Standards for Existing Sources
PSNS: Pretreatment Standards for New Sources

Chapter 5: Facility Impact Analysis

INTRODUCTION

The ***facility*** impact analysis assesses whether the MP&M effluent guidelines are likely to impose severe or moderate economic and financial impacts on MP&M facilities. EPA undertook the facility impact analysis to aid in assessing the rule's economic achievability. ***Severe impacts*** are facility closures and the associated losses in jobs, earnings, and output at facilities that close due to the rule. EPA also assessed moderate economic impacts to support its evaluation of regulatory options and to understand better the rule's economic impacts. ***Moderate impacts*** are adverse changes in a facility's financial position that are not threatening to its short-term viability.

The options considered for regulation would have affected three major categories of MP&M facilities: privately-owned, railroad line maintenance, and government-owned facilities. EPA developed separate analytic methodologies to assess economic and financial impacts for each type of facility:

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1. ***Private MP&M facilities***: This group includes all privately-owned facilities that do not perform railroad line maintenance. This major category of facilities operates in various subcategories and includes private businesses in a wide range of sectors or industries, including facilities that manufacture and rebuild railroad equipment. Only facilities that repair railroad track and equipment along the railroad line are excluded. There are 39,248 private MP&M facilities other than railroad line maintenance facilities nationally that may be affected by the rule, representing 89.5 percent of the 43,858 facilities that discharge process wastewater from MP&M activities.

2. ***Railroad line maintenance facilities***: Railroad line maintenance facilities maintain and repair railroad track and vehicles. EPA administered a separate economic and financial survey to these facilities and applied a different impact analysis methodology than that used for other private facilities. This methodology used the same impact tests as used for other private facilities but applied these tests to the aggregate of maintenance facilities owned by a single railroad company instead of to individual facilities. There are 826 railroad line maintenance facilities in the analysis, representing 1.9 percent of all facilities in the analysis.

3. ***Government-owned facilities***: Government-owned facilities include MP&M facilities operated by municipalities, state agencies and other public sector entities such as state universities. Many of these facilities repair, rebuild, and maintain buses, trucks, cars, utility vehicles (e.g., snow plows and street cleaners), and light machinery. Government-owned facilities operate in two major subcategories: General Metals and Oily Waste. There are 3,785 government-owned facilities in the analysis, representing 8.6 percent of the total.

The specific methodology used to assess impacts differs for each of the three types of MP&M facilities. In each case, EPA established thresholds for measures of financial performance and compared performance before and after compliance with each regulatory option to these thresholds.

This chapter describes the methodology used to assess facility-level economic impacts for the three types of facilities, and then presents the results of the analyses.

5.1 DATA SOURCES

The economic impact analyses rely on data provided in the financial portion of the detailed questionnaires distributed to MP&M facilities by EPA under the authority of Section 308 of the Clean Water Act. The surveys were conducted in two phases, covering different MP&M industry sectors in each phase. The Phase I survey covered seven industry sectors and reported data for respondent's fiscal years 1987 to 1989. The Phase II survey covered an additional ten industry sectors (all remaining MP&M sectors except Iron and Steel, which was the subject of a separate survey) and reported data for fiscal years 1994 to 1996.[1] EPA administered each survey to a random stratified sample of facilities and assigned each facility a sample weight based on the stratification process and the number of facilities surveyed, so that sample-weighted results would represent all potentially-affected MP&M facilities at the national level. The results of the impact analyses for the sample facilities were extrapolated to the national level using these facility sample weights.

The survey financial data for private businesses included three years of facility and parent firm income statements and balance sheets, and the composition of revenues by MP&M business sector to which the facility's goods and services are sold.

Data for railroad line maintenance facilities came from a modified version of the Phase II survey administered to railroad operating companies. The questionnaire was modified because railroad operating companies generally do not monitor financial performance or collect financial data at the facility level for their numerous line maintenance facilities. The railroad operating companies reported the number of line maintenance facilities in each operating unit, and provided both operating company and parent firm financial data. They also provided technical data for each line maintenance facility.

Data for facilities in the Iron and Steel sector came from a 1997 Section 308 survey of iron and steel facilities. This survey requested financial data generally similar to that collected by the MP&M surveys, including income statements and balance sheets for fiscal years 1995-1997 for the facility and the parent firm.

Government-owned MP&M facilities provided data in the Phase II Section 308 survey of municipal and other government agency facilities. This survey requested information on fiscal year 1996 sources and amounts of revenue and debt levels for both the government entity and their MP&M facilities, and demographic data for the population served by the government entity.

In addition to the survey data, a number of secondary sources were used to characterize economic and financial conditions in the industries subject to the MP&M effluent guidelines. Secondary sources used in the analyses include:

- Department of Commerce economic census and survey data, including the *Censuses of Manufactures, Annual Surveys of Manufactures,* and international trade data;
- the *Benchmark Input-Output Tables of the United States*, published by the U.S. Department of Commerce's Bureau of Economic Analysis;
- price index series from the Bureau of Labor Statistics, Department of Labor;
- U.S. *Industry and Trade Outlook*, published by McGraw-Hill and the U.S. Department of Commerce; and
- industry trade publications.

5.2 METHODOLOGY

The facility impact analysis starts with compliance cost estimates from the EPA engineering analysis and then calculates how these compliance costs would affect the financial condition of MP&M facilities.[2] EPA first eliminated from the analysis those facilities showing materially inadequate financial performance in the baseline, that is, in the absence of the rule. EPA judged these facilities, which are referred to as ***baseline closures***, to be at substantial risk of financial failure regardless of any

[1] Appendix A provides a detailed description of the surveys and describes how EPA combined data from different surveys.

[2] EPA made several changes in the facility impact methodology between proposal and final regulation. These changes, which to a large degree address comments on the proposal impact methodology, are documented in the Notice of Data Availability (reference).

financial burdens that may result from the MP&M rule. Second, for the remaining facilities, EPA evaluated how compliance costs would likely affect facility financial health. In this analysis of compliance cost impact, EPA accounted for potential price increases that may help facilities recover compliance costs. EPA's estimate of potential price increases was based on a ***cost pass-through analysis***, which used historical input and output price changes for the years 1982 through 1991 to estimate how prices might change in response to regulation-induced production cost increases. A facility is identified as a ***regulatory closure*** if it would have operated under baseline conditions but would fall below an acceptable financial performance level when subject to the new regulatory requirements.

EPA also identified private MP&M facilities that would likely incur moderate impacts from the rule but that are not expected to close as a result of the rule. The test of moderate impacts examined two financial ratios pre-tax return on assets and interest coverage ratio calculated on a baseline and post-compliance basis. Incremental moderate impacts are attributed to the rule if both financial ratios exceeded threshold values in the baseline (i.e., no moderate impacts in the baseline), but at least one financial ratio fell below the threshold value in the post-compliance case.

5.2.1 Converting Engineering Compliance Costs and Survey Financial Data to Current Year Dollar Values

The facility survey data underlying the facility financial impact analysis are based on the periods 1987-1989 (Phase I) and 1994-1996 (Phase II). The estimates of costs for complying with the MP&M regulation were developed, however, in dollars of the year 1996, the baseline year of the MP&M regulatory analysis.[3] To ensure consistent impact analyses, EPA aligned facility financial data and compliance cost estimates in dollars of the same year. In addition, for understanding the significance of the rule's potential costs in today's economy, EPA further brought all dollar values forward to 2001. EPA used the following procedures to perform these adjustments.

EPA used the ***Construction Cost Index (CCI)*** to convert compliance cost estimates into 2001 constant dollar equivalents. The CCI is a price index that engineers often use to estimate costs associated with building, installing, and operating waste treatment equipment and facilities. The CCI includes the costs of labor and building materials in 20 major cities. Table 5.1 shows CCI values from 1996 to 2001.

Table 5.1: Construction Cost Index

Year	Value	% Change
1996	5620	
1997	5825	3.6%
1998	5920	1.6%
1999	6060	2.4%
2000	6221	2.7%
2001	6342	1.9%

Source: Engineering News-Record

EPA used the ***Producer Price Index (PPI)*** to bring MP&M survey financial data to the current year. The PPI measures average changes in selling prices that domestic producers receive for their output.[4] EPA used sector-specific PPI averages to

[3] The engineering cost estimates are described in the *Technical Development Document* accompanying this rule.

[4] EPA used the PPI to bring all financial statement values forward to 2001. EPA understands that the PPI is an output price index and that operating statement costs and balance sheet values may not change over time in the same way as output prices (and revenue). However, in adjusting financial statement values from the original survey data years to the current year, EPA's purpose is to bring the statement values forward to the present while preserving the cost and financial structure relationships as reflected in the original income statements and balance sheets. Accordingly, use of a single index is appropriate for this adjustment and EPA judged the industry-specific PPI values as a better basis for this adjustment than other non-industry specific measures of inflation.

update financial data from Phase I and Phase II survey respondents to 1996, the base year of the analysis. EPA applied an aggregate PPI to update from 1996 to 2001 dollars.

Table 5.2 shows aggregate PPI values for all finished goods. Prices increased by 6.6 (135.7/127.3) percent from 1996 to 2001, and by 32.3 percent from 1987 to 2001 (135.7/102.6).

Table 5.2: Producer Price Index Industrial Commodities

Year	Value	% Change
1987	102.6	
1988	106.3	3.6%
1989	111.6	5.0%
1990	115.8	3.8%
1991	116.5	0.6%
1992	117.4	0.8%
1993	119.0	1.4%
1994	120.7	1.4%
1995	125.5	4.0%
1996	127.3	1.4%
1997	127.7	0.3%
1998	124.8	-2.3%
1999	126.5	1.4%
2000	134.8	6.6%
2001	135.7	0.7%

Source: Bureau of Labor Statistics

5.2.2 Market-level Impacts and Cost Pass-Through Analysis

Increased costs from the regulation can be expected to affect industry-level prices and output. Changes in prices and output in turn determine the distribution of economic impacts among directly- and indirectly-affected industries and their customers and suppliers. The facilities and industries directly affected by the final rule might ultimately experience little adverse impact, for example, if they are able to recover most or all of their added costs by raising prices to their customers or by lowering the prices paid to their suppliers *and* without a material reduction on the production quantity sold. Some regulated facilities and companies could even be better off financially as a result of the rule, if they benefit from industry-wide product price increases and incur no or relatively-low compliance costs (e.g., if they already have treatment in place). Understanding impacts at the industry level is therefore important to understanding who bears the impacts of the rule.

The MP&M effluent guidelines affect facilities in a wide range of industries, and some of those industries produce a diverse slate of products that are sold in multiple industrial sectors. Detailed partial equilibrium modeling of product-level market dynamics in each of the affected industries was therefore not feasible. EPA instead used a combination of quantitative and qualitative methods to estimate a proportion of compliance costs that might be recovered through price increases in each MP&M sector. This cost pass-through analysis provided sector-specific coefficients that were applied to total compliance costs in each sector to estimate percentage changes in prices and revenues. EPA then evaluated facility-level impacts assuming that all analyzed facilities in each sector benefit from the same percentage increase in prices and revenues.[5]

The estimated cost pass-through potential for each sector reflects an econometric analysis of historical pricing and cost trends in each MP&M industry sector, coupled with a qualitative market structure analysis. The market structure factors include:

- market power based on horizontal and vertical integration;
- extent of competition from foreign suppliers (in both domestic and export markets);
- barriers to competition, as indicated by above-normal, risk-adjusted profitability; and
- the long-term growth trend in the industry.

EPA developed cost pass-through coefficients that indicate the percentage of compliance costs that EPA expects firms subject to regulation to recover from customers through increased revenues.[6] This approach may either overstate or understate the true changes in revenue for any one particular facility, depending on the diversity of products produced by the facility and the percentage of competitors in each product market that incur compliance costs.

This approach to estimating market-level adjustments is a simplification because it does not simultaneously estimate changes in prices and output. Instead, EPA estimated price changes and then estimated changes in output based on predicted closures, taking into account the effect of the predicted price increases on facilities' financial performance. It is difficult to assess how this simplified approach might affect the estimated economic impacts of the rule. However, EPA does not believe that the overall impact analysis results are highly sensitive to the potential biases introduced by this approach.

5.2.3 Impact Measures for Private Facilities

a. Test of severe impacts

The analysis of severe impacts estimates the number of facilities that could potentially close due to the regulation. EPA predicted that a facility will close if compliance costs cause the facility's overall financial performance and resulting implied financial value to fall below a specified threshold level. Compliance costs are determined by the type and number of processes that a facility performs, the characteristics of its wastewaters, and the level of treatment performed in the baseline. EPA took the number and type of processes and pollutants produced into account when subcategorizing the industry. However, EPA was not able to link estimated compliance costs to specific products. Nor was EPA able to link facility financial performance to specific products. It was therefore not possible to conduct an impacts analysis at the product level.

In particular, the analysis does not consider output reductions short of closure for example, closing one of several production lines/processes or continuing to produce the same products at a reduced level. It is quite possible that a facility with no or relatively low compliance costs for most processes could choose to out-source products made using a process that had significant compliance costs associated with it, instead of performing the process in-house. This is particularly true if it is a process that is performed infrequently. It is also possible that firms with multiple facilities could consolidate similar processes at individual facilities to reduce their compliance costs. These situations are not considered in this economic impact analysis. Numerous compliance responses are available to firms and facilities that EPA is unable to model. In addition, the analysis of severe impacts does not attempt to forecast future business circumstances for a facility and thus does not account for potential improvements in business outlook that might strengthen a facility's ability to afford compliance outlays and thus prevent a potential closure decision. Because of these unknowns, estimated severe impacts are worst case and are likely to be overstated. In addition, the relationship between the compliance costs associated with the specific processes performed, specific products made from these processes, and the multiple industrial sectors to which these products are sold, is unknown and can not be accounted for in this analysis.

[5] EPA also performed an analysis in which complying facilities are assumed to pass none of their compliance costs through to consumers (zero-cost pass-through analysis). The results of this analysis are in the in the Record to the final rule (see Section *25.3.2*, DCN *37070*).

[6] Appendix B provides a detailed description of the cost pass-through analysis.

The assessment of severe impacts for MP&M private facilities[7] is based on the change in the facility's estimated business value, as determined from a discounted present value analysis of baseline cash flow and the change in cash flow resulting from regulatory compliance. If the estimated discounted cash flow value of the facility is positive before considering the effects of regulatory compliance but becomes negative as a result of compliance outlays, then the facility is considered a regulatory closure. In this impact test, the estimated ongoing business value of the facility is compared with a threshold value of zero for the closure decision: as long as the discounted cash flow value of the facility is greater than zero, the business is earning its cost of invested capital and continuation of the business is warranted. If the discounted cash flow value of the facility is less than zero in the baseline or becomes less than zero as a result of compliance outlays, then the business will not earn its cost of invested capital and the business owners will be better off financially by terminating the business. As noted in earlier discussion, facilities for which EPA estimated a negative baseline value were considered baseline closures and were not tested for additional adverse impacts from regulatory compliance.

In an alternative, theoretically more accurate, formulation of this concept, business owners would compare the discounted cash flow value of the facility with the value that the facility's assets would bring in liquidation. In this case, the estimated ongoing business value would be compared with a value that may be different from zero: ***liquidation value*** could be positive or negative. When liquidation value is positive, business owners might benefit financially by terminating a business and seeking its liquidation value even when the ongoing business value is positive but less than the estimated liquidation value. With negative liquidation value which generally would result from business termination liabilities (e.g., site clean-up) the opposite result could occur: business owners may find it financially advantageous to remain in business *even though the business earns less than its cost of invested capital* if the liquidation value of the business is "more negative", and thus less in value, than the ongoing business based on the discounted cash flow analysis. EPA attempted to implement this alternative impact test formulation. However, liquidation values were unavailable for over 75 percent of sample facilities. Moreover, EPA judges that the liquidation value estimates are substantially speculative and subject to considerable error. For these reasons, EPA decided against using liquidation value for comparison with ongoing business value in the closure test.

The cash flow concept used in calculating ongoing business value for the closure analysis is ***free cash flow*** available to all capital. Free cash flow is the cash available to the providers of capital both equity owners and creditors on an after-tax basis from business operations, and takes into account the cash required for ongoing replacement of the facility's capital equipment. Free cash flow is discounted at an estimated after-tax total ***cost of capital*** to yield the estimated business value of the facility. Details of the calculation of free cash flow and the discounting of free cash flow to yield the facility's estimated value are explained in the following sections.

❖ *Calculation of Baseline Free Cash Flow and Performance of Baseline Closure Test*

Calculation of baseline free cash flow and performance of the baseline closure test involved the following steps:

1. *Average survey income statement data over response years and convert to 2001 dollars:* EPA averaged income statement data over the years for which survey respondents reported data. For example, if a facility reported income statement data for 1995, 1996, and 1997, then a simple average was calculated for the three reported years. Reported values were brought forward from the initial reporting period to 1996 using MP&M sector-specific PPI adjustment factors and then from 1996 to 2001 using an aggregate PPI value as described above.

2. *Calculate after-tax income excluding the effects of financial structure:* The questionnaire responses include a calculation of after-tax income in accord with conventional accounting principles. However, this calculation reflects the financial structure of the business, which may include debt financing and thus interest charges against income. Because the cash flow concept to be discounted in the business value analysis is cash flow available to *all* capital, it is necessary to restate after-tax income to exclude the effects of debt financing, or on a *before-interest* basis. This restatement involves: (1) increasing after-tax income by the amount of interest charges and (2) increasing taxes (and thereby reducing after-tax income) by the amount of tax reduction provided by interest deductibility. This adjustment amounts to adding tax-adjusted interest expense to after-tax income and yields an estimate of after-tax income *independent of capital structure or financing effects*. In calculating the tax adjustment for interest, EPA used a combined federal/state corporate income tax rate of 39 percent, which reflects a combination of an approximate average state rate of 7.5 percent and a federal rate of 34 percent with state taxes deductible from federal income tax liability. After-tax income, *before interest,* was calculated as follows:

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[7] As opposed to non-business, government entities.

$$ATI\text{-}BI = ATI + I - \tau I \text{ or}$$
$$ATI\text{-}BI = ATI + (1 - \tau)I \quad (5.1)$$

where:

- ATI-*BI* = after-tax income *before interest*;
- ATI = after-tax income from baseline financial statement;
- I = interest charge from baseline financial statement; and
- τ = estimated combined federal-state tax rate of 39 percent.

3. *Calculate after-tax cash flow from operations, before interest, by adjusting income for non-cash charges:* The calculation of after-tax income may include a non-cash charge for depreciation (and potentially amortization). To calculate ***after-tax cash flow (ATCF)*** from operations, it is therefore necessary to add back any depreciation charge to the calculation of after-tax income, before interest. Cash flow, *before interest*, was calculated as follows:

$$ATCF\text{-}BI = ATI\text{-}BI + D \quad (5.2a)$$

where:

- ATCF-*BI* = after-tax cash flow *before interest*;
- ATI-*BI* = after-tax income *before interest*; and
- D = baseline depreciation.

4. *Calculate free cash flow by adjusting after-tax cash flow from operations for ongoing capital equipment outlays:* The measure of after-tax cash flow from the previous step, cash flow from operations, reflects the cash receipts and outlays from ordinary business operations and includes no allowance for replacement of the facility's existing capital equipment. However, to sustain ongoing operations, a business must expend cash for capital replacement. Accordingly, to understand the true cash flow of a business and thus provide a conceptually valid cash flow measure for business valuation, it is necessary to reduce cash flow from operations by an allowance for capital replacement. For the calculation of free cash flow, EPA estimated baseline capital outlays from a regression analysis of capital expenditures by public firms in the MP&M business sectors over a 10-year period (details of this analysis and estimation framework are contained in Appendix D). Free cash flow is calculated as follows:

$$FCF = ATCF\text{-}BI - CAPEX \quad (5.2b)$$

where:

- FCF = free cash flow
- ATCF-*BI* = after-tax cash flow *before interest*; and
- CAPEX = estimated baseline capital outlays.

Or on a more detailed accounting statement basis:

$$FCF = REV - TC - T - \tau I - CAPEX \quad (5.2c)$$

where:

- FCF = free cash flow
- REV = revenue
- TC = total operating costs, *excluding interest, depreciation, and taxes*
- T = baseline income tax
- τ = estimated combined federal-state tax rate of 39 percent;
- I = interest charge from baseline financial statement; and
- CAPEX = estimated annual baseline capital outlays.

This calculation of free cash flow is based on a static representation of a facility's business. Revenue and expenses are not projected forward and the analysis of the business assumes, in effect, that the facility's business will continue in the future absent the effects of regulation exactly as reflected in the baseline financial statements provided in the survey questionnaire. Consistent with this framework, the estimation of free cash flow includes no adjustment for changes in working capital, which might ordinarily be included in the capital outlay adjustment to operating cash flow.

5. *Calculate baseline facility value as the present value of free cash flow over a 15-year analysis horizon:* To calculate baseline business value, EPA discounted free cash flow over a 15-year period at an estimated real (i.e., excluding the effects of inflation), after-tax cost of capital of 7 percent. The use of 15 years as the discounting horizon reflects the expected useful life of capital equipment to be installed for MP&M regulation compliance. Facility baseline business value is calculated as follows:

$$VALUE = \sum_{t=0}^{14} \frac{FCF}{(1 + CoC)^t} \qquad (5.3)$$

where:

VALUE = estimated baseline business value of the facility
FCF = free cash flow
CoC = after-tax cost-of-capital; and
t = year index, t = 0-14 (15-year discounting horizon).

In the present value calculation, yearly cash flows accrue at the beginning of the year. As a result, the first year of cash flows is not discounted i.e., t = 0 for the first year of the analysis and cash flows in the fifteenth and final year of the analysis period are discounted over a 14-year period i.e., t = 14 in the final year of the analysis.

As explained above, EPA considered a facility to be a baseline closure if its estimated business value was negative before incurring regulatory compliance costs. Baseline closures were not tested for adverse impact in the post-compliance impact analysis.

❖ *Calculation of Post-Compliance Free Cash Flow and Performance of Post-Compliance Closure Test*

For the post-compliance closure analysis, EPA recalculated annual free cash flow accounting for changes in revenue, operating costs, and taxes that are estimated to result from compliance-related outlays. EPA combined the post-compliance free cash flow value and the estimated compliance capital outlay in the present value framework to calculate business value on a post-compliance basis.

Calculation of post-compliance free cash flow and performance of the post-compliance closure test involved the following steps:

1. *Adjust baseline annual free cash flow to reflect compliance revenue and expense effects:* Compliance-related effects on annual free cash flow include compliance ***operating and maintenance (O&M)*** expenses, post-compliance change in revenue (from the compliance ***cost pass-through analysis***), and change in taxes. The change in taxes includes: (1) the tax effect of compliance expense and revenue changes and (2) the tax effect from depreciation of compliance capital outlays. For calculating the tax effect of depreciation, EPA assumed that compliance capital outlays would be depreciated for tax purposes on a 15-year straight-line schedule. Post-compliance free cash flow was calculated as follows:

$$FCF_{PC} = FCF_{BL} + \Delta REV - \Delta TC - \tau(\Delta REV - \Delta TC - \Delta D) \qquad (5.4)$$

where:

FCF_{PC} = post-compliance free cash flow;
FCF_{BL} = baseline free cash flow, as calculated above;
ΔREV = post-compliance change in revenue, as calculated in the cost pass-through analysis;
ΔTC = change in total facility operating costs (excluding interest, depreciation and taxes), calculated as operating and maintenance costs of compliance;
τ = marginal tax rate for calculating compliance-related tax effects (combined federal-state tax rate of 39 percent); and
ΔD = change in depreciation expense, calculated as compliance capital outlay (CC) divided by 15.

The operating and maintenance cost of compliance (ΔTC, above) is the change in costs estimated to result from operating and maintaining pollution controls adopted to comply with effluent guidelines. Operating costs include the costs of monitoring.

2. *Limit tax adjustment to not exceed taxes as reported in baseline financial statement:* The tax effect of compliance will generally be to reduce tax liability. That is, in the prior formulation, the term $\tau(\Delta REV - \Delta TC - \Delta D)$, which is the tax effect of compliance, will generally be negative as the increase in revenue will be less than compliance-related operating expenses and compliance equipment depreciation: $(\Delta TC + \Delta D) > \Delta REV$. As a result, in the free cash flow calculation, the tax adjustment will generally increase cash flow and business value and, all else equal, will reduce the likelihood that a facility will fail the post-compliance closure test. However, the extent to which a facility will realize this contribution to cash flow depends on its tax circumstances. In particular, some businesses may not be paying sufficient taxes in the baseline to take full benefit of the implied tax reduction *at the facility level* unless the unused tax loss can be transferred to other, profitable business units in the firm, these businesses will not be able to use fully the implied tax reduction on a current basis. Also, the marginal tax rate for businesses with relatively lower pre-tax income may be less than the assumed 39 percent rate used in the analysis. While businesses may be able to carry forward tax losses to reduce taxes in later years, EPA recognizes that the implied cash flow benefit from tax reduction may not be fully realized, particularly in circumstances involving single-facility firms. To be conservative in its analysis, EPA therefore limited the amount of tax reduction from compliance outlays to be no greater than the amount of tax paid by facilities in the baseline financial statement. The analysis effectively assumes that facilities will not be able to offset an implicit negative tax liability against positive tax liability elsewhere in its operations or to carry forward (or back) the negative income and its implicit negative tax liability to other positive income/positive tax liability operating periods. On average, this approach will overstate impacts on facilities, because some MP&M businesses may be able to benefit from tax reductions that exceed facility baseline taxes, especially if the facility is owned by a multiple-site firm. Accordingly, EPA constrained the tax effect term in the free cash flow calculation, $[-\tau(\Delta REV - \Delta TC - \Delta D)]$ as specified above, to be no greater than baseline financial statement tax liability, T.

3. *Calculate post-compliance facility value, including post-compliance free cash flow and the compliance capital outlay:* As in the baseline analysis, EPA calculated post-compliance facility value as the present value of free cash flow and accounting for the compliance capital outlay as an undiscounted cash outlay in the first analysis period. Facility post-compliance business value was calculated as follows:

$$VALUE_{PC} = \sum_{t=0}^{14} \frac{FCF_{PC}}{(1 + CoC)^t} - CC \qquad (5.5)$$

where:

$VALUE_{PC}$	=	estimated post-compliance business value of the facility
FCF_{PC}	=	estimated post-compliance free cash flow
CoC	=	after-tax cost-of-capital;
t	=	year index, t = 0-14 (15-year discounting horizon); and
CC	=	compliance capital outlay.

EPA considered a facility to be a post-compliance closure if its estimated business value was positive in the baseline but became negative after adjusting for compliance-related cost, revenue and tax effects. In addition to tallying closure impacts in terms of the number of estimated facility closures, EPA also measured the significance of closures in terms of losses in employment and output. Employment losses equal the number of employees reported by closure facilities in survey responses; output losses equal total revenue reported for regulatory closure facilities. EPA estimated national results by multiplying facility results by facility sample weights.

b. Test of moderate impacts

EPA also conducted an analysis of financial stress short of closure to identify the rule's moderate impacts. Facilities experiencing moderate impacts are not projected to close due to the MP&M effluent guidelines. The rule, however, might reduce their financial performance to the point where they might have difficulty obtaining financing for future investments.

The analysis of moderate impacts examined two financial measures:

Pre-Tax Return on Assets (PTRA): ratio of pre-tax operating income earnings before interest and taxes (EBIT) to assets. This ratio measures the operating performance and profitability of a business' assets independent of financial structure and tax circumstances. PTRA is a comprehensive measure of a firm's economic and financial performance. If a firm cannot sustain a competitive PTRA on a post-compliance basis, it may have difficulty financing its investments, including the outlay for compliance equipment.

Interest Coverage Ratio (ICR): ratio of pre-tax operating cash flow earnings before interest, taxes, and depreciation (EBITDA) to interest expense. This ratio measures the facility's ability to service its debt on the basis of current, ongoing financial performance and to borrow for capital investments. Investors and creditors will be concerned about a firm whose operating cash flow does not comfortably exceed its contractual obligations. The greater the ICR, the greater the firm's ability to meet interest payments, and, generally speaking, the greater the firm's credit-carrying ability. ICR also provides a measure of the amount of cash flow available for equity after interest payments.

Creditors and equity investors review the above two measures as criteria to determine whether and under what terms they will finance a business. PTRA and ICR also provide insight into a firm's ability to generate funds for compliance investments from internally-generated equity, i.e., from after-tax cash flow. The measures are defined as follows:

Pre-Tax Return on Assets

$$PTRA = \frac{EBIT}{TA} \quad (5\text{-}6)$$

where:

PTRA = pre-tax return on assets,
EBIT = pre-tax operating income, or *earnings before interest and taxes*, and
TA = total assets.

Or, stated in terms of MP&M income statement accounts,

$$PTRA = \frac{REV - (TC + D)}{TA} \quad (5.7)$$

where:

PTRA = pre-tax return on assets;
REV = revenue;
TC = total operating costs (excluding interest, taxes, and depreciation/amortization);
D = depreciation; and
TA = total assets.

Interest Coverage Ratio

$$ICR = \frac{EBITDA}{I} \quad (5.8)$$

where:

ICR = interest coverage ratio;
EBITDA = pre-tax operating cash flow, or *earnings before interest, taxes, and depreciation (and amortization)* and
I = interest expense.

Or, stated in terms of MP&M income statement accounts,

$$ICR = \frac{REV - TC}{I} \qquad (5.9)$$

where:

- PTRA = pre-tax return on assets;
- REV = revenue;
- TC = total operating costs (excluding interest, taxes, and depreciation/amortization); and
- TA = total assets.

Including the effects of MP&M compliance costs, post-compliance PTRA and ICR are:

$$PTRA_{pc} = \frac{[(REV + \Delta REV) - (TC + \Delta TC + D + \Delta D)]}{(TA + CC)} \qquad (5.10)$$

$$ICR_{pc} = \frac{[(REV + \Delta REV) - (TC + \Delta TC)]}{(I + \Delta I)} \qquad (5.11)$$

where:

- $PTRA_{pc}$ = pre-tax return on assets, post-compliance;
- ICR_{pc} = interest coverage ratio, post-compliance;
- ΔREV = post-compliance change in revenue, as calculated in the cost pass-through analysis;
- ΔTC = change in total facility operating costs (excluding interest, depreciation and taxes), calculated as operating and maintenance costs of compliance;
- ΔD = change in depreciation expense, calculated as compliance capital outlay (CC) divided by 15;
- CC = compliance capital outlay (assuming all of the outlay would be capitalized and reported as an addition to assets on the balance sheet); and
- ΔI = incremental interest expense from financing of compliance capital outlay. As a simplifying, conservative assumption, incremental interest expense is calculated assuming that the compliance capital outlay is fully debt financed at the overall real cost-of-capital of 7 percent. The annual incremental interest value is calculated as the annualized value of interest payments over 15 years, assuming a constant annual payment of principal and interest.

For evaluating MP&M facilities according to the moderate impact measures, EPA compared baseline and post-compliance PTRA and ICR to MP&M sector-specific thresholds that were developed from data compiled by Risk Management Association, Inc. (RMA). RMA compiles and reports financial statement information by industry as provided by member commercial lending institutions. The threshold values represent the 25th percentile values of PTRA and ICR for statements received by RMA for the eight years from 1994 to 2001 within relevant industries. EPA developed MP&M sector-level values by weighting and summing the RMA industry values according to the definition of MP&M sectors (see Appendix C for details of moderate impact threshold development and sector-specific threshold values). Thresholds by sector ranged from 0 to 3.1 percent for PTRA and from 1.4 to 2.9 for ICR. Because the financial statements received by RMA are for businesses applying for credit from member institutions, the data don't represent a random sample. In particular, the RMA data will likely exclude representation from the financially weakest businesses, which are unlikely to be seeking credit. As a result, EPA views the threshold values as being relatively conservative and likely to overstate the occurrence of moderate impacts.

Both measures are important to financial success and firms' ability to attract capital. Facilities failing at least one of the moderate impact measures in the baseline were deemed to be already experiencing moderate financial weakness and were not tested for additional financial impact in the moderate impact analysis. Facilities that passed both moderate impact tests in the baseline but failed one or both threshold comparisons, post-compliance, were considered to incur moderate financial impacts, short of closure, as a result of the MP&M regulation.

5.2.4 Impact Measures for Railroad Line Maintenance Facilities

The proposed MP&M rule would have applied to some railroad facilities that maintain and repair railroad track and that perform similar operations on railroad and other vehicles. Railroad representatives indicated during data collection that the industry does not collect or monitor significant financial data at the facility level. These discussions led EPA to administer a modified version of the survey to railroad operating units and to perform the primary economic impact analysis at the operating unit level.

The analysis of impacts for railroad line maintenance facilities uses the same measures of impact as for other private MP&M facilities, but applies these measures for the railroad operating unit as a whole. Compliance costs for each railroad are the sum of compliance costs at each MP&M railroad line maintenance facility identified by the operating company.

5.2.5 Impact Measures for Government-Owned Facilities

Government-owned MP&M facilities include all facilities owned by government entities that discharge process wastewater from MP&M activities. Most government-owned facilities that fall under the MP&M rule provide or support transportation services. These facilities repair, rebuild, and maintain buses, trucks, cars, utility vehicles (e.g., snow-plows and street cleaners), and light machinery. The MP&M profile describes government-owned facilities in detail.

Each government subject to the MP&M effluent guidelines at its facilities has a number of choices, which include:

- contracting out the service to a private provider or other governmental agency,
- discontinuing these services altogether, or
- paying for compliance and continuing operations.

The impact analysis does not predict how the government will respond. The analysis evaluates only whether a community incurring compliance costs and continuing operations under the rule would incur a severe burden. A government may choose a different option and avoid some of the budgetary impacts estimated here.

EPA evaluated impacts for government-owned facilities by using three tests. A government that fails all three tests is likely to suffer severe adverse impacts as a result of the rule. The first test is applied at the facility level, and the other two tests are applied at the government level.

a. Impacts on site-level cost of service test

The impacts on site-level cost of service test considers whether a government-owned facility's compliance costs exceed one percent or more of its total baseline cost of service. This test is similar to the test used to assess impacts on private facilities and firms, which compares costs to post-compliance revenues. The facility will likely absorb compliance costs within its current budget if those costs do not exceed one percent of the total. Compliance costs in this scenario will not significantly impact the municipal budget. Costs in excess of one percent do not, in and of itself, indicate that a budgetary impact will occur, but only that additional analysis should be performed to determine if there is an impact.

EPA calculated the ratio of compliance costs to cost of service, R_C, for each government-owned facility as follows:

$$R_C = \frac{TACC}{C_{Baseline}} \qquad (5.12)$$

where:

R_C	=	ratio of compliance costs to cost of service,
TACC	=	total annualized compliance cost for the facility, and
$C_{Baseline}$	=	total baseline cost of service at the facility.

A facility whose R_C is equal to or greater than one percent fails this test.

b. Impacts on taxpayers test

The impacts on taxpayers test evaluates the significance of compliance costs to the people served by the government. A government will fail this test if the ratio of total annualized pollution control costs per household to median household income exceeds one percent, post-compliance. Post-compliance pollution control costs include all pollution control costs (for whatever purpose) reported by the government in the baseline plus the sum of MP&M effluent guideline compliance costs at all MP&M facilities owned by the government. This test closely follows the methodology developed for EPA's Water Quality Standards Workbook (EPA, 1995).

The survey requests information about current municipal expenditures on pollution control. ***Total annualized compliance costs (TACC)*** for each government-owned facility is the sum of costs and an amortized capital cost. The sum of TACC at all MP&M facilities for each government, plus baseline municipal expenditures on pollution control, yields a post-compliance total annualized pollution control cost. EPA divided total annualized pollution control costs by the number of households to calculate an average cost per household. The questionnaire also asks for median household income in the geographic area served by the responding government.

EPA calculated a ratio of compliance costs to median household income, R_H, for each government as follows:

$$R_H = \frac{C_{BPB} + \sum_i TACC_i}{MHI} \qquad (5.13)$$

where:

R_H = ratio of total annualized pollution control cost to median household income,
C_{BPC} = total baseline municipal expenditures on pollution control, and
$TACC_i$ = total annualized compliance cost for government-owned facility *i,*
MHI = median household income for the government jurisdiction.

Governments that incur compliance costs that cause this ratio to exceed one percent fail this test. Governments that fail this test in the baseline as well as post-compliance are not judged to experience major budgetary impacts attributable to the rule. If the rule causes an increase in this ratio to above one percent, then EPA concludes that the rule might present a burden to the taxpayers that support the affected government. The calculation is a conservative estimate of the impact on taxpayers because it does not take into account the fact that non-residential taxpayers (businesses) will bear some of the tax burden or that some costs might be recovered in fees.

This test is used in EPA's *Economic Guidance for Water Quality Standards*. This guidance is used by States and EPA Regions to assess economic factors in setting or revising water quality standards. The guidance includes as a screening measure of economic impact, average total pollution control cost per household divided by median household income. A value less than one percent indicates that a community would incur "little economic impact".[8]

c. Impacts on government debt test

The impacts on government debt test assesses the government's ability to finance compliance with the rule by issuing debt. A government must be able to finance capital compliance costs in addition to meeting ongoing compliance costs. Governments often finance capital compliance costs by issuing debt. This criterion tests each government's capacity to issue debt by examining the ratio of post-compliance debt service costs to the government's total revenue. This measure is analogous to the interest coverage ratio for private firms.

The ratio of debt service costs to revenue, R_D, for each government is:

[8] Source: EPA's *Economic Guidance for Water Quality Standards: Workbook* (1995) (Chapter 2 "Evaluating Substantial Impacts: Public Sector Entities"). Values between one and two percent indicate potential "mid-range economic impact." Governments with values above one percent are subject to further analysis to determine whether a significant economic impact would in fact occur.

$$R_D = \frac{D_B + C_k}{TR_B} \tag{5.14}$$

where:

- R_D = debt-to-revenue ratio;
- D_B = baseline municipal debt service costs (principal payments and interest);
- C_k = annualized capital cost of compliance, summed over all government-owned facilities in each government; and
- TR_B = baseline municipal revenue.

EPA judged that debt service costs above 25 percent of revenues might impede a government's ability to issue debt in the future and present a burden on the budget.

This criterion is used in EPA's MUNIPAY model. This model is used in enforcement cases to assess whether municipalities (e.g., towns, villages, cities, counties, and public utilities) can afford to pay a specific level of compliance costs, Superfund cleanup contributions, or penalties. The model's affordability assessment limits the amount of debt that can finance these costs, capping the debt service ratio at 25 percent.[9] A higher ratio "may reduce the confidence of creditors that the municipality can repay its debt on time." The MUNIPAY manual states that this value slightly exceeds the "warning marks" found in the public finance and management literature.

5.3 RESULTS

This section presents the results of the facility impacts analyses. The first section presents the results of the baseline closure analysis. The subsequent sections report the results of the analyses for the rule and the three other regulatory options that EPA analyzed. Section 5.3.2 presents the predicted price increases. Section 5.3.3 presents an overview of impacts for all MP&M facilities, and then results are provided for indirect dischargers (Section 5.3.4), direct dischargers (Section 5.3.5), private facilities (Section 5.3.6), and government-owned facilities (Section 5.3.7). Section 5.3.8 provides results by subcategory.

5.3.1 Baseline Closures

Table 5.3 shows the results of the baseline closure analysis by subcategory. EPA estimated that a total of 3,593 facilities have a negative business value before incurring regulatory compliance costs. These facilities are projected to close in the baseline and are not considered in the analysis of impacts attributable to the regulation.

Appendix A provides information on typical average closure rates in the MP&M industry sectors. Census data show that over 10,000 facilities, or almost eight percent of all facilities in these industries, close annually. The number of baseline closures predicted in this analysis is consistent with this typical closure rate.

[9] Source: EPA Office of Compliance and Enforcement Assurance, *MUNIPAY User's Manual*, September 1999, p. 4-14.

Table 5.3: Summary of Baseline Closures

Subcategory	Total Number of Dischargers	Number of Baseline Closures	Percent Closing in the Baseline	Number Operating in the Baseline
General Metals	11,364	880	7.7%	10,484
Metal Finishing Job Shops	1,542	50	3.2%	1,491
Non-Chromium Anodizing	122	29	23.8%	93
Oily Wastes	29,185	2,409	8.3%	27,776
Printed Wiring Boards	848	239	28.2%	609
Railroad Rebuilders	826	0	0.0%	826
Shipbuilding Dry Dock	14	0	0.0%	14
All Subcategories[a]	43,858	3,593	8.2%	40,265

[a] The total number of facilities does not sum to the number of facilities by subcategory because some facilities operate in more than one subcategory and have an indirect and direct discharging operation within the same facility.

Source: U.S. EPA analysis

5.3.2 Price Increases

The price increases predicted for the final rule and alternative regulatory options are shown in Table 5.4. The percentage price increases are small, falling well below one-half of one percent for all sectors under the final rule.

Table 5.4: Cost Pass-Through Analysis: Percentage Price Increases by Regulatory Option and Sector

Sector	Option I: Selected Option (Directs Only)	Option II: Proposed/NODA Option	Option III: Directs + 413 to 433 Upgrade	Option IV: Directs + All to 433 Upgrade
Aerospace	0.00%	0.04%	0.00%	0.00%
Aircraft	0.00%	0.03%	0.00%	0.01%
Bus and Truck	0.00%	0.06%	0.00%	0.01%
Electronic Equipment	0.00%	0.04%	0.00%	0.00%
Hardware	0.00%	0.08%	0.01%	0.01%
Household Equipment	0.00%	0.02%	0.00%	0.00%
Instrument	0.00%	0.08%	0.00%	0.01%
Iron and Steel	0.00%	0.20%	0.00%	0.00%
Job Shop	0.00%	0.61%	0.09%	0.09%
Mobile Industrial Equipment	0.00%	0.16%	0.01%	0.01%
Motor Vehicle	0.00%	0.07%	0.00%	0.00%
Office Machine	0.00%	0.00%	0.00%	0.00%
Ordnance	0.00%	0.12%	0.00%	0.00%
Other Metal Products	0.00%	0.04%	0.00%	0.01%
Precious and Non-Precious Metals	0.00%	0.03%	0.00%	0.00%
Printed Circuit Board	0.00%	0.00%	0.00%	0.00%
Railroad	0.00%	0.02%	0.00%	0.00%
Ships and Boats	0.00%	0.03%	0.00%	0.00%
Stationary Industrial Equipment	0.00%	0.05%	0.01%	0.01%

Source: U.S. EPA analysis

5.3.3 Overview of Impacts

Table 5.5 provides an overview of the numbers of facilities closing and experiencing moderate economic impacts, by regulatory option. These national estimates include all types of dischargers (direct and indirect) and types of facilities (private MP&M, railroad line maintenance, and government-owned facilities.)

Table 5.5: Regulatory Impacts for All Facilities by Option, National Estimates				
	Option I: Selected Option (Directs Only)	**Option II: Proposed/NODA Option[a]**	**Option III: Directs + 413 to 433 Upgrade**	**Option IV: Directs + All to 433 Upgrade**
Number of facilities operating in the baseline: total	40,265	60,253	40,265	40,265
private MP&M and railroad line maintenance	*36,480*	*54,526*	*36,480*	*36,480*
government-owned	*3,785*	*5,727*	*3,785*	*3,785*
Number of facilities below low flow cutoffs		51,502		
Number of facilities with subcategory exclusions	37,883	136	36,820	36,339
Percent of facilities operating in the baseline excluded or below cutoffs	94.1%	85.7%	91.4%	90.3%
Number of facilities operating subject to regulatory requirements	2,382	8,615	3,445	3,926
Number of regulatory closures	0	785	120	120
Percent of facilities operating in the baseline that are regulatory closures	0.0%	9.1%	3.5%	3.1%
Number of facilities experiencing moderate impacts	0	257	37	49
Percent of facilities operating in the baseline that experience moderate impacts	0.0%	3.0%	1.1%	1.2%

[a] The total number of facilities reported for the Proposed/NODA Option (Option II) analysis differs from the facility count reported for the final rule and Options III and IV. After deciding in July 2002 to not consider the NODA option as the basis for the final rule, EPA performed no more analysis on the NODA option, including not updating facility counts and related analyses for the change in subcategory and discharge status classifications. These differences in facility counts by regulatory option appear in subsequent tables.

Source: U.S. EPA analysis.

Table 5.5 shows that the final rule substantially reduces facility-level impacts as compared to the three alternative regulatory options considered by EPA. None of the facilities that continue to operate in the baseline close or experience moderate impacts due to the final rule. The large difference in results between the final rule and other options stems largely from the exclusion from regulatory requirements of over 94 percent of facilities that continue to operate in the baseline: the final rule excludes from regulatory requirements all indirect dischargers and direct dischargers in all subcategories except for Oily Wastes. Significantly larger numbers of facilities are projected to close under the Proposed/NODA Option and 433 Upgrade Options (785 and 120 facilities, respectively). See Chapter 4 for a discussion of the options and subcategory exclusions.

Table 5.6 shows the estimated burden on facilities from regulatory compliance by option, discharge status, and subcategory. The estimated burden includes annualized compliance costs and any estimated increase in facility revenue as a result of the regulation, and, for private facilities, reflects the effects of taxes on compliance costs and revenue. These compliance costs therefore represent the total after-tax cash flow impact on regulated facilities.

Table 5.6: Total Annualized Facility[a] After-tax Compliance Costs by Subcategory, Discharge Status, and Regulatory Option (millions, 2001$)								
Subcategory	**Option I: Selected Option (Directs Only)**		**Option II: Proposed/NODA Option**		**Option III: Directs + 413 to 433 Upgrade**		**Option IV: Directs + All to 433 Upgrade**	
	Direct	**Indirect**	**Direct**	**Indirect**	**Direct**	**Indirect**	**Direct**	**Indirect**
General Metals	$0.0	$0.0	$267.6	$476.7	$0.0	$16.5	$0.0	$46.5

Metal Finishing Job Shop	$0.0	$0.0	$2.9	$139.9	$0.0	$8.2	$0.0	$8.2
Non-Chromium Anodizing	$0.0	$0.0	$23.1	$0.0	$0.0	$0.0	$0.0	$0.0
Oily Waste	$11.9	$0.0	$29.0	$72.3	$12.0	$0.0	$12.1	$0.0
Printed Wiring Board	$0.0	$0.0	$0.2	$106.4	$0.0	$15.0	$0.0	$15.0
Railroad Line Maintenance	$0.0	$0.0	$0.6	$0.0	$0.0	$0.0	$0.0	$0.0
Shipbuilding Dry Dock	$0.0	$0.0	$2.4	$0.0	$0.0	$0.0	$0.0	$0.0
Steel Forming & Finishing[b]			$25.5	$16.1				
All Categories: Annual Costs	$11.9	$0.0	$351.2	$811.4	$12.0	$39.7	$12.1	$69.7
All Categories: Number of Facilities Operating Post-Compliance Subject to Requirements	2,382	0	4,143	3,688	2,382	1,063	2,382	1,544
Total Costs to Industry by Option, Directs + Indirects	$11.9		$1,162.5		$51.7		$81.8	

[a] This table reflects after-tax cash flow impacts to facilities and does not represent the cost of society from regulatory compliance. Chapter 11 discusses the social costs of the final rule and the other options. The estimates in this table exclude baseline and regulatory closures, and are after-tax.
[b] The Steel Forming & Finishing subcategory was removed from the MP&M universe after deciding not to consider the Proposed/NODA Option (Option II) for the final rule. As a result, compliance costs are included in the Steel Forming & Finishing subcategory for Option II only.

Source: U.S. EPA analysis.

Oily Wastes direct dischargers account for the total compliance costs of $11.9 million under the final rule. Total compliance costs incurred by facilities that continue to operate post-compliance are almost 100 times higher under the Proposed/NODA Option than under the final rule, over four times higher under the Directs and 413 to 433 Upgrade Option than under the final rule, and almost seven times higher under the Directs and All to 433 Upgrade Option than under the final rule.

5.3.4 Results for Indirect Dischargers

The sum of facilities individually identified as indirect and direct dischargers exceeds the total of all facilities as identified in Table 5.5, above. Some facilities operate in more than one subcategory, and some have both an indirect and direct discharging operation in the same facility. Facilities with both indirect and direct discharging operations are reported in the tables for both discharge categories: Table 5.7, for indirect dischargers, and Table 5.8, for direct dischargers.

Table 5.7 summarizes the results of the facility impact analysis for indirect dischargers, including both private businesses and government-owned facilities.

Table 5.7: Regulatory Impacts for Indirect Dischargers by Option, National Estimates				
	Option I: Selected Option (Directs Only)	**Option II: Proposed/ NODA Option**	**Option III: Directs + 413 to 433 Upgrade**	**Option IV: Directs + All to 433 Upgrade**
Number of facilities operating in the baseline: total	37,652	56,071	37,652	37,652
private MP&M and railroad line maintenance	*34,325*	*51,066*	*34,325*	*34,325*
government-owned	*3,327*	*5,005*	*3,327*	*3,327*
Number of facilities below low flow cutoffs		51,502		
Number of facilities with subcategory exclusions	37,652	136	36,589	36,108
Percent of facilities operating in the baseline excluded or below cutoffs	100.0%	92.1%	97.2%	95.9%
Number of facilities operating in the baseline subject to regulatory requirements	0	4,433	1,063	1,544
Number of regulatory closures	0	746	120	120
Percent of facilities operating in the baseline and subject to regulatory requirements that are regulatory closures	0.0%	16.8%	11.3%	7.8%
Number of facilities experiencing moderate impacts	0	228	37	49
Percent of facilities operating in the baseline and subject to regulatory requirements that experience moderate impacts	0.0%	5.1%	3.5%	3.2%

Source: U.S. EPA analysis.

Indirect discharging facilities account for over 93 percent of water discharging MP&M facilities as a whole. However, because all indirect discharging are excluded from regulatory requirements under the final rule, EPA estimates that no indirect dischargers will incur impacts under the final rule.

5.3.5 Results for Direct Dischargers

Table 5.8 summarizes the facility impact results for direct dischargers, which represent approximately seven percent of all facilities that continue to operate in the baseline. In addition, most operating direct dischargers are subject to requirements under the final rule: only 10 percent are excluded from requirements as a result of subcategory exclusions. As shown in the table, EPA estimates that no direct dischargers will close or incur moderate impacts as a result of the final rule's requirements. Impacts on direct dischargers are the same under the 433 Upgrade Option impacts as under the final rule, since these Options apply the same requirements to the same universe of facilities. The Proposed/NODA Option would have yielded more regulatory closures and moderate impacts than the final rule and 433 Upgrade Options.

Table 5.8: Regulatory Impacts on Direct Dischargers by Option, National Estimates				
	Option I: Selected Option (Directs Only)	**Option II: Proposed/NODA Option**	**Option III: Directs + 413 to 433 Upgrade**	**Option IV: Directs + All to 433 Upgrade**
Number of facilities operating in the baseline	2,641	4,182	2,641	2,641
private MP&M and railroad line maintenance	*2,183*	*3,459*	*2,183*	*2,183*
government-owned	*458*	*722*	*458*	*458*
Number of facilities with subcategory exclusions	259	0	259	259
Percent of facilities operating in the baseline with subcategory exclusions	9.8%	0.0%	9.8%	9.8%
Number of facilities operating in the baseline subject to regulatory requirements	2,382	4,182	2,382	2,382
Number of regulatory closures	0	39	0	0
Percent of facilities operating in the baseline and subject to regulatory requirements that are regulatory closures	0.0%	0.9%	0.0%	0.0%
Number of facilities experiencing moderate impacts	0	28	0	0
Percent of facilities operating in the baseline that experience moderate impacts	0.0%	0.7%	0.0%	0.0%

Source: U.S. EPA analysis.

5.3.6 Results for Private Facilities

Table 5.9 provides the facility impact analysis results for privately-owned facilities, including Railroad Line Maintenance facilities. Because privately-owned facilities account for over 90 percent of all MP&M facilities operating in the baseline, these results are similar to the results reported for all MP&M facilities in Table 5.5. Almost 95 percent of facilities operating post-compliance are excluded from requirements under the final rule, due to the subcategory exclusions for all indirect dischargers and all direct dischargers except for Oily Wastes.

Table 5.9: Regulatory Impacts for Private Facilities by Option, National Estimates

	Option I: Selected Option (Directs Only)	Option II: Proposed/NODA Option	Option III: Directs + 413 to 433 Upgrade	Option IV: Directs + All to 433 Upgrade
Number of facilities operating in the baseline	36,480	54,526	36,480	36,480
Number of facilities below low flow cutoffs		46,582		
Number of facilities with subcategory exclusions	34,556	136	33,123	32,745
Percent of facilities operating in the baseline excluded or below cutoffs	94.7%	0.2%	90.8%	89.8%
Number of facilities operating in the baseline subject to regulatory requirements	1,924	7,808	3,357	3,735
Number of regulatory closures	0	785	120	120
Percent of facilities operating in the baseline and subject to regulatory requirements that are regulatory closures	0.0%	10.1%	3.6%	3.2%
Number of facilities experiencing moderate impacts	0	257	37	49
Percent of facilities operating in the baseline and subject to regulatory requirements that experience moderate impacts	0.0%	3.3%	1.1%	1.3%

Source: U.S. EPA analysis.

5.3.7 Results for Government-Owned Facilities

Table 5.10 provides facility impact analysis results for government-owned facilities. The 3,785 government-owned facilities that continue to operate in the baseline represent over 9 percent of all MP&M facilities operating in the baseline. As discussed above, instead of a closure test, the impact analysis for government-owned facilities assesses whether the rule would impose major budgetary impacts on these facilities and the governments that own them.

Under the final rule, 88 percent of government-owned facilities would be excluded from requirements because they qualify for subcategory exclusions. EPA's analysis indicates that none of the options would impose major budgetary impacts on the governments operating the facilities.

Table 5.10: Regulatory Impacts for Government-Owned Facilities by Option, National Estimates

	Option I: Selected Option (Directs Only)	Option II: Proposed/NODA Option	Option III: Directs + 413 to 433 Upgrade	Option IV: Directs + All to 433 Upgrade
Number of government-owned facilities operating in the baseline & post-regulation	3,785	5,727	3,785	3,785
Number of facilities below low flow cutoffs		4,920		
Number of facilities with subcategory exclusions	3,327	0	3,327	3,305
Percent of facilities operating in the baseline excluded or below cutoffs	87.9%	85.9%	87.9%	87.3%
Number of facilities operating subject to regulatory requirements	458	807	458	480
Number of facilities experiencing significant budgetary impacts[a]	0	0	0	0
Percent of facilities operating in the baseline that experience significant budgetary impacts	0%	0%	0%	0%

[a] A government is judged to experience major budgetary impacts if (1) any of its facilities incur compliance costs exceeding 1% of baseline cost of service and (2) the governmental unit fails both the taxpayers impact and government debt impact tests.

Source: U.S. EPA analysis.

Tables 5.11 and 5.12 provide additional detail on the results of the facility impact analysis for government-owned facilities. Table 5.11 shows the number of government-owned facilities by type and size of government, and the number that fall below relevant flow cutoffs under the final rule.

Table 5.11: Number of Government-Owned Facilities by Type and Size of Government Entity

	Municipal Government	State Government	County Government	Regional Governmental Authority	Total
Large Governments (population> 50,000)					
# of regulated government entities	26	129	23	0	178
# of government entities with exclusions	592	248	758	46	1,645
Small Governments (population <= 50,000)					
# of regulated government entities	280	0	0	0	280
# of government entities with exclusions	1,470	0	212	0	1,682
All Governments					
# of regulated government entities	306	129	23	0	458
# of government entities with exclusions	2,062	248	970	46	3,327
Total	2,368	377	993	46	3,785

Source: U.S. EPA analysis of Municipal Survey.

Table 5.12 provides additional information on the results of the three tests performed in the government impact analysis. The vast majority of facilities, 95.7 percent, are estimated to incur costs less than one percent of their baseline cost of service. EPA assumes that these facilities (and their owning governments) can absorb compliance costs within their current budgets with no material burden. The remaining 162 facilities, or 4.3 percent of government-owned facilities, incur costs exceeding one percent of their baseline costs of service. Although EPA estimates that these facilities will incur costs exceeding the one percent no-impact threshold, whether these costs represent a material burden to the owning government depends on the magnitude of costs at the government level. To understand whether this higher facility-level cost would constitute a significant burden, EPA estimated the total of compliance costs incurred by a government for all of its affected MP&M facilities and assessed the impact of these costs under the two tests outlined above: the taxpayer impact test and the government debt service impact test. For the final rule, EPA estimated that none of the governments with facilities incurring costs greater than one percent of baseline values would fail either of the two government-level impacts tests.

Table 5.12: Impacts on Governments of MP&M Facility Compliance Costs by Size of Government

	Owned by Small Governments		Owned by Large Governments		All Government-Owned Facilities	
Number of government-owned MP&M facilities affected	1,962		1,823		3,785	
	Number	**Percent**	**Number**	**Percent**	**Number**	**Percent**
Number and percent of governments failing all three budgetary impact criteria	0	0.0%	0	0.0%	0	0.0%
Individual Test Results: number and percent of failures						
Compliance costs > one percent of baseline cost of service test	140	7.1%	22	1.2%	162	4.3%
Impacts on taxpayers test	0	0.0%	0	0.0%	0	0.0%
Impacts on government debt test	0	0.0%	0	0.0%	0	0.0%

Source: U.S. EPA analysis.

That no governments incur budgetary impacts at the government level is not surprising. The MP&M activities regulated under the final rule typically represent a very small portion of governments' budgets. Even a significant percentage increase in the cost of MP&M activities (as measured by the comparison of post-regulation costs to baseline costs) is unlikely to present any serious burden on the budgets of the affected governments.

Moreover, the costs to government-owned facilities are quite low. The large majority (3,327 or 88 percent) of the 3,785 government-owned facilities are excluded from the final rule. Of the 458 government facilities remaining under regulation, 183 facilities incur no costs, and 275 incur annualized costs averaging $32,674.

GLOSSARY

after-tax cash flow (ATCF): After-tax cash flow available to equity.

baseline closures: Facilities showing inadequate financial performance in the baseline, that is, in the absence of the rule. These facilities closures would have occurred with or without the rule.

Construction Cost Index (CCI): Measures how much it cost to purchase a hypothetical package of goods and services compared to what is was in the base year. It applies to general construction costs. The CCI can be used where labor costs are a high proportion of total costs. The CCI uses 200 hours of common labor, multiplied by the 20-city average rate for wages and fringe benefits. (http://www.enr.com/cost/costfaq.asp)

cost of capital: Costs incurred for a firm to obtain financing from all capital sources including, in particular, equity and debt.

cost pass-through analysis: Calculates the percentage of compliance costs that EPA expects firms subject to regulation to recover from customers through increased revenues.

facility: A contiguous set of buildings or machinery on a piece of land under common ownership.

free cash flow: Cash flow generated by the company that is available to all providers of the company's capital, both creditors and shareholders.

government-owned facility: Includes facilities operated by municipalities, state agencies and other public sector entities such as state universities.

interest coverage ratio (ICR): Ratio of cash operating income to interest expenses. This ratio measures the facility's ability to service its debt and borrow for capital investments.

liquidation value: Net amount that could be realized by selling the assets of a firm after paying the debt. (http://www.duke.edu/~charvey/Classes/wpg)

moderate impacts: Adverse changes in a facility's financial position that are not threatening to its short-term viability.

operating and maintenance (O&M): Costs estimated to result from operating and maintaining pollution controls adopted to comply with effluent guidelines. Operating costs include the costs of monitoring.

pre-tax return on assets (PTRA):Ratio of cash operating income to assets. This ratio measures facility profitability.

private MP&M facility: Includes all privately-owned facilities that do not perform railroad line maintenance.

Producer Price Index (PPI): A family of indexes that measures the average change over time in the selling prices received by domestic producers of goods and services. PPI's measure price change from the perspective of the seller. This contrasts with other measures, such as the Consumer Price Index (CPI), that measure price change from the purchaser's perspective. Sellers' and purchasers' prices may differ due to government subsidies, sales and excise taxes, and distribution costs. (http://stats.bls.gov/ppifaq.htm#1)

railroad line maintenance facility: Facilities that maintain and repair railroad track and other vehicles.

regulatory closure: A facility that is predicted to close because it can not afford the costs of complying with the rule.

severe impacts: Facility closures and the associated losses in jobs, earnings, and output at facilities that close due to the rule.

total annualized compliance cost (TACC): Sum of annual operating and maintenance costs and the annualized equivalent of one-time costs, calculated over 15 years assuming a seven percent discount rate.

ACRONYMS

ATCF: after-tax cash flow
CCI: construction cost index
ICR: interest coverage ratio
O&M: operation and maintenance
PPI: producer price index
PTRA: pre-tax return on assets
TACC: total annualized compliance cost

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Chapter 6: Employment Effects

INTRODUCTION

CHAPTER CONTENTS

This chapter discusses the employment effects associated with the final rule and the alternative regulatory options considered by EPA. The MP&M regulation can generate both positive and negative impacts on employment. Any facility closures induced by the rule would result in reduced demand for labor and compliance activities at facilities that close, but would also increase employment requirements in facilities that remain open and continue to operate. The regulation could also create a demand for compliance-related equipment and installation, which would also generate new employment requirements.

EPA assumed that any estimated facility closures would result in the loss of ***full-time equivalents (FTEs)***.

The MP&M rule may affect overall employment in three ways.

Direct labor requirements. Direct labor requirements are job losses from closures and job gains from manufacturing, installing, and operating compliance-related equipment. Direct labor requirements also include labor to implement the rule's pollution prevention activities.[1]

Indirect labor requirements. Compliance expenditures may increase employment in industries doing business with compliance equipment and service providers. Economists refer to these as ***linked industries***. For example, a firm that manufactures a treatment system will purchase pumps, pipes, and other intermediate goods and services from other firms and sectors of the economy. Employment in these linked industries increases when treatment equipment manufacturers purchase goods and services from them. Closures of MP&M facilities can also lead to reduced requirements for inputs to MP&M industry products, and therefore indirect job losses in the supplier industries.

Induced labor requirements. Increased direct and indirect labor employment also increases spending on consumer-oriented service and retail businesses. Economists refer to the additional labor demand in the businesses patronized by people working in the direct and indirect labor industries as "induced" labor requirements. Conversely, people who are laid off from MP&M facilities that close due to the rule may spend less, reducing employment in sectors providing consumer services and products.

EPA is not including a total estimate of indirect and induced job gains and losses, however, because the magnitude of losses and gains is very small at the national level and occur across all states. The job gains after the first three years are expected to be approximately two jobs per year, without any regulation-related losses. The low magnitude of these gains means that it is highly unlikely that there will be any material secondary and induced impacts from the regulation.

Because EPA estimates that no facility closures will occur under the final rule, EPA expects that the rule will cause no job losses. However, EPA estimates that the regulation will increase employment, with the manufacture and installation of compliance equipment causing a short-term gain in direct employment of 20 FTEs. In addition, EPA estimates that operation and maintenance of compliance equipment will cause a continuing direct requirement for two FTEs per year. The net effect on direct employment of the regulation is an estimated increase of 47 ***FTE-years***, a measure that reflects both the number and duration of jobs gained. This number represents an average gain of three FTEs per year over the 15 year analysis period.

Although EPA expects no job losses under the final rule, EPA considered other regulatory options that would likely have caused facility closures and job losses. The following sections of this chapter review first the job losses from facility closures under the alternative regulatory options, and second the expected job gains from compliance equipment installation and

[1] See the *Technical Development Document* for more information on compliance costs.

operation for both the final rule and the alternative options. The last section discusses net impacts on employment and the expected timing of those effects.

6.1 Job Losses Due to Closures

As discussed, EPA estimates that the final rule will cause no facility closures and thus no job losses.[2] However, EPA considered other regulatory options that would likely cause facility closures and job losses. To calculate job losses for these options, EPA assumed that all employees working at closing facilities will lose their jobs, and that one-third of the facilities estimated to close do so in each of the first three years after promulgation of the option. The §308 surveys provide the number of employees at each facility, expressed in FTEs. The job losses attributable to an option are simply the sum of employment at the plants estimated to close. EPA did not analyze the job losses that would occur if facilities cut production or ceased production of products that required certain processes instead of closing. Table 6.1 shows the total employment and estimated job losses by subcategory due to facility closures under the alternative regulatory options and as a percent of the total employment in the baseline.

Table 6.1: Job Losses for the Alternative Regulatory Options by Subcategory; Final Rule

Subcategory	Total Employment in the Baseline	Option I: Selected Option	Option II: NODA/Proposed Option		Option III: 413 to 433 Upgrade Option		Option IV: All to 433 Upgrade Option	
			Estimated Job Losses	% of Total Jobs	Estimated Job Losses	% of Total Jobs	Estimated Job Losses	% of Total Jobs
General Metals	3,641,623	n/a	7,895	0.2%	6,087	0.2%	6,087	0.2%
Metal Finishing Job Shop	63,083	n/a	19,072	30.2%	1,425	2.3%	1,425	2.3%
Non-Chromium Anodizing	13,464	n/a	0	0.0%	0	0.0%	0	0.0%
Oily Waste	3,143,544	n/a	104	0.0%	0	0.0%	0	0.0%
Printed Wiring Board	110,644	n/a	3,998	3.6%	363	0.3%	363	0.3%
Railroad Rebuilders[a]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Shipbuilding Dry Dock	994	n/a	0	0.0%	0	0.0%	0	0.0%
Steel Forming and Finishing[b]	21,753		1,660	7.6%				
All Subcategories	6,973,352	n/a	32,729	0.5%	7,874	0.1%	7,874	0.1%

[a] Employment is only available at the firm level for the Railraod Rebuilders subcategory.
[b] The Steel Forming & Finishing subcategory was removed from the MP&M universe after deciding not to consider the Proposed/NODA Option (Option II) for the final rule. As a result, estimated job losses are included in the Steel Forming & Finishing subcategory for Option II only. Accordingly, the employment from this subcategory is not included in the total.

Source: U.S. EPA analysis.

Job losses under the Proposed/NODA Option equal 0.5 percent of total employment at water discharging MP&M facilities and 0.1 percent under the 433 Upgrade Options. The metal finishing job shop subcategory accounts for 19,072 of the job losses under the Proposed/NODA Option or over 58 percent of the total 32,729 estimated job losses. The subcategories with the highest percent of job losses under the Proposed/NODA Option are the Metal Finishing Job Shops (30.2 percent of total employment in the subcategory), Steel Forming and Finishing (7.6 percent) and Printed Wiring Boards (3.6 percent). Job

[2] EPA's analysis considers employment losses only for facility closures. As discussed in Chapter 5, firms may consider a range of responses in structuring a compliance strategy, including consolidation and/or transfer of production among facilities to minimize the financial burden of compliance. In some instances, these actions could result in employment losses in some facilities and possible increases in others. Because of the complexity of these decisions, EPA's analysis cannot consider the full range of such compliance responses and does not consider the potential employment effects – negative or positive – associated with these compliance options.

losses under the 433 Upgrade Options are estimated in the General Metals, Metal Finishing Job Shops, and Printed Wiring Boards subcategories of 6,087, 1,425, and 363 employees, respectively.

6.2 JOB GAINS DUE TO COMPLIANCE REQUIREMENTS

Direct labor requirements arise from the employment necessary to manufacture, install, and operate equipment that MP&M facilities need to comply with the final rule, as well as pollution prevention activities undertaken to comply with the regulation. The following sections discuss labor requirements associated with manufacturing compliance equipment, equipment installation, and operation, respectively. This section provides a detailed analysis for the final rule only. A summary of the net job gains due to compliance with the alternative regulatory options is presented at the end of the section. Some more detail on the compliance costs that went into calculating job gains under the alternative regulatory options is available in Appendix E.

a. Direct labor requirements for manufacturing compliance equipment

EPA estimated the direct labor requirements for manufacturing wastewater treatment systems using three steps:

- Calculate the cost of compliance equipment;
- Estimate the share of the cost of compliance equipment due to labor inputs. This estimate shows how much money goes to employees of equipment manufacturers; and
- Convert the dollars spent on manufacturing employees to a full-time employment equivalent (FTE), based on a yearly labor cost.

❖ *Compliance cost*

EPA used the total one-time capital costs estimated by the engineers to calculate the purchase cost paid to manufacturers of compliance equipment. The estimated one-time direct capital equipment cost is $3.1 million for the final regulatory option. Appendix E explains in more detail how this value was calculated.

❖ *Labor share*

The Bureau of Economic Analysis (BEA) calculates ***direct requirements coefficients*** that measure how many dollars of each input are purchased to produce a dollar of a given output.[3] EPA used requirements coefficients for BEA Sector 40, the "Heating, Plumbing, and Fabricated Structural Metal Products Industry," for the employment analysis. MP&M project engineers identified BEA Sector 40 as the industrial sector that most nearly matches the businesses that would make, install, and operate waste treatment systems for MP&M facilities complying with the rule. The inputs into Sector 40 production include intermediate goods, materials, and services, as well as labor.

BEA's direct requirements table shows that every dollar of Sector 40 output delivered to final demand requires $0.30632 expended to compensate Sector 40 employees. Multiplying labor's share of output value (30.63 percent) by the value of compliance equipment purchases for the regulation ($3.1 million) yields the labor cost of manufacturing treatment system equipment: $0.9 million.

❖ *FTE jobs*

EPA converted the total labor cost to the number of FTE-equivalent jobs by dividing the total labor cost by an estimated yearly labor cost per FTE employee. EPA used the hourly labor rate used in the engineering cost analysis – $29.67 per hour in 1996 dollars. The $29.67 per hour rate includes fringe benefits (e.g., holidays, vacation, and various insurances) and payroll taxes. EPA adjusted this amount to 2001 dollars using the Bureau of Labor Statistics Employment Cost Index for manufacturing of durable goods, to provide an hourly rate in 2001$ of $34.69. The gross 2001 dollar annual labor cost per FTE position for a 2,000-hour work year is $69,373. EPA estimated that one-time spending on manufacturing treatment system equipment would require 14 FTEs (941 (in thousands) / 69.4). EPA assumed that one-third of facilities come into compliance in each of the first three years, therefore, one-third of these FTEs (5) would be associated with equipment purchases in each of the first three years after promulgation of the rule.

[3] See "Benchmark Input-Output Accounts for the U.S. Economy, 1992," in *Survey of Current Business*, July 1997, U.S. Department of Commerce, Bureau of Economic Analysis.

b. Direct labor requirements for installing treatment systems

EPA's method for estimating the direct labor requirements to install treatment system equipment parallels its method for analyzing the labor requirements for equipment manufacturing.

❖ ***Compliance cost***

EPA used the total one-time capital costs estimated by the engineers to calculate the cost of installation. The estimated one-time cost of installation labor is $0.5 million for the final regulatory option. Appendix E explains in more detail how this value was calculated.

❖ ***Labor share***

One hundred percent of the installation is a labor cost.

❖ ***FTE jobs***

EPA used the loaded hourly labor cost of $34.69 per hour and 2,000 hours per year to convert labor costs to numbers of FTE jobs. Complying facilities will require an estimated 7 FTEs (455 (in thousands) / 69.4) to install the equipment needed to comply with the regulation. This corresponds to 2 FTEs in each of the first three years after promulgation of the rule.

c. Direct labor requirements for operating and maintaining treatment systems

MP&M project engineers estimated that labor costs represent one percent of total compliance operating and maintenance (O&M) costs. For the final rule, the labor cost of O&M is $0.1 million per year (2001$), corresponding to 2 FTEs (131 (in thousands) / 69.4). EPA assumed that one-third of facilities come into compliance in each of the first three years after promulgation of the rule. Therefore, one-third of these FTEs (1) would have operating maintenance requirements in the first year, two-thirds of these FTEs (1) would have operating maintenance requirements in the second year, and all of these FTEs (2) would have operating maintenance requirements in the third year when all facilities reach compliance.

d. Total direct labor requirements

The total direct labor requirement for complying with the MP&M rule is the sum of the direct labor requirements of manufacturing, installing, and operating treatment systems. Table 6.2 summarizes the direct labor requirements from compliance expenditures under the regulation. These requirements include total one-time expenditures to manufacture and install compliance equipment equal to 20 FTEs, and continuing requirements for operating and maintenance of 2 FTEs per year.

Table 6.2: Total Direct Labor Requirements of the Final Rule, National Estimates (millions, 2001$, before tax)

	Total Cost	Labor Share	Total Labor Cost	FTEs[a]
One-time compliance cost	***$3.6***		***$1.4***	***20***
Capital equipment manufacturing	$3.1	30.6%	$0.9	14
Installation labor	$0.5	100.0%	$0.5	7
Annual operating and maintenance cost	***$13.1***	***1.0%***	***$0.1***	***2***

[a] Number of jobs calculated on the basis of an average annual labor cost of $69,373 which assumes an average hourly wage of $34.69 and 2,000 hours per labor-year.

Source: U.S. EPA analysis, Bureau of Labor Statistics, Bureau of Economic Analysis.

Table 6.3 summarizes the total direct labor requirements from compliance expenditures under the final rule and alternative regulatory options.

Table 6.3: Total Direct Labor Requirements of the Final Rule and Alternative Regulatory Options				
Option	One-time manufacturing and installation of compliance equipment			Annual operating and maintenance
	Manufacturing	Installation labor	Total	
Option I: Selected Option	14	7	20	2
Option II: NODA/Proposed Option	2,467	1,195	3,662	215
Option III: 413 to 433 Upgrade Option	294	142	436	8
Option IV: All to 433 Upgrade Option	457	221	678	13

Source: U.S. EPA analysis, Bureau of Labor Statistics, Bureau of Economic Analysis.

Requirements under the Proposed/NODA Option include total one-time expenditures to manufacture and install compliance equipment equal to 3,662 FTEs, and continuing requirements for operating and maintenance of 215 FTEs per year. EPA expects the 413 to 433 Upgrade Option and the All to 433 Upgrade Option to require 436 and 678 one-time FTEs and 8 and 13 continuing FTEs per year, respectively.

6.3 NET EFFECTS ON EMPLOYMENT

The timing and duration of employment changes resulting from the rule or the alternative options depend on the type of employment demands and the condition of the economy at the time those demands occur. The increased employment resulting from facilities' purchase and installation of compliance equipment will be short-term and is expected to occur in the early years of implementation. However, the increased employment needed to operate and maintain compliance systems will persist, presumably for the life of the compliance equipment. For job losses that might accompany the alternative options, the duration of unemployment would depend on labor demand in the economy and specifically in the locations at which facilities close, and the skill level of those individuals becoming unemployed.

Table 6.4 reports the estimated level and timing of direct employment impacts of the final rule. The estimates assume that: (1) facilities come into compliance or close over a three year period, (2) displaced workers are out of work for one year on average, and (3) the requirements to operate and maintain compliance systems continue for 15 years. As shown in Table 6.4, the final rule results in a small increase in employment in all years of the analysis period. Summing employment each year over the 15 year analysis period indicates that the regulation would increase direct labor requirements by 47 "FTE-years", or an average gain of 3 FTEs per year. The comparable estimates for the alternative options (shown in Table 6.5) include the effect of job losses from facility closures.

The industries in which employment changes are expected to occur also depend on the type of employment demands under the rule. Increases in employment for operation and maintenance of compliance equipment are expected to occur in the MP&M industries. In addition, because the MP&M industry, itself, is likely to be a manufacturer of compliance equipment, a material portion of the increase in employment for producing and installing compliance equipment is likely to occur in the MP&M industries. Accordingly, a substantial part of the total employment increase will likely occur in the MP&M industries. Still, on balance, the impact on total employment – both in the economy as a whole and in the MP&M industries – is expected to be very small. The average net gain of 3 FTEs for the final rule equals a negligible percent of total employment in the MP&M facilities potentially subject to the rule and even less compared with total 1996 employment in the industries that make up the larger MP&M industry.[4]

EPA did not consider the possible effects of excess capacity or underemployment in the equipment manufacturing and installation industries, and assumed that all compliance requirements would result in proportional changes in employment.

[4] Total employment in the potentially regulated MP&M facilities is 6,973,352 FTEs, as reported in the Section 308 surveys.

Table 6.4: Estimated Final Rule Net Direct Employment Impacts over 15 Years (number of FTEs per year and total FTE-years)

Year	One-Time Manufacturing & Installation[a]	Annual O&M[a]	Closures	Net Change in Employment
1	7	1	0	7
2	7	1	0	8
3	7	2	0	9
4		2		2
5		2		2
6		2		2
7		2		2
8		2		2
9		2		2
10		2		2
11		2		2
12		2		2
13		2		2
14		2		2
15		2		2
Total FTEs over 15 years	20	26	0	47

[a] Assumes that one-third of facilities come into compliance in each of 3 years.

Source: U.S. EPA analysis.

Table 6.5 presents the estimated direct employment impact of the final rule and the alternative options. As discussed earlier, the final rule would increase direct labor requirements over the 15 year period by an estimated 47 FTEs; however under each of the alternative regulatory options, direct labor requirements would decrease. The total estimated net decrease in direct labor requirements under the NODA/Proposed Option of 26,060 FTEs is driven by the 32,729 job losses from estimated facility closures under the option. The 7,874 job losses from projected facility closures under the 433 Upgrade Options result in a net decrease in direct labor requirements under the 413 to 433 Upgrade Option of 7,319 FTEs and the All to 433 Upgrade Option of 7,011 FTEs.

Table 6.5: Estimated 15 Year Net Employment Effects for the Final Rule and Alternative Regulatory Options

Option	Net Change in Employment (FTEs)
Option I: Selected Option	47
Option II: NODA/Proposed Option	(26,060)
Option III: 413 to 433 Upgrade Option	(7,319)
Option IV: All to 433 Upgrade Option	(7,011)

Source: U.S. EPA Analysis.

GLOSSARY

direct labor requirements: employment losses resulting from lost MP&M output caused by the rule and employment gains caused by compliance expenditures resulting from the rule in the directly-affected industries.

full-time equivalent (FTE): hours of employment equivalent to one full-time job.

FTE-year: one year of full-time employment.

indirect labor requirements: changes in employment in industries that supply directly affected industries resulting from increased purchases or reduced output in the directly affected industries.

induced labor requirements: changes in employment in industries providing goods and services to people whose employment is directly or indirectly affected by the rule.

linked industries: industries that sell goods and services to or purchase output from a directly-affected industry.

ACRONYM

FTE: full-time equivalent

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Chapter 7: Government and Community Impact Analysis

INTRODUCTION

In this chapter, EPA examines how the final MP&M rule and alternatives for regulation considered by EPA might affect the economic welfare of communities, where communities are defined as States, counties and metropolitan areas. Communities may suffer adverse impacts from a rule in two ways. First, local governments may incur costs to comply with the rule, if they operate MP&M facilities, or to administer the rule. Second, communities may be affected if MP&M facility closures resulting from the rule affect the health of their local economies.

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This analysis was undertaken in part to meet potential requirements of the ***Unfunded Mandates Reform Act (UMRA)***. However, the final rule does not contain a Federal mandate under UMRA because the rule will not result in expenditures of $100 million or more for State, local, and tribal governments, in the aggregate, or the private sector in any one year. Thus, the final rule is not subject to the requirements of the UMRA sections 202 and 205. Although the final rule does not contain a Federal mandate under UMRA, this chapter summarizes the impacts of the final rule on State and local governments as part of its decision-making process.

7.1 IMPACTS ON GOVERNMENTS

The analysis considered two effects on governments:[1]

- Government-owned MP&M facilities may be subject to the regulation, and therefore incur compliance costs; and
- Municipalities that own ***publicly-owned treatment works (POTWs)*** that receive influent from MP&M facilities subject to the rule may incur costs to implement the regulation. These include costs of permitting MP&M facilities that have not been previously permitted, and repermitting some MP&M facilities with existing permits earlier than would otherwise be required.

7.1.1 Impacts on Governments that Operate MP&M Facilities

Chapter 5 presented EPA's analysis of the final rule's impacts on government-owned MP&M facilities and on the governments that own them. The analysis shows that the final rule imposes only limited costs on government-owned facilities, because 3,327 (88 percent) of the 3,785 facilities are not subject to this regulation (121 General Metals facilities and 3,206 Oily Wastes facilities.) Thus, the final rule applies to 458 government owned facilities.

An estimated 162 government-owned facilities (4.3 percent of the total) would incur costs under the final rule exceeding one percent of their baseline cost of service. Therefore, 96.3 percent of the government-owned facilities either incur no costs or are likely to be able to absorb the added costs within their existing budgets. None of the affected governments incur costs that

[1] A third potential cost would be implementation cost for *direct* dischargers. However, all direct dischargers regulated under the final rule (and any alternative options considered) must already have NPDES permits in the baseline. EPA therefore does not expect governments to incur incremental administrative costs as a result of this rule for direct dischargers, because governments will incorporate the new standards into existing NPDES permits.

cause them to exceed the thresholds for impacts on taxpayers or for government debt burden. EPA therefore has concluded that the final rule will not impose budgetary burdens on any of the governments that own MP&M facilities.

7.1.2 POTW Administrative Costs

The selected option excludes all indirect dischargers from MP&M regulation. Therefore, there are no POTW administrative costs associated with the final rule. However, under some of the alternative regulatory options considered, State and local governments would incur implementation costs for indirect dischargers. This section describes the administrative activities involved and presents estimates of their costs.

EPA is able to estimate total costs to POTWs, but is not able to estimate the costs to any one POTW, since it is not possible to determine which POTWs receive discharges from the regulated MP&M facilities. EPA is also not able to assess budgetary impacts on community-owned POTWs, since available data do not provide estimates of financial characteristics for the specific POTWs receiving effluent affected by this rule. The relatively low POTW permitting costs per facility and the potential cost savings estimated in this section, however, suggest that impacts on individual POTWs, if any, would be minor.

a. Permitting activities

The General Pretreatment Regulations (40 CFR Part 403) establish procedures, responsibilities, and requirements for EPA, States, local governments, and industry to control pollutant discharges to POTWs. Under the Pretreatment Regulations, POTWs or approved States implement categorical pretreatment standards (i.e., PSES and PSNS).

Discharges from an MP&M facility to a POTW may already be permitted in the baseline.[2] For example, industrial users subject to another Categorical Pretreatment Standard would have a discharge permit. Other significant industrial users (SIU) that are typically permitted by POTWs include industrial users that:

- discharge an average of 25,000 gallons per day or more of process wastewater to a POTW,
- contribute a process waste stream which makes up 5 percent or more of the average dry weather hydraulic or organic capacity of the POTW treatment plant, or
- have a reasonable potential for adversely affecting the POTW's operation or for violating any pretreatment standard.

Since all indirect dischargers have been excluded from the final rule, EPA expects no POTW administrative costs to be associated with the rule. Under the alternative options, which include indirect dischargers, EPA expects no increase in permitting costs for facilities that already hold a permit in the baseline. However, governments will incur additional permitting costs for unpermitted facilities (under the NODA/Proposal option only) and to accelerate repermitting for some indirect dischargers that currently hold permits. On the other hand, some administrative costs might decrease. For example, control authorities would no longer have to repermit facilities that are estimated to close as the result of the regulatory options considered. Communities that own POTWs that must issue permits might therefore experience a change in costs as a result of some of the alternative regulatory options considered.

b. Data sources

EPA collected information from POTWs to support development of the MP&M effluent guideline. Of 150 surveys mailed, EPA received responses to 147, for a 98 percent response rate. The POTW Survey asked respondents to provide information on administrative permitting costs for indirect dischargers, sewage sludge use and disposal costs and practices, and general information (including number of permitted users and number of known MP&M dischargers). The administrative cost information included the number of hours required to complete specific permitting and repermitting, inspection, monitoring, and enforcement activities. Respondents were also asked to provide an average labor cost for all staff involved in permitting activities. EPA used the survey responses on administrative costs to estimate a range of costs incurred by POTWs to permit a single MP&M facility.

EPA also used the data provided in the Association of Metropolitan Sewerage Agencies (AMSA) survey to verify and, in some cases, supplement its own analyses of POTW administrative costs of the final MP&M rule. AMSA provided EPA with

[2] Under the General Pretreatment Program, a facility's discharges may be controlled through a "permit, order or similar means". For simplicity, this report refers to the control mechanism as a permit.

comments on the proposed MP&M rule and supplemented these comments with a spreadsheet database. The database contains data from an AMSA formulated survey and covers responses from 176 POTWs, representing 66 pretreatment programs. The AMSA survey was conducted to verify data from EPA's survey of POTWs and therefore included similar, although fewer, variables compared to EPA's survey. Elements EPA verified using the AMSA survey include: (1) the estimated number of indirect dischargers and (2) the unit costs of certain permitting activities, including permit implementation, sampling, and sample analysis. Elements EPA added to its analysis using the AMSA data include: (1) screening costs for POTWs that do not currently operate under a pretreatment program and (2) management oversight costs associated with implementing the MP&M regulation.

c. Methodology

EPA estimated the annualized costs of permitting indirect dischargers under the different regulatory options using the following steps:

- **Determine the number and characteristics of indirect dischargers that will be permitted under each regulatory option.** Only the NODA/Proposal option includes costs for permitting an MP&M facility for the first time. The final rule does not cover indirect dischargers while the other regulatory options only regulate those indirect dischargers that already hold permits in the baseline. For the NODA/Proposal option, EPA determined how many new permits would be issued. The NODA/Proposal option only requires concentration-based permits, no mass-based permits. In addition, EPA determined the number of facilities that currently hold a permit and that would have to be repermitted sooner than would otherwise be the case.

- **Use the data from the POTW Survey to determine a high, middle, and low hourly burden for permitting a single facility.** EPA defined the low and high estimates of hours such that 90% of the POTW responses fell above the low value and 90% of responses fell below the high value. The median value is used to define the middle hourly burden.

- **Use the data from the POTW Survey to determine the average frequency of performing certain administrative functions.** For administrative functions that are not performed at all facilities, survey data were used to calculate the portion of facilities requiring these functions. For example, the survey data show that on average 38.5% of facilities submit a non-compliance report.

- **Multiply the per-facility burden estimate by the average hourly wage.** EPA determined a high, middle, and low dollar cost of administering the rule for a single facility by multiplying the per-facility hour burden by the average hourly wage. The POTW Survey reported an average hourly labor rate of $39.33 ($2001) for staff involved in permitting. This is a fully-loaded cost, including salaries and fringe benefits.

- **Calculate the annualized cost of administering the rule.** The number of facilities, hourly burden estimate, frequency estimates, and hourly wage estimates are all combined to determine the total cost of administering the rule. The type of administrative activities required varies over time and the total administrative cost is calculated over a 15 year time period. EPA calculated the present value of total costs using a seven percent discount rate, and then annualized the present value using the same seven percent discount rate.

d. Unit costs of permitting activities

EPA estimated unit costs for the following permitting activities:

- ***Permit application and issuance***: developing and issuing concentration-based permits at previously unpermitted facilities; providing technical guidance; and conducting public and evidentiary hearings;

- ***Inspection:*** inspecting facilities both for the initial permit development and to assess subsequent compliance;

- ***Monitoring:*** sampling and analyzing permittee's effluent; reviewing and recording permittee's compliance self-monitoring reports; receiving, processing, and acting on a permittee's non-compliance reports; and reviewing a permittee's compliance schedule report for permittees in compliance and permittees not in compliance;

- ***Enforcement:*** issuing administrative orders and administrative fines; and

- ***Repermitting.***

EPA believes that these functions constitute the bulk of the required administrative activities. To these costs, EPA added a provision for managerial oversight of 25 percent.[3] There are other relatively minor or infrequent administrative functions (e.g., providing technical guidance to permittees in years other than the first year of the permit, or repermitting a facility in significant non-compliance), but their costs are likely to be insignificant compared to the estimated costs for the five major categories outlined above. EPA also added a cost for identifying facilities to be permitted for POTWs that do not currently operate under a Pretreatment Program. EPA estimates this cost to be approximately $0.8 million. This cost only applies to the NODA/Proposal Option since facilities subject to the upgrade options already hold permits.

Table 7.1 provides a summary of the estimated unit costs for each permitting activity. Appendix F provides a detailed discussion of these unit costs.

Table 7.1: Government Administrative Activities for Indirect Dischargers: Per Facility Hours and Costs

Administrative Activity	Percent of facilities for which activity is required	Frequency of activity	Typical hours and costs (2001$)		
			Low	Median	High
Develop and issue a concentration-based permit at a previously unpermitted facility	100% of unpermitted facilities (applicable to NODA/Proposal option only)	One time	4.0 hours; $122	10.0 hours; $304	40.0 hours; $1,217
Develop and issue a mass-based permit at a previously unpermitted facility	100% of MP&M facilities being issued a new mass-based permit (estimates used for the proposed rule)	One time	4.0 hours; $122	13.0 hours; $396	40.0 hours; $1,217
Develop and issue a mass-based permit at a facility holding a concentration-based permit	100% of MP&M facilities with permit conversion (estimates used for the proposed rule)	One time	2.0 hours; $61	8.0 hours; $243	20.0 hours; $608 year
Provide technical guidance to a permittee on permit compliance	100% of MP&M facilities being issued a new concentration-based permit (applicable to NODA/Proposal option only)	One time	1.5 hour; $46	4.0 hours; $122	12.0 hours; $365
	100% of MP&M facilities being issued a new mass-based permit (estimates used for the proposed rule)	One time	2.0 hours; $61	4.0 hours; $122	12.0 hours; $365
Conduct a public or evidentiary hearing	3.2% of MP&M facilities being issued a new mass-based or concentration-based permit (applicable to NODA/Proposal option only)	One time	2.0 hours; $61	8.0 hours; $243	40.0 hours; $1,217
Inspect facility for permit development	100% of MP&M facilities being issued a new permit (applicable to NODA/Proposal option only)	One Time	2.2 hours; $66	5.0 hours; $152	12.0 hours; $365
Inspect facility for compliance assessment	100% of MP&M facilities being issued a new permit (applicable to NODA/Proposal option only)	Annual	2.0 hours; $61	3.3 hours; $101	10.0 hours; $304
Sample and analyze permittee's effluent	100% of MP&M facilities being issued a new permit (applicable to NODA/Proposal option only)	Annual	1.0 hour; $30	3.0 hours; $91	17.7 hours; $537

[3] The 25 percent oversight cost provision is based on comments and data received from the Association of Metropolitan Sewerage Agencies (AMSA).

Table 7.1: Government Administrative Activities for Indirect Dischargers: Per Facility Hours and Costs					
Administrative Activity	Percent of facilities for which activity is required	Frequency of activity	Typical hours and costs (2001$)		
			Low	Median	High
Review and enter data from permittee's compliance self-monitoring reports	100% of MP&M facilities being issued a new permit (applicable to NODA/Proposal option only)	2 reports per year	0.5 hours; $15	1.0 hour; $30	4.0 hours; $122
Receive, process and act on a permittee's non-compliance reports	38.5% of all indirect dischargers receiving a new permit (applicable to NODA/Proposal option only)	5 times per year	1.0 hour; $30	2.0 hours; $61	6.0 hours; $183
Review a compliance schedule report	Meeting milestones: 16.0% of all facilities issued a new permit – 94% of the 17% who have compliance milestones (applicable to NODA/Proposal option only)	2 reports per year	0.5 hours; $15	1.0 hour; $30	2.7 hours; $81
	Not meeting milestones: 1% of all facilities issued a new permit – 6% of the 17% who have compliance milestones (applicable to NODA/Proposal option only)	2 reports per year	1.0 hours; $30	2.0 hours; $61	6.0 hours; $183
Minor enforcement action e.g., issue an administrative order	7% of MP&M facilities being issued a new permit (applicable to NODA/Proposal option only)	Annual	1.0 hour; $30	3.7 hours; $112	12.0 hours; $365
Minor enforcement action, e.g., impose an administrative fine	7% of MP&M facilities being issued a new permit (applicable to NODA/Proposal option only)	Annual	1.0 hour; $30	5.0 hours; $152	24.0 hours; $730
Repermit	100% of MP&M facilities being issued a new permit (applicable to NODA/Proposal option only)	Every 5 years	1.0 hour; $30	4.0 hours; $122	20.0 hours; $608

Source: U.S. EPA analysis of POTW Survey responses.

e. Results

Table 7.2 summarizes the number of facilities permitted and the estimated POTW permitting costs for the final rule and the alternative options considered. Appendix F presents detailed calculations of permitting costs for these regulatory options.

The results presented in Table 7.2 reflect three effects of the regulatory options on the cost of permitting indirect dischargers: (1) incremental costs from permitting currently unpermitted facilities that require a new permit for the first time (NODA/Proposal option only); (2) incremental costs from repermitting some facilities that currently hold a permit earlier than would otherwise be the case (within three years rather than within five years); and (3) cost savings from facilities that close as a result of the regulation and no longer require repermitting.

The first part of the table shows the incremental *number of facilities* requiring a new permit, requiring early repermitting, or estimated to close as a result of the rule. The second part of the table presents the resulting change in *permitting costs*. Costs are calculated by multiplying the incremental number of facilities in each year by the unit hours and cost per facility for those activities. All facilities are assumed to receive a permit within a three-year compliance period. Some facilities with existing permits are repermitted sooner than they otherwise would be on the normal five-year permitting cycle. The cost analysis calculates incremental costs by subtracting the costs of repermitting these facilities on a five-year schedule from the costs of repermitting all such facilities within three years. EPA assumes that the required initial permitting activities will be equally divided over the three-year period. The analysis also calculates the net change in the number of facilities requiring permitting by subtracting the number of facilities that close due to the rule from the number of facilities that will require new permits under each regulatory option.

Table 7.2: POTW Permitting Costs by Regulatory Option

	I: Selected Option	II: NODA/Proposal Option	III: Directs + 413 to 433 Upgrade	IV: Directs + 413+50%LL Upgrade
Number of facilities permitted:				
New concentration-based permit	n/a	103	0	0
New mass-based permit[a]	n/a	0	0	0
Conversion of existing concentration-based to a mass-based permit[a]	n/a	0	0	0
Repermitted within 3 rather than 5 years	n/a	1,434	382	566
Regulatory closures (no longer requiring permits)[b]	n/a	722	120	120
POTW permitting costs over 15 years (2001$):				
Net present value				
Low	n/a	($422,000)	($238,000)	($236,000)
Medium		($1,802,000)	($509,000)	($501,000)
High		($9,357,000)	($1,982,000)	($1,940,000)
Annualized (at 7%)				
Low	n/a	($46,000)	($26,000)	($26,000)
Medium		($198,000)	($56,000)	($55,000)
High		($1,027,000)	($218,000)	($213,000)
Maximum costs in any one year				
Low	n/a	$1,023,000	($6,000)	($3,000)
Medium		$1,022,000	($4,000)	$6,000
High		$991,000	$1,000	$48,000

[a] EPA does not require mass-based permits under any of the option considered for the final rule.
[b] Some facilities with existing permits will no longer require permitting due to regulatory closures.

Source: U.S. EPA analysis.

Because indirect dischargers were excluded from the final regulation, EPA expects no additional POTW administrative costs from the final rule. Each of the three alternative regulatory options considered would result in *reduced* POTW regulatory costs. These cost savings result from regulatory closures (i.e., facilities that currently hold a permit and would have required repermitting in the baseline, but that will no longer require repermitting under the regulatory options). The cost savings as a result of regulatory closures outweigh the additional costs associated with issuing new permits (under the NODA/Proposal option only) and repermitting on an accelerated, three-year schedule. Estimated annualized cost savings to POTWs for the three alternative regulatory options range between $0.04 and $1.0 million under the NODA/Proposal option, and between $0.03 and $0.2 million under the Directs + 413 to 433 Upgrade option and the Directs + 413+50%LL Upgrade option (all costs in ($2001).

7.2 Community Impacts of Facility Closures

EPA considered the potential for adverse impact of regulation-induced changes in employment on communities where MP&M facilities are located. Because EPA anticipates no facility closures and associated employment losses from the final regulation, EPA expects no employment-related impacts on communities in which MP&M facilities operate. See Chapter 6 for further discussion of potential employment effects.

GLOSSARY

publicly-owned treatment works (POTW): a treatment works as defined by section 212 of the Clean Water Act, which is owned by a State or municipality. This definition includes any devices or systems used in the storage, treatment, recycling, and reclamation of municipal sewage or industrial wastes of a liquid nature. (http://www.epa.gov/owm/permits/pretreat/final99.pdf)

Unfunded Mandates Reform Act (UMRA): Title II of the Unfunded Mandates Reform Act of 1995 (UMRA), Public Law 104-4, establishes requirements for Federal agencies to assess the effects of their regulatory actions on State, local, and Tribal governments and the private sector. Under §202 of the UMRA, EPA generally must prepare a written statement, including a cost-benefit analysis, for proposed and final rules with "Federal mandates" that may result in expenditures to State, local, and Tribal governments, in the aggregate, or to the private sector, of $100 million or more in any one year. Before promulgating an EPA rule for which a written statement is needed, §205 of the UMRA generally requires EPA to identify and consider a reasonable number of regulatory alternatives and adopt the least costly, most cost-effective or least burdensome alternative that achieves the objectives of the rule.

ACRONYMS

POTW: publicly-owned treatment works

UMRA: Unfunded Mandates Reform Act

Chapter 8: Foreign Trade Impacts

Chapter Contents

Introduction

EPA assessed the likely impacts on foreign trade as a result of the final rule and the alternatives considered for regulation as part of the analysis of the rule's effect on the national economy. Changes in the balance of trade have the potential to affect currency exchange rates, money supply, interest rates, inflation, capital flows and labor migration. The MP&M industry sectors include a substantial portion of the nation's economy, and significant impacts on the balance of trade in these industries could affect the overall economy.

As part of the facility impact analysis in Chapter 5, EPA assessed potential price increases and output losses that may result from the rule. EPA assessed the impact of these market-level changes on the U.S. balance of trade using information provided by MP&M private facility surveys on the source of competition in domestic and foreign markets. The trade analysis allocates the value of changes in output for each facility that is projected to close due to the rule to exports, imports or domestic sales, based on the predominant source of competition in each market reported in the surveys.

EPA's analysis predicts no foreign trade impacts as a result of the final rule because no facility closures are expected. This analysis does not account for factors such as price increases from the rule or the response of foreign producers to the rule, but EPA believes that these factors will have a negligible effect on the U.S. balance of trade. This chapter analyzes the impact on foreign trade of the alternative regulatory options for which closures are predicted.

8.1 Data Sources

The assessment of foreign trade impacts is based on the facility closure analysis in Chapter 5. The revenue from any closing facilities is assumed to be lost output attributable to the rule.

The analysis uses survey responses to determine whether a closed facility's revenues are more likely to be replaced by either domestic or foreign producers. Question 5 in the Phase I §308 survey asked respondents to identify their "major source of competition" in each of three markets: local/regional, national, and international. Question 8 in the Phase II survey asked respondents to identify their "most significant source of competition" in domestic and international markets. Respondents selected one of the following possible responses:

- domestic firms,
- foreign firms,
- no competition in this market, and
- do not operate in this market.

During the process of clarifying survey answers with respondents, EPA found that most respondents who did not select any of the sources of competition said that they did not participate in the relevant market. Therefore, if a respondent did not answer the question regarding the most important source of competition in the domestic or international markets, EPA classified the facility as not operating in the respective market (domestic or foreign).

The analysis also uses survey responses to determine revenues from exports. The Phase I §308 survey reported the percentage of revenues earned from domestic customers and from overseas markets. EPA used export share and total revenues for each facility to calculate export and domestic revenues. The Phase II survey asked respondents to report revenues from MP&M exports. EPA then calculated domestic sales by subtracting export revenues from total revenues for each facility.

The Iron & Steel survey did not report comparable information on the source of competition in domestic and foreign markets. EPA relied on published trade statistics for the products produced by facilities in the Steel Forming & Finishing subcategory to assess potential impacts on trade for these facilities.

EPA obtained 1996 import and export data from the Bureau of the Census, Foreign Trade Division for those commodities determined to be MP&M-related. The data included imports and exports by all facilities in relevant industries, including both dischargers and non-dischargers.

8.2 METHODOLOGY

The effect of an increase in domestic production costs on the foreign trade balance is influenced by a variety of factors, including:

- the extent to which domestic producers attempt to raise prices to recover costs,
- the price elasticity of demand in both domestic and export markets,
- the likely pricing and supply response of foreign producers, and
- trends in currency exchange rates.

EPA did not attempt to simultaneously model changes in prices, output, and sales in domestic and foreign markets for the products and services produced by the MP&M industry sectors. As in the facility impact analysis described in Chapter 5, the trade analysis relies on a sequential analysis that assesses price increases and then predicts output adjustments based on closures. EPA used facilities' own assessments of their competitive status relative to foreign producers, as reported in the survey, to assess impacts of these output adjustments on the balance of trade.

EPA expects that foreign firms would replace some but not all of the output from any closing facilities. Domestic firms that remain open or enter the market might also win customers that used to buy from the closing facility. Revenues lost by closing facilities are assigned to domestic or foreign producers as follows:

- ***Lost exports:*** If a closing facility stated that most of its international competition came from foreign firms, then EPA assigned the facility's export revenues to foreign firms. U.S. exports would therefore decline by the amount of the closing facility's exports. If the facility identified domestic businesses as its greatest source of competition in foreign markets, then EPA assigned the closing facility's export revenues to other domestic firms. Closures of these facilities, which reported relatively low foreign competition for exports, will have no impact on U.S. exports under the expected scenario.

- ***Increased imports:*** If a closing facility identified foreign producers as the main source of domestic sector competition, then EPA assigned the facility's lost domestic revenues to foreign firms. Imports would increase by the same amount. If other domestic businesses posed the strongest competition, then EPA assigned the closing facility's domestic sales to other U.S. producers, and imports would remain constant.

The survey data collected for the Steel Forming and Finishing facilities did not provide export data. EPA assumed that the ratio of exports to value of shipments for any closing facilities in the analysis was the same as the ratio for the industry as a whole.

From the estimated changes in exports and imports, EPA calculated the net trade impact (reduction in exports *plus* increase in imports) and compared this value to baseline trade levels for (1) all commodities and (2) MP&M sector commodities, only.

8.3 RESULTS

Chapter 3 provides an overview of exports, imports and the balance of trade in the MP&M industry sectors. U.S. MP&M producers as a group exported products with a value of $345 billion in 1996. Imports to the U.S. of the same products in 1996 totaled $421 billion, resulting in an overall net MP&M commodity trade deficit of $76 billion. Some MP&M sectors contribute to a positive commodity trade balance (e.g. aircraft, with a $27 billion positive balance in 1996). In other sectors, substantially more products are imported than exported (e.g. motor vehicles, with a net negative balance of $63 billion.)

Table 8.1, below, summarizes the estimated impact of the final rule and alternative options on the U.S. balance of trade for all commodities. Because EPA's analysis indicates that the final rule will cause no facility closures, EPA expects that the final regulation will not affect the balance of trade. As shown in the table, the other regulatory options would have a negligible impact on U.S. imports, exports, and the national trade balance. Option II (NODA option) results in the most closures and thus the largest trade impacts. However, even in this option, projected imports increase by only $85 million, or slightly more than one hundredth of one percent of baseline imports, and exports decrease by only $55 million, less than one hundredth of one percent of baseline exports. The net result for the NODA option is an insignificant 0.08 percent decline in the national balance of trade.

Table 8.1: Estimated National Impacts on Total U.S. Foreign Trade (millions, 2001$)

	1996 Exports	1996 Imports	Trade Balance[a]
Baseline	**$666,321**	**$847,767**	**($181,446)**
Option I: Selected Option			
Change due to the rule[b]	n/a	n/a	n/a
Option II: Proposed/NODA Option			
Change due to the rule	($55)	$85	($141)
Post-compliance	$666,266	$847,852	($181,587)
% Change from baseline	-0.008%	0.010%	0.078%
Option III: 413 to 433 Upgrade Option			
Change due to the rule	$0	$22	($22)
Post-compliance	$666,321	$847,789	($181,468)
% Change from baseline	0%	0.0026%	0.012%
Option IV: All to 433 Upgrade Option			
Change due to the rule	$0	$22	($22)
Post-compliance	$666,321	$847,789	($181,468)
% Change from baseline	0%	0.0026%	0.012%

[a] Trade balance is equal to exports minus imports.
[b] There were no regulatory closures in the selected option, and so this analysis predicts no foreign trade impacts.

Source: Bureau of Census and U.S. EPA analysis.

Table 8.2 shows regulatory impacts on foreign trade in MP&M industry commodities. As noted above, EPA estimates that the final rule will cause no closures and thus have no foreign trade impacts. In the other options, the projected changes in exports and imports represent only an insignificant percentage of commodity trade in the MP&M industry sectors. The largest impacts occur in Option II (NODA Option), but even these impacts result in only a 0.2 percent decline in the net trade balance in these industries.

Table 8.2: Estimated National Impacts on MP&M-Related Foreign Trade (millions, 2001$)

	1996 Exports	1996 Imports	Trade Balance[a]
Baseline	**$345,274**	**$421,015**	**($75,741)**
Option I: Selected Option			
Change due to the rule[b]	n/a	n/a	n/a
Option II: Proposed/NODA Option			
Change due to the rule	($55)	$85	($141)
Post-compliance	$345,219	$421,100	($75,882)
% Change from baseline	-0.016%	0.020%	0.186%
Option III: 413 to 433 Upgrade Option			
Change due to the rule	$0	$22	($22)
Post-compliance	$345,274	$421,037	($75,763)
% Change from baseline	0%	0.005%	0.030%
Option IV: All to 433 Upgrade Option			
Change due to the rule	$0	$22	($22)
Post-compliance	$345,274	$421,037	($75,763)
% Change from baseline	0%	0.005%	0.030%

[a] Trade balance is equal to exports minus imports.
[b] There were no regulatory closures in the selected option, and so this analysis predicts no foreign trade impacts.

Source: Bureau of Census and U.S. EPA analysis.

The analysis of trade impacts does not explicitly account for responses to price increases caused by the rule, as noted previously. However, EPA expects little change in exports and imports as a result of the minimal price increases predicted for the final rule. The estimated price increases are less than one half of one percent in all sectors (see Table 5.4 in Chapter 5). Annual rates of inflation for the United States' major trading partners are generally well above the projected increases in MP&M prices, and price increases in the projected range are not likely to materially affect the terms of U.S. trade in MP&M products.[1]

[1] The following are 1990-98 annual inflation rates, as measured by the GDP implicit deflator, for nine of the U.S.' s top ten trading partners: Canada 1.4%, Mexico 19.5%, Japan 0.2%, China 9.7%, Germany 2.2%, United Kingdom 3.0%, Republic of Korea 6.4%, France 1.7%, and Singapore 2.1%. The annual change in the U.S. GDP deflator over the same period is 1.9% (Data were not reported for Taiwan.) World Bank, *2000 World Development Indicators*, Table 4.16.

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Chapter 9: Firm Level, New Source, and Industry Impacts

INTRODUCTION

The previous chapters assessed impacts on MP&M facilities, on governments and communities, and on the U.S. balance of trade. This chapter considers impacts on private businesses in more detail, by addressing three categories of impacts. First, the analysis of impacts on firms builds on the facility impact analysis to assess whether firms that own multiple facilities are likely to incur more significant impacts than indicated by the facility impact analysis. Second, the ***new source*** facility impact analysis considers whether the final rule might impose disproportionate burdens on new sources relative to existing sources, and thereby pose a barrier to new entry. Third, this chapter discusses potential industry-level impacts of the final rule.

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9.1 FIRM LEVEL IMPACTS

EPA analyzed economic impacts on firms for the following reasons:

- Impacts may be more significant at the firm level than at the facility level if a firm owns a number of facilities that incur significant costs. To the extent allowed by the available data, the analysis therefore looks at the combined effect of the facility compliance costs for all facilities owned by a given firm.

- A firm-level analysis is needed to assess impacts on small businesses, as required by the Regulatory Flexibility Act and SBREFA. Certain findings from the firm-level analysis are used in the small business impact analysis presented in the following Chapter 10.

9.1.1 Sources

The firm-level analysis begins from the results of the facility-level analysis presented in Chapter 5, supplemented by firm-level information provided by the MP&M facility surveys and publically available information.

EPA was not able to conduct a rigorous national analysis of firm-level impacts because the sample frame used to provide national estimates from surveyed facilities reflects the population of facilities rather than firms. EPA therefore analyzed impacts for a hybrid dataset of MP&M firms that includes both national estimates (for single-facility firms) and sample firms (for multiple-facility firms), The Agency believes that the analysis of firm-level impacts presented in this chapter provides a useful indication of national firm-level impacts, however, for two reasons:

- Most MP&M facilities are single-facility firms. The survey facility sample weights can be used to extrapolate to the national number of firms for these single-site firms.

- EPA requested voluntary information in the Phase II detailed questionnaires on other MP&M facilities owned by the firms responding to the survey for a sampled facility. EPA aggregated multiple-facility compliance costs to the firm-level by including costs for all surveyed facilities and, for the Phase II survey, facilities identified in voluntary responses.

It is unlikely that firm-level impacts would be material among all MP&M firms in the nation, if this partial analysis does not indicate significant impacts among the firms identified in this analysis.

9.1.2 Methodology

The various surveys asked respondents to provide firm-level revenues for the parent firm. For single-facility firms, firm revenue and compliance costs are identical to those for the facility. For firms that own more than one sample facility, compliance costs are the sum of costs for all facilities reported on in the survey.

In Part V of the detailed Phase II questionnaire, respondents had the option to submit additional voluntary data for other MP&M facilities owned by the same parent firm. EPA did not perform a detailed engineering analysis to develop detailed estimates of compliance costs for these facilities; however, EPA used the detailed estimates of compliance costs to estimate costs for these additional facilities. EPA assumed that these additional facilities would have the same average compliance costs as facilities in the same subcategory, flow range, and discharge type for which detailed cost estimates were developed.

EPA then grouped together all facilities with a common parent firm from the Phase I, Phase II and Iron and Steel surveys. For each firm in the analysis, firm-level compliance cost is:

$$CC_{firm} = \sum_{i} CC_i \tag{9.1}$$

where:

CC_{firm} = firm-level compliance cost
CC_i = compliance cost for surveyed facility *i* owned by the firm

Firm-level compliance costs were compared to firm revenues. EPA judged that firms with compliance costs less than one percent of revenues would not be materially affected by the regulation. EPA identified firms as subject to potentially more serious impacts if their compliance costs exceeded three percent of revenues.

All firm-level data were inflated to 2001 dollars using the ***Producer Price Index (PPI)***, as described in Chapter 5.

9.1.3 Results

As noted in the introduction, the Agency was not able to estimate the national numbers of firms that own MP&M facilities precisely, because the sample weights based on the survey design represent numbers of facilities rather than firms. EPA assumed that the national facilities that are represented by the 307 sample single-site firms that remain open in the baseline are also all single-site firms. Based on this assumption, EPA estimated that 26,472 of 36,480 (or 73 percent) of private MP&M facilities nationwide are single-facility firms.

In addition, from the survey responses, EPA identified 389 sample facilities that are owned by 276 multi-facility firms. It is not known how many multi-facility firms exist at the national level, so EPA included these 276 firms in the firm-level analysis without extrapolation to the national level.

The combined set of 26,748 firms (26,472 national-level single-facility firms plus 276 sample multi-facility firms) provided the basis for the firm-level analysis. This total does not represent a valid national total for the number of affected MP&M firms. Nonetheless, this analysis provides a reasonable indication of likely firm-level impacts, given the large number of single-facility firms and the use of Part V facility data to supplement the sample facility data for multi-facility firms.

Table 9.1 presents the number of firms in the firm-level analysis. Of the 26,472 facilities that are single-facility firms, 25,297 are owned by potentially small firms. Of the 276 firms that own more than one sample facility, 85 are potentially small firms.

Table 9.1: Number of Privately Owned Facilities and Firms by Firm Type and Size[a]

	Total Firms	Owned by a small firm	Owned by a large firm
National number of single-facility firms (304 unique sample firms)	26,472	25,297	1,175
Sample multi-facility firms	276	85	191
Number of firms in the firm-level analysis	26,748	25,382	1,366

[a] Excludes firms whose only facilities close in the baseline.

Source: U.S. EPA analysis.

Table 9.2 presents estimated firm-level impacts of the MP&M rule. None of the firms in the analysis incur after-tax compliance costs greater than 1 percent of annual revenues. Of the 1,027 firms that incur any costs at all, none close or incur moderate impacts as a result of the rule.

Table 9.2: Firm-level After-Tax Annual Compliance Costs as a Percent of Annual Revenues

Firm Type	Number of Firms in the Analysis[a]	Number and Percent with After-Tax Annual Compliance Costs/Annual Revenues Equal to:					
		0% (no costs)		Between 0% and 1%		>1%	
		Number	%	Number	%	Number	%
Single-site	26,472	25,453	96.2%	1,019	3.8%	0	0.0%
Multi-site	276	269	97.5%	8	2.9%	0	0.0%
Total	26,748	25,722	96.2%	1,027	3.8%	0	0.0%

[a] Single-site firms whose only MP&M facilities close in the baseline are excluded. To be conservative, EPA included compliance costs for facilities that are owned by multi-site firms but predicted to be baseline closures in the facility impact analysis.

Source: U.S. EPA analysis.

This analysis is likely to overstate costs at the firm level because it does not consider the actions a multi-facility firm might take to reduce its compliance costs under the final rule. These include transferring functions among facilities to consolidate wet processes and take advantage of scale economies in wastewater treatment.

9.2 New Source Impacts

This section assesses the impacts of ***New Source Performance Standards (NSPS)*** and ***Pretreatment Standards for New Sources (PSNS)*** limitations on new direct and indirect MP&M dischargers. EPA examines the impact of these regulations on new dischargers to determine whether new source limitations may pose sufficient financial burden on new facilities to constitute a material barrier to entry of new establishments into the MP&M industry sectors. The first section summarizes the framework for assessing new source impacts and the second section reviews the findings from our analysis.

Disproportionate regulatory burdens for new sources could cause adverse industry-level outcomes in the long-run in several ways:

- Imposing more significant costs on new facilities can make existing sources more competitive than new sources, causing barriers to new entry.

- Barriers to entry may increase the market power of existing firms and could discourage competition over time, with resulting losses in market efficiencies.
- Creating a competitive advantage for existing facilities may hinder technological innovation, with resulting losses in productivity.

9.2.1 Methodology

EPA used the existing facility database, sample-weighted, as the basis for the new source analysis. This assumes that future entrants to the industry will look the same as indicated by the sample of facilities in the existing facility database.

To assess the potential impact of new source limitations, EPA assessed compliance costs for two cases: (1) the capital and operating cost of compliance systems for a new facility built in compliance with existing new source discharge limits ("current limits"), and (2) the capital and operating cost of compliance systems for a new facility built in compliance with discharge limits under consideration ("revised limits"), which would be more stringent than the current new source limits. The estimated capital costs for these cases account for the lower cost of a new-construction installation compared to retrofit construction at existing facilities. These compliance cost estimates are described in detail in the *Technical Development Document*. For analyzing the additional cost burden of meeting new limits, EPA calculated the incremental cost of compliance as the cost of meeting the revised limits less the cost of meeting current limits.

As noted above, EPA based its analysis of new source limits on the economic and financial information for the sample of facilities in the existing facility database. The new source analysis excludes sample facilities that are projected to close or to experience moderate economic impacts in the baseline, since the economic characteristics of these financially-weak facilities are unlikely to be representative of new facilities. In addition, EPA excluded some sample facilities from the analysis because of issues in the engineering estimation of compliance costs.

The analysis assumes that new sources would benefit from price increases resulting from the final rule for existing sources in the same way as existing sources. EPA therefore increased the average baseline revenue for new facilities by the average percentage price increase estimated for existing facilities in each subcategory/discharge category, to calculate post-regulation revenues for new sources. This effect of this adjustment on new facility revenue is minor.

To test of financial burden of revised limits and whether this burden might pose a material barrier to entry for new establishments, EPA compared the incremental total annualized cost, after-tax, with facility revenue (cost-to-revenue ratio). EPA classified the results in ranges as follows, fraction of sample-weighted facilities with cost-to-revenue ratio of less than one percent, one to three percent, three to five percent, and greater than five percent.

Table 9.3 shows the total number of privately owned MP&M facilities in the survey sample, the number of existing facilities excluded from the new source analysis, and the number of existing facilities used in this analysis.

Table 9.3: Number of Existing Facilities Used in New Source Analysis

Subcategory	Discharger Type	Total Number of Private MP&M Facilities[a]	Number of Existing Facilities Excluded from New Source Analysis[b]	Number of Existing Facilities Included in New Source Analysis
General Metals	Direct	888	181	707
	Indirect	10,419	1,824	8,594
MF Job Shop	Direct	12	0	12
	Indirect	1,530	165	1,365
Non-Chromium Anodizer	Direct[c]	122	29	93
Oily Wastes	Direct	2,108	936	1,172
	Indirect	23,292	6,148	17,144
Printed Wiring Boards	Direct	8	0	8
	Indirect	840	288	552
Railroad Rebuilders	Direct	6	0	6
Shipbuilding Dry Dock	Direct	6	0	6
All Subcategories		**39,230**	**9,571**	**29,659**

[a] EPA did not estimate new source impacts for municipal operations because "barrier to entry" is not a relevant consideration.
[b] EPA excluded an existing facility from the new source analysis either because it was financially weak in the baseline or because the engineers were unable to accurately estimate compliance costs.
[c] For the analysis of new source limit impacts on the *direct discharge* Non-Chromium Anodizer category, EPA used sample facility information for *indirect dischargers*. The final sample facility database contained no observations for direct dischargers.

Source: U.S. EPA analysis.

9.2.2 Results

Table 9.4 summarizes (1) the currently applicable discharge limit or technology option for new sources in each subcategory and discharge status, and (2) the alternative discharge limits or technology option that EPA considered in assessing whether revised new source discharge limits would constitute a barrier to entry. See Preamble Section VI and the Technical Development Document for discussion of the specific discharge limits and technology options that EPA considered for revised new source discharge limits.

Table 9.4: Current New Source Requirements and Potential Revised New Source Requirements

Subcategory	Discharge Type	Current New Source Requirements	Revised New Source Requirements
General Metals	Direct	40 CFR 433	"Modified" Option 2, (Two-Stage Precipitation)
	Indirect	40 CFR 433	Option 2
MF Job Shops	Direct	40 CFR 433	"Modified" Option 2, (Two-Stage Precipitation)
	Indirect	40 CFR 433	Option 2
Non-Chromium Anodizer	Direct	40 CFR 433	Option 2
Oily Waste	Direct	Estimated existing baseline	Option 6
	Indirect	Estimated existing baseline	Option 6
Printed Wiring Boards	Direct	40 CFR 433	Option 2
	Indirect	40 CFR 433	Option 2
Railroad Rebuilders	Direct	Option 6	Option 10
Shipbuilding Dry Dock	Direct	Option 10	Option 8

Source: U.S. EPA analysis.

Table 9.5 reports the estimated percentages of new facilities incurring cost-to-revenue impacts of: (1) less than one percent, (2) one to three percent, (3) three to five percent, and (4) greater than five percent. As discussed earlier, these estimates are based on estimated incremental new source compliance costs compared to revenues for existing facilities in the MP&M survey universe.

From this analysis, EPA found that revised new source limits would create a barrier to entry for direct discharging facilities in the General Metals, Metal Finishing Job Shops, and Non-Chromium Anodizer subcategories and indirect discharging facilities in the General Metals, Metal Finishing Job Shops, Printed Wiring Board, and Oily Wastes subcategories. On the basis of this finding, EPA decided against issuing revised new source discharge limits for these subcategories. The new source analysis indicated that revised new source limits would *not* create a barrier to entry for direct discharging facilities in the Oily Wastes, Printed Wiring Board, and Railroad Rebuilders subcategories. This finding supported EPA's decision to promulgate new source limits for the Oily Wastes direct discharger subcategory. Although the economic analysis did not indicate a barrier to entry for the Printed Wiring Board and Railroad Rebuilders direct dischargers subcategories, EPA decided against issuing new source limits for these subcategories based on other technical considerations as discussed in Preamble Section VI.

Table 9.5: Estimated Percentages of New Facilities by Cost-to-Revenue Impact Ranges

Subcategory	Discharger Type	After-Tax Compliance Costs as a Percent of Revenue			
		< 1%	1-3%	3-5%	>5%
General Metals	Direct	62%	14%	22%	2%
	Indirect	65%	14%	20%	1%
MF Job Shop	Direct	0%	0%	0%	100%
	Indirect	80%	9%	5%	6%
Non-Chromium Anodizer	Direct	25%	0%	26%	49%
Oily Wastes	Direct	97%	3%	0%	0%
	Indirect	95%	1%	5%	0%
Printed Wiring Boards	Direct	100%	0%	0%	0%
	Indirect	92%	3%	0%	5%
Railroad Rebuilders	Direct	100%	0%	0%	0%
Shipbuilding Dry Dock	Direct	100%	0%	0%	0%

Source: U.S. EPA analysis.

9.3 INDUSTRY LEVEL IMPACTS

Potential industry-level impacts include price increases, reduced competitiveness within the domestic industry and in world markets, and reduced rates of innovation. EPA did not perform a sector-specific analysis for several reasons:

- Sector-level impacts are complicated by the large number of product and service markets included in the MP&M category (e.g., over 200 SICs and three activities – manufacturing, rebuilding, and repair).

- Revenue and cost information is not available on a product by product basis, so it is impossible to link price increases to individual products. and

- Many MP&M facilities derive revenue from multiple industry sectors.

EPA's analysis of facility- and firm-level impacts suggests, however, that material industry-level impacts are unlikely in any of the affected sectors.

The Agency does not expect any industry level impacts from the MP&M regulation because of: (1) the low number of facilities that will have costs, (2) the absence of regulatory closures, and (3) the absence of moderate impacts. Of the estimated 89,000 facilities performing MP&M activities, slightly over half, or about 45,000, do not discharge water and thus will not be affected by the rule. An additional 3,593 discharge water but are expected to close in the baseline. Of the remaining 40,265 facilities that do discharge water and remain open in the baseline, EPA estimates that only 1,380 will incur costs under the final rule. That so few MP&M industry facilities incur costs results from the rule's subcategory exclusions and low-flow cutoffs.

As discussed in Chapter 5, EPA estimates that no facilities will close or incur moderate impacts as a result of the final regulation. Given no regulatory closures or moderate impacts, EPA concludes that the final rule is unlikely to impose significant costs on a substantial number of facilities in the MP&M industry as a whole or at the subcategory level.

Chapter 5 also presented information on the prices increases predicted to occur in each industry sector due to the final rule. Table 5.4 in Chapter 5 presented EPA's estimates of price increases by sector. Projected price increases are less than one half of one percent for all sectors. Price increases of these magnitudes are unlikely to impose burdens on customers of the regulated facilities or substantially affect MP&M producers' position relative to competitive products (e.g., products made with plastics) or foreign producers. Price increases may affect only some components of a product. In these cases, prices to end-users would rise even less than the amounts detailed in Chapter 5.

EPA does not expect the final rule to affect the rate of technological innovation in the MP&M industry. Innovation impacts could result if the rule discouraged new entry, contributed to increased concentration in the affected industries, or specified the use of particular technologies. The following factors suggest that these conditions do not apply for the final rule:

- EPA's analysis of new source impacts presented in the previous section suggests that the final rule will not affect entry of new businesses in the regulated sectors. The final rule will increase the investment required to build a new facility somewhat. However, the increased capital costs are generally small relative to the overall financial resources of the MP&M facilities, as indicated by the results of the facility impact analysis. In addition, the low flow cutoffs applicable to a large number of MP&M facilities reduce the potential impacts of large capital requirements on small facilities.

- Given the small fraction of facilities regulated in each sector, and absence of closures of moderate impacts for the final regulation, EPA does not expect the rule to increase concentration in any of the MP&M sectors.

- The rule does not require the use of specific production or pollution control processes or technologies. Rather, it specifies a performance standard, based on levels of pollutants in wastewaters that have been shown to be achievable by available technologies. Facilities have the flexibility to achieve these limitations using a variety of approaches, which is likely to encourage rather than discourage innovation in production and pollution control processes.

The final rule may affect the relative competitive position of different firms and facilities in those sectors that incur costs. Facilities that may benefit from the rule include those that: (1) do not discharge wastewater, (2) are eligible for the subcategory exclusions and low-flow cutoffs, (3) already have treatment in place, or (4) can more easily make process changes to reduce pollutant loads.

Facilities that have little or no treatment in place and that discharge substantial pollutant loads may become less competitive. The final rule may level the competitive playing field for facilities that have taken steps to reduce their environmental impacts, relative to facilities that have avoided investments to reduce or eliminate pollutant discharges. EPA views these effects as beneficial, given that the final regulation does not have significant impacts on the industry as a whole, and as long as the rule does not disproportionately impact small entities as a group (impacts on small entities are addressed in the next chapter).

GLOSSARY

new source: Any building, structure, facility, or installation from which there is or may be a discharge of pollutants, the construction of which commenced after promulgation of standards of performance under Section 306 of the Clean Water Act which are applicable to such source; and which (1) is constructed at a site at which no other source is located; (2) totally replaces the process or production equipment that causes the discharge of pollutants at an existing source; or (3) consists of processes that are substantially independent of an existing source at the same site.

New Source Performance Standards (NSPS): effluent limitations for new direct dischargers based on the best available demonstrated control technology. NSPS represents the greatest degree of effluent reduction attainable through the application of the best available demonstrated control technology for all pollutants (i.e., conventional, nonconventional, and priority pollutants). In establishing NSPS, EPA considers the cost of achieving the effluent reduction and any non-water quality environmental impacts and energy requirements.

Pretreatment Standards for New Sources (PSNS): pretreatment standards for new indirect dischargers, designed to prevent discharges of pollutants that pass through, interfere with, or are otherwise incompatible with the operation of POTWs. Addresses all pollutants (i.e., conventional, nonconventional, and priority pollutants). Based on the same factors as are considered in promulgating NSPS.

Producer Price Index (PPI): a family of indexes that measures the average change over time in the selling prices received by domestic producers of goods and services. PPI's measure price change from the perspective of the seller. This contrasts with other measures, such as the Consumer Price Index (CPI), that measure price change from the purchaser's perspective. Sellers' and purchasers' prices may differ due to government subsidies, sales and excise taxes, and distribution costs. (http://stats.bls.gov/ppifaq.htm#1)

ACRONYMS

NSPS: New Source Performance Standards
PPI: Producer Price Index
PSNS: Pretreatment Standards for New Sources

REFERENCES

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Chapter 10: Small Entity Impact Assessment

INTRODUCTION

The Regulatory Flexibility Act ***(RFA)***, as amended by the Small Business Regulatory Enforcement Fairness Act (***SBREFA***), requires EPA to consider the economic impacts a rule will have on ***small entities***. RFA/SBREFA requires an agency to prepare a ***Regulatory Flexibility Analysis*** for any rule subject to notice and comment rulemaking requirements, unless the Agency certifies that the rule will not have a significant economic impact on a substantial number of small entities (Small Business Regulation Enforcement Fairness Act of 1996, P.L. 104-121, Section 243).

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The economic analysis prepared for the 1995 MP&M Phase I proposal indicated that large numbers of small facilities could be impacted by the rule and that a significant number of publically-owned treatment works ***(POTWs)*** would also be affected by the rule.

EPA addressed this issue by crafting the final rule to exclude as many small facilities as possible while still covering as much of the pollutant discharge as possible. With this in mind, EPA sought, from the beginning, to design a combined phase regulation that would not unreasonably burden small entities.

To ensure that all small entities were considered in developing the MP&M regulation, EPA developed, administered, and analyzed questionnaires for all entities that could potentially be affected, including: privately- and government-owned facilities that would have to comply with the regulation, and POTWs that receive MP&M discharges. The Agency balanced several factors when defining the final rule, including:

- the predominance of small entities in the MP&M industry,
- the pounds of pollutants discharged by large and small facilities,
- the toxicity of the pollutants discharged by large and small facilities,
- the need for additional reduction in effluent discharges from the MP&M industry,
- the need to achieve these reductions without imposing unreasonable burdens on small entities, and
- the need to minimize burden on POTWs.

Given the large number of small entities that could be affected by the final rule, EPA undertook detailed analyses of potential small entity impacts and carefully considered the findings from this analysis in defining the final rule. From these assessments and based on the coverage and requirements of the final rule, EPA concluded that the final rule will not have a significant economic impact on a substantial number of small entities. EPA has therefore not prepared a Regulatory Flexibility Analysis. The following sections of this chapter describe the methodology and results of EPA's small entity impact assessment, and discuss EPA's consideration of small entity impacts in designing the rule.

10.1 DEFINING SMALL ENTITIES

EPA identified small entities using Small Business Administration ***(SBA)*** size threshold guidelines.[1] These thresholds define the minimum firm-level employment or revenue size, by industry (four-digit SIC codes), below which a business qualifies as a ***small business*** under SBA guidelines. The SBA guidelines also set a threshold for small public sector entities. A ***small government*** is one that serves a population of 50,000 or less. MP&M facilities were determined to be owned by a small entity if the parent firm or government fell below the SBA threshold.

The SBA guidelines for businesses use either employment or revenue to measure size, depending on the specific four-digit SIC industry. Manufacturing industries generally have employment size thresholds, while non-manufacturing industries typically have revenue size thresholds. EPA used employment-based thresholds for the manufacturing portion of each MP&M sector, and separate non-manufacturing thresholds for sectors that include non-manufacturing activities (e.g., maintenance and repair).

EPA selected the SBA threshold occurring most frequently among each sector's four-digit SIC codes as the sector threshold.[2] Table 10.1 presents the resulting employment size thresholds for manufacturers.

Table 10.1: Small Business MP&M Sector Thresholds for Manufacturers

MP&M Sector	Employees
Aerospace	1,000
Aircraft	1,000
Bus and Truck	500
Electronic Equipment	750
Hardware	500
Household Equipment	500
Instrument	500
Job Shop	500
Mobile Industrial Equipment	500
Motor Vehicle	500
Office Machine	1,000
Ordnance	1,000
Other Metal Products	500
Precious and Non.Precious Metals	500
Printed Circuit Board	500
Railroad	1,000
Ship and Boat	1,000
Stationary Industrial Equipment	500
Steel Forming & Finishing	1,000

Source: SBA and U.S. EPA analysis.

[1] The SBA website provides the most recent size thresholds at http://www.sba.gov/regulations/siccodes.

[2] The SBA thresholds for four-digit SICs were not used directly because the Phase II §308 survey reports revenues by MP&M sector but does not report facility SIC codes.

Table 10.2 presents the employment size thresholds for non-manufacturers, which are based on revenue except for the railroad sector. Some sectors do not have non-manufacturing industries and do not appear in this table.

Table 10.2: Small Business MP&M Sector Thresholds for Non-Manufacturers

MP&M Sector	Revenue
Aircraft	$5,000,000
Bus and Truck	$5,000,000
Household Equipment	$5,000,000
Instrument	$5,000,000
Motor Vehicle[a]	$5,000,000
Office Machine	$18,000,000
Other Metal Products	$5,000,000
Precious and Non-Precious Metals	$5,000,000
Railroad	1,500[b]
Ship and Boat[c]	$5,000,000
Stationary Industrial Equipment	$5,000,000

[a] Also has a threshold of 100 employees.
[b] Employees.
[c] Also has a threshold of 500 employees.

Source: SBA and U.S. EPA analysis.

EPA classified facilities as manufacturing or non-manufacturing and selected an MP&M sector threshold based on the sector from which they received the most revenue, as reported in the §308 surveys.[3] EPA then compared the firm-level employment or revenue for the firm owning each facility to the appropriate manufacturing or non-manufacturing threshold for that sector.

The Phase II survey asked each respondent to provide firm-level employment and revenue data. The Phase I survey also asked for firm-level revenue but not for firm employment. This omission did not matter in the case of single facility businesses, where the facility's reported employment is the firm-level employment. For multiple-facility firms in the Phase I survey, EPA estimated firm-level employment by assuming that the number of employees per revenue dollar for the firm was the same as the employees per dollar at the facility. Thus,

$$E_{firm} = E_{facility} \times \frac{R_{firm}}{R_{facility}} \qquad (10.1)$$

where:

E_{firm} = firm-level employment,
$E_{facility}$ = facility-level employment,
R_{firm} = firm-level revenue, and
$R_{facility}$ = facility-level revenue.

EPA identified facilities operated by governments that serve a population of 50,000 or fewer as being operated by small government entities. The §308 municipal survey responses provided population data in most cases, which EPA supplemented using the Bureau of the Census online 1990 Population Census database (Bureau of the Census.)

[3] The §308 MP&M surveys did not collect firm-level revenues by sector and therefore cannot be used to assign a unique sector to each firm. The assignment of a threshold was therefore based on the facility-level revenues by sector.

10.2 Methodology

EPA used several impact measures for its small entity impact analysis. First, EPA reviewed the results of the facility impact analyses described in Chapter 5 according to business size to determine whether facilities owned by small entities are disproportionately subject to moderate impacts at the facility level. Second, EPA calculated the ratio of annualized compliance costs to facility revenues and examined the distribution of this ratio for facilities owned by small versus large firms.

The analysis excluded facilities that the facility impact analysis identifies as baseline failures (see Chapter 5).

10.3 Results

10.3.1 Number of Affected Small Entities

There are an estimated 40,265 MP&M facilities nationwide (excluding baseline closures). A large number of these facilities are owned by small entities, based on SBA thresholds. Table 10.3 shows the total number of facilities operating in the baseline and the number owned by small entities. Overall, 73 percent of all MP&M facilities are owned by small entities.

Table 10.3: Number and Percent of MP&M Facilities Owned by Small Entities

Type of Facility	Number of Facilities of all Sizes Operating in the Baseline	Number of Facilities Owned by Small Entities	Percent of Facilities Owned by Small Entities
Owned by small business	36,480	27,418	75%
Owned by small government	3,785	1,962	52%
Total owned by small entities[a]	40,265	29,380	73%

[a] Excludes baseline closures.

Source: U.S. EPA analysis.

EPA has limited the scope of the final rule to MP&M facilities performing oily operations. Table 10.4 shows that only a small percentage (five percent) of small entities are potentially subject to regulation. The final rule excludes a large percentage (95 percent) of small entity-owned MP&M facilities from regulation.

Table 10.4: Percent of Facilities Owned by Small Entities Excluded under the Final Option

Type of Facility	Number of Facilities Operating in the Baseline	Number of Facilities Not Subject to the Final Rule	Percentage of Facilities Not Subject to the Final Rule
Owned by small business	27,418	26,368	96%
Owned by small government	1,962	1,682	86%
Total owned by small entities	29,380	28,050	95%

Source: U.S. EPA analysis.

10.3.2 Impacts on Facilities Owned by Small Entities

The facility impact analysis findings provide the first measure EPA used to assess impacts on facilities owned by small entities. No facilities, small or large, are projected to close or experience moderate impacts as a result of the final rule. A second approach to assessing small entity impacts – based on a comparison of compliance costs to post-compliance revenues – indicates that no facilities will incur costs exceeding 1 percent of revenues, and only 1,019 facilities owned by small private businesses will incur any costs at all. This corresponds to 3.7 percent of the facilities owned by small private businesses that operate in the baseline.

Table 10.5 summarizes the results of the facility impact analysis for facilities owned by small entities for the final rule and the options considered by EPA.

Table 10.5: Closures and Moderate Impacts for Facilities Owned by Small Entities

	Final Option	Option II	Option III	Option IV
Number of facilities operating in the baseline	29,380	29,380	29,380	29,380
Number of facilities excluded from option	28,050	23,893	27,118	26,907
Percent excluded	95.5%	81.3%	92.3%	91.6%
Number of facilities with closures	0	813	109	109
Facilities with closures as a percent of facilities operating in the baseline	0.0%	2.8%	0.4%	0.4%
Facilities with closures as a percent of regulated facilities	0.0%	14.8%	4.8%	4.4%
Number of facilities with moderate impacts	0	0	37	37
Facilities with moderate impacts as a percent of facilities operating in the baseline	0.0%	0.0%	0.1%	0.1%
Facilities with moderate impacts as a percent of regulated facilities	0.0%	0.0%	1.6%	1.5%

Source: U.S. EPA analysis.

In summary, no facilities owned by small entities that operate in the baseline are expected to close or experience moderate impacts under the final rule.

Table 10.6 shows the results of the second approach to assessing small entity impacts, based on a comparison of compliance costs with facility revenues. EPA conducted this analysis only for MP&M facilities owned by private entities (i.e., businesses, but not governments), because of the low level of impacts on all sizes of governments.

Table 10.6: After-Tax Annual Compliance Costs as a Percent of Annual revenues under the Final Option for Facilities Owned by Private Small Businesses[a]

Discharge Status	Number of Facilities Owned by Small Private Businesses Operating in the Baseline	Number and Percent of Facilities Owned by Small Businesses that are Not Regulated		Number and Percent of Facilities Owned by Small Businesses with After-Tax Annual Compliance Costs/Annual Revenues Equal to:					
				No Cost		More than 0% and less than 1%		Over 1%	
		Number	%	Number	%	Number	%	Number	%
Direct	1,168	119	13.9%	31	2.5%	1,019	83.6%	0	0.0%
Indirect	26,253	26,253	100.0%	0	0.0%	0	0.0%	0	0.0%
Total[b]	27,418	26,368	96.2%	31	0.1%	1,019	3.7%	0	0.0%

[a] Includes only facilities that remain open in the baseline.
[b] The sum of the number of direct and indirect dischargers does not add up to the total because some facilities are both indirect and direct dischargers.

Source: U.S. EPA analysis.

Of the facilities owned by small entities that operate in the baseline, 96.2 percent are not regulated under the final rule. Another 0.1 percent are regulated but do not incur costs. The remaining 3.7 percent incur compliance costs but none incur after-tax annualized costs exceeding 1 percent of annual revenue. These results are consistent with the finding that no facilities owned by small business will close or experience moderate financial impacts.

10.3.3 Impacts on Small Firms

EPA also performed a firm-level analysis in which it compared compliance costs with revenue at the firm level as a measure of compliance cost burden. EPA applied this analysis only for facilities owned by private entities (i.e., businesses, but not governments). Table 10.7 shows the results of this comparison. The Agency was not able to estimate national numbers of firms that own MP&M facilities precisely, because the sample weights based on the survey design represent numbers of facilities rather than firms. Most of the facilities owned by small firms (25,297 of 27,578, or 92 percent) are single-facility firms, however. These single-facility firms can be analyzed using sample weights. In addition, 85 small multi-facility firms own at least one sample facility. These firms are included in the analysis but with a sample weight of one, since it is not known how many sample firms these 85 small firms represent. The results shown in Table 10.7 therefore represent a total of 25,382 small MP&M firms (25,297 + 85).

Table 10.7: Firm Level Before-Tax Annual Compliance Costs as a Percent of Annual Revenues for Private Small Businesses

Number of Small Firms in the Analysis[a]	Number and Percent with Before-Tax Annual Compliance Costs/Annual Revenues Equal to:					
	0% (no costs)		>0% and <1%		Over 1%	
	Number	%	Number	%	Number	%
25,382	24,363	95.99%	1,019	4.01%	0	0%

[a] Firms whose only MP&M facilities close in the baseline are excluded.

Source: U.S. EPA analysis.

The vast majority, 96 percent, of the small businesses in the analysis incur no costs due to the rule. The remaining 4 percent, equal to 1,019 firms, incur before-tax compliance costs of less than 1% of their after-tax revenues. Of these 1,019 small firms, none were reported in the facility impact analysis to experience moderate impacts due to the final rule.

10.4 Consideration of Small Entity Impacts in Developing the Final Rule

EPA gave special consideration to impacts on small entities in defining the final regulation. In particular, EPA attempted to minimize impacts on small entities while at the same time meeting Clean Water Act objectives of reducing pollutant discharges to the nation's waterways. The final rule minimizes impacts on small entities primarily by excluding all indirect dischargers and direct dischargers in all subcategories except Oily Wastes.

Table 10.8 shows the number and percentage of facilities owned by small versus large entities that are projected to close or experience moderate impacts under the final and alternative regulatory options analyzed by EPA in developing the final regulation.

Table 10.8: Percent of Facilities Estimated to Close or Experience Moderate Impacts by Owning Entity Size Class and by Regulatory Option

Regulatory Option and Type of Facility	Number of Facilities				
	Subject to Regulation	Projected to Close	Percent Closing	Experiencing Moderate Impacts	Percent with Moderate Impacts
Final Regulatory Option					
Owned by Small Entities	1,330	0	0.0%	0	0.0%
Owned by Large Entities	1,052	0	0.0%	0	0.0%
Total	2,382	0	0.0%	0	0.0%
Option II					
Owned by Small Entities	5,487	813	14.8%	0	0.0%
Owned by Large Entities	2,863	0	0.0%	0	0.0%
Total	8,350	813	9.7%	0	0.0%
Option III					
Owned by Small Entities	2,262	109	4.8%	37	1.6%
Owned by Large Entities	1,182	0	0.0%	0	0.0%
Total	3,444	109	0.5%	37	1.1%
Option IV					
Owned by Small Entities	2,473	109	4.4%	37	1.5%
Owned by Large Entities	1,453	0	0.0%	12	0.8%
Total	3,926	109	2.8%	49	1.2%

Source: U.S. EPA analysis.

As reported in the table, the final rule avoids entirely the more material impacts on small entities that likely would have occurred under the alternative regulatory options.

In addition to avoiding impacts in the regulated community, the final rule, by excluding indirect discharging facilities from revised limits, also eliminated the potential additional burden to POTWs, including small POTWs, from issuance of new and revised permits. Chapter 11 and Appendix F discuss POTW administrative activities and costs under the four regulatory options.

GLOSSARY

Regulatory Flexibility Analysis: an evaluation of the impact of a rule and alternative regulatory options on small entities.

small entity: a business, government or non-profit organization defined as small for EPA's RFA/SBREFA evaluation.

small business: a business with employment or revenue below the threshold specified by the Small Business Administration for each 4-digit SIC.

small government: a government that serves a population of 50,000 or less, as defined by the Small Business Administration.

ACRONYMS

POTW: Publicly-owned treatment works
RFA: Regulatory Flexibility Act
SBA: Small Business Administration
SBREFA: Small Business Regulatory Enforcement Fairness Act

REFERENCES

U.S. Department of Commerce, Bureau of the Census. Statistics of U.S. Businesses.

U.S. Small Business Administration. http://www.sba.gov/regulations/siccodes.

Chapter 11: Social Costs

INTRODUCTION

CHAPTER CONTENTS

This chapter presents EPA's estimates of the regulation's costs to society. Previous chapters described the economic impacts of the final rule in terms of facility closures and moderate financial impacts, employment losses, community impacts, international trade effects, financial impacts on firms owning MP&M facilities, and impacts on small entities. The economic impact analyses were based on the estimated costs to MP&M facilities of complying with the regulation. These costs of labor, equipment, material, and other economic resources needed for regulatory compliance are also the major component of the cost to society of the regulation. Other components of social costs include costs to governments administering the regulation, and the social costs associated with unemployment resulting from facility closures.

Section 11.1 provides an overview of the three components of social cost analyzed for this regulation: the cost of society's economic resources used to comply with the rule; the cost to governments of administering the rule; and the social costs of unemployment resulting from the rule. The next three sections discuss each of these three components of social cost in more detail. The last section, Section 11.5, summarizes the estimated total social costs.

11.1 COMPONENTS OF SOCIAL COSTS

The ***social costs*** of regulatory actions are the ***opportunity costs*** to society of employing scarce resources in pollution prevention and pollution control activities. The social costs of regulation include both monetary and non-monetary outlays made by society. Monetary outlays include the resource costs of compliance, government administrative costs, and other adjustment costs, such as the cost of relocating displaced workers. Non-monetary outlays, some of which can be assigned monetary values, include losses in consumers' and producers' surplus in affected product markets, the adverse effects of involuntary unemployment, possible loss of time (e.g., delays in investment decisions), and possible adverse impacts on the rate of innovation.

To assess the MP&M regulation's social costs, EPA relied first on the estimated costs to MP&M facilities for the labor, equipment, material, and other economic resources needed to comply with the regulation. The compliance costs used to estimate total social costs differ from those used to assess facility- and firm-level economic impacts in their consideration of taxes and revenue effects. In the facility and firm impact analysis, compliance costs are measured as they affect the financial performance of regulated facilities and firms. The analyses therefore explicitly consider the tax deductibility of compliance expenditures.[1] In the analysis of costs to society, however, these compliance costs are considered on a before-tax basis. In general, because tax deductibility reduces the burden of compliance expenditures to private firms, the estimated compliance costs are greater from the perspective of society than from the perspective of private industry. In addition, the analysis of the regulation's impact on regulated facilities and firms accounted for potential recovery of compliance costs through output price increases. The assessment of social cost ignores these potential cost offsets because, like taxes, they represent only a transfer of compliance costs from the complying entity and not a true reduction in compliance cost.

Social costs also include lost producers' and consumers' surplus that result from reduction in the quantity of goods and services produced. Lost ***producers' surplus*** is measured as the difference between revenues earned and the cost of production for the lost production. Lost ***consumers' surplus*** is the difference between the price paid by consumers for the lost production and the maximum amount they would have been willing to pay for those goods and services.

[1] Costs incurred by government facilities are not adjusted for taxes, since these facilities are not subject to income taxes.

Accurate calculation of lost producers' and consumers' surplus requires knowledge of market supply and demand characteristics for each affected industry. EPA was not able to conduct an industry-specific partial equilibrium analysis of changes in market prices and output, both because of the very large number of markets involved and because it was not possible to link compliance costs to specific products at multi-sector facilities.

EPA's assessment of social cost includes two additional cost elements: the cost to governments of administering permitting and compliance monitoring activities under the regulation, and the social costs associated with unemployment that may result from facility closures. The unemployment-related costs include the cost of administering unemployment programs for workers who are projected to lose employment (but not the cost of unemployment benefits, which are a transfer payment within society); and an estimate of the amount that workers would be willing to pay to avoid involuntary unemployment.

11.2 RESOURCE COSTS OF COMPLIANCE

This section reviews the resource costs of compliance for the final rule and the costs for the alternative regulatory options considered by EPA. The resource costs of compliance are the value of society's productive resources – including labor, equipment, and materials – expended to achieve the reductions in effluent discharges required by the regulation. The social costs of these resources are higher than the financial burden borne by facilities because facilities are able to deduct the costs from their taxable income and may be able to recover some of the costs through price increases to customers. The costs to society, however, are the full value of the resources used, whether paid for by the regulated facilities, by taxpayers in the form of lost tax revenues, or by customers through increased prices. EPA included no costs for facilities assessed as baseline closures.

EPA estimated after-tax annualized compliance costs of $11.9 million for the final regulation (see *Chapter 5: Facility Impact Analysis*, Table 5.6). The estimated social value of these compliance costs, however, is $13.8 million, as shown in Table 11-1. This amount represents the value to society of the resources that would be used to comply with the rule.

For the alternative regulatory options, EPA's estimates included compliance costs both for facilities estimated to close because of the rule and for facilities estimated to continue operating under the regulation. This approach results in an upper-bound estimate of the social costs of compliance, since the lost value incurred by closing facilities is presumably less than the estimated cost of compliance.[2]

Under the Proposed/NODA Option, annual compliance costs amount to $1,111.4 million for indirect dischargers and $508.9 million for direct dischargers (2001$). The total annualized compliance costs are $1,620.3 million, or approximately 117 times the compliance costs under the final rule. This cost increase results from including additional subcategories under the Proposed/NODA Option. General Metals indirect dischargers, which are excluded from the final regulation, account for approximately 40 percent of the total compliance costs under the Proposed/NODA Option.

Under the Directs + 413 to 433 Upgrade Option, annual compliance costs amount to $83.0 million for indirect dischargers and $13.8 million for direct dischargers (2001$). The total annualized compliance costs are $96.8 million, or approximately 7 times the final rule's compliance costs. This cost increase results from requiring indirect dischargers that currently comply with the standards of 413 to upgrade to 433 standards. General Metals facilities, which are excluded from the final regulation, account for approximately 44 percent of the total compliance costs under this option.

Under the Directs + All to 433 Upgrade Option, annual compliance costs amount to $124.4 million for indirect dischargers and $13.8 million for direct dischargers (2001$). The total annualized compliance costs are $138.2 million, or approximately 10 times the compliance costs under the final rule. This cost increase results from requiring general metals facilities that currently comply local limit standards to upgrade to 433 standards. General Metals facilities, which are excluded from the final regulation, account for approximately 61 percent of the total compliance costs under this option.

[2] Including costs for regulatory closures yields an estimate of social costs assuming that every facility continued to operate post-regulation. Calculating costs as if all facilities continue operating will overstate social costs if some facilities find it more economical to close than comply with the regulation.

Table 11.1: Resource Value of Compliance Costs (millions, 2001$)

Subcategory	Indirect	Direct	Total
Option I: Selected Option (Directs Only)			
General Metals	$0.0	$0.0	$0.0
MF Job Shop	$0.0	$0.0	$0.0
Non Chromium Anodizing	$0.0	$0.0	$0.0
Oily Wastes	$0.0	$13.8	$13.8
Printed Wiring Boards	$0.0	$0.0	$0.0
Railroad Rebuilders	$0.0	$0.0	$0.0
Shipbuilding Dry Docks	$0.0	$0.0	$0.0
Total	**$0.0**	**$13.8**	**$13.8**
Option II: Proposed/NODA Option			
General Metals	$652.9	$396.1	$1,049.0
MF Job Shop	$185.2	$4.6	$189.8
Non Chromium Anodizing	$0	$38.0	$38.0
Oily Wastes	$92.8	$35.9	$128.7
Printed Wiring Boards	$157.9	$0.3	$158.2
Railroad Rebuilders	$0.0	$0.7	$0.7
Shipbuilding Dry Docks	$0.0	$3.2	$3.2
Steel Forming & Finishing	$22.6	$30.1	$52.7
Total	**$1,111.4**	**$508.9**	**$1,620.3**
Option III: Directs + 413 to 433 Upgrade Option			
General Metals	$42.4	$0.0	$42.4
MF Job Shop	$17.1	$0.0	$17.1
Non Chromium Anodizing	$0.0	$0.0	$0.0
Oily Wastes	$0.0	$13.8	$13.8
Printed Wiring Boards	$23.5	$0.0	$23.5
Railroad Rebuilders	$0.0	$0.0	$0.0
Shipbuilding Dry Docks	$0.0	$0.0	$0.0
Total	**$83.0**	**$13.8**	**$96.8**
Option IV: Directs + All to 433 Upgrade Option			
General Metals	$83.8	$0.0	$83.8
MF Job Shop	$17.1	$0.0	$17.1
Non Chromium Anodizing	$0.0	$0.0	$0.0
Oily Wastes	$0.0	$13.8	$13.8
Printed Wiring Boards	$23.5	$0.0	$23.5
Railroad Rebuilders	$0.0	$0.0	$0.0
Shipbuilding Dry Docks	$0.0	$0.0	$0.0
Total	**$124.4**	**$13.8**	**$138.2**

Source: U.S. EPA analysis.

11.3 POTW Administration Costs

This section discusses the POTW administrative costs of the final rule and the costs of the alternatives considered by EPA. EPA estimates that the final rule will not increase POTW administrative costs. EPA expects no increase in permitting costs for facilities that already hold a permit in the baseline. However, governments will incur additional permitting costs from (1) permitting of unpermitted facilities (under the NODA/Proposal option only) and (2) acceleration of repermitting for some indirect dischargers that currently hold permits. The alternative regulatory options may also cause some administrative costs to decrease. For example, control authorities will no longer have to repermit facilities that are estimated to close as a result of the MP&M rule.

Table 11.2 shows the number of facilities requiring a new permit under the four options considered for the final rule. Only the NODA/Proposal option would require POTWs to issue new concentration-based permits for the first time. None of the options considered would require a new mass-based permit or a conversion from a concentration-based to a mass-based permit. The table also shows the number of facilities that will require early repermitting (within three years rather than within five years), the number of estimated regulatory closures, and the total number of facilities that are expected to require permits under the different regulatory options.

Table 11.2: Permitting Requirements for Regulatory Alternatives (number of indirect discharging facilities)

Permitting required:	Option I: Selected Option	Option II: NODA/Proposal Option	Option III: Directs + 413 to 433 Upgrade	Option IV: Directs + All to 433 Upgrade
New concentration-based permit	n/a	103	0	0
New mass-based permit[a]	n/a	0	0	0
Convert from existing concentration-based to mass-based[a]	n/a	0	0	0
Repermit within 3 rather than 5 years	n/a	1,434	382	566
Regulatory closures (no longer requiring permits)[b]	n/a	722	120	120
Number of facilities operating post-regulation requiring a permit	n/a	3,687	954	1,414

[a] EPA does not require mass-based permits under any of the option considered for the final rule.
[b] Some facilities with existing permits will no longer require permitting due to regulatory closures.

Source: U.S. EPA analysis.

Table 11.3 below presents the estimated permitting costs to governments of administering the final rule and alternative options. *Chapter 7: Government and Community Impact Analysis* describes the methodology used to estimate these administrative costs.

Because the final regulation excludes from coverage all indirect dischargers, EPA estimates that the final rule will not increase POTW administrative costs. Each of the three alternative regulatory options considered would result in *reduced* POTW regulatory costs. These cost savings result from regulatory closures (i.e., facilities that currently hold a permit and would have required repermitting in the baseline, but that will no longer require repermitting under the regulatory options). The cost savings from regulatory closures outweigh the additional costs for issuing new permits (under the NODA/Proposal option only) and repermitting on an accelerated, three-year schedule. Estimated annualized cost savings to POTWs for the three alternative regulatory options range between $0.05 and $1.0 million under the NODA/Proposal option, and between $0.03 and $0.2 million under the Directs + 413 to 433 Upgrade option and the Directs + 413+50%LL Upgrade option (all costs in ($2001).

Table 11.3: Annualized Government Administrative Costs by Regulatory Option ($2001)

Option	Low	Medium	High
Option I: Selected Option (Directs Only)	n/a	n/a	n/a
Option II: Proposed/NODA Option	($46,000)	($198,000)	($1,027,000)
Option III: Directs + 413 to 433 Upgrade Option	($26,000)	($56,000)	($218,000)
Option IV: Directs + All to 433 Upgrade Option	($26,000)	($55,000)	($213,000)

Source: U.S. EPA analysis.

11.4 Social Costs of Unemployment

This section discusses the social costs of unemployment associated with the final rule and the alternatives EPA considered. The loss of jobs from facility closures would represent a social cost of the regulation. However, from its facility impact analysis, EPA estimates that no facilities will close as a result of the regulation. EPA did not recognize possible savings in unemployment-related costs from jobs created by the rule as a negative cost (benefit) of the regulation. Accordingly, EPA estimates a zero cost of unemployment for the final rule.

Chapter 6: Employment Effects discusses the effects of the alternative regulatory options on employment, including the jobs potentially lost due to facility closures and the jobs potentially created by expenditures to comply. This section estimates the social cost of the estimated changes in employment. EPA considered two components of the social cost of unemployment:

- The cost of worker dislocation (exclusive of cash benefits) to unemployed individuals, as measured by their willingness to pay to avoid unemployment; and

- The additional cost to governments to administer unemployment benefits programs.

11.4.1 Social Cost of Worker Dislocation

EPA calculated the cost of worker dislocation based on an estimate of the value that workers would pay to avoid involuntary job losses. The amount that workers would pay to avoid a job loss was derived from hedonic studies of the compensation premium required by workers to accept jobs with a higher probability of unemployment. This framework has been used in the past to impute a trade-off between wages and job security (Topel, 1984; Adams, 1985; Anderson and Chandran, 1987). Specifically, this estimate approximates a one-time willingness-to-pay to avoid an involuntary episode of unemployment and reflects all monetary and non-monetary impacts of involuntary unemployment incurred by the worker. It does not include any offsets to the cost of unemployment, such as unemployment compensation or the value of increased leisure time.

Studies by Topel (1984) and Adams (1985) suggest that the compensation premium for accepting a one percent increase in the annual probability of unemployment is in the range of 2.5 percent to 3.3 percent of the base compensation value. To illustrate this finding, assume that a worker is presented with a choice between two employment opportunities: one with compensation of $30,000 per year and an annual unemployment probability of zero, and a second otherwise equivalent opportunity but with an annual unemployment probability of one percent. For the worker to accept the second opportunity, his or her compensation must be at least 2.5 to 3.3 percent greater than the $30,000 offered for the first opportunity, or at least $30,750 to $30,990 (depending on the percentage premium used). In this case, the dollar premium required to accept the additional one percent annual probability of unemployment is $750 to $990.

For analyzing the unemployment-related costs of the MP&M regulation, the hypothetical choice is assumed to be between an employment opportunity with a zero percent annual probability of unemployment and a second opportunity with a 100 percent annual probability of unemployment. In this case, the one-time premium for accepting the employment opportunity with the 100 percent probability of employment is assumed to be 250 to 330 percent of the compensation for the otherwise comparable employment opportunity with the assumed zero probability of employment.[3] To estimate the premium for an increase in the probability of unemployment requires an estimate of the average compensation to workers in the MP&M industry. EPA calculated an average annual compensation for MP&M industry production workers of $38,309 (2001$)[4] Accordingly, the annual compensation premium for a one percentage point increase in the annual probability of unemployment would be $958 to $1,264 and the cost of a 100 percent probability event would be $95,772 to $126,420 (2001$). This calculation assumes that the cost of a certainty unemployment event is directly proportional to the increase in probability from the low probability event (i.e., one percent) on which the calculation is based.

Chapter 6: Employment Effects presents EPA's estimate that as many as 32,729 jobs might be lost due to facility closures under the Proposed/NODA Option. Multiplying these 32,729 job losses by the estimated range of willingness-to-pay values for avoiding unemployment results in a total cost of unemployment for the Proposed/NODA Option of $3.1 billion to $4.1 billion (2001$). EPA annualized these values over a 15-year period at a 7 percent rate, yielding an annualized cost of $344 to $454 million. These values are the annualized amounts over a 15-year period that workers would be willing to pay to avoid the job losses projected to result from compliance with the Proposed/NODA Option.

EPA estimates that as many as 7,874 jobs might be lost due to facility closures under the Directs + 413 to 433 Upgrade Option and the Directs + All to 433 Upgrade Option. Multiplying these 7,874 job losses by the estimated range of willingness-to-pay values for avoiding unemployment results in a total cost of unemployment for both of the 433 Upgrade Options of $754 million to $995 million (2001$). EPA annualized these values over a 15-year period at a 7 percent rate, yielding an annualized cost of $83 to $109 million.

11.4.2 Cost of Administering Unemployment Benefits Programs

Unemployment as the result of regulation also imposes costs on society through the additional administrative burdens placed on the unemployment system. The cost of unemployment benefits *per se* is not a social cost but instead a transfer payment within society from taxpayers to the unemployed. Administrative costs include the cost of processing unemployment claims, retraining workers, and placing workers in new jobs. Data obtained from the Interstate Conference of Employment Security Agencies indicated that the cost of administering an initial unemployment claim over the period 1991-1993 averaged $93.25 (1991$-1993$). These costs included total Federal and State funding for administering unemployment benefit programs but not the cost of the benefits themselves. Inflating this estimate to 2001 dollars using the BLS Employment Cost Index for and Local Government workers yields a value of $122 per claim.[5] Based on this estimate, EPA assumed that the cost of administering unemployment programs would amount to approximately $122 per job loss. Multiplying this figure by the estimated loss of 32,729 jobs under the Proposed/NODA Option yields an additional $4.0 million in social costs. EPA annualized this value over the 15-year analysis period at a 7 percent rate to yield an annual cost of approximately $438,027 (2001$). Multiplying the per job loss estimate of the cost of administering unemployment by the estimated loss of 7,874 jobs under the 433 Upgrade Options yields almost an additional $960,000 in social costs. EPA annualized these values over the 15-year analysis period at a 7 percent rate to yield an annual cost of $105,000 under the 433 Upgrade Options.

11.4.3 Total Cost of Unemployment

As mentioned above, EPA did not estimate a cost of unemployment for the final rule because no job loss is expected. As shown in Table 11.4 below, the 32,729 estimated job losses at facility closures under the Proposed/NODA Option have an estimated social cost of $345 million to $455 million (2001$). The 7,874 estimated job losses at facility closures under the 433 Upgrade Options have an estimated social cost of $83 million to $109 million (2001$).

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[3] This analysis has a considerable artificiality in that a worker would not realistically be presented with this choice. The artificiality of the choice in turn underscores the very strong assumption in the analysis. That is, that the cost of an unemployment event can be estimated by linearly extrapolating the premium estimated for small percentage differences in the probability of unemployment to a circumstance in which the probability of unemployment is 100 percent. An investigation of literature on unemployment failed to find an alternative method for estimating unemployment costs. This analytic issue warrants further research.

[4] Calculated the total payroll ($407.7 billion) / total employment (12.2 million) in MP&M SIC codes based on data obtained from the 1997 Economic Censuses which is $33,508. Inflated this estimate to 2001 dollars using the BLS Seasonally Adjusted Employment Cost Index (ECI) for Private Industry Manufacturing - 1997 (4th Qtr): 135.4, 2001 (4th Qtr): 154.8.

[5] BLS, 2000. Table 1a: Employment Cost Index (Compensation), State and Local Government: 1992 (December): 118.5, 1999 (December): 144.2.

Table 11.4: Total Annual Social Costs of Unemployment (millions, 2001$)				
Social Cost of Unemployment Categories	**Option I: Selected Option (Directs Only)**	**Option II: Proposed/NODA Option**	**Option III: Directs + 413 to 433 Upgrade**	**Option IV: Directs + All to 433 Upgrade**
Employment Loss in Closing Facilities	**n/a**	**32,729**	**7,874**	**7,874**
Annualized Worker Dislocation Cost				
Low Unit Cost (based on 2.5 percent premium)	n/a	$344.16	$82.80	$82.80
High Unit Cost (based on 3.3 percent premium)	n/a	$454.29	$109.30	$109.30
Annualized Unemployment Administration Cost (million 2001$)	n/a	$0.44	$0.11	$0.11
Sum, Worker Dislocation and Unemployment Administration Costs (based on employment loss in closing facilities)				
Low Value	n/a	$344.60	$82.91	$82.91
High Value	n/a	$454.73	$109.40	$109.40

Source: U.S. EPA analysis.

11.5 Total Social Costs

Summing across the final rule's social cost components results in a total social cost estimate of $13.8 million annually (2001$), as shown in Table 11.5. The total social costs of the Proposed/NODA Option range between $2.0 billion and $2.1 billion. The total social costs for the Directs + 413 to 433 Upgrade Option range between $180 million and $206 million. The total social costs for the Directs + All to 433 Upgrade Option range between $221 million and $247 million.

Table 11.5: Total Social Cost (millions, 2001$)							
Social Cost Categories	**Option I: Selected Option (Directs Only)**	**Option II: Proposed/NODA Option**		**Option III: Directs + 413 to 433 Upgrade**		**Option IV: Directs + All to 433 Upgrade**	
		Low	**High**	**Low**	**High**	**Low**	**High**
Resource cost of compliance expenditures	$13.8	$1,620.3		$96.8		$138.2	
Costs to POTWs of administering the rule	$0.0	($0.05)	($1.0)	($0.03)	($0.2)	($0.03)	($0.2)
Social costs of unemployment	$0.0	$344.6	$454.7	$82.9	$109.4	$82.9	$109.4
Total Social Cost	**$13.8**	**$1,964.8**	**$2,074.0**	**$179.7**	**$206.0**	**$221.1**	**$247.4**

Source: U.S. EPA analysis.

GLOSSARY

consumers' surplus: the value that consumers derive from goods and services above the price they have to pay to obtain the goods and services.

opportunity cost: the lost value of alternative uses of resources (capital, labor and raw materials) used in pollution control activ ities.

producers' surplus: the difference between what producers' earn on their output and the economic costs of producing that output, including a normal return on capital.

social costs: the costs incurred by society as a whole as a result of the final rule; does not include costs that are simply transfers among parties but that do not represent a net cost overall.

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Chapter 12: Benefit Overview

INTRODUCTION

Part III of the EEBA assesses the benefits to society from the reduced effluent discharges that will result from the MP&M industry regulations. EPA expects that benefits will accrue to society in several broad categories, including reduced health risks, enhanced environmental quality, and increased productivity in economic activities that are adversely affected by MP&M industry discharges.

This chapter provides a discussion of the ***pollutants of concern (POCs)***, their effect on human health, their environmental effects, a framework for understanding the benefits likely to be achieved by the MP&M regulation, and a qualitative discussion of those benefits. The following chapters quantify and estimate the economic value of these benefit categories. Appendices I and H provide further information on environmental effects of MP&M pollutants and water quality models used to assess these effects.

CHAPTER CONTENTS

EPA estimated national benefits expected to accrue from the regulation on the basis of sample facility data. The Agency extrapolated findings from the sample facility analyses to the national level using two alternative extrapolation methods: (1) traditional extrapolation and (2) post-stratification extrapolation. The traditional extrapolation approach relies on sample facility weights that were developed based on information about the economic and technical characteristics of the regulated community. This extrapolation approach does not incorporate information that could significantly affect the occurrence and distribution of regulatory benefits, such as characteristics of the receiving water body and the size of the population that may benefit from reduced pollutant discharges. EPA recognizes that using a traditional extrapolation method to estimate national level benefits may lead to a large degree of uncertainty in benefits estimates. Thus, EPA also used an alternative set of sampling weights, based on a post-sampling stratification method, to calculate alternative national estimates of benefits. EPA adjusted the original sample weights using two variables that are likely to affect the occurrence and size of benefits associated with reduced discharges from sample MP&M facilities: receiving water body type and size, and the size of the population residing in the vicinity of the sample facility. The following chapters present two sets of estimates of benefits expected to accrue from the MP&M regulation based on both traditional and post-stratification extrapolation approaches. Appendix G of this report provides detailed information on extrapolation methods.

In addition, the Agency used the Ohio case study results to develop a third estimate of the monetary value of national benefits.[1] EPA extrapolated the Ohio case study results to the national level based on three key factors that affect the occurrence and magnitude of benefits: (1) the estimated change in the MP&M pollutant loadings, (2) the level of recreational activities on the reaches affected by MP&M discharges, and (3) state level income. The Agency recognizes that this method is not rigorous for extrapolation to the national level. Therefore, EPA used this method only as a sensitivity analysis (see Appendix G of this report for detail).

EPA notes that effluent limitations guidelines for the MP&M industry are technology-based. EPA is not required to demonstrate environmental benefits of its technology-based rules. It is well established that EPA is not required to consider receiving water quality in setting technology-based effluent limitations guidelines and standards. Weyerhaeuser v. Costle, 590 F. 2nd 1011, 1043 (D.C. Cir. 1978) ("The Senate Committee declared that '[t]he use of any river, lake, stream or ocean as a waste treatment system is unacceptable' regardless of the measurable impact of the waste on the body of water in question. Legislative History at 1425 (Senate Report). The Conference Report states that the Act 'specifically bans pollution dilution as

[1] See Chapter 21 for a detailed discussion the Ohio case study.

an alternative to treatment.' " Id. at 284). In establishing effluent limitations and standards, EPA considers benefits as one of the factors that the Agency evaluates.

12.1 MP&M POLLUTANTS

EPA defines three general categories of pollutants: priority or toxic pollutants; nonconventional pollutants; and conventional pollutants. ***Priority pollutants (PPs)*** are defined as any of 126 named pollutants.[2] Conventional pollutants include ***biological oxygen demand (BOD)***, ***total suspended solids (TSS)***, ***oil and grease (O&G)***, ***pH***, and anything else the Administrator defines as a conventional pollutant. Nonconventionals are a catch-all category that includes everything that is not in the two previously described categories. The naming system is somewhat confusing in that some nonconventional pollutants may be as "toxic" as, or more "toxic" than some of the PPs.

MP&M effluents contain a variety of priority, nonconventional, and conventional pollutants. The release of these pollutants to our nation's surface water degrades aquatic environments, alters aquatic habitats, and affects the diversity and abundance of aquatic life. It also increases the health risks to humans who ingest contaminated surface waters or eat contaminated fish and shellfish (U.S. EPA, 1997). A number of the pollutants commonly found in MP&M effluents also inhibit biological wastewater treatment systems or accumulate in sewage sludge or sediment.

Metals are a particular concern because of their prevalence in MP&M effluents. Metals are inorganic compounds, generally non-volatile (with the notable exception of mercury), and cannot be broken down by biodegradation processes. Metals can accumulate in biological tissues, sequester into sewage sludge in ***publicly-owned treatment works (POTWs)***, and contaminate soils and sediments when released to the environment. Sediments contaminated with metals become resuspended by dredging, boat propellers, water currents or wave action, and storm events, releasing metals back into the water column. Metals can also become biologically available and enter terrestrial food chains once the sludge is applied on land. Sludges with high concentrations of metals are therefore unsuitable for land application. Some metals are quite toxic even when present at relatively low levels.

Some of the inorganic POCs found in MP&M effluents are also natural constituents of water, including potassium, calcium, magnesium, iron, chlorine, fluoride, sulfate, phosphates, silica, and a number of trace metals such as copper and zinc.

Human and ecological exposure and risk from environmental releases of MP&M pollutants depend on chemical-specific properties, the mechanism and medium of release, and site-specific environmental conditions. Chemical-specific properties include toxicological effects on living organisms, ***hydrophobicity/lipophilicity***, reactivity and persisistence. These properties are described in sections 12.1.1 through 12.1.4.

12.1.1 Characteristics of MP&M Pollutants

EPA sampled MP&M facilities nationwide to assess the concentrations of pollutants in MP&M effluents. The Agency collected samples of raw wastewater from MP&M facilities and applied standard water analysis protocols to identify and quantify the pollutant levels in each sample. EPA used these analytical data, along with selection criteria, to identify 132 contaminants of potential concern.[3]

EPA then evaluated the potential environmental fate and transport of these pollutants and their toxicity to humans and aquatic receptors. Fate of the MP&M pollutants was estimated based on the propensity of those pollutants to volatilize, adsorb onto sediments, bioconcentrate, and biodegrade. Table I.1 in Appendix I lists MP&M pollutants and provides data on human health concerns, and fate and effects.

EPA used various data sources to evaluate pollutant-specific fate and toxicity. To evaluate potential human health effects, the Agency relied on ***reference doses (RfDs)*** and ***cancer potency slope factors (SFs)***, ***human health-based water***

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[2] The Agency originally had 129 PPs, but 3 have been dropped from the list bringing the number of PPs to 126.

[3] EPA originally identified 150 MP&M POCs. Of these 150 POCs, the Agency estimated loadings for 132 pollutants for the phase 2 proposal and NODA. The benefits analysis presented in this chapter and the following chapters was based on 132 pollutants for which loadings are available. The final regulation covers only the Oily Wastes subcategory and benefit reductions were estimated for 122 pollutants.

quality criteria (WQC), ***maximum contaminant levels (MCLs)*** for drinking water protection and other drinking water related criteria, and ***hazardous air pollutant (HAP)*** and PP lists. Appendix I.1.2 provides short descriptions and definitions for each of these measures of human health effects.

To evaluate potential fate and effects in aquatic environments, the Agency relied on measures of ***acute*** and ***chronic toxicity*** to aquatic species, bioconcentration factors for aquatic species, ***Henry's Law constants*** (to estimate volatility), ***adsorption coefficients (Koc)*** (to estimate association with bottom sediments), and ***biodegradation half-lives*** (to estimate the removal of chemicals via ***microbial metabolism***).

The data sources used in the assessment include EPA ***ambient water quality criteria (AWQC)*** documents and updates, EPA's ***ASsessment Tools for the Evaluation of Risk (ASTER)***, the ***AQUatic Information REtrieval System (AQUIRE)***, and the ***Environmental Research Laboratory-Duluth fathead minnow database***, EPA's ***Integrated Risk Information System (IRIS)***, EPA's ***Health Effects Assessment Summary Tables (HEAST)***, EPA's 1991 and 1993 ***Superfund Chemical Data Matrix (SCDM)***, Syracuse Research Corporation's ***CHEMFATE*** and ***BIODEG*** databases, EPA and other government reports, scientific literature, and other primary and secondary data sources.

To ensure that the assessment is as comprehensive as possible, EPA also obtained data on chemicals for which physical-chemical properties and/or toxicity data were not available from the sources listed above. To the extent possible, EPA estimated values for the chemicals using the ***quantitative structure-activity relationship (QSAR)*** model incorporated in ASTER, and for some physical-chemical properties, used published linear regression correlation equations.

12.1.2 Effects of MP&M Pollutants on Human Health

Individuals are potentially exposed to MP&M pollutants released to the aquatic environment via consumption of contaminated fish. Populations served by drinking water utilities located downstream of effluent discharges from MP&M facilities are also exposed to MP&M pollutants via contaminated drinking water. Many of these pollutants may increase risks to human health.

Based on the available human health toxicity data for the 132 POCs presented in Table I.1 (Appendix I), EPA found that:[4]

- 76 pollutants are human ***systemic toxicants***;
- 13 pollutants with published SFs are classified as known, probable, or possible human carcinogens when ingested via drinking water or food. Lead is also classified as a possible human carcinogen in IRIS but EPA has not developed a SF for it (U.S. EPA, 1998/99d);
- 36 pollutants have drinking water criteria (27 with enforceable health-based MCLs, 7 with ***secondary MCLs*** for taste or aesthetics, and 2 with action levels for treatment);
- 35 pollutants are designated as HAPs in wastewater;
- 43 pollutants are identified as PPs; and
- 76 pollutants have human health-based water quality criteria (WQC) to protect against the ingestion of water and organisms or organisms only (see Chapter 13, Table 13.3).

The carcinogens identified by EPA in MP&M effluent samples include known (A), probable (B1 and B2) and possible (C) human carcinogens. These pollutants are associated with the development of cancers in the spleen, liver, kidney, lung, bladder, and skin, among others. These pollutants and target organs are shown in Table 12.1.

[4] Facilities in the Oily Wastes subcategory discharge: 75 of the 76 systemic toxicants; all 13 human carcinogens; all 36 pollutants with drinking water criteria; all 35 pollutants designated as HAPs; 41 of the 43 priority pollutants; and 75 of the 76 pollutants that have human health-based water quality criteria. Of the 132 POCs evaluated, facilities in the Oily Wastes subcategory do not discharge the following 10 pollutants: amenable cyanide, boron, cadmium, cyanide, phosphate, sodium, sulfide, total dissolved solids, weak-acid dissociable cyanide, and ziram/cymate.

Table 12.1: Human Carcinogens Evaluated, Weight-of-Evidence Classifications, and Target Organs

CAS Number	Carcinogen	Weight-of-Evidence Classification	Target Organs
62533	Aniline	B2	Spleen
7440382	Arsenic	A	Liver, kidneys, lungs, bladder, skin
117817	Bis(2-ethylhexyl) phthalate	B2	Liver
75003	Chloroethane [a]		
75092	Dichloromethane	B2	Liver, lungs
75354	Dichloroethene, 1,1-	C	Inconclusive [b]
123911	Dioxane, 1,4-	B2	Liver, nasal cavity, gall bladder
78591	Isophorone	C	Preputial gland
62759	Nitrosodimethylamine, N-	B2	Liver, lungs, skin, seminal vesicle, lymphatic/hematopoetic system
86306	Nitrosodiphenylamine, N-	B2	Bladder tumors, reticulum cell sarcomas
127184	Tetrachloroethene	B2	Liver
79016	Trichloroethene [a]		
67663	Trichloromethane	B2	Kidneys

A = Human Carcinogen
B1 = Probable Human Carcinogen (limited human data)
B2 = Probable Human Carcinogen (animal data only)
C = Possible Human Carcinogen
[a] Pollutant has been withdrawn from the IRIS database for additional study.
[b] There is equivocal evidence for the oral route of exposure. This chemical is likely a systemic carcinogen via inhalation. Target organs include: kidney, pancreas, skin, mammary gland, and blood forming elements (lymphoma and leukemia).

Source: U.S. Environmental Protection Agency verified (IRIS) or provisional (HEAST) (U.S. EPA (1998/99d), U.S. EPA (1997)).

Non-carcinogenic hazards associated with pollutants in MP&M effluent include systemic effects (e.g., impairment or loss of neurological, respiratory, reproductive, circulatory, or immunological functions), organ-specific toxicity (e.g., kidney, small intestines, blood, testes, liver, stomach, thyroid), fetal effects (e.g., increased fetal mortality, decreased birth weight), other effects (e.g., lethargy, cataracts, weight loss, hyperactivity), and mortality. These effects are listed by pollutant in Table 12.2.

CAS Number	Toxicant	RfD Target Organ and Effects
Table 12.2: MP&M Pollutants Exhibiting Systemic and Other Non-Cancer Human Health Effects[a]		
83329	Acenaphthene	Liver, hepatotoxicity
67641	Acetone	Increased liver and kidney weights, nephrotoxicity
98862	Acetophenone	General toxicity
107028	Acrolein	Cardiovascular toxicity[c]
7429905	Aluminum	Renal failure, intestinal contraction interference, adverse neurological effects[d]
120127	Anthracene	General toxicity
7440360	Antimony	Longevity, blood glucose, cholesterol
7440382	Arsenic	Hyperpigmentation, keratosis and possible vascular complications
7440393	Barium	Increased kidney weight
65850	Benzoic acid	General toxicity
100516	Benzyl alcohol	Forestomach, epithelial hyperplasia
7440417	Beryllium	Small intestinal lesions
92524	Biphenyl	Kidney damage
117817	Bis(2-ethylhexyl) phthalate	Increased relative liver weight
7440428	Boron	Testicular atrophy, spermatogenic arrest
85687	Butyl benzyl phthalate	Significantly increased liver-to-body and liver-to-brain weight
7440439	Cadmium	Significant proteinuria (protein in urine)
75150	Carbon disulfide	Fetal toxicity, malformations
108907	Chlorobenzene	Histopathologic changes in liver
75003	Chloroethane	General toxicity
7440473	Chromium	Renal tubular necrosis (kidney tissue decay)[d]
18540299	Chromium-hexavalent	Reduced water consumption
7440484	Cobalt	Heart effects[d]
7440508	Copper	Gastrointestinal effects, liver necrosis[d]
95487	Cresol, o-	Decreased body weight and neurotoxicity
106445	Cresol, p-	Central nervous system hypoactivity and respiratory system distress
57125	Cyanide	Weight loss, thyroid effects and myelin degeneration
75354	Dichloroethene, 1,1-	Toxic effects on kidneys, spleen, lungs[d]; hepatic lesions
75092	Dichloromethane	Liver toxicity
68122	Dimethylformamide, N,N-	Liver and gastrointestinal system effects
105679	Dimethylphenol, 2,4-	Clinical signs (lethargy, prostration, and ataxia) and hematological changes
84742	Di-n-butyl phthalate	Increased mortality
51285	Dinitrophenol, 2,4-	Cataract formation
606202	Dinitrotoluene, 2,6-	Mortality, central nervous system neurotoxicity, blood heinz bodies and methemoglobinemia, bile duct hyperplasia, kidney histopathology
117840	Di-n-octyl phthalate	Kidney and liver increased weights, increased liver enzymes
122394	Diphenylamine	Decreased body weight, and increased liver and kidney weights
100414	Ethylbenzene	Liver and kidney toxicity
206440	Fluoranthene	Nephropathy, increased liver weights, hematological alterations, clinical effects
86737	Fluorene	Decreased red blood cell count, packed cell volume and hemoglobin
16984488	Fluoride	Objectionable dental fluorosis (soft, mottled teeth)
591786	Hexanone, 2-	Hepatotoxicity and nephrotoxicity[c]

Table 12.2: MP&M Pollutants Exhibiting Systemic and Other Non-Cancer Human Health Effects[a]

CAS Number	Toxicant	RfD Target Organ and Effects
7439896	Iron	Liver pathology, diabetes mellitus, endocrine disturbance, and cardiovascular effects[c]
78831	Isobutyl alcohol	Hypoactivity and ataxia
78591	Isophorone	Kidney pathology
7439965	Manganese	Central nervous system effects
78933	Methyl ethyl ketone	Decreased fetal birth weight
108101	Methyl isobutyl ketone	Lethargy, increased liver and kidney weights and urinary protein
80626	Methyl methacrylate	Increased kidney to body weight ratio
91576	Methylnaphthalene, 2-	
7439987	Molybdenum	Increased uric acid
91203	Naphthalene	Decreased body weight
7440020	Nickel	Decreased body and organ weights
100027	Nitrophenol, 4-	
59507	Parachlorometacresol	
108952	Phenol	Reduced fetal body weight
129000	Pyrene	Kidney effects (renal tubular pathology, decreased kidney weights)
110861	Pyridine	Increased liver weight
7782492	Selenium	Clinical selenosis (hair or nail loss)
7440224	Silver	Argyria (skin discoloration)
100425	Styrene	Red blood cell and liver effects
127184	Tetrachloroethene	Liver toxicity, weight gain
7440280	Thallium	Liver toxicity, gastroenteritis, degeneration of peripheral and central nervous system[c]
7440315	Tin	Kidney and liver lesions
7440326	Titanium	Considered to be physiologically inert[c]
108883	Toluene	Changes in liver and kidney weights
79016	Trichloroethene	Bone marrow, central nervous system, liver, kidneys[4]
75694	Trichlorofluoromethane	Histopathology and mortality
67663	Trichloromethane	Fatty cyst formation in liver
7440622	Vanadium	Kidney and central nervous system effects[b]
108383	Xylene, m-	Central nervous system hyperactivity, decreased body weight
179601231	Xylene, m- & p- (c)	
95476	Xylene, o-	Central nervous system hyperactivity, decreased body weight
136777612	Xylene, o- & p- (c)	
7440666	Zinc	47% decrease in erythrocyte superoxide dismutase (ESOD) concentration in adult human females after 10 weeks of zinc exposure
137304	Ziram \ Cymate	

[a] Chemicals with EPA verified (IRIS) or provisional (HEAST, or other Agency document)) human health-based RfDs, referred to as “systemic toxicants” (U.S. EPA (1998/99d), U.S. EPA (1997)).

[b] RfD based on a no-observed-adverse-effect level (NOAEL). Health effects summarized from Amdur, M.O., Doul, J., and Klaassen, C.D., eds. *Cassarett and Doul’s Toxicology*, 4th edition, 1991.

[c] Target organ and effects summarized from Amdur, M.O., Doul, J., and Klaassen, C.D., eds. *Cassarett and Doul’s Toxicology*, 5th edition, 1996.

[d] Target organ and effects summarized from Wexler, P., ed. *Encyclopedia of Toxicology*, Volumes 1-3, 1998.

Source: U.S. EPA analysis.

12.1.3 Environmental Effects of MP&M Pollutants

Ecological impacts of MP&M pollutants include acute and chronic toxicity to aquatic receptors by dozens of pollutants present in MP&M effluents, ***uptake*** of certain pollutants into aquatic food webs, sub-lethal effects on metabolic and reproductive functions, habitat degradation from turbidity, eutrophication, dissolved oxygen depletion, and loss of prey organisms. Metals are of particular concern to this regulation because they (1) do not volatilize, (2) do not biodegrade, (3) can be toxic to plants, invertebrates and fish, (4) adsorb to sediments and (5) bioconcentrate in biological tissues.

EPA obtained the environmental fate and toxicity information for the 132 MP&M POCs. Table I.1 in Appendix I shows the environmental fate and toxicity of each MP&M pollutant.[5] EPA found that:

- 56 pollutants are not volatile or are only slightly volatile (all metals were assumed to be non-volatile except for mercury);
- 57 pollutants have moderate to high adsorption potentials (all metals were assumed to have high adsorption potential except for nickel);
- 42 pollutants have moderate to high bioconcentration factors;
- 62 pollutants biodegrade slowly or are resistant to biodegradation altogether (all metals were assumed to be resistant to biodegradation);
- For freshwater environments, 32 pollutants have acute toxicities to aquatic life that range from moderate to high, and 33 pollutants have chronic toxicities that range from moderate to high;
- For saltwater environments, 20 pollutants have acute toxicities to aquatic life that range from moderate to high, and 23 pollutants have chronic toxicities that range from moderate to high.

The available information shows that dozens of the MP&M POCs have the potential to pose significant hazards to the aquatic environment when released to receiving waters. A number of pollutants are of particular concern because of their combined toxicity and fate. These include several polyaromatic hydrocarbons (acenaphthene, anthracene, 3,6-dimethyl-phenanthrene, fluoranthene, phenanthrene, and pyrene), several metals (aluminum, cadmium, copper, mercury, and selenium) and several phthalates (di-n-octyl phthalate, butyl benzyl phthalate, and di-n-butyl phthalate). Other pollutants are of concern chiefly because of their toxicity (arsenic, cyanide, chromium, lead, nickel, silver, and zinc) or their fate (bis(2-ethylhexyl)phthalate, bromo-2-chlorobenzene, bromo-3-chlorobenzene, dibenzofuran, dibenzothiophene, diphenylamine, long-chained petroleum hydrocarbons, 1-methylfluorene, N-nitrosodiphenylamine, and several metals).

The available fate and toxicity data indicate that many MP&M pollutants tend (1) to be "toxic", (2) to not readily volatilize from the water column, (3) to adsorb to sediments, (4) to bioconcentrate in aquatic organisms, and (5) do not biodegrade. Such pollutants accumulate in sediments and reach concentrations which can impair ***benthic*** communities. Pollutants that have accumulated in sediments can be released back into the water column because sediments act as long-term sinks. The pollutants can also enter soils and reach high levels over time if present in sewage sludge that is applied to land. The tendency of these pollutants to resist biodegradation and to bioconcentrate in biological tissue also causes them to be taken up into aquatic food chains where they can affect predators or humans who consume fish and shellfish (U.S. EPA, 1998).

The toxicity data also indicate that a sizable number of the POCs in MP&M effluents have toxicities that result in lethal or sub-lethal responses in aquatic receptors, including algae, ***vascular plants***, invertebrates, fish, and amphibians. Responses include death, which may occur within a matter of hours to days, or longer-term sub-lethal responses (such as reproductive failure or growth impairment) that manifest themselves over weeks, months, or even years. The effects of toxic chemicals are not shared equally among exposed species: sensitive species are typically more affected than species that are more resistant. Hence, toxic conditions could selectively remove sensitive species from receiving waters. Such a pattern is of particular concern to ***threatened and endangered (T&E)*** species, which may already be close to extinction. Aquatic receptors are exposed to many different toxicants at the same time, which may have additive effects. The EPA assessment is based on a

[5] Note that EPA was unable to obtain fate or toxicity data for a substantial number of POCs.

chemical-by-chemical approach and therefore does not consider additive effects. This approach may understate the benefits of the rule.

EPA also did not evaluate the potential fate and effects of the four conventional pollutants (BOD, pH, O&G, TSS) and several other pollutants, including ***Total Petroleum Hydrocarbon (TPH), Total Kjeldahl Nitrogen (TKN)***, phosphorus, and ***chemical oxygen demand (COD)***, which may nonetheless adversely affect aquatic environments.[6,7]

Effluents with high levels of BOD or COD consume large amounts of dissolved oxygen in a short time, causing surface waters to become oxygen-depleted, thereby killing or excluding aquatic life (U.S. EPA, 1986). At current discharge levels, MP&M facilities discharge 1.1 million pounds of BOD per year.

Low pH (high acidity) water can be lethal to aquatic organisms; sensitive species of fish and invertebrates are eliminated from surface waters at pH's between 6.0 and 6.5 (U.S. EPA, 1999).

O&G and TPH can have lethal effects on fish by coating gill surfaces and causing asphyxia, depleting dissolved oxygen levels due to excessive BOD, and impairing stream re-aeration due to the presence of surface films. Compounds present in O&G or TPH can also be detrimental to waterfowl by affecting the buoyancy and insulating capacity of their feathers (U.S. EPA, 1998). At current discharge levels, MP&M facilities discharge 553,481 pounds per year of O&G, including 67,427 pounds a year of TPH.

TSS increases the turbidity of surface water and impairs underwater visibility and transparency, thereby inhibiting photosynthesis by diminishing the amount of sunlight that reaches algae or submerged aquatic plants. TSS also causes a general degradation of aquatic habitats by increasing the rate of sedimentation, which smothers eggs, covers aquatic plants, and affects benthic invertebrates (U.S. EPA, 1998).

High input of nitrogen in estuarine and marine systems or phosphorus in freshwater systems can increase primary productivity and result in eutrophication. Such a process overloads surface waters with algae and reduces the transparency of the water column. The excess algae sink to the bottom and decompose at the end of their life cycle. This process consumes large amounts of dissolved oxygen and can turn surface waters anoxic (U.S. EPA, 1998; U.S. EPA, 1995).

12.1.4 Effects of MP&M Pollutants on Economic Productivity

Most MP&M pollutants associated with adverse health effects are subject to drinking water criteria. Thus, MP&M discharges to surface water can increase the cost of municipal water treatment by requiring investment in chemical treatment and filtration. Public water treatment systems must comply with drinking water criteria MCLs and secondary standards. Compliance may require treatment to reduce the levels of regulated pollutants below their MCLs. Capital investment and operating and maintenance (O&M) costs associated with treatment technologies can be substantial. To the extent that the MP&M regulation reduces the concentration of MP&M pollutants in source waters to values that are below pollutant-specific drinking water criteria, public drinking water systems will accrue benefits in the form of reduced water treatment costs.

Releases of MP&M pollutants to surface waters may also increase treatment costs of irrigation water and industrial water.

Releases of large quantities or high concentrations of toxic pollutants in MP&M effluents may interfere with POTW processes (e.g., inhibiting microbial degradation), reduce the treatment efficiency or capacity of POTWs, and reduce disposal options for the sludge. In addition, toxic pollutants present in the effluent discharges may pass through a POTW and adversely affect receiving water quality, or may contaminate sludges generated during primary or secondary wastewater treatment. EPA expects no changes in the current status of POTW processes or disposal options for the sludge at POTWs receiving effluent discharges from MP&M facilities associated with the MP&M rule since all indirect dischargers have been excluded from the final option. EPA, however, analyzed changes in interferences of POTW operations and contamination of sewage sludge at

[6] TKN is defined as the total of organic and ammonia nitrogen. It is determined in the same manner as organic nitrogen, except that the ammonia is not driven off before the digestion step.

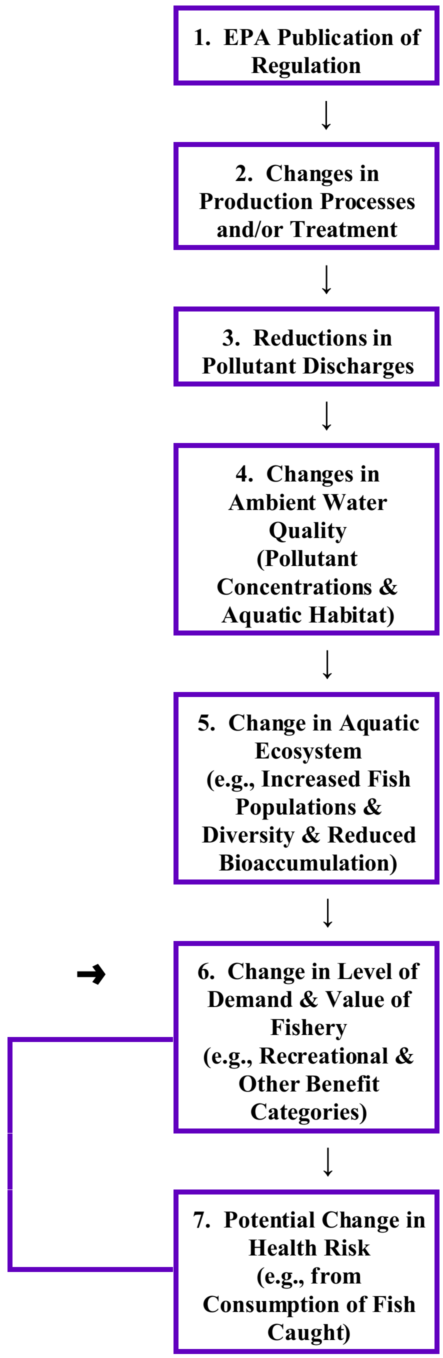
[7] EPA, however, considered environmental effects of TKN in the Ohio case study. EPA evaluated the impact of in-stream TKN concentrations on recreational value of fishing, boating, swimming, and wildlife viewing sites. For detail see Chapter 21 of this report.

POTWs receiving effluent discharges from MP&M facilities for the alternative regulatory options which include indirect dischargers.

12.2 Linking the Regulation to Beneficial Outcomes

This section describes the linkages between promulgation of a regulation and the expected benefits to society. As indicated in Figure 12.1, the benefits of the MP&M regulation occur from a chain of events. These events include: (1) Agency publication of the regulation, (2) industry changes in production processes and/or treatment systems, (3) reductions in pollutant discharges, (4) changes in water quality, (5) changes in ecosystem attributes and sewage sludge quality, (6) changes in human responses, and (7) changes in human health and ecological risk. The first two events reflect the institutional and technical aspects of the regulation. The benefit analysis begins with the third event, the changes in the pollutant content of effluent discharges.

Figure 12.1: Chain of Events in a Benefits Analysis



Source: U.S. EPA analysis.

In event four, changes in pollutant discharges translate into improvements in water and sludge quality. In event five, these improvements in turn affect in-stream and near-stream biota (e.g., increased diversity of aquatic species and size of species populations) and sludge disposal options. Finally, human effects and the related valuation of benefits occur in events six and seven. For example, improvements to recreational fisheries and enhanced enjoyment by recreational anglers is connected to improved water quality and the value of reduced risk to human health. These linkages are the basis of the benefits analysis presented in this and the following chapters.

12.3 Qualitative and Quantitative Benefits Assessment

A benefit assessment defines and quantifies the types of improvements to human health and ecological receptors that can be expected from reducing the amount of MP&M pollutants released to the environment. The following sections provide an overview of the concepts and analytic approaches involved in the benefits assessment. The first section describes the general categories of benefits expected to result from the regulation and the level of analysis undertaken for them. The following three sections review, within the broad categories of benefits likely to be achieved by the MP&M regulation, the specific benefits that are evaluated in this analysis. Finally, Section 12.3.5 summarizes methods for attaching values to some of the benefit measures. Chapters 13 through 16 present the quantitative assessment of benefits.

12.3.1 Overview of Benefit Categories

The benefits of reduced MP&M discharges may be classified in three broad categories: human health, ecological, and economic productivity benefits. Table 12.3 summarizes the different types of benefits that fall in each of these categories. Each category is comprised of a number of more narrowly defined benefit categories. EPA expects that the MP&M regulation will provide benefits to society in all of these categories. EPA was not able to bring the same depth of analysis to all of these categories, however, because of imperfect understanding of the link between discharge reductions and benefit categories, and how society values some of the benefit events. EPA was able to quantify and monetize some benefits, quantify but not monetize other benefits, and assess still other benefits only qualitatively.

In addition to the national-level benefits analysis, the Agency conducted a case study in the state of Ohio to provide in-depth analysis of the regulation's expected benefits. The Ohio case study improves on the national analysis in two ways. First, the analysis uses improved data and methods to address co-occurrence of MP&M facility benefits and other-source contributions of MP&M pollutants in the same locations. Second, the analysis of recreational benefits is based on original travel cost models of resource valuation in a random utility framework. The analysis values changes in the value of water resources for four recreational activities -- fishing, boating, swimming, and near-water recreation. Due to data limitations, only three of these four activities were valued at the national-level benefits analysis.

To provide perspective on the extent to which this regulatory impact assessment was able to comprehensively analyze the benefits, Table 12.3 summarizes the specific benefits within each of the three broad benefit categories that are expected to accrue from the MP&M regulation and the level of analysis applied to each category. As shown in Table 12.3, only a few of the relevant benefit categories can be both quantified and monetized.

Table 12.3: Level of Analysis Performed for Specific Benefit Categories

Benefit Category	Quantified and Monetized	Quantified but Not Monetized	Qualitative
Human Health Benefits			
Reduced cancer risk due to ingestion of chemically-contaminated fish and unregulated pollutants in drinking water	X		
Reduced non-cancer adverse health effects (e.g. reproductive, immunological, neurological, circulatory, or respiratory toxicity) due to ingestion of chemically-contaminated fish and unregulated pollutants in drinking water		X	
Reduced non-cancer adverse health effects from exposure to lead from consumption of chemically-contaminated fish	X		
Reduced cancer risk and non-cancer adverse health effects from exposure to unregulated pollutants in chemically-contaminated sewage sludge[a]			X
Reduced health hazards from exposure to contaminants in waters used recreationally (e.g., swimming)			X
Ecological Benefits			
Reduced risk to aquatic life		X	
Enhanced water-based recreation including fishing, boating, and near-water (wildlife viewing) activities	X		
Other enhanced water-based recreation such as swimming, waterskiing, and white water rafting			X
Increased aesthetic benefits such as enhancement of adjoining site amenities (e.g. residing, working, traveling, and owning property near the water)			X
Nonuser value (i.e., existence, option, and bequest value)	X		
Reduced contamination of sediments			X
Reduced non-point source nitrogen contamination of water if sewage sludge is used as a substitute for chemical fertilizer on agricultural land[a]			X
Satisfaction of a public preference for beneficial use of sewage sludge[a]			X
Economic Productivity Benefits			
Reduced sewage sludge disposal costs[a]	X		
Reduced management practice and record-keeping costs of sewage sludge that meets exceptional quality criteria[a]	X		
Reduced interference with POTW operations[a]		X	
Benefits to tourism industries from increased participation in water-based recreation			X
Improved commercial fisheries yields			X
Improved crop yield (the organic matter in land-applied sewage sludge increases soil's water retention)[a]			X
Avoidance of costly siting processes for more controversial sewage sludge disposal methods (e.g., incinerators) because of greater use of land application[a]			X
Reduced water treatment costs for municipal drinking water, irrigation water, and industrial process and cooling water			X

[a] These benefit categories are not applicable to the final rule since all indirect dischargers have been excluded from the selected option. EPA, however, analyzed these benefit categories for the alternative regulatory options which include indirect dischargers.

Source: U.S. EPA analysis.

Each category of benefits and the level of analysis applied to this category are discussed in greater detail below.

12.3.2 Human Health Benefits

Reduced pollutant discharges to the nation's waterways will generate human health benefits by several mechanisms. The most important and readily analyzed benefits stem from reduced risk of illness associated with the consumption of water, fish, shellfish, and other aquatic organisms that is taken from waterways affected by MP&M discharges. Human health benefits are typically analyzed by estimating the change in the expected number of adverse human health events in the exposed population resulting from a reduction in effluent discharges. While some health effects such as cancer are relatively well understood and thus may be quantified in a benefits analysis, others are less well characterized and cannot be assessed with the same rigor or at all.

EPA analyzed the following direct measures of change in risk to human health: incidence of cancer from fish and water consumption; reduced risk of non-cancer toxic effects from fish and water consumption; and lead-related health effects to children and adults. EPA was able to monetize only two of the three measures (cancer-related and lead-related health risks). Incidence of cancer was translated into an expected number of avoided mortality events and, on that basis, monetized. Lead impacts to children were evaluated in terms of potential intellectual impairment as measured by estimated changes in IQ. Changes in adverse health effects to adults from lead exposure were measured in terms of reduced risk of hypertension, non-fatal coronary heart disease, non-fatal strokes, and mortality.

EPA also quantified but did not monetize the expected reduction of pollutant concentrations in excess of health-based AWQC limits. This benefit measure was obtained by comparing in-waterway pollutant concentrations to toxic effect levels.

In concept, the value of these health effects to society is the monetary value that society is willing to pay to avoid the health effects, or the amount that society would need to be compensated to accept increases in the number of adverse health events. ***"Willingness-to-pay" (WTP)*** values are generally considered to provide a fairly comprehensive measure of society's valuation of the human and financial costs of illness associated with the costs of health care, losses in income, and pain and suffering of affected individuals and of their family and friends.

In some cases, available economic research provides little empirical data for society's WTP to avoid certain health effects. One component of the cost of an illness estimates the direct medical costs of treating a health condition (e.g., hypertension), and can be used to value changes in health risk from reduced exposure to toxic pollutants such as lead. These estimates represent only one component of society's WTP to avoid adverse health effects and therefore produce a partial measure of the value of reduced exposure to MP&M pollutants. Employed alone, these monetized effects will significantly underestimate society's WTP.

12.3.3 Ecological Benefits

EPA expects that the ecological benefits from the regulation will include protection of fresh- and saltwater plants, invertebrates, fish, and amphibians, as well as terrestrial wildlife and birds that prey on aquatic organisms exposed to MP&M pollutants. The regulation will reduce the presence and discharge of various pollutants and will enhance or protect aquatic ecosystems currently under stress. The drop in pollutant loading is expected to reestablish productive ecosystems in damaged waterways and to protect resident species, including T&E species. EPA also expects that the regulation will enhance the general health of fish and invertebrate populations, increase their propagation to waters currently impaired, and expand fisheries for both commercial and recreational purposes. Improvements in water quality will also favor increased recreational activities such as swimming, boating, fishing, and water skiing. Finally, the Agency expects that the regulation will augment nonuse values (e.g., option, existence, and bequest values) of the affected water resources.

It is frequently difficult to quantify and attach economic values to ecological benefits. The difficulty results from imperfect understanding of the relationship between changes in effluent discharges and the specific ecological changes, lack of water quality monitoring data for most locations, and time lags between water quality changes and changes in species population and composition. In addition, it is difficult to attach monetary values to these ecological changes because they often do not occur in markets in which prices or costs are readily observed. As such, ecological benefits may be loosely classified as nonmarket benefits. This classification can be further divided into nonmarket *use* benefits and nonmarket *nonuse* benefits.

Nonmarket use benefits stem from improvements in ecosystems and habitats, which in turn lead to enhanced human use and enjoyment of these areas. For example, reduced discharges may lead to increased recreational use and enjoyment of affected waterways in such activities as fishing, swimming, boating, hunting or near-water activities such as bird watching. In some cases, it may be possible to quantify and attach partial economic values to ecological benefits using market values (e.g., an increase in tourism or boat rentals associated with improved recreational fishing opportunities); in this case, these benefit events might better be classified as economic productivity related events, which are discussed below. Economic markets, however, do not provide enough information to fully capture the value of these benefits. Such markets capture only related expenditures made by recreationists (e.g., food and lodging) and do not capture the value placed on the experience itself. A variety of nonmarket valuation techniques can be used to capture the value placed on the resource in question. These techniques include hedonic valuation (wage-risk studies) and ***travel cost methods (TCM)***, stated preferences methods (i.e., ***contingent valuation (CV)***, ***contingent rating (CR)***, ***contingent activity (CA)***, benefits transfer, and averting behavior models.

Nonmarket nonuse benefits are not associated with current use of the affected ecosystem or habitat, but rather arise from (1) the *realization* of the improvement in the affected ecosystem or habitat resulting from reduced effluent discharges and (2) the value that individuals place on the *potential for use* sometime in the future. Nonmarket nonuse benefits may also be manifested by other valuation mechanisms, such as cultural valuation, philanthropy, and bequest valuation. It is often extremely difficult to quantify the relationship between changes in discharges and the improvements in societal well-being associated with such valuation mechanisms. That these valuation mechanisms exist, however, is indisputable, as evidenced, for example, by society's willingness to contribute to organizations whose mission is to purchase and preserve lands or habitats to avert development.

12.3.4 Economic Productivity Benefits

Reduced pollutant discharges may also benefit economic productivity. First, economic productivity benefits may accrue from reduced treatment costs of drinking water, irrigation water, and industrial use water. Reduced pollutant concentrations in public water systems source water to levels at or below MCLs or secondary standards could reduce ongoing treatment costs and avoid the need to invest in treatment technologies in the future. Reduced pollutant discharges may also reduce sediment dredging costs. Contaminated sediments may contribute substantially to contamination of aquatic biota and to human exposure of human health toxicants. Controlling point source discharges of toxic pollutants can prevent sediment contamination and eliminate the need for future remediation (i.e., dredging) of contaminated sediments.

Other economic productivity gains may result from improved tourism opportunities in areas affected by MP&M discharges. Improved aquatic species survival may contribute to increased commercial fishing yield. When such economic productivity effects can be identified and quantified, they are generally straightforward to value because they involve market commodities for which prices or unit costs are readily available.

Economic productivity gains may also occur through reduced costs to public sewage systems (POTWs) for managing and disposing of the sludge (i.e., biosolids) from treating effluent discharges. For example, higher quality sludge may be applied to agricultural land or otherwise beneficially used rather than being incinerated or disposed of in landfills. POTWs may also incur lower costs because of lower record keeping requirements. Under the final regulatory option, EPA expects no POTW productivity gains since all indirect dischargers have been excluded from the final regulatory option.

12.3.5 Methods for Valuing Benefit Events

Some of the benefits expected from the MP&M regulation will manifest themselves in economic markets through changes in price, cost, or quantity of market-valued activities. For benefits endpoints traded in markets, such as increased yields from commercial fisheries, benefits can be measured by market prices or market-based factor pricing. Competitive prices can be used also to measure ***avoided cost*** type of benefits. For example, reduced pollutant loadings to public water supplies may lower costs of drinking treatment. Market prices can be used also to value direct medical costs of illnesses associated with exposure to pollutants. For this analysis, EPA used medical costs associated with treating hypertension, coronary heart disease, and stroke to estimate benefits from reduced exposure to lead (see Chapter 14). The estimated values can be used as minimum measures of the benefits associated with reduced cases of these illnesses.

In other cases, benefits involve activities or sources of value that either do not involve economic markets or involve them only indirectly. Methods used to value such benefits are described briefly below:

a. Wage-risk approach.

The wage-risk approach uses regression estimates of the wage premium associated with greater risks of death on the job to estimate the amount that persons are willing to pay to avoid death. Benefit values based on this approach are used as part of the basis for valuing reduced cancer cases due to fish consumption in Chapter 13.

b. Travel cost method

The TCM uses information on costs incurred by people in traveling to a site and in using the site to estimate a demand curve for that site. The demand curve is then used to estimate the "consumer surplus" associated with the use of the site, that is, the value that consumers receive from the site over and above the costs that they incur in using it. Consumer surplus is an estimate of the net benefits of the resource to the people using that resource. For example, if the resource is a recreational fishing site, the TCM can be used to value the recreational fishing experience. The Agency used an original travel cost study to value benefits from enhanced water-based recreation in Ohio (see Part V: Chapter 21). The analysis of recreational benefits in Chapter 15 uses a meta-analysis of water-based recreation studies (including TCM studies) to derive the baseline and post-compliance values of water-based recreation activities (including fishing, boating, and wildlife viewing) and to estimate benefits to consumers of water-based recreation from improved water quality resulting from reduced MP&M dischargers.

c. Contingent valuation

In the CV method, surveys are conducted to elicit individuals' WTP for a particular good, such as a fishery, or clean water. CV is more broadly applicable than TCM. Like TCM, CV can be used to estimate the consumer surplus associated with recreational fisheries. CV can also be used to estimate less tangible values, such as how much people care about a clean environment. Values from both the CV approach and the wage-risk approach support the estimated value of avoided death that is used to monetize reduced cancer cases from consumption of contaminated fish (Chapter 13). Similarly to the TCM studies, CV studies are used in a meta-analysis to derive the baseline and post-compliance values of water-based recreation activities (including fishing, boating, and wildlife viewing) and to estimate benefits from improved opportunities for water-based recreation from reduced MP&M dischargers (Chapter 15).

d. Benefits transfer

When time and resource constraints preclude primary research, benefit assessment based on benefits transfer from existing studies is used. This approach involves extrapolating benefit findings for one analytic situation to another. The relevant study situations are defined by type of environmental resource (e.g., fishery), policy variable(s), and the characteristics of user populations. The benefits transfer approach is used to monetize several benefit categories, including changes in the incidence of cancer cases (Chapter 13) and the national-level benefits from enhanced water-based recreation (Chapter 15).

The techniques described above form the basis of the benefits methodologies described in Chapters 13,14, and 15.

GLOSSARY

acute toxicity: the ability of a substance to cause severe biological harm or death soon after a single exposure or dose. Also, any poisonous effect resulting from a single short-term exposure to a toxic substance. (See: chronic toxicity, toxicity.) (http://www.epa.gov/OCEPAterms/aterms.html)

adsorption coefficients (Koc): represents the ratio of the target chemical absorbed per unit weight of organic carbon in the soil or sediment to the concentration of that same chemical in solution at equilibrium.

ambient water quality criteria (AWQC): AWQC present scientific data and guidance of the environmental effects of pollutants which can be useful to derive regulatory requirements based on considerations of water quality impacts; these criteria are not rules and do not have regulatory impact (U.S. EPA. 1986. Quality Criteria for Water 1986. U.S. Environmental Protection Agency, Office of Water Regulations and Standards, Washington, DC. EPA 440/5-86-001).

AQUatic Information REtrieval System (AQUIRE): a web-based ecotoxicity database maintained by EPA's Mid-Continent Ecology Division (MED) which summarizes ecotoxicity data retrieved from the literature. (http://www.epa.gov/med/databases/databases.html#aquire) (U.S. EPA, 1998/99b)

ASsessment Tools for the Evaluation of Risk (ASTER): an ecological risk assessment tool developed by EPA's Mid-Continent Ecology Division (MED); ASTER integrates information from the AQUIRE toxic effects database and the QSAR system (a structure activity-based expert system) to estimate ecotoxicity, chemical properties, biodegradation and environmental partitioning. (http://www.epa.gov/med/databases/aster.html) (U.S. EPA, 1998/99c)

avoided cost: costs that are likely to be incurred in the future if current conditions still prevail at the time, but which will be avoided if particular actions are taken now to change the status quo.

benthic: relating to the bottom of a body of water; living on, or near, the bottom of a water body.

BIODEG: a web-based biodegradation database developed by Syracuse Research Corporation. (http://esc.syrres.com/efdb/BIODGSUM.HTM) (Syracuse Research Corporation, 1999)

biodegradation half-lives: represents the number of days a compound takes to be degraded to half of its starting concentration under prescribed laboratory conditions.

biological oxygen demand (BOD): the amount of dissolved oxygen consumed by microorganisms as they decompose organic material in an aquatic environment.

cancer potency slope factor (SF): a plausible upper-bound estimate of the probability of a response per unit intake of a chemical over a lifetime. The slope factor is used to estimate an upper-bound probability of an individual developing cancer as a result of a lifetime of exposure to a particular level of a potential carcinogen.

CHEMFATE: a web-based chemical fate database developed by Syracuse Research Corporation. (http://esc.syrres.com/efdb/Chemfate.htm) (Syracuse Research Corporation, 1999)

chemical oxygen demand (COD): a measure of the oxygen required to oxidize all compounds, both organic and inorganic, in water. (http://www.epa.gov/OCEPAterms/cterms.html)

chronic toxicity: the capacity of a substance to cause long-term poisonous health effects in humans, animals, fish, and other organisms. (http://www.epa.gov/OCEPAterms/cterms.html)

contingent activity: one of the stated preference methods (see: contingent valuation and contingent activity). Survey respondents are asked how their behavior would change in response to a proposed change in one or more attributes of an activity (e.g., cost of the activity, site accessibility, or site attractiveness). Given responses to this type of question, and given information about incremental travel costs and value of time, a revealed preference method can be used to estimate the value of change.

contingent rating: one of the stated preference methods (see: contingent valuation and contingent activity). Survey respondents are asked to rate several alternatives on an ad hoc utility scale (e.g., 1 to 10). The choice set of alternatives usually includes the environmental effect to be valued, substitutes for the effect, and a good with a monetary price to act as a threshold. Based on the respondent's rating of the environmental effect and the threshold good, and the monetary price of the threshold good, the value of the environmental effect can be determined.

contingent valuation (CV): a method used to determine a value for a particular event, where people are asked what they are willing to pay for a benefit and/or are willing to receive in compensation for tolerating a cost. Personal valuations for increases or decreases in the quantity of some good are obtained contingent upon a hypothetical market. The aim is to elicit valuations or bids that are close to what would be revealed if an actual market existed. (http://www.damagevaluation.com/glossary.htm)

Environmental Research Laboratory-Duluth fathead minnow database: a database developed by EPA's Mid-Continent Ecology Division (MED) which provides data on the acute toxicity of hundreds of industrial organic compounds to the fathead minnow. (http://www.eoa.gov/med/databases/fathead_minnow.html) (U.S. EPA, 1998/99a)

hazardous air pollutant (HAP): compounds that EPA believes may represent an unacceptable risk to human health if present in the air.

Health Effects Assessment Summary Tables (HEAST): a comprehensive listing of provisional human health risk assessment data relative to oral and inhalation routes for chemicals of interest to EPA. Unlike data in IRIS, HEAST entries have received insufficient review to be recognized as high quality, Agency-wide consensus information. (U.S. EPA. 1997. Health Effects Assessment Table; FY 1997 Update. EPA-540-R-97-036)

Henry's Law constant: a numeric value which relates the equilibrium partial pressure of a gaseous substance in the atmosphere above a liquid solution to the concentration of the same substance in the liquid solution.

human health-based water quality criteria (WQC): human health-based criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, fish production, or industrial processes (see ambient water quality criteria (AWQC)). (http://www.epa.gov/OCEPAterms/wterms.html).

hydrophobicity: having a strong aversion to water. (http://www.epa.gov/OCEPAterms/hterms.html)

Integrated Risk Information System (IRIS): IRIS is an electronic database with information on human health effects of various chemicals. IRIS provides consistent information on chemical substances for use in risk assessments, decision-making and regulatory activities.

lipophilicity: having a strong attraction to oils

maximum contaminant levels (MCLs): the maximum permissible level of a contaminant in water delivered to any user of a public system. MCLs are enforceable standards. (http://www.epa.gov/OCEPAterms/mterms.html)

metals: inorganic compounds, generally non-volatile, and which cannot be broken down by biodegradation processes. They are a particular concern because of their prevalence in MP&M effluents. Metals can accumulate in biological tissues, sequester into sewage sludge in POTWs, and contaminate soils and sediments when released to the environment. Some metals are quite toxic even when present at relatively low levels.

microbial metabolism: biochemical reactions occurring in living microorganisms such as bacteria, algae, diatoms, plankton, and fungi. POTWs make use of bacterial metabolism for wastewater treatment purposes. This process is inhibited by the presence of toxins such as metals and cyanide because these pollutants kill bacteria.

oil and grease (O&G): organic substances that may include hydrocarbons, fats, oils, waxes, and high-molecular fatty acids. Oil and grease may produce sludge solids that are difficult to process. (http://www.epa.gov/owmitnet/reg.htm)

pH: an expression of the intensity of the basic or acid condition of a liquid; natural waters usually have a pH between 6.5 and 8.5. (http://www.epa.gov/OCEPAterms/pterms.html)

pollutants of concern (POCs): are the 150 contaminants identified by EPA as being of potential concern for this rule and which are currently being discharged by MP&M facilities.

priority pollutant (PP): 126 individual chemicals that EPA routinely analyzes when assessing contaminated surface water, sediment, groundwater, or soil samples.

publicly-owned treatment works (POTWs): a treatment works, as defined by section 212 of the Act, that is owned by a State or municipality. This definition includes any devices or systems used in the storage, treatment, recycling, and reclamation of municipal sewage or industrial wastes of a liquid nature. It also includes sewers, pipes, or other conveyances only if they convey wastewater to a POTW Treatment Plant. (http://www.epa.gov/owm/permits/pretreat/final99.pdf)

quantitative structure-activity relationship (QSAR) model: an expert system which uses a large database of measured physicochemical properties such as melting point, vapor pressure, and water solubility to estimate the fate and effect of a specific chemical based on its molecular structure. (http://www.epa.gov/med/databases/aster.html) (U.S. EPA, 1998/99)

reference doses (RfDs): chemical concentrations expressed in mg of pollutant/kg body weight/day, that, if not exceeded, are expected to protect an exposed population, including sensitive groups such as young children or pregnant women.

secondary MCLs: human health-based drinking water criteria to assess the health hazards associated with the presence of certain toxic chemicals in drinking water. SMCLs are established for taste or aesthetic effects.

Superfund Chemical Data Matrix (SCDM): a source for factor values and benchmark values applied when evaluating potential National Priorities List (NPL) sites using the Hazard Ranking System (HRS). (http://www.epa.gov/superfund/resources/scdm/index.htm).

suspended solids: small particles of solid pollutants that float on the surface of, or are suspended in, water bodies. (http://www.epa.gov/OCEPAterms/sterms.html)

systemic toxicants: chemicals that EPA believes can cause significant non-carcinogenic health effects when present in the human body above chemical-specific toxicity thresholds.

threatened and endangered (T&E): animals, birds, fish, plants, or other living organisms threatened with extinction by anthropogenic (man-caused) or other natural changes in their environment. Requirements for declaring a species endangered are contained in the Endangered Species Act.

Total Petroleum Hydrocarbon (TPH): a general measure of the amount of crude oil or petroleum product present in an environmental media (e.g., soil, water, or sediments). While it provides a measure of the overall concentration of petroleum hydrocarbons present, TPH does not distinguish between different types of petroleum hydrocarbons.

Total Kjeldahl Nitrogen (TKN): the total of organic and ammonia nitrogen. TKN is determined in the same manner as organic nitrogen, except that the ammonia is not driven off before the digestion step.

total suspended solids (TSS): a measure of the suspended solids in wastewater, effluent, or water bodies, determined by tests for "total suspended non-filterable solids." (See: suspended solids.) (http://www.epa.gov/OCEPAterms/tterms.html)

travel cost method (TCM): method to determine the value of an event by evaluating expenditures of recreators. Travel costs are used as a proxy for price in deriving demand curves for the recreation site. (http://www.damagevaluation.com/glossary.htm)

uptake: the movement of one or more chemicals into an organism via ingestion, inhalation, and/or through the skin.

vascular plants: plants that are composed of, or provided with, vessels or ducts that convey fluids. (www.infoplease.com)

willingness-to-pay (WTP): maximum amount of money one would give up to buy some good. (http://www.damagevaluation.com/glossary.htm)

ACRONYMS

AQUIRE: AQUatic Information REtrieval System
ASTER: ASsessment Tools for the Evaluation of Risk
AWQC: ambient water quality criteria
BIODEG: biodegradation
BOD: biological oxygen demand
CA: contingent activity
CHEMFATE: chemical fate
CR: contingent rating
CV: contingent valuation
COD: chemical oxygen demand
HAP: hazardous air pollutant
HEAST: Health Effects Assessment Summary Tables
IRIS: Integrated Risk Information System
Koc: adsorption coefficient
MCL: maximum contaminant level
O&G: oil and grease
POC: pollutant of concern
POTW: publicly-owned treatment work
PP: priority pollutant
QSAR: quantitative structure-activity relationship
RfD: reference dose
SCDM: Superfund Chemical Data Matrix
SF: cancer potency slope factor
T&E: threatened and endangered
TCM: travel cost method
TKN: Total Kjeldahl Nitrogen
TPH: Total Petroleum Hydrocarbon
TSS: total suspended solids
WQC: human health-based water quality criteria
WTP: willingness-to-pay

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Chapter 13: Human Health Benefits

INTRODUCTION

EPA expects that the final MP&M regulation will yield a range of human health benefits by reducing effluent discharges to ***waterways*** used for fishing or drinking water.

This chapter analyzes four categories of expected human health benefits. The first two categories involve reductions in cancer cases from two exposure pathways: consumption of contaminated fish tissue and ingestion of contaminated drinking water for the exposed population. EPA evaluated the expected annual reduction in cancer cases in the exposed population and the associated monetary value of avoiding those cancer cases.

EPA quantified, but did not monetize, two additional measures of human health-related benefits. The first is the changes in fish consumption and drinking water exposures to non-cancer causing pollutants measured against non-cancer health effect ***reference doses (RfDs)***, an indicator of non-cancer health risk. The second benefit measure is the change in occurrence of pollutant concentrations that are estimated to exceed human health-based ***ambient water quality criteria (AWQC)***.

EPA also quantified and monetized changes in health risk to adults and children from reduced exposure to lead. This analysis is presented in Chapter 14.

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The health-related measures were estimated for the baseline and for the final option for all of the benefit categories analyzed. In addition, EPA estimated health benefits for alternative options which EPA considered for the MP&M regulation. The reduction in the health-related measures (i.e., number of annual cancer cases) from baseline to the post-compliance case is the estimated benefit of the MP&M regulation. As discussed in Chapter 12, EPA estimated national benefits for the regulation based on sample facility data. The Agency extrapolated findings from the sample facility analyses to the national level using two alternative extrapolation methods: (1) traditional extrapolation and (2) post-stratification extrapolation. Appendix G provides detailed information on the extrapolation approaches used in this analysis.

EPA estimated that, for combined recreational and subsistence angler populations, the final option would lead to a marginal reduction in cancer cases. The total monetized human health benefits from reduced cancer cases from both the fish consumption and drinking water pathways are essentially negligible (i.e., $90 per year based on the traditional extrapolation and $134 per year based on the post-stratification extrapolation (2001$)).

Benefits will also be realized in the form of reductions in non-cancer human health effects (e.g., systemic effects, reproductive toxicity, and developmental toxicity) from reduced contamination of fish tissue and drinking water sources. For this analysis, EPA estimates the numbers of individuals in the exposed populations who might be expected to realize reduced risk of non-cancer health effects in the post-compliance scenario. To evaluate the potential benefits of reducing the in-stream concentrations of 76 pollutants that cause non-cancer health effects, EPA estimated target organ-specific hazard indices (HI) for drinking water and fish ingestion exposures in both the baseline and post-compliance scenarios. HI values below one are generally considered to suggest that exposures are not likely to result in appreciable risk of adverse health effects during a lifetime, and values above one are generally cause for concern, although an HI greater than one does not necessarily suggest a likelihood of adverse effects.

The results of EPA's analysis suggest that the incremental risk of non-cancer effects from pollutants discharged by MP&M facilities alone is quite low. This analysis found that HIs for the entire population associated with sample facilities is less than one in the baseline. The results of EPA's analysis of the post-compliance scenario indicate that hazard indices for individuals in the exposed population may decrease after facilities comply with the MP&M regulation. Increases in the percentage of exposed populations that would be exposed to no risk of non-cancer adverse human health effects due to the MP&M discharges occur in both the fish and drinking water analyses. Whether the incremental shifts in HIs are significant in reducing absolute risks of non-cancer adverse human health effects is uncertain and will depend on the magnitude of contaminant exposures for a given population from risk sources not accounted for in this analysis.

Finally, EPA analyzed the effect of the final regulation on occurrence of pollutant concentrations resulting from MP&M discharges that exceed human health-based AWQC. EPA estimated that, as the result of baseline MP&M pollutant discharges, in-stream concentrations exceed human health-based AWQC in 78 and 112 receiving reaches nationwide based on the traditional extrapolation and post-stratification extrapolation, respectively. EPA estimated that none of these exceedances will be eliminated under the final option.

13.1 Methodology & Data Sources

Individuals are potentially exposed to pollutants from MP&M facilities via consumption of contaminated fish tissue and drinking water. Potential human health effects include cancer and non-cancer health effects. Risks such as skin, lung, liver, kidney, and bladder cancer and leukemia are associated with exposure to 13 MP&M pollutants (see Table 13.1). Non-cancer health effects are associated with exposure to 76 MP&M pollutants. These effects include increased blood pressure, gastrointestinal effects, liver and kidney toxicity, cardiovascular and central nervous system effects, and decreased birth weight (see Table 13.2).

This section summarizes the methodology for estimating national benefits for three benefit categories:

1. reduced incidence of cancer from consumption of fish taken from waterways affected by MP&M industry discharges,

2. reduced incidence of cancer from ingestion of water taken from waterways affected by MP&M industry discharges, and

3. reduced occurrence of pollutant concentrations resulting from MP&M discharges that exceed human health-based AWQC.

This analysis does not include all possible human health benefits and does not provide a comprehensive estimate of the total human health benefits associated with the final MP&M rule. Analyses of health benefits are not possible for a significant number of the pollutants whose discharges will be reduced under the post-compliance scenario due to the lack of data on a quantitative relationship between ingestion rate and the potential health effects associated with these chemicals.

Beyond these important limitations, the methodologies used to assess the human health benefits involve significant simplifications and uncertainties. Elements of the analysis involving significant simplifications and uncertainties include the following: sample design and analysis of benefits by location of occurrence; estimation of in-waterway concentrations of MP&M pollutants; consideration of the joint effects of pollutants; consideration of background concentrations of MP&M pollutants; consideration of downstream effects; and estimation of the exposed fishing population. Section 13.3 provides more detail on limitations and uncertainties associated with the human health benefits analyses. Whether these simplifications and uncertainties, taken together, are likely to lead to an understatement or overstatement of the estimated economic values for the human health benefits that were analyzed is not known.

13.1.1 Cancer from Fish Consumption

The analysis of reduced annual occurrence of cancer in exposed populations via the fish consumption pathway involves three analytic steps:

- estimating the reduced annual risk of incurring cancer per exposed individual;

- estimating the population that would be expected to benefit from reduced contamination of fish; and

- calculating the change in the number of cancer events in the exposed population.

Each step is discussed in detail below.

a. Estimating change in individual cancer risk

The estimated incremental risk to an individual of developing cancer is based on four factors:[1]

- the quantity of carcinogenic chemicals that MP&M facilities discharge to waterways,
- the rate at which the discharged chemicals accumulate in fish tissue,
- the cancer effect of the chemicals, and
- the rate of personal consumption of contaminated fish.

For each sample MP&M facility and the waterway to which it discharges, EPA calculated the incremental cancer risk to four population classes with different fish consumption rates: children in families that participate in recreational angling, children in families that participate in subsistence angling, adults in families that participate in recreational angling, and adults in families that participate in subsistence angling. EPA calculated the incremental cancer risk values for baseline (i.e., before regulation) pollutant discharges and for post-compliance discharges based on the policy options considered in the final rule analysis. The following discussion summarizes the incremental cancer risk calculations.

EPA calculated the in-waterway pollutant concentrations for each reach receiving discharges from an MP&M facility using a simplified dilution model for all chemicals for which a quantitative relationship between ingestion rate and the annual probability of developing cancer has been estimated. A "***reach***" is a specific length of river, lake shoreline, or marine coastline, and an "***MP&M reach***" is one to which an MP&M facility discharges.[2] This analysis considered only the discharge reach and did not estimate concentrations below the initial MP&M reach. The water quality model used for calculating in-waterway pollutant concentrations accounts for the dilution characteristics of different water body types (i.e., streams, estuaries, and lakes). It does not account for other fate processes, such as chemical degradation or photolysis. The estimated pollutant concentrations reflect the average pollutant concentrations in the reach to which a facility discharges. For additional details on the calculation of waterway concentrations, see Appendix I.

The incremental cancer risk associated with each pollutant was calculated based on the estimated concentration of the pollutant in the affected waterway, the assumed uptake of the pollutant into fish flesh, the daily rate of fish ingestion, and the cancer risk factor for each pollutant. The formula for calculating the risk to an individual from consumption of a given chemical is as follows:

$$Risk = \frac{C \times CF_1 \times BCF \times CR \times EF \times ED}{BW \times LT \times CF_2} \times SF \qquad (13.1)$$

where:

Risk	=	incremental risk of incurring cancer from fish consumption (change in probability);
C	=	pollutant concentrations in surface water (μg/l);
CF_1	=	conversion factor, micrograms to milligrams (0.001 mg/μg);
BCF	=	bioconcentration factor of pollutant in fish (l/kg);
CR	=	human consumption rate of fish (kg/day);
EF	=	exposure frequency (365 days/year);
ED	=	exposure duration (years);
BW	=	human body weight (70 kg for adults and 30 kg for children under 18);

[1] The risk value is referred to as the *incremental* risk because it is the incremental lifetime probability that an individual will develop cancer above and beyond the baseline probability posed by all other extant factors that contribute to a risk of developing cancer.

[2] A reach is a length of river, shoreline, or coastline with relatively uniform water flow characteristics. Thus, it is reasonable to assume that pollutant dischargers have a relatively uniform effect on concentrations within a reach.

LT = human lifetime (years);
CF_2 = conversion factor, years to days (365 days/year); and
SF = pollutant cancer potency factor $(mg/kg/day)^{-1}$.

The pollutants analyzed and their cancer potency factors are presented in Table 13.1. EPA used the relationship outlined above to estimate lifetime risk values for individuals in subsistence and recreational fishing households. The risks to recreational and subsistence households are estimated over two lifetime segments. Specifically, children living in recreational fishing households are assumed to consume 7.27 grams per day (0.007 kg/day) of freshwater/estuarine fish over an 18-year period (ages 0 to 18). Adults are assumed to consume 17.5 grams per day (0.018 kg/day) of freshwater/estuarine fish over a 52-year period (ages 18 to 70). Risks for individuals living in recreational and subsistence fishing households differ in the assumed consumption rates. Children living in subsistence fishing households are assumed to consume 60.58 grams per day (0.061 kg/day) of freshwater/estuarine fish over an 18-year period (ages 0-18). Adults in subsistence households are assumed to consume 142.4 grams per day (0.142 kg/day) of freshwater/estuarine fish over a 52-year period (ages 18 to 70). The total lifetime incremental risk for these households is calculated by summing the risks for both lifetime segments.

Fish consumption rates for adults are taken from the *Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health* (EPA, 2000a). Both these rates, 142.4 g/day for adult subsistence anglers and 17.5g/day for adult recreational anglers, are used for the specific sub-population that they represent. EPA was not able to break the data supporting these rates down by gender or age group for use in this analysis.

EPA has determined that the fish consumption rate of 142.4 g/day for adult subsistence anglers falls within the range of the arithmetic mean of adult subsistence angler studies representative of the United States (EPA, 1998). The value represents the average consumption rate for this population of anglers. It represents uncooked, fresh and estuarine finfish and shellfish. This rate is reported on an uncooked basis because pollutant concentration data is reported on an uncooked weight basis. Similarly, the fish consumption rate of 17.5 g/day falls within the average consumption rate for adult recreational anglers. This rate also represents uncooked, fresh and estuarine finfish and shellfish.[3]

Fish consumption rates for children in recreational angling households are based on West et al. (1989) in the Exposure Factors Handbook (EPA 1997c). This study has the most specific data for this population group and cites an intake of 7.27 grams/day of freshwater and estuarine fish for children in recreational angling households. For children in subsistence angling households, the consumption rate was extrapolated from the 7.27 grams/day rate for children in recreational angling households using the proportional relationship between consumption rates for adult subsistence and recreational anglers (142.4 grams/day divided by 17.5 grams/day). The consumption rate for children in subsistence angling households is calculated to be 60.58 grams/day.

Currently, data on marine fish consumption rates for recreational anglers and subsistence anglers are not readily available. Given that there are few ***marine reaches*** affected by the MP&M effluent guideline, EPA decided to use the fresh and estuarine fish consumption rates in lieu of marine fish consumption rates. This may result in underestimation of benefits, however, it may also be argued that few subsistence fishers eat fresh/estuarine fish and marine fish at the same rate.

[3] For detail see memorandum *Fish Consumption Rates* by Lynn Zipf (EPA, 2002).

Table 13.1: Cancer Potency Factors for MP&M Pollutants

CAS Number	Regulated Pollutant	Cancer Potency Factor (mg/kg/day)[a]	Drinking Water Criterion?
62533	Aniline	0.0057	
62759	Nitrosodimethylamine, N-	51	
67663	Trichloromethane	0.0061	Yes
75003	Chloroethane	0.0029	
75092	Dichloromethane	0.0075	Yes
75354	Dichloroethene, 1,1-	0.6	Yes
78591	Isophorone	0.00095	
79016	Trichloroethene	0.011	Yes
86306	Nitrosodiphenylamine, N-	0.0049	
117817	Bis(2-ethylhexyl) phthalate	0.014	Yes
123911	Dioxane, 1,4-	0.011	
127184	Tetrachloroethene	0.052	Yes
7440382	Arsenic	1.5	Yes

[a] The cancer potency factor is the incremental probability of developing cancer over a lifetime resulting from ingestion of the indicated chemical at the rate of one milligram per day per kilogram of body mass. For the incremental rates of exposure in this analysis and assuming reasonable background chemical exposures, the potency factor may be reasonably assumed to be a linear constant.

Source: U.S. EPA (1998/99); U.S. EPA (1997a).

The pollutant-specific risks to recreational and subsistence anglers from MP&M facility discharges were then summed *across pollutants* for each type of angler, to obtain incremental risks for each population group from each facility's discharge. EPA developed separate estimates of cancer risk for each combination of angler type and facility discharging at least one pollutant with a cancer risk factor. The total change in probability of developing cancer from exposure to *more than one* MP&M pollutant is assumed to be the sum of the incremental risk effects from each pollutant: that is, the effects of the individual pollutants are assumed to be linearly additive.[4] The annual increased risk of cancer was estimated by dividing the increased lifetime risk values by 70 (an estimate of lifetime).

b. Estimating the affected population

The population exposed to contaminated fish and thus expected to benefit from reduced discharges includes recreational and subsistence anglers who fish the affected reaches, as well as members of such anglers' households. The geographic area from which anglers would travel to fish a reach is assumed to include only those counties that abut a given reach.[5] This assumption is based on the finding in the *1991 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation* that 65 percent of anglers travel less than 50 miles to fish (U.S. Department of the Interior, 1993). The average diameter of the counties abutting the reaches receiving discharges from the sample MP&M facilities is approximately 20 miles. Given that counties may have different shapes and that the road distance to the fishing site is likely to be greater than a straight line, the MP&M approach is likely to account for the majority of anglers that are likely to fish the affected reach. It is, however, likely to

[4] Note that the assumption of linear additivity of cancer risk effects applies not only to the combination of pollutants from a single facility but also to the combined effects of multiple facility discharges. When more than one MP&M facility discharges to the same affected waterway a circumstance found to occur with some frequency in the sample facility data the combination of the multiple facility discharges may be accounted for by simply analyzing the effects of each facility independently. The cancer effects from multiple facilities can be aggregated to estimate cancer cases in the exposed population.

[5] The exposed, and thus potentially benefiting, population would also include a category of "all other individuals" who consume freshwater and estuarine fish. Although these individuals are expected to have a much lower average daily consumption rate than anglers in the adjacent counties, they nevertheless would likely receive some benefit from reduced exposure to pollutants through fish consumption. This analysis omits this consumption category and the associated benefit estimate.

introduce a downward bias into the estimate of the affected population. Given that anglers tend to travel farther to visit sites of very good or exceptional quality, the magnitude of this bias will depend on the fishing quality of the affected sites.

Estimating the number of persons fishing a reach involved the following steps:

- estimating the licensed fishing population in counties abutting MP&M reaches;
- estimating the population of subsistence fishermen in counties abutting MP&M reaches;
- estimating the fraction of the total fishing population in counties abutting an MP&M reach that fish the MP&M reach and, from that fraction, the size of population expected to fish each MP&M reach;
- adjusting the calculated fishing populations for the presence of fish advisories; and
- including family members in the exposed population estimates.

❖ *Estimating the licensed fishing population in counties abutting MP&M reaches*

The number of fishing licenses sold in counties abutting MP&M reaches is assumed to approximate the number of anglers residing in the abutting counties. EPA excluded the nonresident, one-day, and three-day license categories from the total number of licenses used in this analysis. Data on fishing licenses are not available for every state in which MP&M facilities are located. EPA used state-level data to estimate the number of fishing licenses per county for those states for which county-level data were not assembled. Total state licenses were apportioned to counties based on the ratio of total population in the county abutting a discharge reach to total state population. Where an MP&M reach spans more than one county, fishing licenses were summed across all counties abutting the discharge reach. Where a reach lies in more than one state, EPA separately calculated the number of licenses for the abutting county(ies) based on the fishing license and county population data for the respective states.

EPA's analysis does not account for recreational anglers who do not purchase licenses as required by law. This may result in a significant underestimate of the fishing population at risk from exposure to MP&M pollutants. For example, the *1996 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation* found that 34 percent of the anglers (16 years of age and older) did not have licenses (U.S. Department of the Interior, 1996).

❖ *Estimating the population of subsistence fishermen in counties abutting MP&M reaches*

Although fishing licenses may be sold to subsistence fishermen, many of these individuals do not purchase fishing licenses. The extent of subsistence fishing in the U.S. or in individual states is not generally known. For this analysis, EPA assumed that the number of subsistence fishermen would be an additional 5 percent of the licensed fishing population.[6] That is, after estimating the licensed fishing population in counties abutting MP&M reaches, EPA added 5 percent to this value as the estimated number of subsistence fishermen.[7]

❖ *Estimating the population fishing an MP&M reach*

EPA assumed that fishing activity among anglers residing within counties abutting a discharge reach is distributed evenly among all reach miles within those counties. Thus, the number of anglers who fish an MP&M reach was estimated by computing the length of the reach as a percentage of total reach miles within corresponding counties and multiplying the estimated ratio by the total fishing population in counties abutting the reach.

❖ *Adjusting for fish advisories*

For MP&M reaches where fish advisories are in place (typically due to non-MP&M regulated pollutants such as dioxin and mercury), EPA assumed that some proportion of anglers would adhere to the advisory and not fish those reaches (U.S. EPA, 1999a). Past studies suggest that anglers have a high, although not complete, level of awareness of fish advisories. These studies further suggest that while anglers may change their behavior in response to fish consumption advisories, they do not necessarily refrain from fishing in these reaches or consuming fish taken from reaches under an advisory. For example,

[6] It is important to estimate recreational and subsistence populations separately because fish consumption rates for subsistence anglers are considerably higher than those for recreational anglers.

[7] The environmental justice analysis presented in Chapter 17 of this report shows that the percent of residents living below the poverty level in the counties affected by MP&M discharges ranges from 7.4 to 25.2. Thus, the assumption that subsistence anglers are an additional 5% of the licensed fishing population is likely to provide a reasonable estimate of the subsistence anglers population.

studies conducted by Belton et al (1986), Knuth and Velicer (1990), Silverman (1990), West et al. (1989), Connelly, Knuth, and Bisogni (1992), and Connelly and Knuth (1993) indicate that 50 to 87 percent of anglers surveyed were aware of state fish advisories on water bodies where they fish.

These studies also indicate that only 10 to 34 percent of anglers who were aware of advisories modified their fishing behavior in response by no longer fishing a particular location, changing the location in which they fish, or taking fewer fishing trips. However, 13 to 68 percent of anglers who were aware of advisories changed their consumption or preparation habits in response to advisories. The study by Knuth and Velicer (1990) also found some confusion among anglers regarding which waters were under advisory: 37 percent of fishermen actually fishing in waters under advisory reported that they were fishing in uncontaminated waters.

On the basis of these data, EPA assumed that recreational fishing activity would be 20 percent less on reaches subject to an advisory than would otherwise be estimated. EPA also assumed that fish advisories *do not* affect fishing participation by subsistence anglers; thus, no adjustment was made to the estimates of the subsistence fishing population based on the presence of fish advisories.

The assumed 20 percent decrease in recreational fishing could lead to either an overestimate or underestimate of the risk associated with consumption of contaminated fish. For one thing, anglers who change locations may simply be switching to other locations where advisories are in place and therefore maintain or increase their current risk. Also, those who continue to fish contaminated waters may change their consumption and preparation habits to minimize the risks. Data on the specific fish advisories was pulled from EPA's on-line Listing of Fish and Wildlife Advisories (U.S. EPA, 1999a).

❖ ***Including family members in the exposed population estimates***

EPA assumed that, in addition to anglers themselves, families of anglers would also consume fish taken from waters affected by MP&M facility discharges. Therefore, for each MP&M reach, EPA multiplied the estimated numbers of recreational and subsistence anglers fishing the affected reaches by 2.65, the size of the average U.S. household in 1996 based on Current Population Reports, (U.S. Bureau of the Census, 1997). These calculations yielded the household populations of recreational and subsistence anglers who are estimated to consume fish from the reach to which the MP&M facility discharges, either directly or indirectly through a POTW. EPA expects that family members will benefit from reduced MP&M industry discharges by consuming fish that has lower levels of pollutant contamination.

c. Calculating the change in the number of cancer events in the exposed population

EPA calculated the number of cancer cases associated with the pollutant discharges (baseline and post-compliance) from each facility by multiplying the incremental cancer risk value for the two population classes times the estimated sizes of the population classes living near the facility. The product of the incremental risk value and the population size yields the number of annual cancer events in the given population class estimated to result from consumption of fish taken from waterways affected by MP&M pollutant discharges. Summing the values for the recreational and subsistence fishing household classes yields the total number of cancer cases associated with the sample facility discharges. Because the number of cancer cases apply to *sample* facilities, EPA extrapolated the sample results to the total MP&M population by multiplying the result obtained for each sample facility by its sample weight and summing the sample-weighted facility results. The formula follows:

$$TCC_{fc} = \sum_{i}^{n} Wt_i \times ((POP_{i,sprt} \times Risk_{i,sprt}) + (POP_{i,sbst} \times Risk_{i,sbst})) \qquad (13.2)$$

where:

TCC_{fc}	=	total national estimate of annual cancer cases associated with consumption of contaminated fish tissue (baseline or post-compliance);
Wt_i	=	facility sample weight *i* (*i* = 1 to *N* facilities, where *N* is the number of facilities in the sample);
$POP_{i,sprt}$	=	exposed population in recreational fishing households for the reach to which facility *i* discharges (with adjustments as indicated for the presence of fish consumption advisories);
$POP_{i,sbst}$	=	exposed population in subsistence fishing households for the reach to which facility *i* discharges;

$Risk_{i,sprt}$ = incremental cancer risk from fish consumption in the recreational fishing household population associated with MP&M pollutant discharges from facility *i*; and

$Risk_{i\ sbst}$ = incremental cancer risk from fish consumption in the subsistence fishing household population associated with MP&M pollutant discharges from facility *i*.

These values were calculated for the baseline and post-compliance discharge cases. The *difference* is the number of cancer cases estimated to be avoided annually through the fish consumption pathway as a result of the final regulation.

13.1.2 Cancer from Drinking Water Consumption

The analysis of reduced cancer incidence via the drinking water pathway involves three analytical steps that are largely parallel to those performed for the fish consumption pathway:

- estimating cancer risk to an exposed individual from consumption of contaminated drinking water,
- estimating the population that would benefit, and
- calculating the change in the number of cancer events in the exposed population.

The major differences in the analysis for the drinking water pathway involve the identification of the exposed population and the analysis of pollutant discharge effects in both the reach to which a facility discharges and reaches downstream of the discharge point.

a. Estimating cancer risk from drinking water consumption

Estimating cancer risk from consumption of drinking water affected by MP&M discharges requires calculating in-waterway pollutant concentrations in locations where drinking water treatment systems draw water for public consumption. This analysis involves three elements:

- estimating in-waterway pollutant concentrations for each pollutant in the reach to which a facility directly or indirectly discharges. The method and formulas for this calculation are identical to those described for the analysis of cancer effects for the fish consumption pathway.
- estimating the pollutant concentrations over a distance of 500 kilometers downstream from each facility's discharge reach, using an exponential decay model in which pollution concentrations diminish below the initial point of discharge (e.g., dilution, adsorption, partitioning, volatilization, and hydrolysis). Methods used to calculate downstream pollutant concentrations are described in more detail in Appendix H.
- identifying the location of any drinking water intakes in the initial and downstream reaches where pollutant concentrations were calculated and assigning pollutant concentration values to each relevant intake point. The EPA's Safe Drinking Water Information System ***(SDWIS)*** file in the Risk Screening Environmental Indicator ***(RSEI)*** model provided information on drinking water intakes (U.S. EPA, 1999b).

Estimated pollutant concentrations at each drinking water intake determines cancer risk. EPA assumed drinking water treatment systems will reduce concentrations to below adverse effect thresholds for all chemicals for which EPA has published a drinking water criterion. Therefore, pollutants examined in the MP&M drinking water analysis include only six carcinogens for which current drinking water criteria are not available. See Table 13.1 for a list of the pollutants, their cancer potency factors, and drinking water criteria.

The formula for calculating the incremental risk to an individual resulting from the discharge of a given pollutant from a given facility at reaches with a known public drinking water intake is as follows:

$$Risk = \frac{C \times CF_1 \times CR \times EF \times ED}{BW \times LT \times CF_2} \times SF \qquad (13.3)$$

where:

Risk = incremental risk of incurring cancer from drinking water consumption (change in probability), calculated at each drinking water intake within 500 km of the initial discharge point;

C	=	pollutant concentration in surface water in the reach with an intake (µg/l);
CF_1	=	conversion factor, micrograms to milligrams (0.001 mg/µg);
CR	=	human consumption rate of water (1.24 l/day);
EF	=	exposure frequency (350 days/year);
ED	=	exposure duration (70 years);
BW	=	human body weight (70 kg);
LT	=	human lifetime (70 years);
CF_2	=	conversion factor (365 days/year); and
SF	=	pollutant cancer potency factor $(mg/kg/day)^{-1}$.

The consumption rate of 1.24 liters per day used in this analysis to represent the average daily consumption of drinking water by a person in the United States is taken from *Estimated Per Capita Water Ingestion in the United States* (EPA, 2000b). As recommended in the Exposure Factors Handbook (1997c), EPA uses an exposure frequency of 350 days per year to estimate the increased risk of cancer from consuming drinking water supplied by drinking water systems with intakes on local surface water bodies.

The incremental individual risk from each facility's pollutants are then summed over pollutants at each drinking water intake to calculate the incremental risk at each intake resulting from pollutant discharges by each upstream facility. The findings carried forward to the next step include the incremental cancer risk for each combination of facility and associated drinking water intake(s).

To estimate the annual increased risk of cancer in consumers served by drinking water intakes affected by MP&M discharges, the lifetime risk values were then divided by 70 years (an estimate of lifetime). These values were calculated for both the baseline and post-compliance discharge cases.

b. Estimating the benefiting population

The exposed population for each combination of discharging facility and drinking water intake is the general population served by the drinking water system for which the drinking water intake was identified. Safe Drinking Water Information System (SDWIS) file in the Risk Screening Environmental Indicator (RSEI) model provided information on drinking water intakes.

c. Calculating the changes in the number of cancer events

EPA calculated the number of cancer cases for baseline and post-compliance pollutant discharges for each combination of facility and affected drinking water intake by multiplying the incremental cancer risk value times the population served by the water system drawing water at the drinking water intake.

The total number of cancer cases associated with the facility discharges is the sum of cancer cases over all drinking water intakes. EPA extrapolated the sample results to the total MP&M population by multiplying the result for each sample facility by its sample weight and summing the sample-weighted facility results. Because incremental cancer effects are assumed to be linearly additive, cancer-risk effects are aggregated over facilities and drinking water intakes by simple addition of the effects calculated separately for each combination of facility and drinking water intake. The formula follows:

$$TCC_{dw} = \sum_{i}^{N} \sum_{j}^{M} Wt_i \times (POP_{i,j} \times Risk_{i,j}) \tag{13.4}$$

where:

TCC_{dw}	=	total national estimate of cancer cases associated with consumption of chemically-contaminated drinking water (baseline or post-compliance);
Wt_i	=	facility sample weight *i* (*i* = 1 to *N* facilities);
$POP_{i,j}$	=	population exposed to discharges by facility i at drinking water intake *j* (*j* = 1 to *M* water supply intakes); and
$Risk_{i,j}$	=	incremental cancer risk for discharges by facility *i* at drinking water intake *j*.

EPA calculated these values for the baseline and post-compliance discharge cases. The difference in the values is the number of drinking water associated cancer cases estimated to be avoided annually by reduced MP&M industry discharges.

13.1.3 Exposures above Non-cancer Health Thresholds

Exposed populations are also at risk of developing non-cancer health problems (including systemic, reproductive, immunological, neurological, or circulatory problems) from fish ingestion and water consumption. The common approach for assessing the risk of non-cancer health effects from the ingestion of a pollutant is to calculate a hazard quotient by dividing an individual's oral exposure to the pollutant, expressed as a pollutant dose in milligrams per kilogram body weight per day (mg/kg/day), by the pollutant's oral reference dose (RfD). An RfD is defined as an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily oral exposure that likely would not result in the occurrence of adverse health effects in humans, including sensitive individuals, during a lifetime. Toxicologists typically establish an RfD by applying uncertainty factors to the lowest- or ***no observed adverse effect level (NOAEL)*** for the critical toxic effect of a pollutant. A hazard quotient less than one means that the pollutant dose to which an individual is exposed is less than the RfD, and, therefore, presumed to be without appreciable risk of adverse human health effects. A hazard quotient greater than one means that the pollutant dose is greater than the RfD. RfDs are available for 77 of the 132 MP&M pollutants of concern. The pollutants analyzed and their RfDs are listed in Table 13.2.

Table 13.2: RfDs for MP&M Pollutants

CAS Number	Regulated Pollutant	RfD (mg/kg/day)	Drinking Water Criterion? [a]	Target Organ and Effects
83329	Acenaphthene	0.060	No	Liver toxicity
67641	Acetone	0.100	No	Increased liver and kidney weights; nephrotoxicity
98862	Acetophenone	0.100	No	General toxicity
107028	Acrolein	0.020	No	Cardiovascular toxicity[b]
7429905	Aluminum	1.000	Yes	Renal failure, intestinal contraction interference, adverse neurological effects[c]
120127	Anthracene	0.300	No	
7440360	Antimony	0.000	Yes	Longevity, blood glucose, cholesterol
7440382	Arsenic	0.000	Yes	Hyperpigmentation, keratosis and possible vascular complications
7440393	Barium	0.070	Yes	Increased kidney weight
65850	Benzoic acid	4.000	No	
100516	Benzyl alcohol	0.300	No	Forestomach, epithelial hyperplasia
7440417	Beryllium	0.002	Yes	Small intestinal lesions
92524	Biphenyl	0.050	No	Kidney damage
117817	Bis(2-ethylhexyl) phthalate	0.020	Yes	Increased relative liver weight
7440428	Boron	0.090	No	Testicular atrophy, spermatogenic arrest
85687	Butyl benzyl phthalate	0.200	No	Significantly increased liver-to-body weight and liver-to-brain weight ratios
7440439	Cadmium	0.001	Yes	Significant proteinuria (protein in urine)
75150	Carbon disulfide	0.100	No	Fetal toxicity, malformations
108907	Chlorobenzene	0.020	No	Histopathologic changes in liver
75003	Chloroethane	0.400	No	
7440473	Chromium	1.500	Yes	Renal tubular necrosis (kidney tissue decay)[c]
18540299	Chromium hexavalent	0.003	Yes	Reduced water consumption
7440484	Cobalt	0.060	No	Heart effects[c]
7440508	Copper	0.040	Yes	Gastrointestinal effects, liver necrosis[c]
95487	Cresol, o-	0.050	No	Decreased body weights and neurotoxicity.

Table 13.2: RfDs for MP&M Pollutants				
CAS Number	Regulated Pollutant	RfD (mg/kg/day)	Drinking Water Criterion? [a]	Target Organ and Effects
106445	Cresol, p-	0.005	No	Central nervous system hypoactivity and respiratory system distress
57125	Cyanide	0.020	Yes	Weight loss, thyroid effects and myelin degeneration
75354	Dichloroethene, 1,1-	0.009	Yes	Toxic effects on kidneys, spleen, lungs[c]; hepatic lesions
75092	Dichloromethane	0.060	Yes	Liver toxicity
60297	Diethyl ether	0.200	No	Depressed body weights
68122	Dimethylformamide, N,N-	0.100	No	Liver and gastrointestinal system effects
105679	Dimethylphenol, 2,4-	0.020	No	Clinical signs (lethargy, prostration, and ataxia) and hematological changes
84742	Di-n-butyl phthalate	0.100	No	Increased mortality
51285	Dinitrophenol, 2,4-	0.002	No	Cataract formation
606202	Dinitrotoluene, 2,6-	0.001	No	Mortality, central nervous system neurotoxicity, blood heinz bodies and methemoglobinemia, bile duct hyperplasia, kidney histopathology
117840	Di-n-octyl phthalate	0.020	No	Kidney and liver increased weights, liver increased SGOT and SGPT activity
122394	Diphenylamine	0.025	No	Decreased body weight, and increased liver and kidney weights
100414	Ethylbenzene	0.100	Yes	Liver and kidney toxicity
206440	Fluoranthene	0.040	No	Nephropathy, increased liver weights, hematological alterations, clinical effects
86737	Fluorene	0.040	No	Decreased red blood cell count, packed cell volume and hemoglobin
16984488	Fluoride	0.060	Yes	Objectionable dental fluorosis (soft, mottled teeth)
591786	Hexanone, 2-	0.040	No	Hypatotoxicity and nephrotoxcity[d]
7439896	Iron	0.300	Yes	Liver, diabetes mellitus, endocrine disturbance, and cardiovascular effects[d]
78831	Isobutyl alcohol	0.300	No	Hypoactivity and ataxia
78591	Isophorone	0.200	No	Kidney pathology
7439965	Manganese	0.140	Yes	Central nervous system effects
78933	Methyl ethyl ketone	0.600	No	Decreased fetal birth weight
108101	Methyl isobutyl ketone	0.080	No	Lethargy, increased liver and kidney weights and urinary protein
80626	Methyl methacrylate	1.400	No	Increased kidney to body weight ratio
91576	Methylnaphthalene, 2-	0.020	No	
7439987	Molybdenum	0.005	No	Increased uric acid
91203	Naphthalene	0.020	No	Decreased body weight
7440020	Nickel	0.020	Yes	Decreased body and organ weights
100027	Nitrophenol, 4-	0.008	No	
59507	Parachlorometacresol	2.000	No	
108952	Phenol	0.600	No	Reduced fetal body weight in rats
7723140	Phosphorus (elemental)	0.000	No	Parturition mortality; forelimb hair loss

Table 13.2: RfDs for MP&M Pollutants				
CAS Number	**Regulated Pollutant**	**RfD (mg/kg/day)**	**Drinking Water Criterion? [a]**	**Target Organ and Effects**
129000	Pyrene	0.030	No	Kidney effects (renal tubular pathology, decreased kidney weights)
110861	Pyridine	0.001	No	Increased liver weight
7782492	Selenium	0.005	Yes	Clinical selenosis (hair or nail loss)
7440224	Silver	0.005	Yes	Argyria (skin discoloration)
100425	Styrene	0.200	Yes	Red blood cell and liver effects
127184	Tetrachloroethene	0.010	Yes	Liver toxicity, weight gain
7440280	Thallium	0.000	Yes	Liver toxicity, gastroenteritis, degeneration of peripheral and central nervous system[b]
7440315	Tin	0.600	No	Kidney and liver lesions
7440326	Titanium	4.000	No	
108883	Toluene	0.200	Yes	Changes in liver and kidney weights
79016	Trichloroethene	0.006	Yes	Bone marrow, central nervous system, liver, kidneys[d]
75694	Trichlorofluoromethane	0.300	No	Survival and histopathology
67663	Trichloromethane	0.010	Yes	Fatty cyst formation in liver
7440622	Vanadium	0.007	No	Kidney and central nervous system effects[b]
108383	Xylene, m-	2.000	Yes	Central nervous system hyperactivity, decreased body weight
179601231	Xylene, m- & p-*	2.000	Yes	
95476	Xylene, o-	2.000	Yes	Central nervous system hyperactivity, decreased body weight
136777612	Xylene, o- & p-*	2.000	Yes	
7440666	Zinc	0.300	Yes	47% decrease in erythrocyte superoxide dismutase (ESOD) concentration in adult human females after 10 weeks of zinc exposure
137304	Ziram \ Cymate	0.020	No	

[a] "Yes"= there is a published drinking water criterion for a given chemical.
[b] Reference dose based on a no observed adverse effect level (NOAEL). Health effects summarized from Amdur, M.O.; Doul, J.; and Klaassen, C.D.,eds. 1991. *Cassarett and Doul's Toxicology*, 4th edition.
[c] Target organ and effects summarized from Wexler, P., ed. 1998. *Encyclopedia of Toxicology,* Volumes 1-3.
[d] Target organ and effects summarized from Amdur, M.O.; Doul, J.; and Klaassen, C.D.,eds. 1996. *Cassarett and Doul's Toxicology*, 5th edition.

Source: U.S. EPA (1998/99); U.S. EPA (1997a).

EPA guidance for assessing exposures to mixtures of pollutants recommends calculating a hazard index (HI) by summing the individual hazard quotients for those pollutants in the mixture that affect the same target organ or system (e.g., the kidneys, the respiratory system). For example, for three liver toxicants discharged from an MP&M facility (pollutant A with a hazard index of 0.10, pollutant B with a hazard index of 0.05, and pollutant C with a hazard index of 0.15), the combined hazard index is 0.30. HI values are interpreted similarly to hazard quotients; values below one are generally considered to suggest that exposures are not likely to result in appreciable risk of adverse health effects during a lifetime, and values above one are generally cause for concern, although an HI greater than one does not necessarily suggest a likelihood of adverse effects.

To evaluate the potential benefits of reducing the in-stream concentrations of 76 pollutants that cause non-cancer health effects, EPA estimated target organ-specific HIs for drinking water and fish ingestion exposures in both the baseline and post-compliance scenarios. HI is calculated for each discharge reach associated with one or more MP&M sample facilities by dividing the estimated ingestion rate of each pollutant by the RfD value for the pollutant. The formula follows:

$$HI = \sum_{k}^{K} \frac{DCR_k}{RfD_k} \tag{13.5}$$

where:

- HI = hazard index for the pollutants discharged from a facility and ingested by a specific consumption pathway;
- DCR_k = estimated daily consumption rate per kilogram of body mass for pollutant *k* via a specific consumption pathway (mg/kg/day);
- RfD_k = reference dose for pollutant *k* (mg/kg/day); and
- K = number of pollutants affecting a given organ or system.

Daily consumption rate (DCR) per kilogram of body mass for pollutant k is estimated as follows:

$$DCR_k = \frac{C \times CF_1 \times CR \times BCF}{BW} \tag{13.6}$$

where:

- DCR_k = estimated daily consumption rate per kilogram of body mass for pollutant *k* via a specific consumption pathway (mg/kg/day);
- C = pollutant concentration in surface water in the MP&M reach (µg/l);
- CF_1 = conversion factor, micrograms to milligrams (0.001 mg/µg);
- CR = human consumption rate of water (mg/day);
- BCF = bioconcentration factor for pollutant *k*;
- BW = human body weight (kg).

These HIs are calculated separately for the fish and water consumption pathways. The fish consumption pathway was further divided into recreational and subsistence fish consumption rates. The procedures and formulas for estimating the in-waterway concentrations and ingestion of pollutants by exposed populations are the same as those used for the fish consumption and drinking water cancer analyses. The only exception is that the analysis of non-cancer health pathways was performed for the discharge reach only and not for reaches downstream, due to time and resource constraints. As a result, this analysis underestimates populations exposed to non-cancer risks via drinking water pathways

EPA then combined estimates of the numbers of individuals in the exposed populations with the HIs for the populations to determine how many individuals might be expected to realize reduced risk of non-cancer health effects in the post-compliance scenario. The basis for identifying exposed populations is the same as that described for the analysis of reduced incidence of cancer via the fish consumption and drinking water consumption pathways.[8] The *shift* in populations from a *higher* to a *lower* HI value from the baseline to post-compliance cases is the quantitative measure of benefits from this analysis. This analysis was limited in two primary ways:

- First, hazard indices estimated in this analysis may understate the actual potential for adverse health effects because this analysis considers contributions to non-cancer risk resulting only from MP&M facility discharges, and does not take into account other sources of exposure to MP&M pollutants or other chemicals that may contribute to an aggregate non-cancer risk. The net result is that the analysis understates the numerical value estimated for HIs, but the incremental change in HIs between the baseline and the final option would remain the same. EPA therefore evaluated potential incremental changes in non-cancer health risks over the entire range of hazard indices, including hazard indices below one.

- Second, EPA used mean individual exposure parameters and not the distribution of exposure parameters to estimate hazard indices for the populations affected by MP&M discharges.

The results from the non-cancer health risk analysis apply to sample discharge locations only. Analytic tractability issues prevented this analysis from being conducted on a sample-weighted national basis. EPA did not monetize these benefits.

[8] The exposed populations for the drinking water consumption pathway are those associated with drinking water intakes only in a facility's discharge reach.

13.1.4 Human Health AWQC

EPA used another approach to quantify reductions in health risk from the final MP&M regulation, based on the extent to which reduced MP&M discharges would decrease the occurrence of pollutant concentrations in affected waterways that exceed human health-based AWQC. This analysis provides a measure of the change in cancer and non-cancer health risk by comparing the number of discharge reaches exceeding health-based AWQC for regulated pollutants due to MP&M activities in the baseline to the number exceeding AWQC under the final option.

AWQC are set at levels to protect human health through ingestion of aquatic organisms and ingestion of water and aquatic organisms. Accordingly, reducing the frequency at which human health-based AWQC are exceeded should translate into reduced risk to human health. This measure should be viewed as an indirect indicator of reduced risk to human health, because it does not reflect the size of the exposed population and is not tied to changes in human health risk *per se*.[9]

EPA estimated the baseline concentrations of all MP&M pollutants for each reach to which one or more MP&M facilities discharge. The calculation of concentrations used the same in-waterway dilution and mixing model described in the analysis of cancer risk for the fish consumption pathway. The baseline concentrations were compared with human health-based AWQC values. (See Table 13.3 for a list of MP&M pollutants with AWQC values.) Reaches in which concentrations of one or more pollutants were estimated to exceed an AWQC value were identified as exceeding AWQC limits in the baseline.

This analysis was repeated using the post-compliance discharge values for the final option. Reaches estimated to have concentrations in excess of AWQC in the baseline but not in the post-compliance case were assessed as having substantial water quality improvements relative to human health-based criteria as a result of regulation. EPA deems such water quality improvements to be indicative of reduced risk to human health. Although not explicitly accounted for in this analysis, human health risk reductions are also likely to occur wherever in-waterway concentrations are reduced, regardless of whether or not they are reduced to levels below AWQC.

Table 13.3: MP&M Pollutants with Human Health-Based AWQC

CAS Number	Pollutant	Human Health-Based AWQC (ug/l)		Target Organ and Effects[a]
		Organisms Only	Water & Organisms	
83329	Acenaphthene	2700	1200	Liver, hepatotoxicity
67641	Acetone	2800000	3500	Increased liver and kidney weights; nephrotoxicity
98862	Acetophenone	98000	3400	General toxicity
107028	Acrolein	1000	410	Cardiovascular toxicity[c]
7429905	Aluminum	47000	20000	Renal failure, intestinal contraction interference, adverse neurological effects[d]
62533	Aniline	95	5.8	Spleen and body cavity
120127	Anthracene	6800	4100	No observed effects
7440360	Antimony	4300	14	Longevity, blood glucose, cholesterol
7440382	Arsenic	0.16	0.02	Liver, kidneys, lungs, bladder, and skin
7440393	Barium		1000	Increased kidney weight
65850	Benzoic acid	2900000	130000	No observed adverse effects
100516	Benzyl alcohol	810000	10000	Forestomach, epithelial hyperplasia
7440417	Beryllium	1100	66	Small intestinal lesions
92524	Biphenyl	1200	720	Kidney damage

[9] The following chapter uses this same information *in part* as a direct indicator of improved water quality.

Table 13.3: MP&M Pollutants with Human Health-Based AWQC				
CAS Number	Pollutant	Human Health-Based AWQC (ug/l)		Target Organ and Effects[a]
		Organisms Only	Water & Organisms	
117817	Bis(2-ethylhexyl) phthalate	5.9	1.8	Liver
85687	Butyl benzyl phthalate	5200	3000	Significantly increased liver-to-body weight and liver-to-brain weight ratios
7440439	Cadmium	84	14	Significant proteinuria (protein in urine)
75150	Carbon disulfide	94000	3400	Fetal toxicity, malformations
108907	Chlorobenzene	21000	680	Histopathologic changes in liver
75003	Chloroethane	520	12	
18540299	Chromium hexavalent	2000	100	Reduced water consumption
7440473	Chromium	1000000	50000	Renal tubular necrosis (kidney tissue decay)[d]
7440508	Copper	1200	650	Gastrointestinal effects, liver necrosis[d]
106445	Cresol, p-	3100	170	Central nervous system hypoactivity and respiratory system distress
95487	Cresol, o-	30000	1700	Decreased body weights and neurotoxicity.
57125	Cyanide	220000	700	Weight loss, thyroid effects and myelin degeneration
117840	Di-n-octyl phthalate	39	37	Kidney and liver increased weights, liver increased SGOT and SGPT activity
84742	Di-n-butyl phthalate	12000	2700	Increased mortality
75354	Dichloroethene, 1,1-	3.2	0.057	Inconclusive
75092	Dichloromethane	1600	4.7	Liver, lungs
60297	Diethyl ether	770000	6900	Depressed body weights
131113	Dimethyl phthalate	2900000	310000	
68122	Dimethylformamide, N,N-	220000000	3500	Liver and gastrointestinal system effects
105679	Dimethylphenol, 2,4-	2300	540	Clinical signs (lethargy, prostration, and ataxia) and hematological changes
51285	Dinitrophenol, 2,4-	14000	70	Cataract formation
606202	Dinitrotoluene, 2,6-	900	34	Mortality, central nervous system neurotoxicity, blood heinz bodies and methemoglobinemia, bile duct hyperplasia, kidney histopathology
123911	Dioxane, 1,4-	2400	3.2	Liver, nasal cavity, gall bladder
122394	Diphenylamine	1000	470	Decreased body weight gain, and increased liver and kidney weights
100414	Ethylbenzene	29000	3100	Liver and kidney toxicity
206440	Fluoranthene	370	300	Nephropathy, increased liver weights, hematological alterations, clinical effects
86737	Fluorene	14000	1300	Decreased red blood cell count, packed cell volume and hemoglobin
591786	Hexanone, 2-	65000	1400	Hypatotoxicity and nephrotoxicity[b]
7439896	Iron		300	Liver, diabetes mellitus, endocrine disturbance, and cardiovascular effects[c]

Table 13.3: MP&M Pollutants with Human Health-Based AWQC				
CAS Number	Pollutant	Human Health-Based AWQC (ug/l)		Target Organ and Effects[a]
		Organisms Only	Water & Organisms	
78831	Isobutyl alcohol	1500000	10000	Hypoactivity and ataxia
78591	Isophorone	2600	36	Preputial gland
7439965	Manganese	100	50	Central nervous system effects
7439976	Mercury	0.051	0.05	
80626	Methyl methacrylate	2300000	48000	Increased kidney to body weight ratio
78933	Methyl ethyl ketone	6500000	21000	Decreased fetal birth weight
108101	Methyl isobutyl ketone	360000	2800	Lethargy, increased liver and kidney weights and urinary protein
91576	Methylnaphthalene, 2-	84	75	
91203	Naphthalene	21000	680	Decreased body weight
7440020	Nickel	4600	610	Decreased body and organ weights
100027	Nitrophenol, 4-	1100	220	
62759	Nitrosodimethylamine, N-	8.1	0.00069	Tumors observed at multiple sites
86306	Nitrosodiphenylamine, N-	16	5	Bladder tumors, reticulum cell sarcomas
59507	Parachlorometacresol	270000	56000	
108952	Phenol	4600000	21000	Reduced fetal body weight in rats
7723140	Phosphorus (elemental)	2.2	0.53	Parturition mortality; forelimb hair loss
129000	Pyrene	290	230	Kidney effects (renal tubular pathology, decreased kidney weights)
110861	Pyridine	5400	35	Increased liver weight
7782492	Selenium	11000	170	Clinical selenosis (hair or nail loss)
7440224	Silver	110000	170	Argyria (skin discoloration)
100425	Styrene	160000	6700	Red blood cell and liver effects
127184	Tetrachloroethene	3500	320	Liver toxicity, weight gain
7440280	Thallium	6.5	1.8	Liver toxicity, gastroenteritis, degeneration of peripheral and central nervous system
108883	Toluene	200000	6800	Changes in liver and kidney weights
79016	Trichloroethene	92	3.1	
75694	Trichlorofluoromethane	66000	9100	Survival and histopathology
67663	Trichloromethane	470	5.7	Kidneys
108383	Xylene, m-	100000	42000	Central nervous system hyperactivity, decreased body weight
136777612	Xylene, o- & p- (c)	100000	42000	
95476	Xylene, o-	100000	42000	Central nervous system hyperactivity, decreased body weight
179601231	Xylene, m- & p- (c)	100000	42000	
7440666	Zinc	69000	9100	47% decrease in erythrocyte superoxide dismutase (ESOD) concentration in adult human females after 10 weeks of zinc exposure

Table 13.3: MP&M Pollutants with Human Health-Based AWQC				
CAS Number	Pollutant	Human Health-Based AWQC (ug/l)		Target Organ and Effects[a]
		Organisms Only	Water & Organisms	
137304	Ziram \ Cymate	220000000	700	

[a] Information on target organs are not available for some pollutants.
[b] Reference dose based on a NOAEL. Health effects summarized from Amdur, M.O.; Doul, J.; and Klaassen, C.D.,eds. 1991. *Cassarett and Doul's Toxicology*, 4th edition/
[c] Target organ and effects summarized from Amdur, M.O.; Doul, J.; and Klaassen, C.D.,eds., C.D., ed. 1996. *Cassarett and Doul's Toxicology*, 5th edition.
[d] Target organ and effects summarized from Wexler, P., ed. 1998. *Encyclopedia of Toxicology*, Volumes 1-3.

Source: U.S. EPA (1980); U.S. EPA (1997a); U.S. EPA (1998/99).

13.2 Results

EPA estimated the monetary value to society associated with reduced cancer risk from consumption of fish and drinking water affected by MP&M pollutant discharges. Little information is available about dose-response relationships for non-cancer health outcomes or about the monetary value of avoiding such health outcomes. As a result, EPA was unable to assign monetary values to the estimated reductions in non-cancer health risks. Such non-cancer health risks include systemic, reproductive, immunological, neurological, and circulatory problems. Although EPA was unable to assign monetary values to the latter two benefit measures for this regulation, the quantitative analyses of these events provide additional insight into the human health-related benefits likely to result from the final regulation.

The following sections present the findings from the analysis of each of the benefit measures.

13.2.1 Fish Consumption Cancer Results

Table 13.4 shows the estimated changes in incidence of cancer cases from consumption of MP&M pollutants in fish tissue and drinking water from regulatory compliance by option. The national-level analysis finds that the final regulation and the 433 Upgrade Options would lead to a marginal reduction in cancer cases resulting from consumption of contaminated fish tissue; correspondingly, monetary benefits estimated from reduced consumption of contaminated fish are negligible under all of these three regulatory alternatives. In contrast, the estimated reductions in carcinogen loadings under the Proposed/NODA Option would result in $3.68 million (2001$) in benefits to recreational and subsistence anglers.

Table 13.4: Estimated Avoided Cancer Cases and Value of Annual Benefits for the Final Option and Regulatory Alternatives[a,b]

Option	Fish Consumption		Drinking Water[c]	
	Avoided Cancer Cases per Year	Mean Value of Benefit (2001$)[c]	Avoided Cancer Cases per Year	Mean Value of Benefit (2001$)[d]
Final Option: Traditional Extrapolation	1.38E-05	$90	0	$0
Final Option: Post-Stratification Extrapolation	2.05E-05	$134	0	$0
Proposed/NODA Option[e]	0.57	$3,684,973	0.001	$6,536
Directs + 413 to 433 Upgrade Option	1.38E-05	$90	0	$0
Directs + All to 433 Upgrade Option	2.6E-05	$169	0	$0

[a] In this analysis, EPA did not consider reductions in discharges of one carcinogen n-nitrosodimethylanine (NDMA) due to the low number of detected values for that pollutant.
[b] Regulatory alternatives are based on the Traditional Extrapolation.
[c] Avoided cancer cases via the drinking water consumption pathway were not included for pollutants with drinking water criteria. EPA has published a drinking water criterion for seven of the 13 carcinogens and it is assumed that drinking water treatment systems will reduce concentrations of these chemicals to below adverse effect thresholds.
[d] Estimated value of one avoided cancer case (2001$): $6.5 million.
[e] The estimated benefits of the Proposed/NODA Option are not directly comparable to the final option alternatives. The total number of facilities reported for the Proposed/NODA Option analysis differs from the facility count reported for the final rule and the two upgrade options. After deciding in July 2002 not to consider the NODA option as the basis for the final rule, EPA performed no more analysis on the NODA option, including not updating facility counts and related analyses for the change in subcategory and discharge status classifications.

Source: U.S. EPA analysis.

The valuation of benefits is based on estimates of society's willingness-to-pay to avoid the risk of cancer-related premature mortality. Although it is not certain that all cancer cases will result in death, avoided cancer cases are valued on the basis of avoided *mortality* to provide a conservative estimate of benefits.

In this analysis, EPA used the $6.5 million estimate of the ***value of a statistical life saved (VSL)*** recommended in the *Guidelines for Preparing Economic Analysis* (EPA, 2000c). EPA based this value on its review and analysis of 26 policy-relevant value of life studies (EPA, 1997b). The reviewed studies used hedonic wage and contingent valuation analyses in labor markets to estimate the amounts that individuals would either be willing to pay to avoid slight increases in the risk of mortality, or would need to be compensated to accept a slight increase in risk of mortality.[10] EPA associated the ***willingness-to-pay (WTP)*** values estimated in these studies with small changes in the probability of mortality. To estimate a WTP value for avoiding certain or high probability mortality events, EPA extrapolated the smaller value to that for a 100 percent probability event.[11] The Agency used the resulting estimates of the value of a "statistical life saved" in regulatory analyses to value regulatory effects that are expected to reduce the incidence of mortality.

The monetary value of a statistical life saved used in this analysis corresponds to the value of unforeseen instant death with no significant period of morbidity. Because a long period of morbidity usually precedes death from cancer, the value of an avoided cancer case may be underestimated. Therefore, the estimated value of the human health benefit of the final regulation may be understated.

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[10] The question analyzed in these studies is: How much more must a worker be paid to accept an occupation with a slightly higher risk of mortality?

[11] These estimates, however, do not represent the willingness-to-pay to avoid the certainty of death.

13.2.2 Drinking Water Consumption Cancer Results

Table 13.4 also shows the number of cancer cases estimated to be avoided for each pollutant analyzed for drinking water populations. The national-level analysis finds that the final regulation and the 433 Upgrade Options would lead to a marginal reduction in cancer cases resulting from consumption of contaminated drinking water; correspondingly, monetary benefits estimated from reduced consumption of contaminated drinking water are essentially zero under all of these three regulatory alternatives. As shown in Table 13.4, the Proposed/NODA Option would eliminate approximately 0.001 cancer cases per year. Annual monetary benefits from reduced cancer risk for the Proposed/NODA Option are estimated at $6,536 (2001$).

As noted in the preceding sections, EPA has established drinking water criteria for seven carcinogens. EPA assumes that public drinking water treatment systems will reduce these seven pollutants in the public water supply to levels that are protective of human health. To the extent that the final regulation reduces the concentration of MP&M pollutants to values that are below pollutant-specific drinking water criteria, public drinking water systems will accrue benefits in the form of reduced water treatment costs. EPA was not able to quantify such cost savings at the national level, however.

Public drinking water supply systems that currently employ various treatment technologies may also reduce concentrations of the six unregulated pollutants to the levels that are protective of human health. However, the Agency does not have information on specific treatment technologies used by the drinking water systems affected by MP&M discharges. It is not feasible to assess whether the technologies employed by the affected drinking water systems reduce concentrations of MP&M pollutants that don't have the published drinking water criteria without collecting detailed information on the affected drinking water systems. Thus, this analysis conservatively assumes that public water supply systems do not monitor pollutants that don't have published drinking water criteria and, as result, these pollutants may be passed through the affected drinking water supply systems.

13.2.3 Non-cancer Health Threshold Results

Table 13.5 summarizes baseline and post-compliance distributions of non-cancer health hazard indices and associated population estimates for each exposed population group for the final option. The shift in populations from higher to lower hazard score values between the baseline and post-compliance cases is the measure of benefit from reduced non-cancer health hazards.

Table 13.5: Change in Risk of Non-cancer Health Hazards from Reduced Exposure to MP&M Pollutants: Distribution of Hazard Indices[a]

Range of Ratios	Fish Consumption				Drinking Water Consumption			
	Baseline		Post-Compliance		Baseline		Post-Compliance	
	Population	Percent	Population	Percent	Population	Percent	Population	Percent
Final Option								
Ratio = 0.00	0	0%	122,865	12.05%	39,822,464	97.48%	40,723,280	99.69%
0.00 - 10^{-6}	121,814	11.95%	103,103	10.12%	1,029,333	2.52%	128,517	0.31%
10^{-6} - 10^{-3}	680,301	66.73%	578,122	56.72%	0	0%	0	0%
10^{-3} - 1.00	217,201	21.31%	215,226	21.11%	0	0%	0	0%
Score > 1.00	0	0%	0	0%	0	0%	0	0%
Totals	1,019,316	100%	1,019,316	100%	40,851,797	100	40,851,797	100%
Proposed/NODA Option[b]								
Ratio = 0.00	0	0%	342,040	8.17%	0	0%	4,308,352	10.95%
0.00 - 10^{-6}	872,003	20.82%	796,003	19.01%	36,552,343	92.93%	33,667,164	85.59%
10^{-6} - 10^{-3}	2,221,724	53.04%	2,310,376	55.16%	2,783,100	7.07%	1,359,927	3.46%
10^{-3} - 1.00	1,054,627	25.18%	737,312	17.60%	0	0%	0	0%
Score > 1.00	40,630	0.97%	3,253	0.08%	0	0%	0	0%
Totals	4,188,984	100%	4,188,984	100%	39,335,442	100%	39,335,442	100%
Directs + 413 to 433 Upgrade Option								
Ratio = 0.00	0	0.0%	169,106	16.59%	39,822,464	97.48%	40,723,280	99.69%
0.00 - 10^{-6}	121,814	11.95%	91,255	8.96%	1,029,333	2.52%	128,517	0.31%
10^{-6} - 10^{-3}	680,301	66.73%	559,690	54.91%	0	0%	0	0%
10^{-3} - 1.00	217,201	21.31%	199,265	19.54%	0	0%	0	0%
Score > 1.00	0	0%	0	0%	0	0%	0	0%
Totals	1,019,316	100%	1,019,316	100%	40,851,797	100%	40,851,797	100%
Directs + All to 433 Upgrade Option								
Ratio = 0.00	0	0.0%	169,106	16.59%	39,822,464	97.48%	40,723,280	99.69%
0.00 - 10^{-6}	121,814	11.95%	91,255	8.96%	1,029,333	2.52%	128,517	0.31%
10^{-6} - 10^{-3}	680,301	66.73%	563,526	55.28%	0	0%	0	0%
10^{-3} - 1.00	217,201	21.31%	195,429	19.17%	0	0%	0	0%
Score > 1.00	0	0%	0	0%	0	0%	0	0%
Totals	1,019,316	100%	1,019,316	100%	40,851,797	100%	40,851,797	100%

[a] This analysis addresses only 76 of 132 chemicals of concern, excludes background exposures, and is based only on *sample* facility discharges and associated populations. The exposed population values are not national estimates of the populations that would benefit by reduced risk of non-cancer health hazards.
[b] The estimated benefits of the Proposed/NODA Option are not directly comparable to the final option alternatives. The total number of facilities reported for the Proposed/NODA Option analysis differs from the facility count reported for the final rule and the two upgrade options. After deciding in July 2002 not to consider the NODA option as the basis for the final rule, EPA performed no more analysis on the NODA option, including not updating facility counts and related analyses for the change in subcategory and discharge status classifications.

Source: U.S. EPA analysis.

For each discharge reach, EPA selected the maximum of the target organ-specific hazard index values calculated for a given discharge reach to characterize the potential for adverse non-cancer health affects from exposure to MP&M pollutants among exposed individuals. The results of EPA's analysis suggest that HIs for individuals in the exposed populations may decrease after facilities comply with the final rule (see Table 13.5 for detail). Increases in the percentage of exposed populations that would be exposed to no risk of non-cancer adverse human health effects due to the MP&M discharges occur in both the fish and drinking water analyses. The shift to lower hazard indices should be considered in conjunction with the finding that the hazard indices for incremental exposures to pollutants discharged by MP&M facilities (for which reference doses are available) are less than one in the baseline analysis for the entire population associated with sample facilities. Whether the incremental shifts in hazard indices are significant in reducing absolute risks of non-cancer adverse human health effects is uncertain and will depend on the magnitude of contaminant exposures for a given population from risk sources not accounted for in this analysis.

Table 13.5 shows that the Proposed/NODA Option and the 433 Upgrade Options would result in similar shifts in the exposed populations from higher to low hazard index values. All of these three alternative regulatory options would increase the population with a zero incremental risk of non-cancer health effects from exposure to MP&M pollutants.

Although EPA was unable to associate an economic value with changes in the number of individuals exposed to pollutant levels likely to result in non-cancer health effects, the reductions in health risk indicated by this benefit measure further indicate that the final regulation can be expected to yield human health benefits.

13.2.4 Human Health AWQC Results

The final human health benefit category is the reduced occurrence of pollutant concentrations that are estimated to exceed human health-based AWQC. This analysis provides an alternative measure of the expected reduction in risk to human health. EPA estimates that in-stream concentrations of 4 pollutants (i.e., arsenic, iron, manganese, and n-nitrosodimethylamine) will exceed human health criteria for consumption of water and organisms in 78 receiving reaches nationwide as the result of baseline MP&M pollutant discharges. EPA estimates that there are human health AWQC exceedances caused by n-nitrosodimethylamine (NDMA). EPA did not consider NDMA pollutant reductions in its benefits analyses because of low number of detected values for that pollutant. EPA estimates that the final rule will not eliminate the occurrence of concentrations in excess of human health criteria for consumption of water and organisms and for consumption of organisms on any of the reaches on which baseline discharges are estimated to cause concentrations in excess of AWQC values.

EPA's analysis of the 433 Upgrade Options yields similar results. However, the Directs +All to 433 option would reduce the number of pollutants causing in-stream concentrations to exceed the human health-based AWQC values from 4 to 2 (i.e., exceedances from iron and manganese are eliminated). As shown in Table 13.6, the Proposed/NODA Option would not result in a significant reduction in the number of reaches that are estimated to exceed human health-based AWQC for consumption of water and organisms under the baseline discharge level. The Proposed/NODA option, however, eliminates human health-based AWQC for consumption of organisms only on 69 (35 percent) of the 197 reaches, in which in-stream pollutant concentrations exceeded the relevant criteria in the baseline. The Agency points out that analytic results corresponding to the Proposed/NODA Option are not directly comparable to the analytic results corresponding to the final rule alternatives due to the inconsistent baseline conditions (see Chapter 5 of this report for detail).

Table 13.6: MP&M Discharge Reaches with Pollutant Concentrations Exceeding Human Health-Based AWQC Limits and Reductions Achieved[a]

Category	Human Health Water and Organisms		Human Health Organisms Only	
	Number of Reaches	Number of Pollutants	Number of Reaches	Number of Pollutants
Final Option: Traditional Extrapolation				
Baseline	78	4	21	1
Post-Compliance	78	4	21	1
Percent Reduction	0.0%		0.0%	
Final Option: Post-Stratification Extrapolation				
Baseline	112	4	21	1
Post-Compliance	112	4	21	1
Percent Reduction	0.0%		0.0%	
Proposed/NODA Option[b]				
Baseline	5,852	26	197	12
Post-Compliance	5,789	21	128	9
Percent Reduction	1.1%		34.6%	
413 to 433 Upgrade Option				
Baseline	78	4	21	1
Post-Compliance	78	4	21	1
Percent Reduction	0.0%		0.0%	
Directs + All to 433 Upgrade Option				
Baseline	78	4	21	1
Post-Compliance	78	2	0	0
Percent Reduction	0.0%		100.0%	

[a] Regulatory alternatives are based on the Traditional Extrapolation.
[b] The estimated benefits of the Proposed/NODA Option are not directly comparable to the final option alternatives. The total number of facilities reported for the Proposed/NODA Option analysis differs from the facility count reported for the final rule and the two upgrade options. After deciding in July 2002 not to consider the NODA option as the basis for the final rule, EPA performed no more analysis on the NODA option, including not updating facility counts and related analyses for the change in subcategory and discharge status classifications.

Source: U.S. EPA analysis.

13.3 Limitations and Uncertainties

This section discusses limitations and uncertainties in the human health benefits analysis. The analysis does not include all possible human health benefits, and therefore does not provide a comprehensive estimate of the total human health benefits associated with the final rule. Quantification of changes in human health risk described in this chapter are not possible for all pollutants whose discharges will be reduced by the final regulation. Due to current research limitations, cancer potency factors, reference doses, and AWQC are not available for 6 metals, 27 organics, 8 nonconventional pollutants, and 3 conventional pollutants. The methodologies used also involve significant simplifications and uncertainties, as described below. Whether these simplifications and uncertainties, taken together, are likely to lead to an understatement or overstatement of the estimated economic values *for the human health benefits that were analyzed* is not known.

13.3.1 Sample Design & Analysis of Benefits by Location of Occurrence

The MP&M industries are estimated to include over 43,867 facilities nationwide that generate wastewater while processing metal parts, metal products, and machinery. Many of these facilities are quite small and, individually, discharge relatively small quantities of pollutants. Most individual facilities are not likely to have a significant adverse impact on human health at any one MP&M reach. The industry discharges a significant quantity of pollutants in the aggregate, however, because of the large number of facilities. Thus, the combined effect of discharges from several facilities at a given reach may well result in appreciable risks to human health. Multiple dischargers affecting a single reach were found to be common, based on the sample facility data.

The sample of MP&M facilities on which this analysis is based (910 facilities) represents only approximately 2 percent of MP&M facilities nationwide. This sample was based on basic industry characteristics rather than geographic location. As a result, the sample does not accurately reflect the likelihood of co-occurrence of MP&M facilities on a reach and, therefore, the contribution to in-waterway pollutant concentrations made by multiple facilities. For example, the sample may include three MP&M facilities, all discharging to the same reach. In reality, however, five MP&M facilities might discharge to this reach.

The omission of co-occurrence of discharges from additional facilities does not create a problem in the analysis of incremental cancer risk, because each facility's contribution to total risk can be estimated separately and is assumed be linearly additive. The cancer effects associated with individual facility discharges can be summed over facilities to estimate occurrence of cancer events in the total population. Therefore, the application of sample weights in the cancer analysis accounts for pollutant contributions from facilities co-occurring on MP&M reaches that are not present in the sample of facilities.

This omission does present a problem, however, when analyzing changes in hazard indices and changes in in-waterway pollutant concentrations relative to human health-based AWQC for reaches to which more than one facility discharge. For these reaches, changes in hazard indices and in-waterway pollutant concentrations from reduced pollutant discharges should account for the total discharge of pollutants over the several facilities whose discharges may affect the reach. When facilities whose discharges to the reach have unequal sample weights, however, results from the sample facility analysis cannot be extrapolated to the population simply by multiplying estimated benefit values by the sum of the sample weights of the individual facilities. See Appendix G for an explanation of the sample weighting methodology devised to partially address this problem.

While this weighting methodology does recognize the contributions of facilities with different sample facility weights to aggregate results, it still does not account for the contributions made by co-occurring facilities *not included in the sample*. The omission of the frequency of true multiple discharger effects on aggregate instream concentrations and pollutant exposures understate the benefits.

13.3.2 In-Waterway Concentrations of MP&M Pollutants

Human health benefits are based on the estimated changes in in-waterway concentrations of MP&M pollutants. A variety of factors affect in-waterway concentrations, including flow rates under average and low flow conditions, flow depth, chemistry of the waterway, mixing processes, longitudinal dispersion, flow geometry, suspension of solids, and reaction rates. This analysis takes into account only site-specific variations in flow rates and flow depth. Standard values are used for other inputs to the water quality model, due to lack of data on the reaches affected by sample facility discharges. These standard values may not be accurate for all the sample facility reaches. In addition, the flow characteristics of the sample facility reaches may not be representative of the national distribution of those characteristics. Extrapolating the sample facility benefits to national results based on sample facility weights may therefore introduce distortions. The net effect of these assumptions and extrapolations on the aggregate benefits estimates is uncertain.

13.3.3 Joint Effects of Pollutants

The analyses of human health benefits ignore the potential for joint effects of more than one pollutant. Each pollutant is dealt with in isolation; the individually estimated effects are then added together. As such, the analyses do not account for the possibility that several pollutants may combine to yield more or less adverse effects to human health than indicated by the simple sum of the individual effects. The impact of this limitation on the results of this analysis is unknown.

13.3.4 Background Concentrations of MP&M Pollutants

Background concentrations of MP&M pollutants are not considered in the benefits analysis. Rather, the analysis assumes that MP&M facilities are the only source of each of the regulated pollutants in the waterway. Background contributions, either from other upstream sources or contaminated sediments from previous discharges, are not considered. Even if discharges of these contaminants are reduced or eliminated, sediment contamination and subsequent accumulation of the regulated pollutants in aquatic organisms may continue for years.

Excluding background contributions to in-waterway pollutant concentrations affects the results for non-cancer risk and changes in human health-based AWQC exceedances. In the non-cancer risk analysis, hazard indices are likely to be systematically biased downwards by the omission of exposures to these chemicals from other water-related and non-water-related sources.[12] The net result is understated absolute risks of non-cancer health hazards. Similarly, reductions in human health-based AWQC exceedances calculated for a given MP&M reach are likely to be systematically biased downwards. The analysis is therefore likely to understate the frequency with which in-waterway pollutant concentrations move from values exceeding pollutant specific AWQC to values less than pollutant specific AWQC as a result of the regulation.

13.3.5 Downstream Effects

The analysis of cancer effects from drinking water consumption considered exposures from intakes downstream of the MP&M discharges. EPA, however, did not evaluate cancer risk to recreational and subsistence fishermen fishing downstream reaches, because of resource constraints. In addition, due to differential weighting of sample facility results, it was not possible to evaluate hazard indices indicating non-cancer health hazards or human health-based AWQC excursions in downstream reaches. By omitting these downstream effects, this analysis potentially understates baseline risks that would be reduced by the final option:

- cancer cases (from fish consumption),
- populations exposed to non-cancer risks, and
- waterways with pollutant concentrations exceeding human health-based AWQC.

13.3.6 Exposed Fishing Population

Estimating the exposed fishing populations for specific MP&M reaches requires statistics on county fishing licences. EPA collects these data for every state where the MP&M facilities are located where the state collects these data at the county level. Where fishing license data were not available at the county level, EPA estimated the exposed fishing population based on state fishing license statistics and census data. This approach is likely to understate actual fishing populations. As noted in Section 13.1.1, the *1996 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation* found that 34 percent of the anglers (16 years of age and older) did not have licenses (U.S. Department of the Interior, 1996). In addition, data limitations hamper the estimate of the number of anglers who actually fish a given MP&M reach. Estimating the number of anglers fishing MP&M reaches based on the ratio of MP&M reach length to the total number of MP&M reach miles in the county recognizes the effect of the quantity of competing fishing opportunities on the likelihood of fishing a given reach, but it does not account for the differential quality of fishing opportunities. If water quality in substitute sites is distinctly worse or better, the estimates of the exposed populations are likely to be overstated or understated.

In addition, the number of subsistence anglers was assumed to equal 5 percent of the recreational fishing population. The magnitude of subsistence fishing in the United States or in individual states is not known. As a result, this estimate may understate or overstate the actual number of subsistence anglers.

Finally, to account for the effect of a fish advisory on fishing activity, and therefore on the exposed fishing population, EPA reduced the fishing population at an MP&M reach under a fish advisory by 20 percent. This could either overestimate or underestimate the risk associated with consumption of contaminated fish, because (1) anglers who change locations may simply be switching to other locations where advisories are in place and therefore maintain or increase their current risk, and (2) anglers who continue to fish contaminated waters may change their consumption and preparation habits to reduce the risks from the contaminated fish.

[12] Ideally, the analysis would include not only background concentration and exposure effects from water-related exposures but would also account for exposures to chemicals by other routes including, air exposures including dust inhalation, and food contamination.

13.3.7 Treatment of Cancer Latency

Cancer latency refers to the time between the initial event that leads to cancer (e.g., chemical damage to DNA) and the onset of cancer. Ideally, cancer would be detected at a very early stage, when very few cells are involved. In reality, cancer latency is a very complex issue, and the time to detection varies considerably.

- Latency is related to health, age, immune status, genetics and other characteristics of the individual.
- Latency is also related to the specific carcinogen, the route of exposure, the type of cancer, the technology used for cancer detection, and numerous other factors.
- Environmentally induced cancers may not follow a typical progression pattern; their latency may be unusually shortened.
- Cancers may begin long before they are detected. The exact progress and time of recognition/detection of cancer cannot be predicted, because of the numerous factors involved.
- Variations in timing of cancer detection are partially attributable to the type of cancer involved, the individuals affected, and differences in the medical technology used.
- The fundamental issue is when the damage related to cancer actually begins in an individual and when the continued cell damage stops. Damage to the individual begins when cancer is induced. Once cellular changes begin, the immune system and other body resources are diverted to limiting the carcinogenic process and organ system damage is occurring.

EPA assumed that benefits of avoiding cancer begin to accrue when the initial events leading to cancer cease, even though the benefits may not be clinically measurable until some point in the future. In making this assumption, the Agency considered two factors:

- uncertainty as to how and when exposure changes translate into reduced cancer risk, and
- economic uncertainty associated with the value of avoiding cancer and the timing at which a value of cancer avoidance is recognized.

The monetary valuation of mortality risk from cancer in EPA benefit-cost analyses is based on the VSL. This is derived from a number of revealed-preference studies that estimate the value of avoided premature mortality. The estimates correspond to the value of unforeseen instant death with no significant period of morbidity. The value of an avoided cancer case used in this analysis may therefore be understated, and ultimately the estimated value of the human health benefit of the final regulation may be understated.

13.3.8 Treatment of Cessation Lag

In August 2001, EPA's Science Advisory Board (SAB) recommended that EPA should not assume that a reduction in cancer cases immediately follows a reduction in exposure (U.S.EPA, 2001). The SAB explained that, in fact, there is a lag between the time when exposures are reduced and the time when a reduction in risk occurs, and that "...if the lag between reduction in exposure and reduction in risk is long, there will be fewer cancer fatalities avoided in years immediately following the policy than if the lag were shorter." However, the Agency points out the published studies that attempted to address cessation lag found that after cessation of exposure, cancer risk begins to decline quickly (U.S. EPA, 2001).

The analysis of cancer benefits presented did not account for a cessation lag because the relevant information was not available for all but one (arsenic) MP&M pollutants. Not accounting for cessation lag results in an upper bound estimate of cancer-related benefits (U.S. EPA, 2001).

13.3.9 Use of Mean Individual Exposure Parameters

EPA used mean individual exposure parameters and not the distribution of exposure parameters to estimate hazard indices, cancer risk, and adverse human health effects associated with exposure to lead for the populations affected by MP&M discharges. Because individuals associated with high-end exposure parameter estimates would have higher health risks, EPA's approach is likely to result in underestimation of human health risk reduction from the final MP&M regulation.

13.3.10 Cancer Potency Factors

EPA's estimates of cancer cases were calculated using cancer potency factors that are upper bound estimates of cancer potency, potentially leading to overestimation of cancer risk.

GLOSSARY

ambient water quality criteria (AWQC): AWQC present scientific data and guidance of the environmental effects of pollutants which can be useful to derive regulatory requirements based on considerations of water quality impacts; these criteria are not rules and do not have regulatory impact (U.S. EPA. 1986. Quality Criteria for Water 1986. U.S. Environmental Protection Agency, Office of Water Regulations and Standards, Washington, DC. EPA 440/5-86-001).

marine reach: a specific length of marine coastline.

MP&M reach: a reach to which an MP&M facility discharges.

no observed adverse effect level (NOAEL): exposure level at which there are no statistically or biologically significant differences in the frequency or severity of any effect in the exposed or control populations.

reach: a specific length of river, lake shoreline, or marine coastline.

reference dose (RfD): an estimate of the maximum daily ingestion in that is likely to be without an appreciable risk of deleterious effects during a lifetime.

value of a statistical life saved (VSL): a monetary value of fatalities. A statistical life is saved when the mortality rate of a group of people is reduced sufficiently that one less person will die than would otherwise be the case. One must distinguish between statistical and actual lives. An actual life is saved when the identity of the beneficiary is known before the lifesaving expenditure is made.

waterway: streams, lakes, bays, and estuaries.

willingness-to-pay (WTP): maximum amount of money one would give up to buy some good. (http://www.damagevaluation.com/glossary.htm)

ACRONYMS

AWQC: ambient water quality criteria
NOAEL: no observed adverse effect level
RfD: reference dose
RSEI: Risk Screening Environmental Indicator Model
SDWIS: Safe Drinking Water Information System
VSL: value of a statistical life saved
WTP: willingness-to-pay

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Chapter 14: Lead-Related Benefits

INTRODUCTION

The human health benefits analysis presented in the previous chapter examined both cancer and ***non-cancer health risks*** from exposure to MP&M pollutants. EPA performed a separate analysis of benefits from reduced exposure to lead. The analysis of health effects from exposure to lead is based on ***dose-response functions*** tied to specific ***health endpoints*** to which monetary values can be applied. In this way it differs from the analysis of non-cancer health risk from exposure to other MP&M pollutants. This analysis assessed benefits of reduced lead exposure from consumption of contaminated fish tissue to three population groups: (1) preschool age children, (2) pregnant women, and (3) adult men and women. These lead-related benefits were estimated for the final MP&M regulation, the 433 Upgrade Options, and the Proposed/NODA option.

EPA estimated benefits to preschool children based on a ***dose-response relationship*** for intelligence quotient (IQ) decrements. The Agency calculated monetary values for avoided neurological and cognitive damages based on the impact of an additional IQ point on an individual's future earnings and the cost of compensatory education for children with learning disabilities. EPA also assessed the incidence of neonatal mortality due to changes in maternal ***blood lead (PbB)*** levels during pregnancy based on ***willingness-to-pay (WTP)*** values for avoiding death. EPA estimated that the final regulation will not yield any benefits to children from reduced exposure to lead.

CHAPTER CONTENTS

The health effects in adults that EPA was able to quantify all relate to lead's effect on blood pressure ***(BP)***. Quantified health effects include incidence of hypertension in adult men, initial non-fatal ***coronary heart disease (CHD)***, non-fatal strokes (***cerebrovascular accidents (CBA)*** and ***atherothrombotic brain infarctions (BI)***), and premature mortality. EPA used cost of illness ***(COI)*** estimates (i.e., medical costs and lost work time) to estimate monetary values of reduced incidence of hypertension, initial CHD, and strokes. EPA used COI estimates to estimate monetary values for reduced incidence of hypertension, initial CHD, and strokes. This analysis uses the $6.5 million estimate of the value of a statistical life saved recommended in the *Guidelines for Preparing Economic Analysis* (EPA, 2000a) to estimate monetary value of reduced incidence of premature mortality. EPA estimated that the final rule will achieve no lead-related health benefits among adults.

14.1 OVERVIEW OF LEAD-RELATED HEALTH EFFECTS

The MP&M regulation will reduce lead exposure by reducing the amount of lead discharged to water bodies from MP&M facilities, thereby reducing health and ecological risks. This section provides a brief summary of the human health effects from exposure to lead. Data for this analysis are taken from the Agency for Toxic Substance and Disease Registry's ***(ATSDR)*** Draft Toxicological Profile for Lead (1997) unless otherwise noted. The discussion provided in this section is qualitative and was not used to generate risk estimates.

Lead and lead compounds are toxic and pose threats to human health and well being. The health effects of very high levels of PbB include convulsions, coma, and death from lead toxicity. These effects have been understood for many years. The effects of lower doses of lead are not fully understood, however, and continue to be the subject of intensive scientific investigation (CDC,1991b).

Lead accumulates in the body and is stored in various organ systems. While high level exposures are of immediate concern due to ***acute toxicity***, exposure to small amounts can accumulate over time to harmful levels. Accumulated lead is very persistent, with a ***half-life*** in bone of approximately 27 years.[1] Known or strongly suspected health effects include kidney, stomach, and respiratory cancer, nervous system disorders, hypertension, anemia and blood disorders, gastrointestinal disorders, renal damage, and other effects (ATSDR, 1997; ***CARB***, 1996). Increased mortality from these effects has been observed in studies (ATSDR, 1997).

Many lead-associated adverse health effects are both chronic in nature and relatively common. These effects include but are not limited to hypertension, coronary artery disease, and impaired cognitive function. Specific cases of these conditions are difficult to link to lead exposure because the same adverse health effects or endpoints can arise from a variety of causes. Despite numerous studies conducted by EPA and other institutions, dose-response functions are available only for a handful of health endpoints associated with elevated PbB levels.[2] The available research does not always allow complete economic evaluation, even for quantifiable health effects.

Lead is harmful to any exposed individual, and the effects of lead on children are of particular concern. Children's rapid development rate makes them more susceptible to ***neurobehavioral deficits*** resulting from lead exposure. U.S. EPA identifies three sensitive populations: children under age one, children between the ages one and seven, and adult men and women (U.S. EPA, 1990). New research suggests that children older than seven may also be a hypersensitive population. Recent research on brain development among 10- to 18-year-old children shows unanticipated and substantial growth in brain development, mainly in the early teenage years (Giedd et al., 1999). This analysis does not, however, include this group due to data limitations. Table 14.1 summarizes the quantifiable health effects on children under seven and adult men and women, along with other important, non-quantified, known health effects on these populations.

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[1] A half-life of 27 years means that it takes 27 years for the levels measured in bone to decrease by 50 percent.

[2] In a pioneering study, Schwartz et al. quantified a number of health benefits that would result from reducing the lead content of gasoline (U.S. EPA, 1985). EPA extended this work by analyzing lead in drinking water (U.S. EPA, 1986a) and by funding the study of lead in the air (U.S. EPA, 1987).

Table 14.1: Quantified and Unquantified Health Effects of Lead

Population Group	Quantified Health Effect	Unquantified Health Effect
Children ages 0-7	Neonatal mortality due to decreased gestational age and low birth weight caused by maternal exposure to lead Nervous system effects in children younger than 7 years - IQ decrements, cases of IQ less than 70, PbB levels greater than 20 μg/dL	Fetal effects from maternal exposure (including diminished IQ and reduced birth weight) Low IQ (70 <IQ< 84) Permanent brain structure changes Slowed/delayed growth Delinquent and anti-social behavior Metabolic effects, impaired ***heme synthesis***, anemia Impaired hearing Possible cancer - stomach, kidney, respiratory tract Lead effects in children over 7 years
Adult Female ages 45-74	Ages 45-74 Non-fatal CHD Non-fatal stroke Mortality	Non-fatal CHD, non-fatal strokes and mortality for women in other age ranges Other cardiovascular diseases Hypertension Hypertension in pregnant women Reproductive effects - reduced fertility ***Neurobehavioral function*** Gastrointestinal effects - nausea, constipation, loss of appetite Renal effects - chronic ***nephropathy***, gout Possible cancer - stomach, kidney, respiratory tract
Adult Male ages 20 - 74	*For men in specified age ranges:* Ages 20-74 Hypertension Ages 40-75 Non-fatal CHD Mortality Ages 45-74 Non-fatal stroke	Non-fatal CHD, non-fatal strokes and mortality for men in other age ranges Other cardiovascular diseases Reproductive - men: sperm abnormalities Neurobehavioral function Gastrointestinal effects - nausea, constipation, loss of appetite Renal effects - chronic nephropathy, gout Possible cancer - stomach, kidney, respiratory tract

Source: U.S. EPA analysis.

14.1.1 Children Under Age One

Fetal exposure to lead *in utero* from maternal lead intake may result in several adverse health effects, including decreased gestational age, body weight, head circumference, body length, late fetal death, and increased infant mortality (Moore et al., 1982; McMichael et al., 1986; Ward et al., 1987; Dietrich et al., 1987; Bornschein et al., 1989; Bellinger et al., 1991). The Centers for Disease Control ***(CDC)*** estimated that the risk of infant mortality increases by 10^{-4} for each 1 μg/dL increase in maternal PbB level during pregnancy (CDC, 1991b). Neurobehavioral deficits in infants can result from both pre-natal and early post-natal exposure. The metabolic effects described for children in the section below have also been identified in infants. These effects can be quantified based on the dose-response relationship between PbB levels and intelligence quotient (IQ) decrements (Schwartz, 1994).

14.1.2 Children Between the Ages of One and Seven

Elevated PbB levels in children may result in metabolic effects such as impaired heme synthesis, anemia, slowed growth, and cancer (U.S. EPA, 1990). Severe lead poisoning may result in seizures, impaired coordination, recurrent vomiting, coma, and acute lead ***encephalopathy***, a potentially fatal condition (Piomelli et al., 1984). Elevated lead exposure may also induce a number of effects on the human nervous system. These effects include hyperactivity, behavioral and attentional difficulties, delayed mental development, and motor and perceptual skill deficits. The neurobehavioral effects on children can be quantified based on the dose-response relationship for IQ decrements (Shwartz,1993).

14.1.3 Adults

EPA has classified lead as a probable human carcinogen (Group 2b) based on animal toxicological evidence (IRIS, 2002a; see file titled Lead and Compounds (inorganic)). Lead also has been strongly suggested as the causative agent in numerous studies of kidney, stomach, and respiratory cancer in humans. The cancers observed in human studies are usually lethal. A cancer potency factor for lead has not been published by U.S. EPA, however, due to uncertainties associated with human studies. The California Environmental Protection Agency ***(CEPA)*** has also classified lead as a carcinogen and estimated a cancer potency factor of 8.5×10^{-3} per mg/kg/day for exposure to lead and lead compounds (California Air Resource Board [CARB], 1996).[3] Reduced cancer risk associated with reduced exposure to lead can be estimated based on cancer cases avoided (see Section 13.2.1). The Agency did not incorporate cancer effects from exposure to lead in the final rule analysis because these effects appeared very small compared to other adverse health effects from exposure to lead (e.g., neurological damages to children).

Elevated PbB has been linked to elevated BP in adults, especially in men aged 40 to 59 (Pirkle et al., 1985). Elevated BP, itself a health hazard, is also a risk factor for heart attack, stroke (Shurtleff, 1974; McGee and Gordon, 1976; Pooling Project Research Group ***[PPRG***], 1978), and premature death. Since heart disease and its related diseases are the primary cause of death in the United States, avoiding their exacerbation by minimizing lead exposure can be assumed to have considerable benefits for the affected population. Although elevated BP in women results in the same effects as for men, the general relationships between BP and these health effects differ somewhat across gender (Shurtleff, 1974).

Other known or strongly suspected health endpoints include nervous system disorders in adults, anemia and blood disorders, gastrointestinal disorders, and renal damage (Roels et al., 1976; Factor-Litvak et al., 1993; 1998; and 1999). Finally, data suggest that lead is ***genotoxic*** and may cause chromosomal damage in humans leading to birth defects (Anwar, 1994; Apostoli et al., 2000; Sallmen et al, 2000). Lead may also cause other adverse reproductive effects in women, including increased miscarriage and stillbirth (U.S. EPA 1990). A study of National Health and Nutrition Examination Surveys ***(NHANES)*** II data by Silbergeld et al. suggests that accumulated lead is stored in women's bone tissues and is mobilized back into the blood during the bone demineralization associated with pregnancy, lactation, and osteoporosis (Silbergeld et al., 1988). Many of these effects cannot be quantified due to a lack of information on the dose-effect relationship.

14.2 HEALTH BENEFITS TO CHILDREN

The following analysis assesses benefits to children from reduced lead exposure, via reduced consumption of contaminated fish tissue.[4] This analysis uses PbB concentrations as a ***biomarker*** of lead exposure.[5] EPA estimated PbB levels in the population of exposed children to obtain both baseline and post-compliance readings. Changes in those readings yielded estimated benefits from reduced lead exposure in the form of avoided damages. Avoided neurological and cognitive damages are expressed as changes in overall IQ levels, including reduced incidence of extremely low IQ scores (<70, or two standard deviations below the mean), and reduced incidence of PbB levels above 20 µg/dL. The neurological and cognitive damages avoided are then quantified using the value of compensatory education that an individual would otherwise need, and the impact on that individual's future earnings. This analysis does not quantify additional benefit categories, such as the costs of PbB screening and medical treatment. The reduced loss in IQ points, reduced cases of IQ levels below 70 points, and reduced special education costs associated with various PbB levels are likely to be the largest benefit categories. This analysis does not estimate the cost of group homes and other special care facilities.

The analysis of health benefits to children involves the following steps:

- estimate the baseline and post-compliance lead discharges from MP&M facilities;

[3] The cancer potency factors for lead acetate and lead subacetate are 28×10^{-1} and 3.8×10^{-2}, respectively.

[4] This analysis does not consider the beneficial effects due to reduced drinking water exposure. EPA has issued drinking water criteria for lead. This analysis assumes drinking water treatment has already reduced lead content below threshold levels.

[5] PbB concentration is the most common measure of body-lead burden. Other measures of body-lead burden include lead in bones, teeth, and hair.

- estimate lead concentrations in receiving water bodies before and after final effluent guidelines based on lead discharge estimates, effluent flow, characteristics of the receiving POTWs, and characteristics of receiving water bodies;

- estimate the baseline and post-compliance dietary lead intake of children via fish consumption;

- estimate PbB levels of exposed children before and after the final regulation, based on in-stream lead concentrations, bioconcentration factors, and fish consumption rates for children;

- assess changes in health impacts to children from reduced lead exposure, including changes in IQ loss, changes in incidence of IQ<70, and changes in neonatal mortality;

- estimate monetary benefits resulting from reduced adverse health impacts to children; and

- estimate benefits from changes in neonatal mortality from reduced maternal exposure to lead.

Figure 14.1 depicts the above steps.

The following sections summarize the relevant dose-response relationships for children, and discuss data sources used for the dose-response relationships. Each section also includes the methods used to value the changes in health effects based upon dose-response relationships.

14.2.1 PbB Distribution of Exposed Children

This section describes the estimation of changes in PbB distribution of exposed children.

a. Estimating lead concentrations in the receiving water bodies

Estimating health risks associated with lead exposure from fish consumption requires calculating in-waterway lead concentrations. The method and formulas for this calculation were identical to those described for the analysis of cancer effects for the fish consumption pathway (see Chapter 13 on Human Health Benefits and the Environmental Assessment in Appendix I for details.)[6]

b. Estimating PbB levels in exposed children

This analysis considers children that are born today and live in recreational and subsistence fishermen households. The analysis considers a continuous exposure pattern for children from birth through the seventh birthday. Exposure, health effects, and benefits are calculated separately for children living in recreational and subsistence fishing households. This analysis relies on EPA's ***Integrated Exposure, Uptake, and Biokinetics (IEUBK)*** Model for Lead in Children (IEUBK version 0.99d, March 8, 1994).

❖ *Description of the IEUBK model*

The IEUBK model uses exposure, uptake, and biokinetic response information to estimate the PbB level distribution for a population of children receiving similar exposures. The estimated distribution may be used to predict the probability of elevated PbB levels in children exposed to a specific combination of environmental-lead levels. The model addresses four components of environmental risk assessment:

- the multimedia nature of exposure to lead;

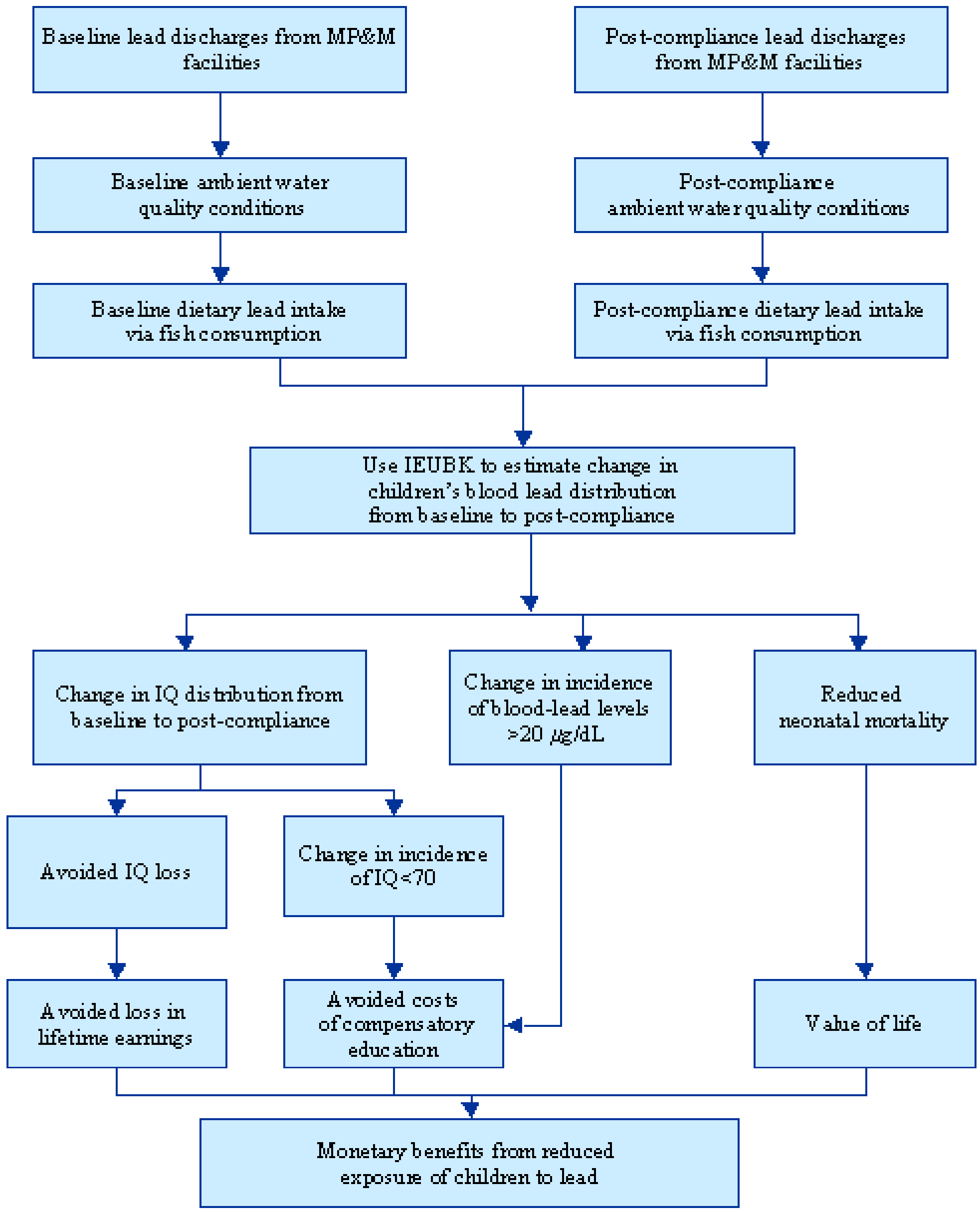
- the differential ***bioavailability*** of various sources of lead;

- the ***pharmacokinetics*** of internal distribution of lead to bone, blood, and other tissues; and

- inter-individual variability in PbB levels.

[6] The water quality model used for the Ohio case study is discussed in Appendix H.

Figure 14.1 Assessing Benefits to Children from Reduced Lead Discharges from MP&M Facilities



Source: U.S. EPA analysis.

The model uses estimated or measured lead concentrations in fish tissues and other media, such as soil, dust, air, and water to estimate a continuous exposure pattern for children from birth through the seventh birthday (U.S. EPA, 1995). The model then estimates a distribution of PbB levels for a population of children receiving similar exposures by predicting its ***geometric mean (GM)***. The inter-individual and biological variability in PbB levels of children exposed to similar environmental lead levels is represented by the ***geometric standard deviation (GSD)***. This analysis uses an empirical estimate of the variability in PbB concentrations, a GSD of 1.6, estimated from residential community PbB studies (U.S. EPA, 1995). This estimate is applied for predictions of the national distribution of PbB concentrations.

The model has three distinct functional components that work together in a series:

- exposure,
- uptake, and
- ***biokinetics*** response.

Each model component is a set of complex equations and parameters. The Technical Support Document (U.S. EPA, 1995) provides the scientific basis of the parameters and equations used in the model, while the Guidance Manual (U.S. EPA, 1994) includes a detailed description of the exposure pathways, absorption mechanism, biokinetic compartments, and associated comparted transfers of lead.

❖ *Inputs to the IEUBK model*

The IEUBK model uses three sets of parameters:

- exposure parameters estimate the amount of environmental lead taken into the body, through breathing or ingestion;
- uptake parameters estimate the amount of lead absorbed from environmental sources;
- biokinetic parameters characterize the transfer of lead between compartments of the body (e.g., between blood and bone) and elimination of lead from the body.

The IEUBK model allows the user to input values for most exposure and uptake parameters. The biokinetic parameter values cannot be altered. When exposure and uptake values are not specified, the IEUBK model provides default values. Table 14.2 summarizes the key parameter values used in this analysis and indicates whether a value is an IEUBK default value or has been specified by EPA.[7]

1. Exposure parameters include exposure rates and exposure concentrations:

   - Exposure rates: Children in recreational fishing households are assumed to consume 6.03 grams of fish per day. Children living in subsistence households are assumed to consume 30.33 grams of fish per day. These fish consumption rates are based on uncooked fish weights. The fish consumption rate for children in recreational fishing households is calculated as a weighted average based on West et al. (U.S. EPA, 1997a) for children ages 1-5 (5.63 grams of fish per day) and children ages 6-10 (7.94 grams of fish per day). For children of subsistence fishing households, the fish consumption rate is calculated as a weighted average based on Columbia River Intertribal Fish Commission (CRITFC, 1994) estimates for children under age 5 (19.6 grams of fish per day) and the Continuing Survey of Foods by Individuals (U.S. EPA, 2002b) for children ages 3-5 (40.31 grams of fish per day) and ages 6-10 (61.49 grams of fish per day).

   - Exposure concentrations: EPA used estimated in-stream concentrations of lead to calculate lead concentration of the fish consumption exposure pathway. The Agency used 1996 monitoring data (U.S. EPA, 1996b) on lead concentrations in air and the Housing and Urban Development National Survey (HUD, 1995) for data on lead concentrations in dust and soil to characterize lead exposure concentrations for these exposure pathways.[8] This

[7] A complete list of IEUBK default parameters is presented in Appendix L.

[8] EPA found that the typical PbB level distribution predicted in the IEUBK Model for Lead in Children based on the default values for air, dust, soil, and drinking water lead concentrations did not correspond to the most recent national population PbB distribution (NHANES III, Phase 2, 1994). Therefore, the Agency used more recent data to characterize the background exposure to environmental

analysis uses median concentration values for these three pathways as inputs to the IEUBK to characterize background exposure to environmental lead. EPA used the IEUBK default value for lead concentration in drinking water that takes into account contributions of lead from plumbing. Because of past use of lead in plumbing, lead concentrations in tap water are likely to be above the current water quality standard for lead in drinking water.

2. Uptake of ingested lead: Lead bioavailability varies across the chemical forms in which lead can exist. Many factors complicate the estimation of bioavailability, including nutritional status and timing of meals relative to lead intake. The Agency used the default media-specific bioavailabilities in the IEUBK model for this analysis.

3. Biokinetic parameters: The data on which these parameter values are based originate from a variety of sources, including available clinical data (U.S. EPA, 1995). These parameters cannot be changed by the user.

lead. Median values from recent monitoring data allowed the Agency to match the IEUBK-predicted PbB distribution to the NHANES-derived distribution.

Table 14.2: Selected List of Parameters Used in the IEUBK Model				
Variable		Value	IEUBK Default	Data Source
Exposure Rates	Fish: Recreational	6.03 g/day	No	The fish consumption rate for children in recreational fishing households is calculated as a weighted average based on West et al. (U.S. EPA, 1997a) for children ages 1-5 (5.63 g/day) and children ages 6-10 (7.94 g/day). The fish consumption rate for children in subsistence fishing households is calculated as a weighted average based on Columbia River Intertribal Fish Commission (CRITFC, 1994) estimates for children under age 5 (19.6 g/day) and the Continuing Survey of Foods by Individuals (U.S. EPA, 2002b) for children ages 3-5 (40.31 g/day) and ages 6-10 (61.49 g/day).
	Fish: Subsistence	30.33 g/day	No	
	Fresh Fruit	38.481 g/day 0-11 months 169.000 g/day 12-23 months 63.166 g/day 24-35 months 61.672 g/day 36-47 months 61.848 g/day 48-59 months 67.907 g/day 60-71 months 80.024 g/day 72-84 months	Yes	Values taken from Pennington, J. A. T. (1983) *Revision of the total diet study food list and diets*. Journal of American Dietetic Association 82(2): 166-173
	Fresh Vegetables	56.84 g/day 0-11 months 106.50 g/day 12-23 months 155.75 g/day 24-35 months 157.34 g/day 36-47 months 158.93 g/day 48-59 months 172.50 g/day 60-71 months 199.65 g/day 72-84 months	Yes	Values taken from Pennington, J. A. T. (1983) *Revision of the total diet study food list and diets*. Journal of American Dietetic Association 82(2): 166-173
	Meat (Including fish and game)	29.551 g/day 0-11 months 87.477 g/day 12-23 months 95.700 g/day 24-35 months 101.570 g/day 36-47 months 107.441 g/day 48-59 months 111.948 g/day 60-71 months 120.961 g/day 72-84 months	Yes	Values taken from Pennington, J. A. T. (1983) *Revision of the total diet study food list and diets*. Journal of American Dietetic Association 82(2): 166-173
	Air (Time spent outdoors)	1 hrs/day 0-11 months 2 hrs/day 12-23 months 3 hrs/day 24-35 months 4 hrs/day 36-47 months 4 hrs/day 48-59 months 4 hrs/day 60-71 months 4 hrs/day 72-84 months	Yes	Based on values reported in (1) U.S. Environmental Protection Agency (U.S. EPA), *Review of the National Ambient Air Quality Standards for Lead: Assessment of Scientific and Technical Information.* OAQPS Staff Paper, Air Quality Management Division, Research Triangle Park, NC (EPA 1989c), and (2) *Report of the Clean Air Scientific Advisory Committee on Its Review of the OAQPS Lead Staff Paper.* EPA-SAB-CASAC-90-002 (EPA 1990a)

Table 14.2: Selected List of Parameters Used in the IEUBK Model

Variable		Value	IEUBK Default	Data Source
	Water (Daily amount of water consumed)	0.20 L/day 0-11 months 0.50 L/day 12-23 months 0.52 L/day 24-35 months 0.53 L/day 36-47 months 0.55 L/day 48-59 months 0.58 L/day 60-71 months 0.59 L/day 72-84 months	Yes	*Exposure Factors Handbook*. U.S. EPA Office of Health and Environmental Assessment, Washington, DC. EPA/600/8-89/043 (1989b)
	Soil (Combined soil and dust consumption)	0.085 g/day 0-11months 0.135 g/day 12-23 months 0.135 g/day 24-35 months 0.135 g/day 36-47 months 0.100 g/day 48-59 months 0.090 g/day 60-71 months 0.085 g/day 72-84 months	Yes	Based on value reported in *Review of the National Ambient Air Quality Standards for Lead: Assessment of Scientific and Technical Information*. OAQPS Staff Paper, Air Quality Management Division, Research Triangle Park, NC (1989c)
Exposure Concentrations	Fish Tissue	site-specific	No	Estimated based on predicted lead concentration in receiving reaches and bioconcentration factor for lead (49 L/Kg)
	Outdoor Air	0.03 $\mu g/m^3$	No	Median value for 1996 from EPA's AIRS (Aerometric Information Retrieval System) air monitoring data (U.S. EPA, 1996b)
	Indoor Air	30% of Outdoor Air	Yes	Based on value reported in *Review of the National Ambient Air Quality Standards for Lead: Assessment of Scientific and Technical Information*. OAQPS Staff Paper, Air Quality Management Division, Research Triangle Park, NC (1989c)
	Water	4.0 µg/L	Yes	Analysis of data from American Water Works Service Co. in *Marcus, A.H. (1989) Distribution of lead in tap water*. Parts I and II. Report to the U.S. EPA Office of Drinking Water/Office of Toxic Substances, from Battelle Memorial Institute under Contract 68-D8-0115.
	Soil	61.78 µg/g	No	Median values from the Housing and Urban Development National Survey (U.S. Department of Housing and Urban Development, 1995)
	Dust	187.11 µg/g	No	
Food Lead Intake	Fresh Fruit	0.039 µg/day 0-11 months 0.196 µg/day 12-23 months 0.175 µg/day 24-35 months 0.175 µg/day 36-47 months 0.179 µg/day 48-59 months 0.203 µg/day 60-71 months 0.251 µg/day 72-84 months	Yes	Based on data provided by FDA in *Air Quality Criteria for Lead Vol I-IV*. U.S. EPA Environmental Criteria and Assessment Office, Research Triangle Park, NC. EPA 600/8-83-028a-d (1986b)

Table 14.2: Selected List of Parameters Used in the IEUBK Model

Variable		Value	IEUBK Default	Data Source
	Fresh Vegetables	0.148 µg/day 0-11 months 0.269 µg/day 12-23 months 0.475 µg/day 24-35 months 0.466 µg/day 36-47 months 0.456 µg/day 48-59 months 0.492 µg/day 60-71 months 0.563 µg/day 72-84 months	Yes	Based on data provided by FDA in *Air Quality Criteria for Lead Vol I-IV*. U.S. EPA Environmental Criteria and Assessment Office, Research Triangle Park, NC. EPA 600/8-83-028a-d (1986b)
	Meat (No fish or game meat)	0.226 µg/day 0-11 months 0.630 µg/day 12-23 months 0.811 µg/day 24-35 months 0.871 µg/day 36-47 months 0.931 µg/day 48-59 months 1.008 µg/day 60-71 months 1.161 µg/day 72-84 months	Yes	Based on data provided by FDA in *Air Quality Criteria for Lead Vol I-IV*. U.S. EPA Environmental Criteria and Assessment Office, Research Triangle Park, NC. EPA 600/8-83-028a-d (1986b)
	Other Foods (No fish or game meat)	3.578 µg/day 0-11 months 3.506 µg/day 12-23 months 3.990 µg/day 24-35 months 3.765 µg/day 36-47 months 3.545 µg/day 48-59 months 3.784 µg/day 60-71 months 4.215 µg/day 72-84 months	Yes	Based on data provided by FDA in *Air Quality Criteria for Lead Vol I-IV*. U.S. EPA Environmental Criteria and Assessment Office, Research Triangle Park, NC. EPA 600/8-83-028a-d (1986b)
Lead Absorption Factor	Food	0.5	Yes	Based on values reported in the *Review of the National Ambient Air Quality Standards for Lead: Exposure Analysis Methodology and Validation*; Report No. EPA-450/2-89/011; U.S. EPA Office of Air Quality Planning and Standards, Research Triangle Park, NC (1989d)
	Air	32%	Yes	
	Water	0.5	Yes	
	Soil	0.3	Yes	
	Dust	0.3	Yes	
Biokinetic Parameters		IEUBK default values and equations were used for all biokinetic parameters (these cannot be changed by the user). The complete list of IEUBK biokinetic parameters is listed in Appendix L and in the *Technical Support Document: Parameters and Equations Used in the IEUBK Model for Lead in Children*. U.S. EPA, EPA 540-R-94-040, (1995)		
Age Fish Introduced in Infant Diet		9 months	N/A	Literature on dietary guidelines for children from various childcare organizations, including the *National Network for Child Care*

Source: U.S. EPA analysis.

c. Estimating changes in the PbB level in exposed children from reduced MP&M discharges

EPA used the IEUBK model in this analysis to estimate the effect of lead-contaminated fish consumption on children's PbB concentrations. The Agency first calculated lead concentration in fish tissue corresponding to each reach affected by MP&M discharges to provide inputs to the IEUBK model. The model uses the specified fish tissue concentrations in conjunction with fish ingestion rates and bioavailability factors to determine the dose of lead absorbed by the body. This dose is then used to predict the GM PbB concentration for children associated with each reach affected by lead discharges from the MP&M facilities.

EPA used the IEUBK model to predict the baseline and post-compliance PbB distributions for children that consume fish from reaches affected by lead discharges from MP&M facilities. The difference between the estimated baseline and post-compliance PbB distribution is the basis for the analysis of benefits to children from the MP&M regulation.

14.2.2 Relationship Between PbB Levels and IQ

A dose-response relationship between PbB and IQ decrements determined by Schwartz (1994) suggests that a decrease of 0.25 IQ points can be expected for every 1 µg/dL increase in PbB (Schwartz, 1994). The ***p-value*** (< 0.0001) indicates that this relationship is highly significant.

EPA multiplied the 0.25 IQ points lost per µg/dL increase in PbB by the average increase in PbB level for children and by the number of exposed children to obtain the total change in number of IQ points for the population. The average PbB level modeled in this analysis is a GM, not the ***arithmetic mean*** used by Schwartz (1993). To adjust for this difference, equation 14.1 uses a ratio between the arithmetic mean and the GM of a ***lognormally-distributed random variable***. The ratio between the expected value (mean) of the distribution and the GM is 1.117 for the assumed GSD of children's PbB levels (1.6).

The total avoided loss of IQ points for each group is estimated as:

$$(AVOIDED\ \ LOSS\ \ of\ \ IQ\ \ POINTS)_k = \Delta GM_k \times .25 \times (Pop_k)\ /7 \tag{14.1}$$

where:

$(Pop)_k$ = the number of children (up to age seven) in anglers' families in the vicinity of a given MP&M reach; and
GM_k = the GM of the PbB distribution in the population of children.

As shown in equation 14.1, the population of children up to age seven is divided by seven to avoid double-counting. The IEUBK model calculates the GM of the PbB distribution in the population of children born today, assuming a continuous exposure pattern for children from birth through the seventh birthday. Assuming that children are evenly distributed by age, this division adjusts this equation to apply only to children age 0-1. Dividing by seven undercounts overall benefits. Children from age 1 to 7 are not accounted for in the base year of the analysis, although they are presumably affected by the lead exposure, because the IEUBK model assumes a continuous exposure pattern for children from birth through the seventh birthday.

14.2.3 Value of Children's Intelligence

Available economic research provides little empirical data on society's overall WTP to avoid a decrease in an infant's IQ. This analysis uses research that monetizes a subset of effects associated with decreased IQ. These effects represent only some components of society's WTP to avoid IQ decreases, and underestimate society's WTP when employed alone. For the purpose of this analysis, these effects are the only ones available at this time to approximate the WTP to avoid IQ decrements.

Recent studies provide concrete evidence of long-term effects from childhood lead exposure (Schwartz, 1994). This analysis assumes a permanent loss of IQ points based on PbB levels estimated for children up to age seven, and considers two consequences of this IQ decrement:

- the decreased present value of the infant's expected lifetime earnings, and
- the increased educational resources expended for an infant who becomes mentally handicapped or needs compensatory education as a consequence of lead exposure.

a. Estimating the effect of IQ on earnings

Reduced IQ has direct and indirect effects on earnings. This analysis models the overall impact from a one-point reduction in IQ as the sum of these direct and indirect effects on lifetime earnings. EPA used the most recent estimates of the effects of IQ on earnings based on Salkever (1995).[9] Salkever provided updated estimates of the direct and indirect effects of IQ loss on earnings, using the most recent available data set, the National Longitudinal Survey of Youth ***(NLSY)***. Salkever used ***regression analysis*** techniques to estimate direct and indirect effects of IQ on earnings. Three different relationships are estimated separately for male and female respondents:

- a ***least-squares regression*** of highest grade on IQ test scores;
- a ***probit regression*** of a 0-1 indicator of positive earnings on highest grade and IQ test scores;
- a least-squares regression, for persons with positive earnings, of the logarithm of earnings on highest grade and IQ test scores.

Other variables were included in each regression to control for effects of family background (parents' education and income), the age of the respondent, ethnic group, and residence location (urban U.S., non-urban U.S., south versus non-south).

Based on the regression results, Salkever estimated the effects of IQ on earnings as the sum of direct and indirect effects:

- The direct effect is the sum of effects of IQ test scores on employment and earnings for employed persons, holding the years of schooling constant.
- The indirect effect is the sum of effects of IQ test scores on years of schooling attained, and the subsequent effect of years of schooling on the probability of employment and on earnings for employed persons.

The analysis found that percentage effects of lead exposure are greater for females than for males. The total estimated effect of the loss of an IQ point on earnings, based on the Salkever study, is an earnings reduction of 1.93 percent for men and 3.22 percent for women. The total effect of the loss of an IQ point on earnings also includes non-IQ effects on schooling (e.g., behavioral problems).

b. Valuing foregone earnings

EPA monetized IQ loss effects by combining the percent earnings loss estimate with an estimate of the present value of expected lifetime earnings. EPA used the 1992 data on money income for the U.S. population (U.S. Department of Commerce, 1993) to calculate the mean present value of lifetime earnings of a person born today. The data included earnings for employed persons and employment rates as a function of educational attainment, age, and gender. The following assumptions were used to calculate the mean present value of lifetime earnings of a person born today:

- The distribution of earnings for employed persons and labor force participation rates remains constant over time.
- A person earns income from age 18 through age 67.
- Real wages grow one percent per year.
- Future earnings are discounted at a three percent annual rate.

The money income data (U.S. Department of Commerce, 1993) form the best available basis for projecting lifetime earnings, but involve some uncertainties. Labor force participation rates of women, the elderly, and other groups will likely continue to change. Currently, men tend to earn more than women due to higher wage rates and higher labor force participation. Expected lifetime earnings increase with education for both men and women. Real earnings of women will probably continue to rise relative to real earnings of men. Educational attainment has risen over time and may continue to rise. Unpredictable

[9] EPA did not incorporate earlier studies of the effects of IQ on earnings in this analysis because the Salkever study is more complete in capturing the various pathways through which IQ affects earnings, such as the indirect effect of IQ on earnings via its effect on educational attainment. Also, other studies are much older. The IQ/earning effect is likely to be higher during the high tech boom in the last decade.

fluctuations in the economy's growth rate will probably affect labor force participation rates and real wage growth for all groups. Medical advances that increase life expectancy will probably increase lifetime earnings.

Although earnings data alone form an incomplete measure of an individual's value to society, this analysis does not account for those individuals who do not participate in the labor force at all throughout their working years and whose productive services are not measured by wage rates. The largest group in this population are those who remain at home doing housework and child rearing. Volunteer work also contributes significantly to social welfare, and volunteerism rates tend to increase with educational attainment and income. Assuming that the ***opportunity cost*** of non-wage-compensated work equals the average wage earned by persons of the same sex, age, and education, the average lifetime earnings estimates would be significantly higher. Recalculating the tables using full employment rates for all age, sex, and education groups would provide higher lifetime earnings estimates. To be conservative, this analysis considered only the value of lost wages and does not include the opportunity cost of non-wage-compensated work.

The adjusted value of expected lifetime earnings equals the present value for an individual entering the labor force at age 18 and working until age 67. Given a three percent social discount rate, the other assumptions mentioned, and current survival probabilities, the present value of lifetime earnings of a person born today in the U.S. would be $448,957 (2001$).[10]

c. Valuing costs of education

The increase in lifetime earnings from additional education equals the gross return on education. The cost of education is subtracted from the gross return to obtain the net increase in earnings from additional education. The cost of education has two components: the direct cost of the education, and the opportunity cost of lost income during the education. The ***marginal cost*** of education used in this analysis was assumed to be $8,898 (2001$) per year. This figure was derived from the U.S. Department of Education's reported ($6,961) average per-student annual expenditure (current plus capital expenditures) in public primary and secondary schools in 1995-96 (U.S. Department of Education, 1998).[11] EPA adjusted this value to 2001 dollars based on CPI for education.

Salkever's study found the estimated effect of IQ on educational attainment to be 0.1007 years per IQ point. The estimated cost of an additional 0.1007 years of education per IQ point is $896 (i.e., 0.1007 × $8,898). This marginal cost was discounted to the time the exposure and damage is modeled to occur (age zero) because this cost is incurred after the completion of formal education. The average level of educational attainment in the population over age 25 is 12.9 years (U.S. Department of Education, 1993). The marginal educational cost was therefore assumed to occur at age 19, resulting in a discounted present value cost of $511 (2001$).

The other component of the cost of education is the opportunity cost of lost income while in school. Income loss is frequently cited as a major factor in the decision to terminate education, and must be subtracted from the gross returns to education. An estimate of the lost income was derived assuming that people in school are employed part-time but that people out of school are employed full-time. The opportunity cost of lost income is the difference between full-time and part-time earnings. The value of lost income associated with being in school an additional 0.1007 years is $746 (2001$) discounted to age zero.

d. Estimating the total effect of IQ on earnings

Combining the value of lifetime earnings ($448,957) with the estimate of percent wage loss per IQ point yielded $10,675 per IQ point. Subtracting the education and opportunity costs reduced this value to $9,419 per IQ point (2001$).

14.2.4 Value of Additional Educational Resources

Children with IQs less than 70 and whose PbB is greater than 20 µg/dL will require additional educational resources including an educational program tailored to the mentally handicapped. Some children whose PbB is greater than 20 µg/dL will need additional instruction while attending school later in life. The following sections describe approaches used to quantify the number of children with IQs less than 70 and to estimate increased educational costs resulting from lead exposure.

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[10] Assuming a seven percent social discount rate, the present value of lifetime earnings of a person born today in the U.S. would be $101,247 (2001$). Appendix M presents a sensitivity analysis with respect to the value of an IQ point.

[11] In comparison, the average annual cost of tuition, fees, room, and board for a four-year public undergraduate institution was $8,655 (2001$) for the year 2000-2001 (U.S. Department of Education, 2001).

a. Children with IQs less than 70

❖ ***Quantifying the number of children with IQs less than 70***

Increases in the mean PbB levels of children results in an increased incidence of children with very low IQ scores. IQ scores are normalized to have a mean of 100 and a standard deviation of 15. An IQ score of 70 is two standard deviations below the mean, and is generally regarded as the point below which children require significant special compensatory education tailored to the mentally handicapped.

The relationship presented here for estimating changes in the incidence of IQs less than 70 used the most current IQ point decrement function provided by Schwartz (1993). It assumed that, for a baseline children's PbB distribution (defined by GM and GSD), the population also has a normalized IQ point distribution with a mean of 100 and a standard deviation of 15. The proportion of the population expected to have IQs less than 70 was determined from the standard **normal distribution** function for this baseline condition:

$$P(IQ<70) = \Phi(z) \qquad (14.2)$$

where:

P(IQ <70) = probability of IQ scores less than 70

z = standard normal variate (i.e., the number of standard deviations); computed for an IQ score of 70, with mean IQ score of 100 and standard deviation of 15 as:

$$z = \frac{70 - 100}{15} = -2 \qquad (14.3)$$

Φ(z) = standard normal distribution function:

$$\frac{1}{\sqrt{2\pi}} \int_{-\infty}^{z} e^{-\frac{u^2}{2}} du \qquad (14.4)$$

The integral in the standard normal distribution function does not have a closed form solution. Values for Φ(z) are usually obtained using software with basic statistical functions or from tables typically provided in statistics texts. The solution for Φ(z) where z = -2 is 0.02275. That is, for the normalized IQ score distribution with a mean of 100 and standard deviation of 15, approximately 2.3 percent of children are expected to have IQ scores below 70.

EPA made two key assumptions to relate changes in the proportion of children with IQ scores below 70 to changes in population mean PbB levels:

1. The mean IQ score will change as a result of changes in the mean PbB level as:

$$\triangle \text{ Mean IQ} = -0.25 \times \triangle \text{ Mean PbB} \qquad (14.5)$$

where:

△ *Mean IQ* = the change in the mean IQ score between the baseline and post-compliance scenarios, and

△ *Mean PbB* = the change in the mean PbB level between the two scenarios.

This relationship relies on Schwartz' estimate (1993) of a decrease of 0.25 IQ points for each µg/dL increase in PbB. The mean PbB level referred to here is the arithmetic mean (or expected value) for the distribution, obtained as described previously from the GM and GSD.

2. The standard deviation for the IQ distribution is 15 for both the baseline and the post-compliance scenario.

Using these assumptions, EPA determined the change in the probability of children having IQ less than 70 for a given change in mean PbB from:

$$\Delta P(IQ<70) = \Phi(z_{Bl}) - \Phi(z_{Pc}) = \Phi(z_{Bl}) - 0.02275 \qquad (14.6)$$

where:

$\Phi(z_{Bl})$ = baseline standard normal distribution function, and

$\Phi(z_{Pc})$ = post-compliance standard normal distribution function.

$$z_{Bl} = \frac{70 - (100 + 0.25 \times \Delta MeanPbB)}{15} \qquad (14.7)$$

EPA then converted a given change in the mean PbB level between the baseline and post-compliance scenarios into a measure of IQ. The procedure above yielded an estimate of the percent of the population with IQs less than 70. EPA multiplied this percent by the population of exposed children to estimate the increased incidence of children with low IQs. As in the IQ point loss equation, EPA applied the results of this function to children age 0-7 and divided by seven to avoid double counting. (See discussion under equation 14.1.)

This procedure quantified only the change in the number of children who pass below the 70 point IQ threshold. EPA quantified other changes in children's IQ using the IQ point loss function (Equation 14.1) described previously. Treating these two endpoints additively does not result in double counting, because the value associated with the IQ point loss function is the change in individual lifetime earnings, while the value associated with IQs less than 70 is the increased educational costs for the individual, as discussed below.

❖ ***Valuing educational costs***

EPA estimated the number of avoided cases of children with IQs less than 70. Compensatory education expenses will no longer be incurred for these cases. Kakalik et al. (1981), using data from a study prepared for the Department of Education's Office of Special Education Programs, estimated part-time special education costs for children who remained in regular classrooms at $3,064 extra per child per year in 1978. Adjusting for changes in the ***GDP price deflator*** yielded an estimate of $6,959 per child in 2001 dollars. EPA used the incremental estimate of the cost of part-time special education to estimate the annual cost per child needing special education as a result of lead impacts on mental development. EPA assumed that compensatory education begins at age seven and continues through age 18 (grades one through twelve). ***Discounting*** future expenses at a rate of three percent yielded an expected present value cost of approximately $58,012 per child (2001$). This discounting underestimates the cost because Kakalik et al. measured the increased cost to educate children attending regular school rather than a special education program. The costs of attending a special education program are likely to be much higher than those associated with regular schooling. In addition, some compensatory education programs begin earlier than at age seven. For example, some states, such as Connecticut and Rhode Island, offer Head Start programs to disadvantaged children beginning at age three.

b. Children with PbB levels greater than 20 µg/dL

❖ ***Quantifying the number of children with PbB levels greater than 20 µg/dL***

EPA obtained the percentage of children with PbB levels greater than 20 µg/dL directly from the estimated distribution of PbB levels for a given location (IEUBK). EPA then multiplied this percentage by the number of exposed children in the vicinity of a given MP&M reach to estimate the number of children with PbB levels greater than 20 µg/dL.[12]

❖ ***Estimating and valuing compensatory education for children with PbB levels greater than 20 µg/dL***

EPA assumed that 20 percent of the children with PbB levels greater than 20 µg/dL would require and receive compensatory education for three years. After this time, no further educational expenditures are incurred by those children. These

[12] See Section 13.1.1 for detail on estimating the affected population. The percentage of children in the affected population is estimated based on the Census data.

assumptions are conservative. Many studies show adverse cognitive effects of PbB levels at 15 μg/dL (CDC, 1991b). Some studies of the persistence of cognitive effects indicate that the effects often last longer than three years.

The Kakalik et al. (1981) estimate of part-time special education costs for children who remained in regular classrooms can be used to estimate the cost of compensatory education for children suffering low-level cognitive damage. As indicated above, the part-time special education cost per child is $6,959 per year in 2001 dollars. The Agency assumes that compensatory education starts at age 7 and continues for 3 years. Discounting future costs at a rate of 3 percent annually to account for the age at which costs are incurred (i.e., age 7 through 9) yields a present value estimate of $16,485 in 2001 dollars.

14.2.5 Changes in Neonatal Mortality

a. Quantifying the relationship between maternal PbB levels and neonatal mortality

U.S. EPA (1990) cites a number of studies linking fetal exposure to lead (via *in utero* exposure from maternal lead intake) to several adverse health effects. These effects include decreased gestational age (i.e., premature birth), reduced birth weight, late fetal death, and increases in infant mortality.

The CDC (CDC, 1991a) developed a method to estimate changes in infant mortality due to changes in maternal PbB levels during pregnancy. The analysis linked the following two relationships:

- gestational age as a function of maternal PbB (Dietrich et al., 1987), and
- infant mortality as a function of gestational age. This is performed using data from the Linked Birth and Infant Death Record Project from the National Center for Health Statistics (CDC, 1991a).

Combining the two relationships provided a decreased risk of infant mortality of 10^{-4} (or 0.0001) for each 1 μg/dL decrease in maternal PbB level during pregnancy. EPA used this relationship for its analysis of maternal PbB levels and neonatal mortality.

b. Valuing changes in neonatal mortality

This analysis used the estimated WTP for avoiding a mortality event to estimate the monetary benefit associated with reducing risks of neonatal mortality. This analysis uses the $6.5 million (2001$) estimate of the value of a statistical life saved recommended in the *Guidelines for Preparing Economic Analysis* (EPA, 2000a). For detail on valuing reduced mortality risks see Section 13.2.1.

14.3 ADULT HEALTH BENEFITS

Lead exposure has been shown to have adverse effects on the health of adults as well as children. The quantified adult health effects included in the benefits analysis all relate to lead's effects on BP.[13] The estimated relationships between these health effects and lead exposure differ between men and women. Quantified health effects include increased incidence of hypertension (estimated for males only), initial CHD, strokes (initial CBA and BI), and premature mortality. This analysis does not include other health effects associated with elevated BP, and other adult health effects of lead including neurobehavioral and possible cancer effects.

[13] Citing laboratory studies with rodents, U.S. EPA (1990) also presents evidence of the genotoxicity and/or carcinogenicity of lead compounds. The animal toxicological evidence suggests that human cancer effects are possible, but dose-response relationships are not currently available.

Estimating adult health benefits from reduced exposure to lead requires analytic steps similar to those used in estimating children's health benefits. These steps are:

- estimate in-stream lead concentrations in the reaches affected by MP&M discharges;
- estimate baseline and post-compliance adult dietary lead intake via fish consumption. The analysis of adult health benefits from reduced exposure to lead via contaminated fish uses the results from water quality modeling efforts described in Appendix I;
- estimate changes in the PbB level distribution in the affected adult population;
- estimate changes in health status in the affected population of adult men, and the monetary value of health benefits from reduced lead discharges from MP&M facilities; and
- estimate changes in health status in the affected population of adult women, and the monetary value of health benefits from reduced lead discharges from MP&M facilities.

Figure 14.2 depicts the above steps. Table 14.3 summarizes per-case costs of lead-related illnesses.

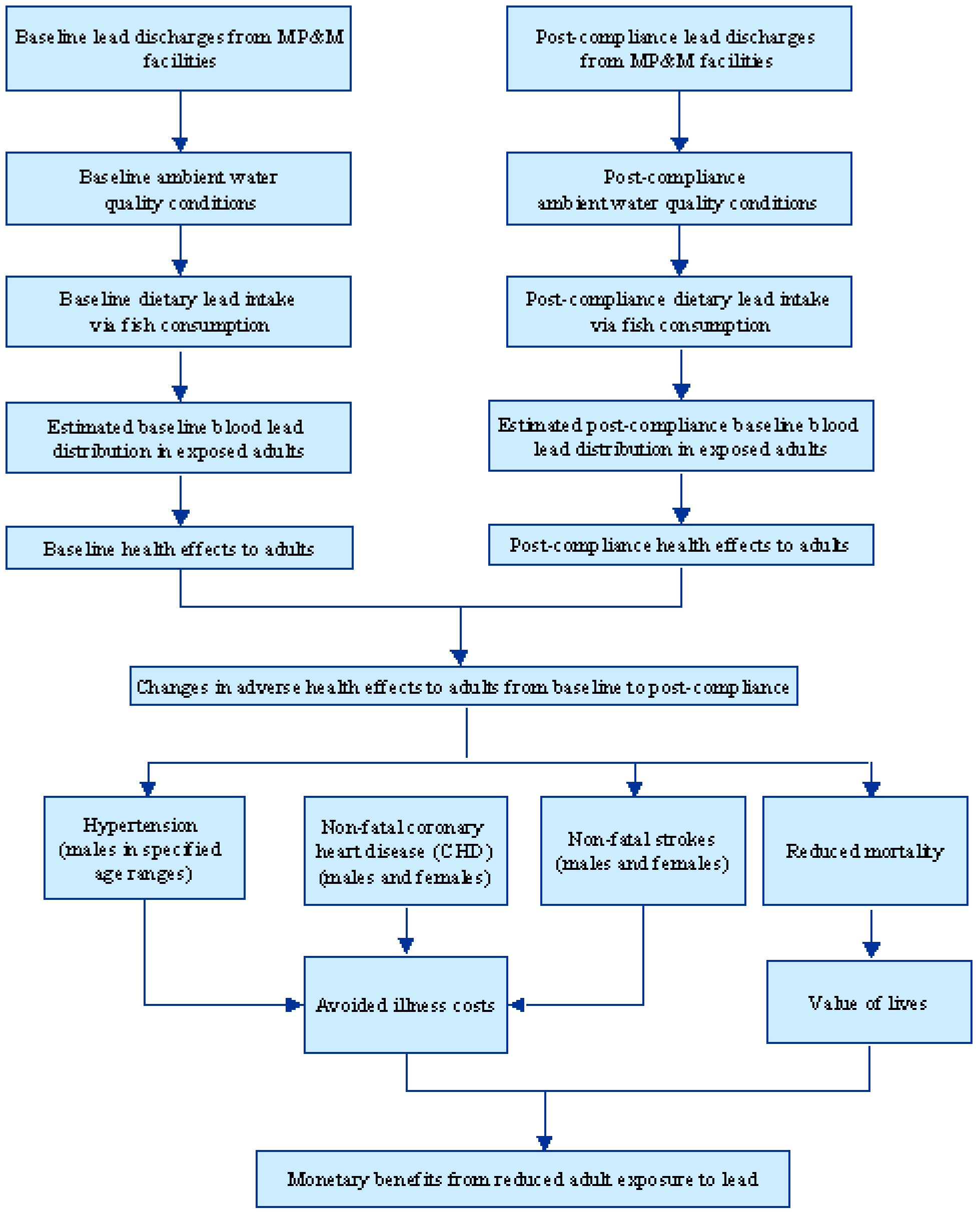
Table 14.3: Per-Case Costs of Lead-Related Illnesses

Illness	Gender	Cost per Case (2001$)	Cost Description
Hypertension[a]	Male	$1,141	The cost estimates were derived by taking Krupnick et al.'s (1989) average annual per-person costs of hypertension. Value adjusted to 2001$ using the CPI for Medical Care.
	Female	$1,141	
CHD[a, b]	Male	$76,347	The costs were estimated (Wittels et al., 1990) for three CHDs (acute myocardial infarction, uncomplicated **angina pectoris**, and unstable angina pectoris) for 5 years post-diagnosis using a three percent discount rate. The probability of medical service was multiplied by the estimated price of the service and the average cost for the three CHD types. Since the effect of elevated PbB on CHD incidence rates is beyond the scope of this analysis, weighting factors were not used to account for the different probabilities of contracting the three types of CHD. Value adjusted to 2001$ using the CPI for Medical Care.
	Female	$76,347	
Stroke[a]	Male	$335,135	The cost estimates (Taylor et al., 1996) represent the expected lifetime cost of a stroke for males and females age 45-74, including the present discounted value of the stream of medical expenditures and the stream of lost earnings. Note that the study used a five percent discount rate. EPA did not adjust this value to reflect a 3 percent discount rate used elsewhere in this analysis. Values adjusted to 2001$ using the CPI for Medical Care.
	Female	$251,351	
Low Birth Weight[c]	Female	$89,503	The cost estimate was extrapolated from direct costs for LBW taken from Lewitt et al., using a three percent discount rate (Lewitt et al., 1995). The value includes medical, special education, and grade repetition costs. Value adjusted to 2001$ using the CPI for Medical Care.
Death -- Any Illness[d]	Male	$6.5 Million	Value taken from U.S. EPA's Guidelines for Preparing Economic Analysis (2000a). The value is the central estimate recommended in the document based on a range of estimates available from studies measuring the value of a statistical life. Value adjusted to 2001$ using the CPI for All Items.
	Female	$6.5 Million	

[a] *Costs were taken from U.S. EPA, 1997b.*
[b] *Extends methodology in U.S. EPA, 1997b to discount medical costs over a 5 year period.*
[c] *Note that this analysis does not estimate occurrence of low birth weight cases, due to data limitations. Cost was taken from U.S. EPA, 1999.*
[d] *Value taken from U.S. EPA, 2000a.*

Source: U.S. EPA analysis.; U.S. EPA 1997b; U.S. EPA 1999, U.S. EPA 2000a.

Figure 14.2 Assessing Benefits to Adults from Reduced Lead Discharges from MP&M Facilities



Source: U.S. EPA analysis.

14.3.1 Estimating Changes in Adult PbB Distribution Levels

a. Estimating values of PbB concentrations in exposed adults

EPA adapted the methodology described in the *Interim Approach to Assessing Risks Associated with Adult Exposure to Lead in Soil* (hereafter, Interim Guidance) to estimate changes in the distribution of PbB levels in exposed adults from reduced MP&M discharges (U.S. EPA, 1996a). The methodology presented in the Interim Guidance used a simplified representation of lead biokinetics to predict ***quasi-steady state*** PbB concentrations among adults who have relatively steady patterns of exposures to lead. This methodology is recommended by the ***Technical Review Workgroup (TRW)*** to assess the effects of ingesting lead-contaminated soil on PbB levels of women of childbearing age, to derive ***risk-based remediation goals (RBRG)*** protective of the developing fetus in exposed adult women.[14] The Interim Guidance describes the basic algorithms to be used in the analysis and provides a set of default parameters that can be used in cases where site-specific data are not available. The TRW points out that this methodology is an interim approach recommended for use pending further development and evaluation of integrated exposure biokinetic models for adults.

The dose-response relationship recommended in the Interim Guidance for exposures to lead-contaminated soil can be modified to analyze PbB levels in recreational and subsistence anglers exposed to lead-contaminated fish tissue. In both cases, the exposure pathways involve ingestion. The Interim Guidance differs from this analysis mainly in the medium containing lead (soil versus fish tissue). Substituting ingestion of lead in fish for ingestion of lead in soil yields the following equation:

$$PbB_{adult,\ central} = PbB_{adult,0} + \frac{PbW \times BCF \times IN_F \times AF_F \times BKSF \times EF \times CF}{AT} \qquad (14.8)$$

where:

$PbB_{adult,\ central}$	=	***central tendency estimate*** of PbB concentrations (µg/dL) in adults exposed to lead in fish at a concentration of PbW;
$PbB_{adult,\ 0}$	=	typical PbB concentration (µg/dL) in adults in the absence of exposures via fish consumption;
PbW	=	in-stream lead concentrations (µg/L);
BCF	=	bioconcentration factor of lead in fish tissue (L/kg);
IN_F	=	average daily fish consumption (g/day);
AF_F	=	***absolute gastrointestinal absorption fraction*** for ingested lead in fish tissue (dimensionless);
BKSF	=	biokinetic slope factor relating (quasi-steady state) increases in typical adult PbB concentrations to average daily lead uptake (µg/dL PbB increase per mg/day lead uptake);
EF	=	exposure frequency for ingestion of contaminated fish (days of exposure during the averaging period); may be taken as days per year for continuing, long-term exposure;
CF	=	conversion factor (10^{-3} kg/g); and
AT	=	averaging time, the total period during which fish consumption may occur; 365 days/year for continuing long-term exposure.

Equation 14.8 is recommended for females aged 17 to 45 (U.S. EPA, 1996a). Studies of adult males, however, provided many of the parameters used in the Interim Guidance. For example, the biokinetic slope factor (BKSF) relating increase in typical adult blood concentrations to average daily lead uptake was developed on data reported by Pocock et al (1983). These data characterize the relationship between tap water lead concentrations and blood lead concentrations for a sample of adult males.[15] Thus, EPA judged that this model can be applicable to all adults. Table 14.4 summarizes values for the model parameters.

[14] EPA's TRW for lead began considering methodologies to evaluate nonresidential adult exposure to lead in 1994. A TRW committee on adult lead risk assessment formed in January 1996 to develop a generic methodology that could be adapted for use in site-specific assessments of adult health risks.

[15] For detail, see p.A-10, *Recommendations of the Technical Review Workgroup for Lead to Assessing Risks Associated with Adult Exposure to Lead in Soil* (U.S. EPA, 1996a).

Table 14.4: Summary of Parameter Values for Estimating PbB Levels in Adults

Parameter	Unit	Value		Comment [a]
$PbB_{adult,0}$	µg/dL	4.55-3.45		Male adult PbB levels based on NHANES III Phase 2 (U.S. EPA, 1991-1994). Female adult PbB levels based on NHANES III Phase 2 (U.S. EPA, 1996a).
BKSF	µg/dL per µg/day	0.4		Based on analysis of Pocock et al. (1983) and Sherlock et al. (1984) data.
INF	g/day	17.5	142.4	Daily fish consumption; lower value (on left) for recreational anglers and higher value (on right) for subsistence anglers. Fish consumption rates for adults are taken from the *Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health* (EPA, 2000b). Both these rates, 142.4 g/day for adult subsistence anglers and 17.5g/day for adult recreational anglers, are used for the specific sub-population that they represent. EPA was not able to break these rates down by gender or age group for use in this analysis.
EF	day/yr	365		Days per year for continual long-term exposure.
BCF	L/kg	49		Bioconcentration factor of lead in fish tissue.
AF_F	dimen-sionless	0.03		Absolute gastrointestinal absorption fraction for ingested lead in fish tissue. Based on Maddaloni (1998).

[a] For detailed information on the sources of the parameters and uncertainties associated with their use, see U.S. EPA, 1996a.

Source: U.S. EPA analysis.

❖ *Typical adult PbB concentrations at baseline*

Previous research suggests males have a higher background PbB level (U.S. EPA, 1996a). This analysis uses population-specific typical concentrations to account for differences in background lead exposure between genders and between two socioeconomic subgroups considered in the analysis (i.e., recreational and subsistence fishermen). EPA used data for adult males and females from NHANES III to characterize the baseline distribution of PbB concentrations in the relevant sub-populations for each MP&M reach and affected population (NHANESIII, 1991-1994). The baseline PbB distribution scenario reflects site-specific population characteristics because baseline PbB levels differ across ethnic, income, and urban status groups.

❖ *Bioavailability of lead from fish tissue*

To identify lead bioavailability in fish tissue, EPA reviewed lead absorption data from various materials reported in the lead toxicity summary document: *Draft Toxicological Profile for Lead* (ATSDR, 1997). EPA also reviewed *Measurement of Soil-Borne Lead Bioavailability in Human Adults, and Its Application to Biokinetic Modeling* (Maddaloni, 1998) and consulted with the study author (March, 2000). Numerous studies have found that lead ingested with food is absorbed at a significantly lower rate than lead ingested after fasting. The Interim Approach reports this dynamic and notes that "the bioavailability of ingested soluble lead in adults varies from less than 10 percent when ingested with a meal to between 60 and 80 percent when ingested after a fast" (U.S. EPA, 1996a). TRW uses a 20 percent lead bioavailability factor for soil. This factor is based on lead consumption interspersed with and between meals throughout the day, and is therefore likely to overestimate PbB levels in adults exposed to lead-contaminated fish. In the absence of data on lead incorporated into food, however, EPA considered this to be the most appropriate data to use in estimating absorption.

In the most recent study reviewed for this analysis (Maddaloni, 1998), non-fasted subjects showed a mean percent absorption of 2.52 with a range of 0.2 to 5.2 percent and a confidence value of 0.66. The male and female study subjects had normal clinical chemistry parameters and were between 21 and 40 years of age. The study used soil as the dosing vehicle. Other studies have used water as the dosing vehicle, but soil is considered to be more similar to fish consumption.

EPA selected an absorption value of 3 percent for lead ingested in fish tissue, based on Maddaloni's results. The value of 3 percent provides a reasonable estimate for most adults. This analysis does not address individuals who may have higher lead absorption, or are at elevated risk due to lead exposure. These individuals include pregnant women, who have higher calcium requirements (and are therefore more likely to be calcium-deficient), people with poor nutritional status (including iron and calcium deficiencies), and individuals with other metabolic disorders. By evaluating subsistence and recreational anglers at proposal and for final rule options with lead benefits, the analysis is already focusing on sub-populations at higher risk than the average population. To maintain an approach that represents likely exposures, intakes, and risks, EPA chose not to consider individuals at unusually high risk within an already-high risk sub-population.

14.3.2 Male Health Benefits

This section describes the health effects of reduced lead exposure that this analysis has quantified for men; the next section presents a similar discussion for women.

a. Hypertension

❖ ***Quantifying the relationship between PbB levels and hypertension***

Studies have linked elevated PbB to elevated BP in adult males, especially men aged 40 to 59 (Pirkle et al., 1985). Further studies have demonstrated a dose-response relationship for hypertension (defined as diastolic BP above 90 mm Hg for this model) in males aged 20 to 74 (Schwartz, 1988). This relationship is:

$$\Delta Pr(HYP) = \frac{1}{1 + e^{2.744 - .793*(\ln PbB_1)}} - \frac{1}{1 + e^{2.744 - 0.793*(\ln PbB_2)}} \tag{14.9}$$

where:

ΔPr(HYP)	=	the change in the probability of hypertension,
e	=	base of the natural logarithm (2.76)
PbB_1	=	PbB level in the baseline scenario, and
PbB_2	=	PbB level in the post-compliance scenario.

❖ ***Valuing reductions in hypertension***

The best measure of the social costs of hypertension, society's WTP to avoid the condition, cannot be quantified without basic research that is well beyond the scope of this project. Ideally, the measure would include all the medical costs associated with treating hypertension, the individual's WTP to avoid the worry that hypertension could lead to a stroke or CHD, and the individual's WTP to avoid the behavioral changes required to reduce the probability that hypertension leads to a stroke or CHD.

This analysis used recent research results to quantify two benefit category components: medical costs and lost work time. Krupnick and Cropper (1989) estimated the medical costs of hypertension, using data from the National Medical Care Expenditure Survey. Medical costs include expenditures for physician care, drugs, and hospitalization. In addition, hypertensives have more bed disability days and work-loss days than non-hypertensives of comparable age and sex. Krupnick and Cropper estimated the increase in work-loss days at 0.8 per year. Valuing this estimate at the estimated mean daily wage rate and adjusting the costs to 2001 dollars yields an estimate of the annual cost of each case of hypertension of $1,141.

The benefits estimate in this analysis likely underestimates the true social benefit of avoiding a case of hypertension for several reasons:

- It does not include a measure of the value of pain, suffering, and stress associated with hypertension.
- It does not value the direct costs (out-of-pocket expenses) of diet and behavior modification (e.g., salt-free diets, etc.). These costs, which are typical for severe modifications, are likely to be significant.
- This analysis does not address the loss of satisfaction associated with the diet and behavior modifications.
- This analysis does not include the value of avoiding side effects associated with the medication for hypertension, which include drowsiness, nausea, vomiting, anemia, impotence, cancer, and depression.
- The analysis does not include the effects of the disease on family members.

b. Changes in CHD

❖ *Quantifying the relationship between PbB and BP*

EPA quantified the effect of changes in PbB levels on changes in BP to predict the probability of both hypertension and other cardiovascular illnesses, such as CHD, strokes, and premature mortality. Several cardiovascular illnesses include PbB as a risk factor (Shurtleff, 1974; McGee and Gordon, 1976; PPRG, 1978). Based on the results of a meta-analysis of several studies, Schwartz (1992) estimated a relationship between a change in BP associated with a decrease in PbB from 10 µg/dL to 5 µg/dL. The following equation uses the coefficient reported by Schwartz to relate BP to PbB for men:

$$\Delta DBP_{men} = 1.4 \times \ln\left(\frac{PbB_1}{PbB_2}\right) \qquad (14.10)$$

where:

ΔDBP_{men} = the change in men's diastolic BP expected from a change in PbB;
PbB_1 = PbB level in the baseline scenario (in µg/dL); and
PbB_2 = PbB level in the post-compliance scenario (in µg/dL).

EPA used this PbB to BP relationship to estimate the incidence of initial CHD, strokes (BI and initial CBA), and premature mortality in men.

❖ *Quantifying the relationship between BP and CHD*

This analysis used estimated BP changes to predict the increased probability of initial CHD and stroke occurrence (U.S. EPA, 1987). Increased BP also increases the probability of CHD and stroke recurrence, but EPA did not quantify these relationships in this analysis. An equation with different coefficients for each of three age groups can predict first-time CHD events in men. A 1978 study by the PPRG supplied information for men between ages 40 and 59. PPRG used a **multivariate** model (controlling for smoking and serum cholesterol) relating the probability of CHD to BP. The model used data from five different epidemiological studies. The equation for the change in 10-year probability of a first-time occurrence of CHD related to an increase in BP is:

$$\Delta Pr(CHD_{40-59}) = \frac{1}{1 + e^{4.996 - 0.030365 * DBP_1}} - \frac{1}{1 + e^{4.996 - 0.030365 * DBP_2}} \qquad (14.11)$$

where:

$\Delta Pr(CHD_{40-59})$ = the change in 10-year probability of an occurrence of a CHD event for men between ages 40 and 59;
DBP_1 = mean diastolic BP in the baseline scenario; based on the Phase 2 NHANES III, mean diastolic BP for subsistence and recreational fishermen aged 40 to 59 is 81.8 and 80.0, respectively; and
DBP_2 = mean diastolic BP in the post-compliance scenario.

Information presented in Shurtleff (1974) helped define the relationship between BP and first-time CHD in older men. This study used data from the Framingham Study (McGee and Gordon, 1976) to estimate univariate relationships between BP and a variety of health effects, by sex and for three age ranges: 45 to 54, 55 to 64, and 65 to 74 years. The study performed single composite analyses for ages 45 to 74 for each sex. For every equation, t-statistics on the BP variable are significant at the 99th percent confidence interval. EPA predicted first-time CHD related to an increase in BP for men aged 60 to 64 from the following equation:

$$\Delta Pr(CHD_{60-64}) = \frac{1}{1 + e^{4.996 - 0.030365 * DBP_1}} - \frac{1}{1 + e^{4.996 - 0.030365 * DBP_2}} \qquad (14.12)$$

where:

$\Delta Pr(CHD_{60-64})$ = the change in 2-year probability of occurrence of a CHD event for men aged 60 to 64;
DBP_1 = mean diastolic BP in the baseline scenario; based on the Phase 2 NHANES III, mean diastolic BP for subsistence and recreational fishermen aged 60 to 64 is 79.5 and 77.8, respectively; and
DBP_2 = mean diastolic BP in the post-compliance scenario.

The following equation uses data from Shurtleff (1974) to predict the probability of first-time CHD related to an increase in BP for men aged 65 to 74:

$$\Delta Pr(CHD_{65-74}) = \frac{1}{1 + e^{4.90723 - 0.02031 * DBP_1}} - \frac{1}{1 + e^{4.90723 - 0.02031 * DBP_2}} \quad (14.13)$$

where:

$\Delta Pr(CHD_{65-74})$	=	the change in 2-year probability of occurrence of a CHD event for men aged 65 to 74;
DBP_1	=	mean diastolic BP in the baseline scenario; based on the Phase 2 NHANES III, mean diastolic BP for subsistence and recreational fishermen aged 65 to 74 is 79.5 and 76.4, respectively; and
DBP_2	=	mean diastolic BP in the post-compliance scenario.

EPA used the above equations to estimate the number of CHD events avoided in a given year due to water quality improvements from reduced MP&M lead discharges. The resulting CHD incidence estimates include both fatal and non-fatal events. Only the non-fatal CHD events are considered here because mortality benefits are estimated independently in this analysis (see Section 14.3.2.d, below). Shurtleff (1974) reported that two-thirds of all CHD events were non-fatal. This factor was therefore applied to the estimate of avoided CHD events due to reductions in PbB and BP for each age category.

❖ ***Valuing reductions in CHD events***

EPA first estimated the number of CHD events avoided each year by multiplying the number of exposed recreational and subsistence anglers in the relevant age group by the change in annual probability of a CHD event. Changes in annual probability of CHD events for different age groups are calculated by dividing the change in probability over ten- and two-year periods by the relevant number of years.

EPA then used the central tendency estimate of the COI associated with pollution-related CHD to estimate the benefits of avoiding an initial CHD event. The cost estimates (Wittels et al., 1990) represent the weighted medical costs of three separate CHDs (acute myocardial infarction, uncomplicated angina pectoris, unstable angina pectoris), experienced within five years of diagnosis. EPA estimated the costs by multiplying the probability of a medical test or treatment (within five years of the initial CHD event) by the estimated price of the test or treatment.[16] The estimated cost for acute myocardial infarction was then reduced by 23%, which represents the proportion of cases that go unrecognized by the patient and therefore do not result in any medical costs (based on Hartunian et al., 1981). EPA used a three percent discount rate to calculate the present value of these costs. EPA then calculated the final cost estimate by taking the simple average of the three CHD types. The central tendency estimate of the COI associated with a case of pollution-related CHD is about $76,347 (2001$).

This estimate likely underestimates the full COI because it does not include lost earnings. It likely underestimates total WTP to avoid CHD to an even greater extent because it does not include WTP to avoid the pain and suffering associated with the CHD event.

This analysis combined the value of reducing CHD events with the value of reducing hypertension, even though these conditions often occur together. The two values represent different costs associated with the conditions. The valuation for hypertension includes hypertension-associated work day loss and medical costs. CHD valuation is based on the medical costs for treatment associated with the CHD itself. EPA estimated these two values separately and added them together.

c. Changes in initial CBA and initial BI

❖ ***Quantifying the relationship between BP and first-time stroke***

Strokes include two types of health events: initial CBA and initial BI. The risk of CBA has been quantified for the male population between 45 and 74 years old (Shurtleff, 1974). For initial CBA, the equation is:

[16] EPA obtained costs from Appendix G of the *Benefits and Costs of the Clean Air Act: 1970 to 1990*, prepared for U.S. Congress by U.S. EPA, Office of Air and Radiation and Office of Policy, Planning, and Evaluation, 1997b.

$$\Delta Pr(CBA_{men}) = \frac{1}{1 + e^{8.58889 - 0.04066*DBP_1}} - \frac{1}{1 + e^{8.58889 - 0.04066*DBP_2}} \quad (14.14)$$

where:

$\Delta Pr(CBA_{men})$ = the change in 2-year probability of CBA in men;
DBP_1 = mean diastolic BP in the baseline scenario; based on the Phase 2 NHANES III, mean diastolic BP for subsistence and recreational fishermen aged 45 to 74 is 81.1 and 78.8, respectively; and
DBP_2 = mean diastolic BP in the post-compliance scenario.

For initial BI, the equation is (Pirkle et al., 1985):

$$\Delta Pr(BI_{men}) = \frac{1}{1 + e^{9.9516 - 0.04840*DBP_1}} - \frac{1}{1 + e^{9.9516 - 0.04840*DBP_2}} \quad (14.15)$$

where:

$\Delta Pr(BI_{men})$ = the change in 2-year probability of brain infarction in men;
DBP_1 = mean diastolic BP in the baseline scenario; based on the Phase 2 NHANES III, mean diastolic BP for subsistence and recreational fishermen aged 45 to 74 is 81.1 and 78.8, respectively; and
DBP_2 = mean diastolic BP in the post-compliance scenario.

Similarly to CHD events, this analysis estimates only non-fatal strokes to avoid double-counting with premature mortality. Shurtleff reported that 70 percent of strokes were non-fatal. EPA applied this factor to the estimates of both CBA and BI to ensure that the estimate of avoided CBA and BI events included only non-fatal events (Shurtleff, 1974).

❖ ***Valuing reductions in strokes***

Similarly to CHD events, EPA first calculates the number of avoided strokes per year and then uses the estimated lifetime cost of a stroke to value reductions in strokes. Taylor et al. estimated the lifetime cost of stroke, including the present value (in 1990 dollars) of the stream of medical expenditures and the present discounted value of the stream of lost earnings, using a five percent discount rate (Taylor et al., 1996). The estimated expected lifetime cost of a non-fatal stroke for males aged 45 to 74 is 335,135 (2001$).[17]

d. Changes in premature mortality

❖ ***Quantifying the relationship between BP and premature mortality***

It is well established that elevated BP increases the probability of premature death. There are, however, several underlying conditions that cause elevated BP (e.g., cholesterol level). U.S. EPA (1987) used population mean values for serum cholesterol and smoking to reduce results from a 12-year follow-up of men aged 40 to 54 in the Framingham Study (McGee and Gordon, 1976) to an equation with one explanatory variable (DBP):

$$\Delta Pr(MORT_{40-54}) = \frac{1}{1 + e^{5.3158 - 0.03516*DBP_1}} - \frac{1}{1 + e^{5.3158 - 0.03516*DBP_2}} \quad (14.16)$$

where:

$\Delta Pr(MORT_{40\text{-}54})$ = the change in 12-year probability of death for men aged 40 to 54;
DBP_1 = mean diastolic BP in the baseline scenario; based on the Phase 2 NHANES III, mean diastolic BP for subsistence and recreational fishermen aged 40 to 54 is 81.9 and 79.9, respectively; and
DBP_2 = mean diastolic BP in the post-compliance scenario.

[17] EPA obtained cost from Appendix G of the *Benefits and Costs of the Clean Air Act: 1970 to 1990*, prepared for U.S. Congress by U.S. EPA, Office of Air and Radiation and Office of Policy, Planning, and Evaluation, 1997b.

This analysis used information from Shurtleff (1974) to estimate the probability of premature death in men older than 54 years. The present analysis estimates a two-year probability based on the Shurtleff study's two-year follow-up period. EPA predicted mortality for men aged 55 to 64 years old using the following equation:

$$\Delta Pr(MORT_{55-64}) = \frac{1}{1 + e^{4.89528 - 0.01866 * DBP_1}} - \frac{1}{1 + e^{4.89528 - 0.01866 * DBP_2}} \quad (14.17)$$

where:

- ΔPr($MORT_{55\text{-}64}$) = the change in two-year probability of death in men aged 55 to 64;
- DBP_1 = mean diastolic BP in the baseline scenario; based on the Phase 2 NHANES III, mean diastolic BP for subsistence and recreational fishermen aged 55 to 64 is 80.6 and 79.0, respectively; and
- DBP_2 = mean diastolic BP in the post-compliance scenario.

Using data from Shurtleff (1974), EPA predicted premature mortality for men aged 65 to 74 using the following equation:

$$\Delta Pr(MORT_{65-74}) = \frac{1}{1 + e^{3.05723 - 0.00547 * DBP_1}} - \frac{1}{1 + e^{3.05723 - 0.00547 * DBP_2}} \quad (14.18)$$

where:

- ΔPr($MORT_{65\text{-}74}$) = the change in two-year probability of death in men aged 65 to 74;
- DBP_1 = mean diastolic BP in the baseline scenario; based on the Phase 2 NHANES III, mean diastolic BP for subsistence and recreational fishermen aged 65 to 74 is 79.5 and 76.4, respectively; and
- DBP_2 = mean diastolic BP in the post-compliance scenario.

❖ ***Valuing reductions in premature mortality***

Similarly to health outcomes discussed in the preceding sections, EPA first estimated changes in annual probability of premature mortality for men in different age groups. The Agency then calculated avoided premature death cases by multiplying the estimated change in annual probability of premature mortality by the relevant population. This analysis uses the $6.5 million (2001$) estimate of the value of a statistical life saved recommended in the *Guidelines for Preparing Economic Analysis* (EPA, 2000a). This value is based on WTP to avoid the risk of death.

The values of avoiding CHD, BA, and BI events are all based on COI estimates associated with a non-fatal health event. On the other hand, the value of the change in premature mortality is based on the value of avoiding a health event that does end in death. Thus, these two endpoints are additive.

14.3.3 Female Health Benefits

Recently expanded analysis of data from NHANES II by Schwartz indicates a significant association between PbB and BP in women (Schwartz, 1990). Another study, by Rabinowitz et al. (1987), found a small but demonstrable association between maternal PbB, pregnancy hypertension, and BP at time of delivery.

a. Relationship between BP and PbB

Although women are at risk for lead-induced hypertension, no dose-response function for hypertension in women is available at this time. Therefore, the Agency did not quantify changes in risk for lead-induced hypertension in women for this analysis. This analysis used an adjusted dose-response function for a change in BP associated with a decrease in PbB in men (Equation 14.10) to estimate lead-induced changes in blood pressure in women. Equation 14.19 is used to provide input values for the analyses discussed in the following sections.

A review of ten published studies examined the effect of lead exposure on the BP of women, relative to the effect on men (Schwartz, 1992). All of the reviewed studies included data for men; some included data for women. Schwartz used a concordance procedure that combined data from each study to predict the decrease in diastolic BP associated with a decrease from 10 µg/dL to 5 µg/dL PbB (Schwartz, 1992). The results suggest that when PbB is decreased, women experience a BP change that is 60 percent of the change seen in men. Equation (14.10) can be rewritten for women as:

$$\Delta DBP_{women} = (0.6 \times 1.4) \times \ln\left(\frac{PbB_1}{PbB_2}\right) \tag{14.19}$$

where:

ΔDBP_{women}	=	the change in women's diastolic BP expected from a change in PbB;
PbB_1	=	PbB level in the baseline scenario; and
PbB_2	=	PbB level in the post-compliance scenario.

b. Changes in CHD

❖ *Quantifying the relationship between BP and CHD*

Elevated BP in women results in the same effects as for men (CHD, two types of stroke, and premature death). However, the general relationships between BP and these health effects are not identical to the dose-response functions estimated for men. All relationships presented here have been estimated for women aged 45 to 74 years old using information from Shurtleff (1974). EPA estimated first-time CHD related to an increase in BP in women using the following equation:

$$\Delta Pr(CHD_{women}) = \frac{1}{1 + e^{6.9401 - 0.03072 * DBP_1}} - \frac{1}{1 + e^{6.9401 - 0.03072 * DBP_2}} \tag{14.20}$$

where:

$\Delta Pr(CHD_{women})$	=	change in 2-year probability of occurrence of CHD event for women aged 45-74;
DBP_1	=	mean diastolic BP in the baseline scenario; based on the Phase 2 NHANES III, mean diastolic BP for women in subsistence and recreational households aged 45 to 74 is 76.5 and 74.8, respectively; and
DBP_2	=	mean diastolic BP in the post-compliance scenario.

EPA estimated non-fatal CHD events by assuming that two-thirds of all estimated CHD events are not fatal (Shurtleff, 1974).

❖ *Valuing reductions in CHD events*

The Agency first calculated the number of avoided CHD events for women using Equation 14.20. EPA assumed that values of reducing CHD events for women equal those calculated for men (above): $76,347 (2001$) per CHD event.

c. Changes in BI and initial CBA

❖ *Quantifying the relationship between BP and first-time stroke*

EPA predicted the relationship between BP and initial CBA for women using the following equation:

$$\Delta Pr(CBA_{women}) = \frac{1}{1 + e^{9.07737 - 0.04287 * DBP_1}} - \frac{1}{1 + e^{9.07737 - 0.04287 * DBP_2}} \tag{14.21}$$

where:

$\Delta Pr(CBA_{women})$	=	change in two-year probability of cerebrovascular accident in women aged 45 to 74;
DBP_1	=	mean diastolic BP in the baseline scenario; and
DBP_2	=	mean diastolic BP in the post-compliance scenario.

The following equation illustrates the relationship between BI and initial BI in women:

$$\Delta Pr(BI_{women}) = \frac{1}{1 + e^{10.6716 - 0.0544 * DBP_1}} - \frac{1}{1 + e^{10.6716 - 0.0544 * DBP_2}} \tag{14.22}$$

where:

$\Delta Pr(BI_{women})$ = change in 2-year probability of brain infarction in women aged 45 to 74;
DBP_1 = mean diastolic BP in the baseline scenario; based on the Phase 2 NHANES III, mean diastolic BP for women in subsistence and recreational households aged 45 to 74 is 76.5 and 74.8, respectively; and
DBP_2 = mean diastolic BP in the post-compliance scenario.

EPA multiplied the predicted incidences of avoided BI and CBA by 70 percent to estimate only non-fatal strokes (Shurtleff, 1974).

❖ ***Valuing reductions in strokes***

EPA calculated the value of avoiding an initial CBA or an initial BI for women in the same way as for men (see above). EPA predicted lead-related stroke for women in the United States between the ages of 45 and 74, of whom 38.2 percent are aged 45 to 54 and the remaining 61.8 percent are aged 55-74. Using the gender- and age-specific values in Taylor et al. (1996), EPA estimated the average value of avoiding a stroke among women aged 45 to 74 to be about $251,351 (2001$).

d. Changes in premature mortality

❖ ***Quantifying the relationship between BP and premature mortality***

The following equation estimates the risk of premature mortality in women (Shurtleff, 1974):

$$\Delta Pr(MORT_{women}) = \frac{1}{1 + e^{5.40374 - 0.01511 * DBP_1}} - \frac{1}{1 + e^{5.40374 - 0.01511 * DBP_2}} \qquad (14.23)$$

where:

$\Delta Pr(MORT_{women})$ = the change in two-year probability of death for women aged 45 to 74;
DBP_1 = mean diastolic BP in the baseline scenario; based on the Phase 2 NHANES III, mean diastolic BP for women in subsistence and recreational households aged 45 to 74 is 76.5 and 74.8, respectively; and
DBP_2 = mean diastolic BP in the post-compliance scenario.

❖ ***Valuing reductions in premature mortality***

EPA predicted changes in lead-related premature mortality for women in the same way as for men (see above). EPA assumed the value of reducing premature mortality in women to be equal to that estimated for all premature mortality, $6.5 million (2001$) per incident (see Section 13.2.1).

14.4 Lead-Related Benefit Results

This section describes the estimated benefits of reduced lead exposure from consumption of fish in three populations: (1) preschool age children, (2) pregnant women, and (3) adult men and women. Benefit estimates for pregnant women appear with those for preschool age children, because the beneficiaries in this category are children under the age of one who suffer *in utero* fetal lead exposure from maternal lead intake during pregnancy. EPA estimated that the final regulation will yield no benefits to children or adults from reduced exposure to lead. Alternative regulatory options considered by EPA were estimated to yield benefits from reduced exposure to lead. The following discussion reviews the estimated benefits from these alternative options.

14.4.1 Preschool Age Children Lead-Related Benefit Results

EPA analyzed the monetary value of health benefits to children from reduced lead exposure in four categories:

- reduced neo-natal mortality,
- avoided IQ loss,
- reduced incidence of IQ below 70, and
- reduced incidence of PbB levels above 20 μg/dL.

From this analysis, EPA estimated that the final rule will yield no lead-related benefits to children.

Other regulatory options considered by EPA were found to yield lead-related benefits to children. Table 14.5 summarizes lead-related benefits estimated for the 433 Upgrade Options. EPA estimated that the Directs + 413 to 433 Upgrade Option and the Directs + All to 433 Upgrade Option would reduce 0.15 and 0.17 cases of neonatal mortality, and avoid the loss of 32 and 36 IQ points, respectively. The Directs + 413 to 433 Upgrade Option and the Directs + All to 433 Upgrade Option would result in $1.3 and $1.5 million (2001$) in annual lead-related benefits for children, respectively.

Table 14.5: National Annual Benefits from Reduced Lead in Children (2001$) — 433 Upgrade Options[a]

Category	Directs + 413 to 433 Upgrade		Directs + All to 433 Upgrade	
	Reduced Cases or IQ Points	Benefit Value (2001$)	Reduced Cases or IQ Points	Benefit Value (2001$)
Neonatal mortality	0.15	$995,630	0.17	$1,109,294
Avoided IQ Loss	31.99	$301,323	36.19	$340,845
Reduced IQ < 70	0.11	$6,637	0.13	$7,501
Reduced PbB > 20 µg/L	0.00	$0	0.00	$0
Total Benefits		$1,303,590		$1,457,640

[a] Based on the Traditional Extrapolation.

Source: U.S. EPA analysis.

Table 14.6 summarizes lead-related benefits estimated for the Proposed/NODA Option. EPA estimated that the Proposed/NODA Option would reduce 1.60 cases of neonatal mortality and avoid the loss of 1,078 IQ points. Annual lead-related benefits for children equal $20.8 million (2001$) under the Proposed/NODA Option, which substantially exceeds estimated lead-related benefits for children under the two 433 Upgrade Options.

Table 14.6: National Annual Benefits from Reduced Lead in Children (2001$) — Proposed/NODA Option[a]

Category	Reduced Cases or IQ Points	Benefit Value (2001$)
Neonatal mortality	1.60	$10,417,781
Avoided IQ Loss	1,078.38	$10,157,286
Reduced IQ < 70	3.72	$216,007
Reduced PbB > 20 µg/L	0.00	$0
Total Benefits		$20,791,073

[a] Based on the Traditional Extrapolation.

Source: U.S. EPA analysis.

The results from the estimated lead-related benefits for children are conservative, because this analysis omits other lead-related impacts, such as the cost of group homes and other special care facilities. Table 14.1 presents other omitted benefits categories. Section 14.5 discusses uncertainty and limitations inherent in this analysis.

14.4.2 Adult Lead-Related Benefit Results

As discussed previously, EPA quantified only the lead-related health effects in adults that relate to lead's effect on BP. These health effects include increased incidence of hypertension, initial non-fatal CHD, non-fatal stokes (CBA and BI), and premature mortality. EPA used COI estimates (i.e., medical costs and lost work time) to estimate monetary values for reduced incidence of hypertension, initial CHD, and strokes. EPA based monetary values for changes in risk of premature mortality on estimates of the value of a statistical life saved. The results are conservative estimates, because this analysis does not include other health effects associated with elevated BP or with lead. Other effects of lead in adults can include nervous system disorders, anemia, and possible cancer effects.

From this analysis, EPA estimated that the final rule will yield no lead-related health benefits to adults.

Other regulatory options considered by EPA were found to yield lead-related benefits to adults. Table 14.7 summarizes lead-related benefits estimated for the 433 Upgrade Options. EPA estimated that the Directs + 413 to 433 Upgrade Option and the Directs + All to 433 Upgrade Option respectively would reduce hypertension among males by 53 and 60 cases annually. Both the 433 Upgrade Options would also reduce the annual incidence of premature mortality among men and women by approximately 0.1 cases. EPA estimated annual lead-related benefits for adults under the Directs + 413 to 433 Upgrade Option at $0.70 million (2001$) and under the Directs + All to 433 Upgrade Option at $0.79 million (2001$).

Table 14.7: National Adult Lead Annual Benefits (2001$) — 433 Upgrade Options[a,b]

Category		Directs + 413 to 433 Upgrade		Directs + All to 433 Upgrade	
		Reduced Cases	Mean Value of Benefits	Reduced Cases	Mean Value of Benefits
Men	Hypertension	53.47	$61,004	59.58	$67,982
	CHD	0.05	$4,155	0.06	$4,631
	CBA	0.02	$5,698	0.02	$6,350
	BI	0.01	$3,226	0.01	$3,596
	Mortality	0.07	$474,735	0.08	$529,125
Women	CHD	0.02	$1,662	0.02	$1,853
	CBA	0.01	$2,417	0.01	$2,694
	BI	0.01	$1,487	0.01	$1,658
	Mortality	0.02	$150,190	0.03	$167,417
Total Benefits			**$704,574**		**$785,304**

[a] Based on the Traditional Extrapolation.
[b] National Level Exposed Population:
(1) *Directs + 413 to 433 Upgrade*
Hypertension: 139,745 men ages 20 to 74;
CHD, CBA, BI, and mortality: 56,564 men and 62,666 women ages 45-74.
(2) *Directs + 413 + 50% LL Upgrade*
Hypertension: 139,745 men ages 20 to 74;
CHD, CBA, BI, and mortality: 56,564 men and 62,666 women ages 45-74.

Source: U.S. EPA analysis.

Table 14-8 summarizes lead-related benefits estimated for the Proposed/NODA Option. EPA estimated that this option would reduce hypertension among males by approximately 545 cases and the incidence of premature mortality among men and women by 0.96 cases annually. Lead-related benefits for adults under the Proposed/NODA Option would be $7.05 million annually, which substantially exceeds estimated benefits under the two 433 Upgrade Options.

Table 14.8: National Adult Lead Annual Benefits (2001$) — Proposed/NODA Option[a,b]

Category		Reduced Cases	Mean Value of Benefits
Men	Hypertension	545.25	$622,126
	CHD	0.54	$41,564
	CBA	0.17	$56,907
	BI	0.10	$32,197
	Mortality	0.73	$4,750,132
Women	CHD	0.22	$16,472
	CBA	0.10	$23,928
	BI	0.06	$14,714
	Mortality	0.23	$1,489,984
Total Benefits			**$7,048,025**

[a] Based on the Traditional Extrapolation.
[b] National Level Exposed Population:
Hypertension: 539,142 men ages 20 to 74;
CHD, CBA, BI, and mortality: 218,226 men and 241,768 women ages 45-74.

Source: U.S. EPA analysis.

14.5 LIMITATIONS AND UNCERTAINTIES

This section discusses limitations and uncertainties in the lead-related benefits analysis. Developing dose-response functions depends on relating lead exposure to PbB levels, then evaluating PbB levels in relation to specific health outcomes. Quantitative dose-response functions for most health effects associated with lead exposure currently do not exist. For this reason, the analysis does not provide a comprehensive estimate of health benefits from reduced lead discharges from MP&M facilities.

Table 14.1 summarizes quantified and non-quantified health effects. Economic research does not always yield a complete evaluation, even for those effects that can be quantified. This uncertainly is likely to bias the estimate of lead-related benefits of the MP&M regulation downward. The analysis methodologies used here also involve significant simplifications and uncertainties. Section 13.3 discusses similar limitations and uncertainties associated with the assessment of risk associated with non-lead-related human health hazards and the possible direction of bias associated with sample design and benefits analysis by:

- occurrence location,
- estimated in-waterway concentrations of MP&M pollutants, and
- estimated exposed fishing population.

The next five sections discuss other omissions, biases, and uncertainties in the lead-benefit analysis. Table 14.9 provides a summary of this discussion.

14.5.1 Excluding Older Children

Recent research on brain development among 10- to 18-year-old children shows unanticipated and substantial growth in brain development, mainly in the early teenage years (Giedd et al., 1999). This growth appears to be a second "burst" of cell development in some brain areas, in addition to the previously recognized period of rapid growth during early childhood. One of lead's fundamental effects is to disrupt the protective coating (myelin) on nerve cells. This disruption can lead to permanent impairment if it occurs during development. New research suggests that older children may be a hypersensitive sub-population, along with children aged 0 to 7. Excluding this sub-population from the analysis may significantly underestimate benefits from reduced lead discharges.

14.5.2 Compensatory Education Costs

This analysis assumes that compensatory education is required only for children with IQs less than 70, and that part-time special education costs are assumed to be incurred only from grades 1 through 12 (Section 14.2.4). This assumption underestimates compensatory education costs for the following reasons:

- Children with IQ scores between 70 and 85 will likely be assigned to special education or "slow" classes that will likely be smaller than regular classes and require more teacher attention. Children in this IQ range may frequently require more than 12 years to graduate and are more likely to drop out of school. Such children therefore require additional education costs.

- Compensatory education may begin before grade one. Some states (e.g., Connecticut) offer compensatory education programs for disadvantaged children beginning at age three.

This analysis is based on a study that measured the increased cost to educate children with low IQs attending a regular school, not a special education program (Kakalik et al., 1981). The cost to attend a special education program is generally much higher than that for regular schooling.

Some overlap may exist between estimates of the avoided costs of compensatory education due to reduced incidence of children with IQ below 70 and PbB levels above 20 µg/dL because children with PbB levels may also have low IQ scores. Estimating the magnitude of this overlap is, however, not feasible due to data paucity. In addition, the estimated avoided cost of compensatory education due to reduced incidence of children with PbB levels above 20 µg/dL is negligible compared to other benefits from reduced exposure to lead. Thus, this overlap does not introduce a significant bias in the estimate of total benefits from reduced exposure to lead to children.

14.5.3 Dose-Response Relationships

The dose-response functions described for each health outcome considered above generally quantify the adverse health effects expected from increased lead exposure. For children, these effects are defined in terms of changes in PbB. For adults, these effects are estimated in terms of changes in BP, which are in turn related to changes in PbB levels. Uncertainty is inherent in the dose-response functions, which are typically expressed in terms of the standard deviations of the dose-response coefficients used in the analysis. Any uncertainty affecting the dose-response coefficients will also indirectly affect the accuracy of this analysis.

14.5.4 Absorption Function for Ingested Lead in Fish Tissue

Numerous research groups have evaluated lead absorption under a variety of conditions. ATSDR reports a range of three percent to 45 percent in the studies they present, which consider lead intake with and without food (ATSDR, 1997). Absorption appears to be affected by total lead intake, with some studies showing a higher absorption proportion with higher doses. Animal studies show a saturation effect, which modifies absorption.

Lead's chemical form also determines its absorption rate. For example, lead sulfide has approximately 10 percent of the bioavailability of lead acetate (ATSDR, 1997). Particle size and solubility are also important absorption factors. EPA could not obtain data to describe lead's precise chemical form, particle size, and other physical parameters in fish tissue, which would allow more refined absorption estimates. These characteristics vary because MP&M facilities produce lead using different processes and release it in different forms.

An individual's nutritional status also affects lead absorption rates. People who are malnourished, particularly with respect to calcium and iron, have high absorption rates (ATSDR, 1997). EPA assumed that anglers were not malnourished, and made no adjustment for their nutritional status. See the section on lead absorption in Maddaloni (1998) for a discussion of factors influencing absorption. In the absence of data on lead incorporated into food, EPA considered data from studies of lead absorption during meals to be the most appropriate data to use in estimating absorption.

14.5.5 Economic Valuation

This analysis used IQ differentials to represent cognitive damage to children resulting from lead exposure. The economic analysis relates IQ level to annual earnings, which serve as the basis for valuing benefits from reduced lead exposure. IQ differentials are used rather than WTP, the preferred measure to use, because WTP values to avoid cognitive damage are not available. This analysis likely underestimates the value of an IQ point because special education and lost wages form only a portion of the costs associated with lost cognitive functioning. A simple IQ change analysis does not capture all the ways in which a child, family, and society are affected by the effects of lead-induced cognitive damage.

Dollar values associated with most of the adult health and welfare endpoints represent only some components of society's WTP to avoid these health effects. EPA used COI estimates to value reductions in CHD events, strokes, and hypertension. These values are likely to be downward-biased because the value of pain and suffering avoided is not included. Employed alone, these monetized effects will underestimate society's WTP.

Table 14.9: Key Omissions, Biases, and Uncertainties in the Lead-Benefit Analysis

Omissions/Biases/ Uncertainties	Directional Impact on Benefits Estimates	Comments
Excluding older children	downward	New research suggests that older children may be a hypersensitive sub-population, as children aged 0 to 7 are now considered. Excluding this sub-population from the analysis may significantly underestimate benefits from reduced lead discharges.
Compensatory education costs	uncertain	Assuming that compensatory education is required only for children with IQs less than 70 and that part-time special education costs are incurred from grades 1 through 12 underestimates the special education costs because: ▶ Children with IQ scores between 70 and 85 will likely be assigned to special education or "slow" classes, requiring more teacher attention, and taking longer to graduate or dropping out altogether. ▶ Compensatory education may begin before grade one. ▶ The cost to attend a special education program is generally much higher than that for regular schooling. A potential overlap exists between estimates of the avoided costs of compensatory education due to reduced incidence of children with IQ below 70 and PbB levels above 20 g/dL because children with PbB levels may also have low IQ scores. This overlap may introduce an upward bias in the estimate of the lead-related benefits to children. This bias is, however, negligible due to the magnitude of the avoided compensatory education cost estimates.
Dose-response relationship	uncertain	Uncertainty is inherent in the dose-response functions (expressed in changes in PbB for children, changes in BP for adults). Any uncertainty affecting the dose-response coefficients will also indirectly affect the accuracy of this analysis.
Absorption factor for lead in fish tissue	uncertain	Absorption rate appears to be affected by: ▶ total lead intake, with some studies showing a higher absorption proportion with higher doses; ▶ lead's chemical form. Because MP&M facilities produce lead using different processes and release it in different forms, EPA could not obtain data to describe lead's precise chemical form, particle size, and other physical parameters in fish tissue, which would allow more refined absorption estimates; ▶ an individual's nutritional status; and ▶ time of lead ingestion. In the absence of data on lead incorporated into food, EPA considered data from studies of lead absorption during meals to be the most appropriate data to use in estimating absorption.
Economic valuation	downward	The values associated with cognitive damage to children and adult health effects are likely to be downward-biased. For children, a simple IQ change analysis does not capture all effects of lead-induced IQ loss on a child, family, and society. The valuation of adults' health effects from lead exposure do not include the value of avoided pain and suffering. Employed alone, these monetized effects will underestimate society's WTP.
Overall impact	downward	

Source: U.S. EPA analysis.

GLOSSARY

absolute gastrointestinal absorption fraction: the fraction of lead in food ingested daily that is absorbed from the gastrointestinal tract.

acute toxicity: the ability of a substance to cause severe biological harm or death soon after a single exposure or dose. Also, any poisonous effect resulting from a single short-term exposure to a toxic substance. (http://www.epa.gov/OCEPAterms/aterms.html)

angina pectoris: a syndrome characterized by paroxysmal, constricting pain below the sternum, most easily precipitated by exertion or excitement and caused by ischemia of the heart muscle, usually due to a coronary artery disease, as arteriosclerosis. (www.infoplease.com)

arithmetic mean: the mean obtained by adding several quantities together and dividing the sum by the number of quantities. (www.infoplease.com)

atherothrombotic brain infarctions (BI): scientific name for a stroke.

bioavailability: degree of ability to be absorbed and ready to interact in organism metabolism. (http://www.epa.gov/OCEPAterms/bterms.html)

biokinetics: the study of movements of or within organisms. (www.infoplease.com)

biomarker: a physical, functional, or biochemical indicator of a certain process or event. It is commonly used to measure the progress of a disease, the effects of treatment, or the status of a condition.

blood lead (PbB): concentration level of lead in blood stream; usually expressed in µg/dL.

blood pressure: the pressure of the blood against the inner walls of the blood vessels, varying in different parts of the body during different phases of contraction of the heart and under different conditions of health, exertion, etc. (www.infoplease.com)

central tendency estimate: major trend in group of data.

cerebrovascular accident (CBA): stroke.

coronary heart disease (CHD): disorder that restricts blood supply to the heart; occurs when coronary arteries become narrowed or clogged due to the build up of cholesterol and fat on the inside walls and are unable supply enough blood to the heart.

diastolic: pertaining to or produced by diastole, or (of blood pressure) indicating the arterial pressure during the interval between heartbeats. (www.infoplease.com)

discounting: degree to which future dollars are discounted relative to current dollars. Economic analysis generally assumes that a given unit of benefit or cost matters more if it is experienced now than if it occurs in the future. The present is more important due to impatience, uncertainty, and the productivity of capital. This analysis uses a three percent discount rate to discount future benefits. (http://www.damagevaluation.com/glossary)

dose response: shifts in toxicological responses of an individual (such as alterations in severity) or populations (such as alterations in incidence) that are related to changes in the dose of any given substance.

dose-response assessment: 1. Estimating the potency of a chemical. 2. In exposure assessment, the process of determining the relationship between the dose of a stressor and a specific biological response. 3. Evaluating the quantitative relationship between dose and toxicological responses.

dose-response curve: graphical representation of the relationship between the dose of a stressor and the biological response thereto.

dose-response functions: see dose-response relationship.

dose-response relationship: the quantitative relationship between the amount of exposure to a substance and the extent of toxic injury or disease produced. (http://www.epa.gov/OCEPAterms/dterms.html)

encephalopathy: any brain disease. (www.infoplease.com)

GDP price deflator: measure of the percentage increase in the average price of products in GDP over a certain base year published by the Commerce Department. (http://www.damagevaluation.com/glossary.htm)

genotoxic: may cause chromosomal damage in humans leading to birth defects.

geometric mean (GM): for a set of n numbers $\{x_1, x_2, x_3, ..., x_n\}$ it is the n-th root of their product: $(x_1 * x_2 * x_3 ... x_n)^{1/n}$.

geometric standard deviation (GSD): a measure of the inter-individual variability in blood lead concentrations in a population whose members are exposed to the same environmental lead levels. For a lognormal distribution, GSD is the exponential of the standard deviation of the associated normal distribution.

half-life: time required for a living tissue, organ, or organism to eliminate one-half of a substance which has been introduced into it.

health endpoints: an observable or measurable biological event or chemical concentration (e.g., metabolite concentration in a target tissue) used as an index of an effect of a chemical exposure.

heme synthesis: creation of heme; an iron compound of protoporphyrin which constitutes the pigment portion or protein-free part of the hemoglobin molecule and is responsible for its oxygen-carrying properties.

Integrated Exposure, Uptake, and Biokinetics (IEUBK): the IEUBK model is an exposure-response model that uses children's environmental lead exposure to estimate risk of elevated blood lead (typically> 10 µg/dL) through estimation of lead body burdens in mass balance framework.

least-squares regression: a tool of regression analysis that computes a best-fit line to represent the relationship between two (or more) variables based on the principle that the squared deviations of the observed points from that line are minimized (see also: regression analysis).

lognormal distribution: a distribution of a random variable for which the logarithm of the variable has a normal distribution. (www.infoplease.com)

lognormally-distributed random variable: same as lognormal distribution.

marginal cost: the increase in total costs as one more unit is produced. (http://www.damagevaluation.com/glossary.htm)

multivariate: (of a combined distribution) having more than one variate or variable. (www.infoplease.com)

nephropathy: any kidney disease. (www.infoplease.com)

neurobehavioral deficits: neurologic effects as assessed by observation of behavior. These effects may include behavioral and attentional difficulties, delayed mental development, lack of motor and perceptual skills, and hyperactivity.

neurobehavioral function: see neurobehavioral deficits.

non-cancer health risks: include systemic effects, reproductive toxicity, and developmental toxicity.

normal distribution: a random variable X is normally distributed if its density is given by $f_x(x) = f(x; \mu, \sigma)$, where μ and σ are the mean and the variance of the distribution.

opportunity cost: the highest-valued sacrifice needed to get a good or service. (http://www.damagevaluation.com/glossary.htm)

p-value: the probability of obtaining a given outcome due to chance alone. For example, a study result with a significance level of $p \leq 0.05$ implies that 5 times out of 100 the result could have occurred by chance. (http://www.teleport.com/~celinec/glossary.htm)

pharmacokinetics: the study of the way drugs move through the body after they are swallowed or injected. (http://www.epa.gov/OCEPAterms/pterms.html)

probability distribution: a distribution of all possible values of a random variable together with an indication of their probabilities. (www.infoplease.com)

probit regression: a regression model, where the dependent variable is set up as a 0-1 dummy variable and regressed on the explanatory variables. The predicted value of the dependent variable could be interpreted as the probability that a certain event will take place (e.g., an individual will buy a car, visit a particular location, or get a specific disease).

quasi-steady state: almost not changing state.

regression analysis: a procedure for determining a relationship between a dependent variable, such as predicted success in college, and an independent variable, such as a score on a scholastic aptitude test, for a given population. The relationship is expressed as an equation for a line. (www.infoplease.com)

risk-based remediation goals (RBRG): target human health and environmental risk levels to be achieved via remedial actions at Superfund sites.

Technical Review Workgroup (TRW): a workgroup formed in 1994 to evaluate methodologies for adult lead risk assessment.

μg/L: microgram per liter

μg/dL: microgram per decaliter

willingness-to-pay (WTP): maximum amount of money one would give up to buy some good. (http://www.damagevaluation.com/glossary.htm)

ACRONYMS

ATSDR: Agency for Toxic Substances and Disease Registry
BI: atherothrombotic brain infarction
BP: blood pressure
CARB: California Air Resources Board
CBA: cerebrovascular accidents
CDC: Centers for Disease Control
CEPA: California Environmental Protection Agency
CHD: coronary heart disease
COI: cost of illness
GM: geometric mean
GSD: geometric standard deviation
IEUBK: Integrated Exposure, Uptake, and Biokinetics
NHANES: National Health and Nutrition Examination Surveys
NLSY: National Longitudinal Survey of Youth
PbB: blood lead
PPRG: Pooling Project Research Group
RBRG: risk-based remediation goals
TRW: Technical Review Workgroup
WTP: willingness-to-pay

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Chapter 15: Recreational Benefits

INTRODUCTION

The final ***Metal Product and Machinery (MP&M)*** regulation is expected to provide ecological benefits through improvements in the habitats or ecosystems (aquatic and terrestrial) that are affected by the MP&M industry discharges. Society is expected to value such ecological improvements by a number of mechanisms, including increased frequency and value of use of the improved habitat for recreational activities. In addition, individuals may also value the protection of habitats and species that are adversely affected by effluent dischargers even when they do not use or anticipate future use of the affected waterways for recreational or other purposes.

CHAPTER CONTENTS

This chapter presents EPA's analysis of ecological benefits from reduced effluent discharges to the nation's waterways as a result of the final MP&M regulation, the 433 Upgrade Options, and the Proposed/NODA option. EPA assessed ecological benefits in terms of reduced occurrence of pollutant concentrations in excess of AWQC protective of aquatic life and human health. For this analysis, EPA estimated the in-waterway pollutant concentrations of MP&M facility discharges for the baseline and the final rule and identified those reaches in which MP&M facility discharges would cause one or more pollutant concentrations to exceed ***ambient water quality criteria (AWQC)*** for aquatic species and human health.[1,2] The change in the number of reaches with concentrations in excess of AWQC from the baseline to post-compliance scenarios provides a quantitative measure of the improvement in aquatic species habitat expected to result from the final regulation.

As discussed in Chapter 12, EPA performed all benefits analysis on a basis of the sample facility data. The Agency then extrapolated findings from the sample facility analyses to the national level using two alternative extrapolation methods: (1) traditional extrapolation and (2) post-stratification extrapolation. EPA also used the differential extrapolation technique in addition to both traditional and post-stratification approaches when a sample reach was estimated to receive discharges from multiple facilities. Appendix G provides detailed information on the extrapolation approaches used in this analysis.

Reducing concentrations of MP&M pollutants to below AWQC limits for protection of aquatic species and human health will generate benefits to users of water resources for recreation, including anglers, boaters, and viewers. These benefits include:

- increased value of the recreational trip or day, and
- increased number of days that consumers of water-based recreation choose to visit the cleaner waterways.

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1 For this analysis, a reach is a length of river, shoreline, or coastline on which a pollutant discharge may be expected to have a relatively uniform effect on concentrations. The typical length of a reach in this analysis was five to ten kilometers, although some were considerably longer.

2 AWQC set limits on pollutant concentrations that are assumed to be protective of aquatic life. Pollutant concentrations that exceed AWQC can harm organisms that live in or consume water. MP&M pollutants can also harm other organisms that consume these organisms. These organisms at risk include humans who may recreate in contaminated waters or consume aquatic organisms living in them.

EPA estimated national annual recreational use benefits for three water-based recreation activities (i.e., recreational fishing, boating, and viewing) and nonuse benefits, but did not estimate national swimming benefits due to data limitations.[3] EPA estimated the following recreational use benefits of the final MP&M rule (2001$):

- recreational fishing benefits range from $287,220 to $923,988 and from $187,123 to $601,976, based on the traditional and post-stratification extrapolation, respectively;
- near-water recreation (viewing) benefits range from $185,172 to $334,315 and from $120,639 to $217,805, based on the traditional and post-stratification extrapolation, respectively; and
- boating benefits range from $114,111 to $316,078 and from $74,343 to $205,924, based on the traditional and post-stratification extrapolation, respectively.

EPA also estimated nonuse benefits from improved water quality in the nation's surface water resulting from the final rule. Empirical estimates from surface water valuation studies indicate that nonuse values for water resources may be substantial because people who do not use or expect to use affected waterways for recreational or other purposes may still value protecting habitats and species impacted by effluent discharges (Harpman, et al., 1993; Fisher and Raucher, 1984; Brown, 1993). The Agency estimated that nonuse benefits will range from $293,252 to $787,190 and from $191,053 to $512,852, based on the traditional and post-stratification extrapolation, respectively.

EPA calculated the total value of enhanced water-based recreation opportunities by summing over the three recreation categories and nonuser value. Since recreational trips corresponding to fishing, boating, and wildlife viewing considered in this analysis are stochastically independent (i.e., only the primary activity is counted on each trip occasion), benefits from improved recreational opportunities corresponding to these activities are additive. The total annual recreational benefit based on the traditional extrapolation is estimated at $879,755 to $2,361,570 (2001$), with a midpoint estimate of $1,499,756 (2001$). Likewise, total annual recreational benefit based on the post-stratification extrapolation is estimated at $573,158 to $1,538,557 (2001$), with a midpoint estimate of $977,087 (2001$).

The analysis of recreational benefits presented in this chapter uses the ***National Demand Study*** **(NDS)** data to estimate the number of participants in wildlife viewing and boating in the counties affected by MP&M discharges.[4] To estimate the number of recreational fishermen, EPA used fishing license data. The NDS survey asked respondents to report the number of recreational trips taken annually for the *primary purpose* of boating and wildlife viewing. The Agency used these data to estimate the number of participants and the number of recreational trips taken annually by state and activity type. Appendix N summarizes this information.

EPA chose to use fish license data rather than the NDS data to estimate the number of recreational anglers fishing the MP&M reaches because these data are often available at the county level and therefore provide location-specific information. Although the use of the NDS and fish license data yields similar estimates of the number of recreational anglers at the state level (see Chapter 21) fish license data are likely to be more accurate at the county level. The use of the fish license data in the recreational fishing benefit analysis also provides consistency with other parts of the benefits analysis (see Chapters 13 and 14 for detail).

Benefit categories examined in this chapter are different from and generally do not overlap with benefits associated with reduced risk to human health discussed in Chapter 13. Nevertheless, there is some likelihood that the valuation of ecological benefits based on enhanced recreational fishing overlaps to a degree with the valuation of human health benefits from reduced cancer risk via fish consumption.

[3] Fewer water bodies are designated for primary contact recreation, such as swimming, than for secondary contact recreation, such as boating and fishing. Assessing recreational swimming benefits requires first obtaining information on designated uses of the sample MP&M reaches from the 305(b) database. This analysis was not feasible due to resource and time constraints.

[4] Additional information on the NDS survey can be found in Chapter 21.

15.1 ECOLOGICAL IMPROVEMENTS FROM THE MP&M REGULATION

15.1.1 Overview of Ecological Improvements

Many MP&M pollutants can adversely affect the survival, growth, and reproduction of aquatic organisms. Such effects are ecologically significant when they affect the size, structure, or function of populations:

- MP&M pollutants can affect ***population size*** by reducing prey, and by affecting development or reproduction in sensitive life stages of target species;

- MP&M pollutants can alter ***population structure*** by impairing sensitive age groups or affecting the development or maturation rates of target species; and

- MP&M pollutants can impact ***population function*** by decreasing genetic diversity and changing interactions among different populations in the affected areas.

MP&M pollutants may also contaminate fish tissue and therefore decrease the value of fishery resources. Thus, the final MP&M regulation may generate a broad range of ecological effects by reducing MP&M pollutant discharges. Ecological effects associated with reductions in MP&M discharges may include:

- recovery of populations of aquatic species that are particularly sensitive to MP&M pollutants;

- decreases in noxious algae, which affect the taste and odor of the receiving waters;

- increases in the concentrations of ***dissolved oxygen (DO)*** in the water column;

- improvements in the natural assimilative capacity of the affected waterways;

- decreases in fish tissue contamination; and

- terrestrial life benefits.

Improvements in aquatic species habitat are expected to improve the quality and value of water-based recreation and nonuse values of the affected resources. Recent studies valuing recreational fishing showed that the value of water resources for recreational fishing increases as the level of toxic contamination in fish tissue decreases (Lyke, 1993; Phaneuf et al., 1998; and Jakus et al., 1997). Thus, knowing that the water is cleaner and does not contain any or contains fewer pollutants that harm humans and aquatic life, increases individuals' enjoyment of their recreational experience. The value of a recreational fishery also increases from increased number, size, diversity, and health of recreational fish species.

Participants in other water-based recreation, such as boating and wildlife viewing, will also benefit from improved abundance and diversity of aquatic and terrestrial species. For example, wildlife viewers may benefit from improved abundance of piscivorous birds (e.g., osprey and cormorants) whose population is likely to increase due to an increase in the forage fish populations. Boaters may benefit from enhanced opportunities for companion activities, such as fishing and wildlife viewing (e.g., piscivorous birds) and from improved water clarity and smell. Reducing conventional pollutant loadings will also improve visual aesthetics, thereby enhancing all water-based recreation experiences.

15.1.2 Quantification of Ecological Improvements

EPA evaluated potential impacts to aquatic life from the final MP&M regulation by estimating in-waterway concentrations of pollutants discharged by MP&M facilities and comparing those concentrations within AWQC limits for protection of aquatic species. Pollutant concentrations in excess of AWQC limits indicate a significant detriment to the aquatic species habitat. EPA expects that eliminating these exceedances as the result of the MP&M regulation will significantly improve aquatic species habitat and thus provide a quantitative measure of ecological benefit for this regulatory analysis.

For this analysis, EPA estimated in-waterway concentrations for all MP&M pollutants for which AWQC limits are available. Of the 132 MP&M pollutants of concern, AWQC values are available for 114 pollutants.[5] Table I.3 in Appendix I lists the pollutants evaluated in this analysis and their acute and chronic aquatic life AWQC. The acute value is the maximum allowable one-hour average concentration at any time at which aquatic life can survive. The chronic value is the average concentration of a toxic pollutant over a four-day period at which aquatic life is not unacceptably affected. The endpoints of concern are one or more sub-lethal responses, such as changes in reproduction or growth in the affected organisms. The chronic levels should not be exceeded more than once every three years.

EPA used the mixing and dilution methods outlined in Appendix I to estimate the in-waterway concentrations resulting from MP&M facility discharges. Acute and chronic exposure concentrations for each pollutant are calculated on the basis of ***7Q10*** and ***1Q10*** stream flow rates, where 7Q10 is the lowest consecutive seven-day average flow with a recurrence interval of ten years, and 1Q10 is the lowest one-day average flow with a recurrence interval of ten years. For reaches to which more than one sample MP&M facility discharge, EPA summed the discharge values by pollutant for all known sample facilities discharging to the reach.

EPA first identified the MP&M discharge reaches in which MP&M discharges alone caused one or more pollutant concentrations to exceed AWQC limits for aquatic species under the baseline discharge level. If concentrations of all MP&M pollutants exceeding the limits in the baseline fell below AWQC limits as a result of the final rule, then aquatic species habitat conditions on that discharge reach would likely improve significantly as a result of the final regulation. The final regulation would result in partial aquatic habitat improvements if concentrations of some, but not all, MP&M pollutants fell below their AWQC limits. Although not explicitly accounted for in this analysis, species habitat conditions are likely to improve whenever in-waterway concentrations are reduced, regardless of whether or not they fall to levels below aquatic AWQC.

EPA's analysis based on the traditional extrapolation method indicates that pollutant concentrations at current industry discharge levels exceed acute exposure criteria for protection of aquatic species on 18 receiving reaches, and exceed chronic exposure criteria for protection of aquatic species on 353 receiving reaches.[6] EPA estimates that the final rule would eliminate concentrations in excess of the acute aquatic life exposure criteria on nine reaches, and would eliminate concentrations in excess of the chronic aquatic life exposure criteria on nine reaches.

Similarly, EPA's analysis based on the post-stratification extrapolation method indicates that baseline pollutant concentrations at current industry discharge levels exceed acute exposure criteria for protection of aquatic species on 15 reaches, and exceed chronic exposure criteria for protection of aquatic species on 350 reaches. EPA estimates that the final rule would eliminate concentrations in excess of the acute aquatic life exposure criteria on six reaches, and would eliminate concentrations in excess of the chronic aquatic life exposure criteria on six reaches. Table 15.1 summarizes these results.

15.1.3 Benefiting Reaches

As a first step in estimating the monetary value of improvements in the aquatic habitats affected by MP&M discharges from the final MP&M rule, EPA identified reaches that are likely to experience significant water quality improvements from reduced MP&M discharges due to the final MP&M rule (hereafter, ***benefiting reaches***). A reach is considered to benefit from the MP&M rule if at least one AWQC exceedance is eliminated due to reduced MP&M discharges. This approach differs from some past approaches where EPA took credit for pollution reductions only in cases where all AWQC exceedances are eliminated. EPA believes that the latter approach significantly underestimates benefits from reduced pollutant discharges.

This analysis combines two AWQC calculation procedures:

- analysis of in-waterway concentrations relative to human health AWQC limits described in Chapter 13,[7] and

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[5] Facilities in the Oily Wastes subcategory discharge 122 of the 132 POCs evaluated. See Chapter 12 for detail.

[6] This analysis used baseline pollutant loads for direct and indirect dischargers belonging to all subcategories considered for regulation.

[7] Although EPA estimated the value of reduced cancer risk from consumption of contaminated fish tissue, the Agency was unable to estimate the value of reduced systemic risk from consumption of fish caught in the reaches affected by MP&M discharges (see Chapter 13). The recreational benefits analysis presented in the following sections assumes that some of the value of reduced systemic health risk is implicitly captured in the increased value of water resources from reduced occurrence of human health-based AWQC exceedances. For

- analysis of in-waterway concentrations relative to aquatic life AWQC limits described in the preceding section of this chapter.

Table 15.1 summarizes the number of reaches with estimated baseline concentrations that exceed AWQC limits for either human health or aquatic species, and the number of those reaches where the regulation is estimated to eliminate or reduce exceedances. Based on the traditional extrapolation, the combined analysis over *all* AWQC limit categories (i.e., acute and chronic aquatic life and human health) indicates that MP&M pollutant concentrations would exceed at least one AWQC limit on 395 reaches as the result of baseline MP&M discharges. The expected discharge reductions from the final rule eliminate exceedances on nine of these discharge reaches, leaving 386 reaches with concentrations of one or more pollutants that exceed AWQC limits.

Likewise, based on the post-stratification extrapolation, the combined analysis indicates that MP&M pollutant concentrations would exceed at least one AWQC limit on 426 reaches as the result of baseline MP&M discharges. The expected discharge reductions from the final rule eliminate exceedances on six of these discharge reaches, leaving 420 reaches with concentrations of one or more pollutants that exceed AWQC limits.

EPA assigned full benefits in situations where the rule eliminates all AWQC exceedances and partial benefits where the rule eliminates one or more, but not all, AWQC exceedances. EPA calculates partial benefits as the ratio of the AWQC exceedances removed by reducing MP&M discharges to the total number of AWQC exceedances caused by MP&M facilities in the baseline. For example, if the MP&M rule removes seven out of a total ten baseline AWQC exceedances on a benefiting reach, the Agency attributes a 70 percent benefit to the MP&M regulation, where 100 percent would represent an "AWQC exceedance-free" level.

Table 15.1: Estimated MP&M Discharge Reaches with MP&M Pollutant Concentrations in Excess of AWQC Limits for Protection of Aquatic Species or Human Health

Regulatory Status	Number of Reaches with Concentrations Exceeding AWQC Limits				Total Number of Reaches with Concentrations Exceeding AWQC Limits	Number of Benefiting Reaches	
	AWQC Limits for Aquatic Species		AWQC Limits for Human Health			All AWQC Exceedances Eliminated	Reaches with Some Exceedances Eliminated
	Acute	Chronic	H20 and Organisms	Organisms Only			
Selected Option: Traditional Extrapolation							
Baseline	18	353	78	21	395	N/A	N/A
Final Option	9	344	78	21	386	9	0
Selected Option: Post-Stratification Extrapolation							
Baseline	15	350	112	21	426	N/A	N/A
Final Option	9	344	112	21	420	6	0

Note: In the baseline, the total number of reaches with concentrations exceeding AWQC limits does not equal the sum of the numbers in the separate analysis categories because some reaches were estimated to have concentrations in excess of AWQC limits for more than one analysis category.

Source: U.S. EPA analysis

Surface water valuation studies show that benefits from partial improvements are likely to be considerable. For example, Carson and Mitchell (1993) found that almost nine out of ten individuals indicated that "halfway" improvements are worth the same as a complete improvement in water quality. The remaining one out of ten individuals were willing to pay a reduced amount for partial improvements in water quality.

example, some studies showed that anglers place a much higher value on fishery resources that are safe for consumption (Lyke, 1993 and Phaneuf, 1997).

The effects of partially removing AWQC exceedances, however, are difficult to generalize. The overall improvement in surface water quality from reduced toxic loadings will depend on the amount and duration of exceedances, together with the kinds of chemical(s) that are removed from the mixture by regulatory action. AWQC are developed on a chemical-by-chemical basis; they are not designed to assess the toxicity of multiple chemicals. In most cases, the toxicities of chemicals in a mixture are considered additive (i.e., the total toxicity is the sum of the toxicities of the individual chemicals). Total toxicity decreases by the amount of a chemical removed from the mixture. Benefits to sensitive aquatic species (i.e., amphibians, fish, benthic invertebrates, zooplankton) could occur if the concentration of one chemical fell below its AWQC even when two or more other chemicals still were at or exceeding their respective AWQC. The reason is that the total toxic pressure in the receiving water decreases so that a smaller fraction of the most sensitive species remain affected. For example, consider a case in which three chemicals exceeding their chronic AWQC adversely affect 7 percent of all aquatic species in a receiving water. If certain species are particularly sensitive to one of the three chemicals, then eliminating the AWQC exceedance for this chemical would lower the percentage of sensitive species being adversely affected.

15.1.4 Geographic Characteristics of MP&M Reaches

EPA cannot identify all of the specific reaches affected by MP&M facilities that reduce discharges under the final rule because location is known only for the facilities included in the random stratified sample. EPA assumes that facilities represented by the sample facility have the same environmental and geographic characteristics that affect benefits from the final rule. These characteristics include water body type and physical characteristics (e.g., stream flow conditions), populations residing near the water body, and the number of potential recreational users affected.

The analysis of the sample reach locations indicates that sample MP&M reaches tend to be located in heavily populated areas. For example, approximately 35 percent of sample reaches receiving discharges from sample MP&M direct dischargers are located adjacent to counties with populations of at least 500 thousand residents. These reaches have a greater number of potential recreational users than do reaches in less populated areas.

15.2 VALUING ECONOMIC RECREATIONAL BENEFITS

The final MP&M rule will improve aquatic habitats by reducing concentrations of ***priority (i.e., toxic)***, ***nonconventional***, and ***conventional*** pollutants in water. In turn, these improvements will enhance the quality and value of water-based recreation, such as fishing, wildlife viewing, camping, waterfowl hunting, and boating. The Agency used the estimated increase in the monetary value of recreational opportunities for fishing, boating, and wildlife viewing as a partial measure of the economic benefit to society from the improvements to aquatic species habitat expected to result from the final MP&M regulation. The Agency also estimated nonuse benefits from improvements in aquatic habitats and ecosystems that are affected by the MP&M industry discharges.

This analysis uses a ***benefits transfer*** approach to monetize changes in water resource recreational values for reaches affected by MP&M discharges.[8] This approach builds upon an analysis of applicable surface water valuation literature to estimate the total ***WTP*** value (including both use and nonuse values) for improvements in surface water quality.

15.2.1 Transferring Values from Surface Water Valuation Studies

EPA identified several surface water evaluation studies that quantified the effects of water quality improvements on various water-based recreational activities. The Agency used the following technical criteria for evaluating study transferability (Boyle and Bergstrom, 1990):

- The environmental change valued at the study site must be the same as the environmental quality change caused by the rule (e.g., changes in toxic contamination vs changes in turbidity);
- The populations affected at the study site and at the policy site must be the same (e.g., recreational users vs nonusers);

[8] Benefits transfer involves the application of value estimates, functions, and/or models developed in one context to address a similar resource valuation question in another context.

- The assignment of property rights at both sites must lead to the same theoretically appropriate welfare measure (e.g., willingness-to-pay vs willingness to accept compensation).

In addition to the above criteria, the Agency considered authors' recommendations regarding robustness and theoretical soundness of various estimates.

Existing studies are unlikely to meet all of the above criteria. Boyle and Bergstrom (1990) reported that most researchers will likely encounter problems with at least one criterion. This analysis is no exception. The major limitation in performing the national analysis is the comparability of the water quality changes considered in the original studies with the water quality changes considered in this analysis. These comparisons are discussed below.

The Agency used eight of the most comparable studies and calculated the changes in recreation values resulting from water quality improvements (as a percentage of the baseline value) implied by those studies. EPA took a simple mean of upper- and lower-bound estimates from these studies to derive a range of percentage changes in the water resource values due to water quality improvements. The studies used for benefits transfer in the MP&M regulatory analysis included Lyke (1993), Jakus et al. (1997), Montgomery and Needelman (1997), Phaneuf et al. (1998), Desvousges et al. (1987), Lant and Roberts (1990), Farber and Griner (2000), and Tudor et al. (2002). Appendix K presents WTP values for various water quality improvements and summarizes EPA's reasoning for selecting specific WTP estimates for benefits transfer. Each of the eight studies and the WTP values selected for benefits transfer are discussed briefly below.

Lyke's (1993) study of the Wisconsin Great Lakes open water sport fishery showed that anglers may place a significantly higher value on a contaminant-free fishery than on one with some level of contamination. Lyke estimated the value of the fishery to Great Lakes trout and salmon anglers if it were improved enough to be "completely free of contaminants that may threaten human health," and found that this value would add between 11 and 31 percent of the fishery's current value.

Jakus et al. (1997) used a repeated discrete choice ***travel cost (TC)*** model to examine the impacts of sport-fishing consumption advisories in eastern Tennessee. The model controlled for anglers' knowledge of advisories, the type of angler (i.e., fish consumption vs. catch and release), and catch rate. The estimated welfare gain (as a percentage of baseline) from cleaning up six reservoirs and removing these advisories ranges from six to 8 percent. These estimates are below Lyke's estimated 11 to 31 percent range, due to the difference in methodology used. The TC method captures use values only, while the combined TC and stated preferences method used in Lyke captures both the use and nonuse components of the resource value to users. Differences in the fisheries and user populations may also affect the estimated percentage changes in the resource value.

Montgomery and Needelman (1997) estimated benefits from removing "toxic" contamination from lakes and ponds in New York State. They used a binary variable as their primary water quality measure, which indicates whether the New York Department of Environmental Conservation considers water quality in a given lake to be impaired by toxic pollutants. The model controls for major causes of impairments other than "toxic" pollutants to separate the effects of various pollution problems that affect the fishing experience. The estimates from Montgomery and Needelman imply that removing "toxic" impairments in all New York lakes and ponds would increase recreational fishing value by 13.7 percent.

Phaneuf et al. (1998) studied angling in the Wisconsin Great Lakes. They estimated changes in recreational fishing values resulting from a 20 percent reduction of toxin levels in lake trout flesh. The study uses a TC model to value water quality improvements when corner solutions are present in the data. Corner solutions arise when consumers visit only a subset of the available recreation sites, setting their demand to zero for the remaining sites. Phaneuf et al. found that improved industrial and municipal waste management results in general water quality improvement. This improvement leads in turn to a 20 percent decrease in fish tissue toxin levels, yielding a welfare gain of $166.21 (2001$) per angler per year.[9] This estimate implies that recreational fishing values would increase by approximately 27.5 to 34.3 percent from reduced toxin levels. This analysis estimates use values only.

Desvousges et al. (1987) used findings from a ***contingent valuation (CV)*** survey to estimate WTP for improved recreational fishing from enhanced water quality in the Pennsylvania portion of the Monongahela River. In a hypothetical market, each survey respondent was asked to provide an option price for different water quality changes, including "raising

[9] The study used the 1989 survey data on recreational angling in Wisconsin's Great Lakes. Therefore, this analysis assumes that all estimates in the original study are in 1989 dollars.

the water quality from suitable for boating (hereafter, "boatable" water) to a level where gamefish would survive (hereafter, "fishable" water)."

In applying Desvousges et al. for the MP&M analysis, EPA assumed that reaches with AWQC exceedences under the baseline conditions are likely to support rough fishing but may not be clean enough to support gamefishing. Removing AWQC exceedences is therefore comparable to shifting water quality from "boatable"to "fishable." This is a relatively conservative assumption. Desvousges et al. found that improving water quality from "boatable" to "fishable" would yield a 5.9 to 7.9 percent increase in water resource value to recreational anglers.

Lant and Roberts (1990) used a CV study to estimate the recreational and nonuse benefits of improved water quality in selected Iowa and Illinois river basins. River quality was defined by means of an interval scale of "poor," "fair," "good," and "excellent." The authors defined "fair" water quality as adequate for boating and rough fishing and "good" water quality as adequate for gamefishing.

For the MP&M analysis, EPA assumes that eliminating AWQC exceedences is roughly equivalent to shifting water quality from "fair" to "good." The estimates from this study imply an increase of 9.7 to 13.1 percent in recreational fishing value from improving water quality from "fair" to "good."

Farber and Griner (2000) used a CV study to estimate changes in water resource values to users from various improvements in water quality in Pennsylvania. The study defines water quality as "polluted," "moderately polluted," and "unpolluted" based on a water quality scale developed by EPA Region III: "Polluted" streams are unable to support aquatic life; "moderately polluted" streams are somewhat unable to support aquatic life; and "unpolluted" streams adequately support aquatic life. Streams unable to support aquatic life (i.e., "polluted") are likely to be affected by environmental stressors unrelated to MP&M discharges, such as acidity or severe oxygen depletion.

The MP&M analysis assumes that most streams affected by MP&M facility discharges are moderately polluted; i.e., these streams support aquatic life, but sensitive species may be adversely affected by MP&M pollutants that exceed AWQC values protective of aquatic life. Removing all AWQC exceedences would make such streams unpolluted. The estimates from this study imply that improving water quality from "moderately polluted" to "unpolluted' would yield an increase in recreation fishery value ranging from 3.9 to 9 percent.

Tudor et al. (2002) used a TC model to estimate changes in water resource recreation values resulting from eliminating MP&M pollutant concentrations in excess of AWQC limits at recreation sites in Ohio.[10] The study involves four recreation activities -- fishing, boating, near-water recreation, and swimming -- and covers most recreationally-important water bodies in all Ohio counties. The study considers two types of water quality effects from MP&M pollutants on consumers' decisions to visit a particular water body:

(1) visible or otherwise perceivable effects (e.g., turbidity and odor); and
(2) "toxic" effects that are not directly perceivable by consumers.

Because priority and nonconventional pollutants at high enough concentrations may adversely affect aquatic species, "toxic" effects may be indirectly observable via species abundance and diversity. The study uses a dummy variable to account for effects of "toxic" MP&M pollutants, identifying recreation sites at which estimated concentrations of one or more MP&M pollutants exceed AWQC for protection of aquatic life. The study estimated that eliminating AWQC exceedances and reducing TKN concentrations would yield per trip benefits of $1.34, $1.78, $.60, and $0.33 (2001$) from improved fishing, boating, wildlife viewing, and swimming opportunities, respectively. The estimated changes in the recreational use value of Ohio water resources, are 0.77, 1.67, and 0.77 percent for fishing, boating, and wildlife viewing, respectively. This analysis estimates use values only.

With the exception of the Tudor et al. (2002) study, the types of water quality changes assessed in these studies are only roughly comparable to those studied in the MP&M analysis. Whereas the analysis of the final MP&M regulation and Tudor et al. (2002) assessed the impact of eliminating AWQC exceedances, the other studies used other measures of water quality improvement. EPA addressed the differences in measurement between the other studies and the MP&M analysis by linking

[10] Preliminary results of this study were presented at the annual American Agricultural Economic Association meeting (Tudor et al., 1999a) and at the annual Northeastern Agricultural and Resource Economic Association Meeting (Tudor et al., 1999b). EPA subjected this study to a formal peer review by experts in the natural resource valuation field. The peer review concluded that EPA had done a competent job, especially given the available data. This study can be found in Chapter 21. The peer review report is in the docket for the rule.

water quality changes expected from the MP&M regulation to the type of water quality changes assessed in the other studies. EPA assumed that eliminating AWQC exceedances is roughly comparable to the following discrete water quality changes:[11]

- "achieving a contaminant free fishery;"
- reducing the level of toxins in fish tissue;
- removing fish consumption advisories (FCA); and
- improving water quality from "boatable" to "fishable," from "fair" to "good," and from "moderately polluted" to "unpolluted."

The MP&M analysis uses the estimates derived from the eight surface water evaluation studies described above to calculate a range of national WTP values. The following sections present the methodology and relevant values used to estimate the value of improved fishing, wildlife viewing, and boating opportunities resulting from the MP&M regulation.

15.2.2 Recreational Fishing

The MP&M rule will improve the recreational angling experience by reducing concentrations of priority, nonconventional, and conventional contaminants in water. EPA estimated the benefits of these reductions by estimating:

- the number of recreational fishing days on benefiting reaches;
- the baseline fishery value of each benefiting reach; and
- changes in recreational fishery value, using values from the available surface water valuation studies.

a. Number of recreational fishing days

EPA calculated the annual number of person-days of recreational fishing for each benefiting reach using a two-step approach:

❖ ***Participating population***

The geographic area from which anglers would travel to fish a reach is assumed to include only those counties that abut a given reach. As noted in Chapter 13, this assumption is based on the finding in the 1991 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation that 65 percent of anglers travel less than 50 miles to fish (U.S. Department of the Interior, 1993). NDS data showed that recreational anglers travel from 20 to 66 miles to their destination, with an average one-way travel distance of 30 miles.[12,13]

EPA estimated the population participating in recreational fishing using the number of licensed fishermen in counties bordering MP&M discharge reaches using the following steps:

- assume that fishing activity among these anglers is distributed evenly among all reach miles within those counties;
- compute the length of the MP&M reach as a percentage of total reach miles within corresponding counties;
- multiply the estimated ratio by the total fishing population in counties abutting the reach to estimate the number of anglers who may fish an MP&M reach; and

[11] Section 15.1.3 discusses a method used for estimating partial water quality improvements.

[12] See Chapter 21 for detail on the NDS data.

[13] These estimates exclude outliers.

- reduce the number of anglers by 20 percent in reaches where MP&M and other pollutants have required a fish consumption advisory. This reduction is an estimate of angler response to the presence of a fish consumption advisory.[14]

❖ ***Average number of fishing days***

Anglers generally participate in recreational fishing several times a year. The **U.S. Fish and Wildlife Service (FWS)** provides estimates of the average number of fishing days per angler in each state. The FWS estimates range from 10.5 days per angler in Arizona to 21.1 days per angler in Alabama for freshwater fishing, and 7.3 days per angler in Louisiana to 18.7 days per angler in Virginia for saltwater fishing.[15]

EPA calculated the total number of angler days by multiplying the number of recreational anglers for each benefiting reach by the average number of fishing days for the reach (based on the state in which the reach is located).

b. Baseline fishery value

The net value of a recreational fishing day is the total value of the fishing day exclusive of any fishing-related costs (e.g., license fees, travel costs, bait, tackle, charter boats, etc.) incurred by the angler.

EPA used two recreational fishing valuation studies (Bergstrom and Cordell (1991) and Walsh et al. (1992)) to calculate the net economic value per recreational fishing day under the baseline conditions. Both studies used a meta-analysis of recreational fishery valuation studies to estimate per-day values of the three types of recreational fishing: warmwater, coldwater, and anadromous. Based on the two studies, EPA developed an average per-day value for each type of recreational fishing. This analysis uses low and high average benefit values for fishing days of $28.11 and $60.43 (2001$) to estimate a range of the baseline fishery values.

Table 15.2: Baseline Values of Fishing

Fishery Type	Per-day Value (2001$)[a]		Average Per-day Value (2001$)
	Bergstrom and Cordell (1991)[b]	Walsh et al. (1992)[c]	
Warmwater	$19.52	$36.70	$28.11
Coldwater	$27.77	$47.71	$37.74
Anadromous	$36.73	$84.15	$60.43
Range of above			$28.11 - $60.43

[a] Original study values were adjusted to 2001 dollars based on the relative change in CPI from 1987 to 2001.
[b] Study location: various U.S. locations. Estimating approach: meta-analysis of TC studies.
[c] Study location: various U.S. locations. Estimating approach: meta-analysis of CV and TC studies.

Source: U.S. EPA analysis

EPA calculated the total baseline value for each fishery located on a benefiting reach by multiplying the estimated net value of a recreational fishing day by the total number of fishing days calculated in subsection (a) above. Applying facility weights and summing over all benefiting reaches provides a total baseline recreational fishing value for MP&M reaches expected to benefit from the elimination of pollutant concentrations in excess of AWQC limits.

[14] See Belton et al. (1986), Knuth and Velicer (1990), Silverman (1990), West (1989), Connelly et al. (1992), and Connelly and Knuth (1993) for more information on angler response to fish advisories.

[15] These averages reflect participation levels in the 48 contiguous states. No sample facility is located in Hawaii or Alaska.

c. Changes in recreational fishery value

Expected benefits from the final MP&M regulation include an increase in the quality of an angler's recreational opportunities and/or the number of days an angler chooses to fish each season.

EPA assumes that the expected welfare gain for recreational anglers is a function of changes in the overall quality of all recreational opportunities available to each angler. Recreational anglers residing in the counties abutting MP&M reaches will therefore benefit from improved recreational opportunities whether or not they actually visit an MP&M reach.

EPA used the eight studies discussed above to calculate the changes in recreation values from water quality improvements (as a percentage of baseline) implied by those studies. Table 15.3 compiles information on the baseline values, values of changes in water quality, and percentage changes in values reported or implied by these studies.

Table 15.3: Studies Estimating Changes in Value of a Recreational Fishery

Study	Type of Water Quality Change Valued	Baseline Value of Recreational Angling (2001$)	Value of Water Quality Change (2001$)	Value of Change as % of Baseline	Type of Benefits Included
Lyke (1993)	Fish tissue is completely free of toxic contaminants that may threaten human health	$95.0-$119.0 million per year [a]	$10.5-$37.1 million per year [a]	11% - 31%[a]	Use and nonuse values for recreational anglers
Jakus et al. (1997)	Lifting FCAs	$26.0-$52.6 per trip	$2.0-$3.2 per trip	6.0% - 8.0%	Use values for recreational anglers
Montgomery and Needelman (1997)	Elimination of toxic impairment	$656.6 per angler per year [b]	$90.3 per angler per year	13.7%	Use values for recreational anglers
Phaneuf at al. (1998)	20% reduction of toxic contamination in trout flesh	$484.5 - $605.8 per angler per year [a]	$166.2 per angler per year	27.5% - 34.3%	Use values for recreational anglers
Desvousges et al. (1987)	Improvement from "boatable" to "fishable"	$28.11- $37.73 per trip [c]	$2.21 per trip [d]	5.9% - 7.9%	Recreational and nonuse values to users
Lant and Roberts (1990)	Improvement from "fair" to "good"	$28.11- $37.73 per trip [c]	$3.67 per trip [e]	9.7% - 13.1%	Recreational and nonuse values to users
Farber and Griner (2000)	Improvement from "moderately polluted" to "unpolluted"	$28.11- $37.73 per trip [c]	$1.49-$2.55 per trip [f]	3.9% - 9.0%	Recreational use values to users and nonusers
Tudor et al. (2002)[g]	Elimination of AWQC exceedances	$173.34 per trip	$1.34 per trip	0.77%	Use values for recreational anglers
Average percentage change in recreational fishery value (based on above studies)[h]				9.8% -14.7 %	Recreational and nonuse values to users

[a] The baseline fishery value for the study site location is based on the baseline fishery value reported in Lyke (1993). The study used data from two mail surveys conducted in 1989 at the University of Wisconsin-Madison. These surveys were originally used by Lyke (1993).
[b] Based on the average value for a coldwater fishing day of $37.74 (see Table 15.2), multiplied by the average number of freshwater (non-Great Lakes) angling days per year in New York State (17.4 days, USFWS, 1996).
[c] Range based on the range of values for a fishing day used in this analysis (see Table 15.2);
[d] Based on the value of water quality improvement of $36.79 per year (updated from 1987 dollars reported in Desvousges et al., 1987). divided by the average number of freshwater angling days per year in Pennsylvania (16.6 days, USFWS, 1996).
[e] Based on the value of water quality improvement of $57.81 per year (updated from 1990 dollars reported in Lant and Roberts) divided by the average number of freshwater angling days per year in Iowa and Illinois (16.6 and 15.5 days, USFWS, 1996).
[f] Based on the values of water quality improvements ranging from $24.55 to $41.93 per year reported in Farber and Griner (2000), divided by the average number of freshwater angling days per year in Pennsylvania (16.6 days, USFWS, 1996).
[g] See Chapter 21 of this report for detail. The baseline value of recreational fishery is based on the estimated mean value of water resources for recreational anglers reported by Tudor et al. (2002). The estimated median value of recreational fishing is $175.48. These values were derived from a September 23, 2002 analysis.
[h] EPA took a simple mean of lower- and upper-bound estimates from the eight studies to calculate a range of percentage changes in the recreational fishery value from improved water quality conditions. When only one value is available from the study (i.e., Tudor et al., 2002), EPA used this value in calculating both the lower- and upper-bound estimates.

Source: U.S. EPA analysis

EPA used the percentage change in the fishery value implied by the eight studies to estimate increased recreational fishing values for all MP&M reaches in which the regulation eliminates AWQC exceedances of one or more MP&M pollutants. That is, the Agency estimated benefits for all MP&M discharge reaches where at least one AWQC exceedance is eliminated due to reduced MP&M discharges. As noted above, EPA took a simple mean of lower- and upper-bound estimates from the eight studies described above to calculate a range of percentage changes in the recreational fishery value from reduced MP&M discharges. These studies yielded estimates of increased value ranging from 9.8 to 14.7 percent. Multiplying these percentages by the baseline value of fisheries located on benefiting reaches yielded a range of benefits from eliminating pollutant concentrations in excess of AWQC limits.

Table 15.4 below summarizes the results of EPA's recreational fishing benefits analysis.

Table 15.4: Summary of Recreational Fishing Benefits (2001$)

	Number of Benefiting Reaches	Participating Population (millions)	Average Number of Fishing Days	Total Angler Days (millions)	Baseline Fishery Value/ Rec. Day	Baseline Fishery Value ($ millions)	% Change in Fishery Value	MP&M Benefits
Selected Option: Traditional Extrapolation								
Low Estimate	9	0.98	17.3	16.98	$28.11	$477	9.8%	$287,220
High Estimate	9	0.98	17.3	16.98	$60.43	$1,026	14.7%	$923,988
Selected Option: Post-Stratification Extrapolation								
Low Estimate	6	1.08	17.2	18.61	$28.11	$523	9.8%	$187,123
High Estimate	6	1.08	17.2	18.61	$60.43	$1,125	14.7%	$601,976

Source: U.S. EPA analysis

15.2.3 Wildlife Viewing

EPA expects that water quality improvements from the MP&M regulation will decrease the uptake of pollutants through aquatic food chains. These changes are expected to increase the health and reproductive success of sensitive wildlife species that feed on fish and other aquatic organisms. In particular, **Piscivorous** (i.e., fish-eating) bird species such as the osprey (*Pandion haliaetus*), bald eagle (*Haliaeetus leucocephalus*), great blue heron (*Ardeidae herodias*), mergansers (*Merginae* sp.), and cormorants (*Phalacrocorax* sp.) will benefit from increased numbers, size, and health of forage fish. Increased food and lower pollutant levels in fish flesh will improve reproduction in these birds, leading to healthier and larger bird populations. Reducing conventional pollutant loadings will also improve visual aesthetics, thereby enhancing wildlife viewing and other near-water-based recreation experiences, such as photography, camping, picnicking, and waterfowl hunting (hereafter, this discussion refers to all of these activities as "wildlife viewing").

As with the recreational fishing analysis, EPA assumes that the expected welfare gain for consumers of viewing activities is a function of changes in the overall quality of all recreational opportunities available to each consumer. Consumers of water-based recreation residing in the counties abutting MP&M reaches are therefore likely to benefit from improved recreational opportunities whether or not they actually visit an MP&M reach.

EPA estimated wildlife viewing benefits using an approach similar to that used in estimating recreational fishing benefits. EPA estimated:

- the number of wildlife viewing days on benefiting reaches;
- the baseline value of wildlife viewing for each benefiting reach; and
- changes in wildlife viewing value, using values from the available surface water valuation studies.

a. Number of wildlife viewing days

EPA calculated the annual number of person-days of wildlife viewing for each benefiting reach using a two-step approach:

❖ ***Participating population***

The analysis of the NDS data showed that participants in viewing activities travel from 16 to 117 miles to their destination, with an average one-way travel distance of 34 miles.[16] EPA therefore assumes that improvements in recreational opportunities will benefit only recreational users residing within the counties abutting MP&M reaches. EPA estimated the population participating in viewing activities using the number of water-based recreation consumers residing in the counties traversed by benefiting reaches using the following steps:

- estimate resident populations in the counties traversed by the benefiting reaches using Census data;
- calculate the number of wildlife viewing participants based on the percent of the population engaged in wildlife viewing activities;
- estimate the percentage of individuals that participate in wildlife viewing in each state using NDS data. The total state population participating in wildlife viewing ranges from 8.6 percent in New Mexico to 44.4 percent in Maine; and
- adjust the number of wildlife viewing participants within the affected county based on the ratio of the affected reach length to the number of total reach miles in the affected county to calculate the population potentially benefiting from the rule.[17,18]

❖ ***Average number of viewing days***

Recreators generally participate in wildlife viewing several times a year. The Agency used NDS data on the number of wildlife viewing trips to estimate the average number of user days in each state. The NDS data show that the number of wildlife viewing trips in the 48 states range from 1.8 days per user in South Dakota to 24.2 days per user in Mississippi.[19]

EPA multiplied the number of wildlife viewing consumers by estimates of the average number of days per user in each state to estimate the annual number of user days for each benefiting MP&M reach.

b. Baseline value of wildlife viewing

EPA estimated the baseline value of wildlife viewing for the benefiting reaches based on the estimated annual person-days calculated in subsection (a) above and the estimated value per person-day of wildlife viewing.

EPA used two recreational activity valuation studies (Bergstrom and Cordell (1991) and Walsh et al. (1992)) to calculate the net economic values per wildlife viewing day. These studies estimate net benefit values for four recreational activities: wildlife viewing, waterfowl hunting, camping, and picnicking. Based on the two studies, EPA developed an average per-day value for three of the four activities.[20] EPA's MP&M benefits analysis uses the lowest average benefit value, $22.73, for the low estimate of wildlife viewing benefits and the highest average value, $28.73, for the high estimate. Table 15.5 presents information on the relevant values reported in these studies.

Using facility sample weights and summing over all benefiting reaches provides the total baseline value of wildlife viewing for MP&M reaches that EPA expects to benefit by eliminating pollutant concentrations in excess of AWQC limits.

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[16] These estimates exclude outliers.

[17] Information in EPA's Reach File 1 indicates that the ratio of affected reach length to the total number of reach miles within a county ranges from 0.02 to 0.39.

[18] This analysis assumes that recreation activities among residents of the counties affected by MP&M discharges are distributed evenly across all reach miles within those counties.

[19] See Chapter 21 for details on the NDS data.

[20] EPA excluded the per-day value of waterfowl hunting ($55.53) from the activities included in this analysis, because this activity is limited to designated hunting areas only.

Table 15.5: Baseline Values of Wildlife Viewing

Recreational Activity	Per-day Value (2001$)[a]		Average Per-day Value (2001$)
	Bergstrom and Cordell (1991)[b]	Walsh et al. (1992)[c]	
Camping	$27.10	$30.38	$28.73
Picnicking	$18.46	$27.00	$22.73
Near-water Activities	$20.07	$34.59	$27.33
Range of above			$22.73 - $28.73

[a] Original study values were adjusted to 2001 dollars based on the relative change in CPI from 1987 to 2001.
[b] Study location: various U.S. locations. Estimating approach: meta-analysis of TC studies.
[c] Study location: various U.S. locations. Estimating approach: meta-analysis of contingent valuation (CV) and TC studies.

Source: U.S. EPA analysis

c. Changes in wildlife viewing value

EPA selected a subset of the candidate benefits transfer studies discussed in Section 15.2.1 to estimate changes in water resource value to wildlife viewers due to the MP&M rule. The four selected studies include Tudor et al. (2002), Desvousges et al. (1987), Lant and Roberts (1990), and Farber and Griner (2000)[21]. Table 15.6 compiles information on the baseline values of wildlife viewing, values of changes in water quality, and percentage change in values reported or implied by these studies.

[21] The remaining four studies value changes in the value recreational fishing only.

Table 15.6: Studies Estimating Changes in Value of Wildlife Viewing

Study	Water Quality Change Valued	Baseline Value of Wildlife Viewing (2001$)	Value of Water Quality Change (2001$)	Value of Change as % of Baseline	Type of Benefits Included
Desvousges et al. (1987)	Improvement from "boatable" to "fishable"	$22.8 - $28.7 per trip [a]	$5.00 per trip [b]	17.4% - 22.0%	Recreational and nonuse values to users
Lant and Roberts (1990)	Improvement from "fair" to "good"	$22.8 - $28.7 per trip [a]	$8.60 per trip [c]	29.9% - 37.8%	Recreational and nonuse values to users
Farber and Griner (2000)	Improvement from "moderately polluted" to "unpolluted"	$22.8 - $28.7 per trip [a]	$3.33 - $5.69 per trip [d]	11.6% - 25.0%	Recreational and nonuse values to users
Tudor et al. (2002)	Elimination of AWQC exceedances	$77.99 per trip [e]	$0.60 per trip	0.77%	Recreational use values to users
Average percentage change (based on the above studies) [f]				14.9% - 21.3%	

[a] Based on the range of median values for a near-water recreation day (updated to 2001 dollars) reported in Walsh et al. (1992) and Bergstrom and Cordell (1991) (see Table15.5).
[b] Based on the value of water quality improvement of $36.79 per person per year (updated from 1987 dollars reported in Desvousges et al.) divided by the average number of near-water recreation days per year in Pennsylvania (7.37 days, NDS, 1993).
[c] Based on the value of water quality improvement of $57.79 per year (updated from 1990 dollars) reported in Lant and Roberts divided by the average number of near-water recreation days per year in Iowa and Illinois (9.58 and 5.04 days, NDS, 1993).
[d] Based on the value of water quality improvements ranging from $24.55 to $41.93 per person per year reported in Farber and Griner (2000) divided by the average number of near-water recreation days per year in Pennsylvania (7.37 days, NDS, 1993).
[e] The baseline value of viewing is based on the estimated mean value of water resources for wildlife viewers reported by Tudor et al. (2002). The estimated median value of recreational fishing is $82.77. These values were derived from a September 23, 2002 analysis.
[f] EPA took a simple mean of lower- and upper-bound estimates from the four studies to calculate a range of percentage changes in the wildlife viewing value from improved water quality conditions. When only one value is available from the study (i.e., Tudor et al., 2002), EPA used this value in calculating both the lower- and upper-bound estimates.

Source: U.S. EPA analysis

This analysis uses the change of 14.9 percent for the low benefits estimate and 21.3 percent for the high benefits estimate to calculate benefits from reduced MP&M facility discharges to users of water-based recreation. These values represent the average of the low and high values, respectively, estimated in the four studies.

Table 15.7 below summarizes the results of EPA's wildlife viewing benefits analysis.

Table 15.7: Summary of Wildlife Viewing Benefits (2001$)								
	Number of Benefiting Reaches	Participating Population (millions)	Ave. Number of Viewing Days	Total Viewing Days (millions)	Baseline Value/ Rec. Day	Total Baseline Value ($ millions)	% Change in Value	Benefit from MP&M
Selected Option: Traditional Extrapolation								
Low Estimate	9	3.12	7.5	23.52	$22.73	$535	14.9%	$185,172
High Estimate	9	3.12	7.5	23.52	$28.73	$676	21.3%	$334,315
Selected Option: Post-Stratification Extrapolation								
Low Estimate	6	3.17	7.5	23.91	$22.73	$544	14.9%	$120,639
High Estimate	6	3.17	7.5	23.91	$28.73	$687	21.3%	$217,805

Source: U.S. EPA analysis.

15.2.4 Recreational Boating

Improvements in water quality from the final MP&M rule may enhance recreational boating by (1) providing more opportunities for companion activities (e.g., fishing and wildlife viewing) and (2) improving visual aesthetics. EPA assumes that the expected welfare gain for boaters is a function of changes in the overall quality of all recreational opportunities available to each boater on a given day.

This analysis estimates recreational boating benefits the same way as recreational fishing and wildlife viewing benefits. The analysis estimates:

- the number of recreational boating days on benefiting reaches,
- the baseline value of boating for each benefiting reach, and
- changes in recreational boating value.

a. Number of recreational boating days

EPA calculated the annual number of recreational boating days for each benefiting reach using two steps:

❖ ***Participating population***

The analysis of the NDS data showed that boaters travel from 10 to 108 miles to their destination, with an average one-way travel distance of 32 miles.[22] This analysis therefore considers only boaters residing in the counties abutting MP&M reaches. EPA estimated the number of boaters residing in the counties traversed by benefiting reaches by combining information from Census data and NDS data on the proportion of individuals participating in boating in each state. The percent of the total state population in the 48 states participating in boating ranges from 8.0 percent in Colorado to 28.7 percent in Washington. EPA further adjusted the number of boaters likely to use MP&M reaches within the affected county based on the ratio of the affected reach length to the number of total reach miles in the affected county.[23]

[22] These estimates exclude outliers.

[23] See section 13.1.1 for detail.

❖ ***Average number of boating days***

People using benefiting reaches for boating generally participate in this activity several times per year. The NDS data show the number of boating trips in the 48 states ranging from 3.2 days per user in New Hampshire to 14.6 days per user in Colorado.

EPA estimated the annual number of user days for recreational boating activities by multiplying the number of boaters by the average number of boating days per user in each state.

b. Baseline value of boating

EPA estimated the baseline value of boating on benefiting reaches using the estimated annual person-days of boating per reach and estimated values per person-day of various types of boating. EPA calculated a range of net economic values per recreation day of boating based on studies by Bergstrom and Cordell (1991) and Walsh et al. (1992). Mean net benefit values for motorized and non-motorized boating are $37.30 to $59.26 in 2001 dollars. Table 15.8 compiles information on the relevant values reported in these studies.

Table 15.8: Baseline Values of a Boating Day

Recreational Activity	Per-day Value (2001$)[a]		Average Per-day Value (2001$)
	Bergstrom and Cordell (1991)[b]	Walsh et al. (1992)[c]	
Motorized	$25.43	$49.18	$37.30
Non-motorized	$42.67	$75.85	$59.26
Boating (any type)			$37.30 - $59.26

[a] Original study values were adjusted to 2001 dollars based on the relative change in CPI from 1987 to 2001.
[b] Study location: various U.S. locations. Estimating approach: meta-analysis of TC studies.
[c] Study location: various U.S. locations. Estimating approach: meta-analysis of CV and TC studies.

Source: U.S. EPA analysis

Weighting by facility sample weights and summing over all benefiting reaches provides a total baseline value of boating for MP&M reaches expected to benefit by eliminating pollutant concentrations in excess of AWQC limits.

c. Changes in recreational boating values

The Agency used the same four studies discussed in Section 15.2.3 to calculate the change in per-day boating value as a result of water quality improvements. EPA expressed this change as a percentage of the baseline value. Table 15.9 compiles information on the baseline values of boating, values of changes in water quality, and percentage change in boating values reported or implied by these studies.

Table 15.9: Studies Estimating Changes in Value of Recreational Boating

Study	Water Quality Change Valued	Baseline Value of Boating (2001$)	Value of Water Quality Change (2001$)	Value of Change as % of Baseline	Type of Benefits Included
Desvousges et al. (1987)	Improvement from "boatable" to "fishable"	$37.30 - $59.26 per trip [a]	$3.92 per trip [b]	6.6% -10.5%	Recreational and nonuse values to users
Lant and Roberts (1990)	Improvement from "fair" to "good"	$37.30 - $59.26 per trip [a]	$7.91 per trip [c]	13.3% -21.2%	Recreational use values to users and nonusers
Farber and Griner (2000)	Improvement from "moderately polluted" to "unpolluted"	$37.30 - $59.26 per trip [a]	$2.62 - $4.48 per trip [d]	4.4%-12.0%	Recreational and nonuse values to users
Tudor et al. (2002)	Elimination of AWQC exceedances	$106.60 per trip [e]	$1.78 pr trip	1.67%	Recreational values for users
Average percentage change (based on the above studies) [f]				6.5% - 11.4%	

[a] Based on the average value for a boating day (updated to 2001 dollars) reported in Walsh et al. (1992) and Bergstrom and Cordell (1991).
[b] Based on the value of water quality improvement of $36.79 per person per year (updated from 1987 dollars) reported in Desvousges et al. divided by the average number of boating days per year in Pennsylvania (9.37 days, NDS, 1993).
[c] Based on the value of water quality improvement of $57.79 per person per year (updated from 1990 dollars) reported in Lant and Roberts divided by the average number of boating days per year in Iowa and Illinois (9.58 and 5.04 days, NDS, 1993).
[d] Based on the value of water quality improvements ranging from $24.55 to $41.93 per person per year reported in Farber and Griner (2000) divided by the average number of boating days per year in Pennsylvania (9.37 days, NDS, 1993).
[e] The baseline value of boating is based on the estimated mean value of water resources for boaters reported by Tudor et al. (2002). The estimated median value of recreational boating is $112.55. These values were derived from a September 23, 2002 analysis.
[f] EPA took a simple mean of lower- and upper-bound estimates from the four studies described to calculate a range of percentage changes in the recreational boating value from improved water quality. When only one value is available from the study (i.e., Tudor et al., 2002), EPA used this value in calculating both the lower- and upper-bound estimates.

Source: U.S. EPA analysis

This analysis uses the change of 6.5 percent for the low benefits estimate and 11.4 percent for the high benefits estimate to calculate benefits to boaters from reduced MP&M facility discharges. These values represent the average of the low and high values, respectively, estimated in the four studies.

Table 15.10 summarizes the results of EPA's recreational boating benefits analysis.

Table 15.10: Summary of Recreational Boating Benefits (2001$)								
	Number of Benefiting Reaches	**Participating Population (millions)**	**Ave. Number of Boating Days**	**Total Boating Days (millions)**	**Baseline Value/ Rec. Day**	**Total Baseline Value ($ millions)**	**% Change in Value**	**MP&M Benefits**
Selected Option: Traditional Extrapolation								
Low Estimate	9	2.53	8.3	21.06	$37.30	$786	6.5%	$114,111
High Estimate	9	2.53	8.3	21.06	$59.26	$1,249	11.4%	$316,078
Selected Option: Post-Stratification Extrapolation								
Low Estimate	6	2.57	8.4	21.47	$37.30	$801	6.5%	$74,343
High Estimate	6	2.57	8.4	21.47	$59.26	$1,272	11.4%	$205,924

Source: U.S. EPA analysis.

15.2.5 Nonuse Benefits

EPA estimated changes in nonuse values for this analysis because nonuse value is a sizeable portion of the total value of water resources. Individuals who never visit or otherwise use a natural resource may still be affected by changes in its status or quality. Empirical estimates indicate that such "nonuse values" may be substantial for some resources (Harpman et al., 1993; Fisher and Raucher, 1984; Brown, 1993). Most studies have found that nonuse values exceed use values. Brown reviewed 31 CV studies in which both use and nonuse values were estimated, and calculated the ratio of nonuse values to use values (Brown, 1993). The goal of Brown's study was to assess consistency of ratios of use to nonuse value and to develop a basis for obtaining a rough estimate of nonuse value, and therefore total values, for the many studies that measured only use values. His 31 estimated ratios range from 0.1 to 10, with the median ratio of 1.92. The ratios of nonuse to use values reported by Brown for the studies that valued environmental improvements in water resources range for users of those resources from 0.85 to 2.56. The estimated average ratio is 1.57. That is, for every dollar of annual use-benefit value to users of the subject environmental resource, the annual nonuse value to resource users for the subject environmental resource is $1.57.

Carson and Mitchell suggested that nonuse benefits account for 19 to 39 percent of total WTP values for water quality improvements depending on the definition of nonuse values (Carson and Mitchell, 1993). The ratio of nonuse to use value ranges from one-fourth to two-thirds based on the Carson and Mitchell study (1993). Fisher and Raucher (1984) found that nonuse benefits comprise one-half of recreational use benefits.

EPA used findings from the Fisher and Raucher (1984) study in which nonuse values are estimated to be equal to 50 percent of use values to estimate nonuse benefits from the final MP&M regulation. The method has long been used by EPA as a pragmatic alternative to omitting nonuse values entirely. EPA acknowledges that this method is crude and nonuse values estimated by the 50 percent of use value approach are quite low given the applicable literature discussed above.

The Agency estimates that nonuse benefits from the final MP&M rule will range from $293,252 to $787,190 and from $191,053 to $512,852, based on the traditional and post-stratification extrapolation, respectively.

15.3 Summary of Recreational Benefits

EPA assumes that eliminating concentrations of MP&M pollutants in excess of AWQC limits will achieve water quality protective of aquatic life and human health. This improved water quality then generates benefits for both users and nonusers of water-based recreation. These benefits can be seen as an increase in the value of each day spent on or near the waterway, as well as an increase in the number of days spent on or near the waterway. EPA estimated the monetary value of improved water-based recreational opportunity for the 9 discharge reaches based on the traditional extrapolation (6 reaches based on the post-stratification extrapolation) for which concentrations in excess of AWQC limits would be eliminated.

EPA first estimated the number of recreational days on benefiting reaches for each water-based activity. The Agency then calculated the baseline value of these activities and then calculated the percentage changes in this value stemming from water quality improvements.

EPA calculated partial benefits for reaches with reduced numbers of AWQC exceedances by adjusting the percentage increase in the recreational value of these reaches. EPA made these adjustments based on the ratio of the number of AWQC exceedances eliminated post-compliance to the number of AWQC exceedances occurring at baseline.

Table 15.11 summarizes benefit estimates by recreational category for the final rule based on the traditional and post-stratification extrapolation methods. The activities considered in this analysis are stochastically independent; EPA calculated the total value of enhanced water-based recreation opportunities by summing over the three recreation categories. EPA also estimated the changes in nonuse value resulting from reduced MP&M discharges based on the ratio of use to nonuse values implied by the Fisher and Raucher study (Fisher and Raucher, 1984). Based on the traditional extrapolation, the estimated increase in nonuse value ranges from $0.29 to $0.79 million (2001$), with a midpoint value of $0.50 million (2001$). The resulting increased value of recreational activities to consumers (users and nonusers) of water-based recreation ranges from an estimated $0.59 to $1.57 million (2001$) annually. The estimated mean value of recreational benefits is $1.00 million (2001$) annually. Likewise, based on the post-stratification extrapolation, the estimated increase in nonuse value ranges from $0.19 to $0.51 million (2001$), with a midpoint value of $0.33 million (2001$). The resulting increased value of recreational activities to consumers (users and nonusers) of water-based recreation ranges from an estimated $0.38 to $1.03 million (2001$) annually. The estimated mean value of recreational benefits is $0.65 million (2001$) annually.

Tables 15.12 and 15.13 summarize benefit estimates for the 433 Upgrade Options and Proposed/NODA Option, respectively. Recreational use and nonuse benefits are almost 200 times higher under the two 433 Upgrade Options, and over 430 times higher under the Proposed/NODA Option.

Table 15.11: Estimated Recreational Benefits from Reduced MP&M Discharges (Thousands, 2001$)

Recreational Activity	Traditional Extrapolation			Post-Stratification Extrapolation		
	Low Value	Midpoint Value	High Value	Low Value	Midpoint Value	High Value
Fishing	$287	$537	$924	$187	$350	$602
Boating	$114	$203	$316	$74	$132	$206
Viewing and near-water activities	$185	$260	$334	$121	$169	$218
Total Recreational Use Benefits	$587	$1,000	$1,574	$382	$651	$1,026
Nonuse Benefits (½ of the Recreational Use Benefits)	$293	$500	$787	$191	$326	$513
Total Recreational Benefits	**$880**	**$1,500**	**$2,362**	**$573**	**$977**	**$1,539**

Source: U.S. EPA analysis.

Table 15.12: Estimated Recreational Benefits from Reduced MP&M Discharges (Thousands, 2001$)[a]

Recreational Activity	Directs + 413 to 433 Upgrade			Directs +All to 433 Upgrade		
	Low Value	Midpoint Value	High Value	Low Value	Midpoint Value	High Value
Fishing	$28,713	$53,703	$92,369	$29,052	$54,337	$93,460
Boating	$36,511	$64,854	$101,134	$36,652	$65,103	$101,523
Viewing and near-water activities	$56,584	$79,434	$102,158	$56,657	$79,536	$102,290
Total Recreational Use Benefits	$121,808	$197,990	$295,661	$122,360	$198,976	$297,272
Nonuse Benefits (½ of the Recreational Use Benefits)	$60,904	$98,995	$147,831	$61,180	$99,488	$148,636
Total Recreational Benefits	**$182,712**	**$296,986**	**$443,492**	**$183,541**	**$298,464**	**$445,908**

[a] Based on the Traditional Extrapolation.

Source: U.S. EPA analysis.

Table 15.13: Estimated Recreational Benefits from Reduced MP&M Discharges (Thousands, 2001$)[a]

Recreational Activity	Proposed/NODA Option[b]		
	Low Value	Midpoint Value	High Value
Fishing	$53,897	$100,805	$173,386
Boating	$75,847	$134,724	$210,089
Viewing and near-water activities	$140,623	$197,410	$253,884
Total Recreational Use Benefits	$270,366	$432,939	$637,360
Nonuse Benefits (½ of the Recreational Use Benefits)	$135,183	$216,469	$318,680
Total Recreational Benefits	**$405,550**	**$649,408**	**$956,040**

[a] Based on the Traditional Extrapolation.
[b] The estimated recreational benefits of the Proposed/NODA Option are not directly comparable to the final option alternatives. The total number of facilities reported for the Proposed/NODA Option analysis differs from the facility count reported for the final rule and the two upgrade options. After deciding in July 2002 not to consider the NODA option as the basis for the final rule, EPA performed no more analysis on the NODA option, including not updating facility counts and related analyses for the change in subcategory and discharge status classifications.

Source: U.S. EPA analysis.

15.4 Limitations and Uncertainties Associated with Estimating Recreational Benefits

EPA assessed recreational benefits in terms of reduced occurrence of pollutant concentrations exceeding acute and chronic toxic effect levels for aquatic species. EPA also attached a monetary value to ecological improvements expected to result from the MP&M regulation, in the form of the increased value of three water-based recreation activities recreational fishing, wildlife viewing, and boating plus the increase in nonuse value. The estimated increase in value detailed in this chapter constitutes only a partial measure of the value to society of improving aquatic habitats and aquatic life. This benefits analysis is limited because it ignores improvements to recreational activities other than fishing, boating, and wildlife viewing (e.g., swimming), as well as non-recreational benefits, such as increased assimilative capacity and improvements in the taste and odor of the affected waters.

The methodologies used to assess ecological benefits also involved significant simplifications and uncertainties, whose combined effect on the estimated benefits is not known. Estimated economic values may be under- or overestimated. Some of these simplifications and uncertainties also apply to the human health benefits analysis, and have been discussed at length in the previous chapter, including those associated with:

- developing the sample of MP&M facilities analyzed in the EEBA,
- estimating in-waterway concentrations of MP&M pollutants,
- considering background concentrations of MP&M pollutants, and
- considering downstream effects.

Table 15.14 summarizes the additional elements of uncertainty that are specific to the recreational benefits analysis.

Table 15.14: Key Omissions, Biases, and Uncertainties in the Analysis for Improved Recreational and Nonuse Benefits

Assumption/Limitation	Direction of Impact on Benefit Estimates
Scope of Recreational Benefits Analysis	
Only the receiving reach itself is estimated to provide benefits.	(-) Water quality in reaches downstream of the reaches affected by MP&M discharges may also improve, generating additional benefits to society. Excluding these benefits from the analysis biases benefits estimates downward.
Only recreational users living in the counties abutting MP&M reaches are assumed to benefit from water quality improvements due to the MP&M rule.	(-) The analysis underestimates the total value of benefits from the MP&M regulation because it does not account for people's WTP for water quality improvements to distant water bodies. For example, economic values for improving nationally-significant water bodies (e.g., Great Lakes, Chesapeake Bay, Long Island Sound) are likely to be substantial at a regional level or even nationwide.
The analysis of recreational fishing ignores effects that occur in secondary industries.	(-) The analysis of recreational benefits ignores potential economic effects on tourism industries stemming from improved recreational opportunities. Improved recreational fishing may have a positive effect on industries supplying bait, tackle, charter boats, etc. An increase in consumer demand for boating may have positive effects on industries such as boat construction, sales, rentals, boating equipment, marinas, racing activities, etc. Improvements in wildlife viewing and near-water recreation opportunities may benefit industries involved in providing other recreational opportunities, such as tours, books, binoculars, etc.
The analysis of recreational benefits ignores changes in the value of water-based recreational activities other than fishing, wildlife viewing, and boating (e.g., swimming or waterskiing).	(-) The estimate of recreational benefits is incomplete because it includes only a subset of recreational activities (i.e., fishing, wildlife viewing, and boating) for which society may value improved aquatic habitat. It ignores changes in value for other water-based recreational activities, such as swimming or waterskiing. In addition, the analysis did not consider other changes in the affected reaches, such as improved taste and odor.

Table 15.14: Key Omissions, Biases, and Uncertainties in the Analysis for Improved Recreational and Nonuse Benefits

Assumption/Limitation	Direction of Impact on Benefit Estimates
Extrapolating from sample facility results to national results is based on the sample facility weights	(?) This extrapolation technique is not ideal and introduces uncertainty into the analysis. Facility sample weights are based on facility size and type of industry. These weights do not necessarily account for the frequency benefit pathway characteristics in the MP&M facility universe. Therefore benefit estimates may suffer from uncertainties associated with the extrapolation method. For example, a sample facility may have a significant impact on benefit estimates if it is more likely to be located in a densely populated area, such as a facility located in Cleveland, Ohio, or a facility discharging in Long Island Sound, than the facilities it represents. The opposite may also be true. To improve accuracy of the national benefit estimates, EPA used an alternative extrapolation method (i.e., post-stratification extrapolation). This method relies on adjusted sample facilities weights that account for the distribution of benefit pathway characteristics, including water body type and population size, in the MP&M facility universe. Appendix G summarizes this extrapolation approach.
Congestion Externalities	(+) Recreational benefits associated with water quality improvements can be eroded by congestion if policies greatly increase the number of participants. This can be particularly problematic when policies affect geographically scattered sites, so that there is considerable switching to the improved site from substitute sites. Congestion may be a lesser problem for national regulations that might affect the total number of recreation days and the overall value of recreational opportunities, but are less likely to have a large effect on industrial sites relative to its substitutes.
Benefits Transfer	
The waters assessed by local-level studies are not necessarily nationally representative.	(?) The studies selected came from the Midwest and the Northeast. As a result, the resources valued, as well as respondent preferences, may not be representative of the rest of the country.
Types of water quality changes expected from the MP&M rule may differ from the water quality changes considered in the original studies.	(?) The types of water quality changes expected from the MP&M regulation are only roughly comparable with the majority of water quality changes considered in the original studies (Tudor et al. is the only exception). Due to the paucity of available studies, the Agency made simplifying assumptions to "map" the water quality changes valued in the original studies onto those expected from the rule. Although these assumptions are likely to increase uncertainty associated with recreational benefits estimates, the direction of bias is not known.
Compatibility of time periods considered in the original studies and in the analysis of MP&M costs and benefits.	(+) Most studies considered in the benefits transfer analysis did not specify payment periods. The scenario in the Farber and Griner (2000) paper asked for payments for the next five years. This scenario implies that five years of pollution control will result in permanent water quality changes. The analysis of the MP&M regulation assumes that pollution control continues over 15 years and that water quality improvements depend on continued operation of the water pollution controls. EPA therefore chose the annual WTP values presented in the paper, as opposed to the total value paid over five years, annualized over the 15 years considered in the cost analysis. This assumption may result in an overestimation of the regulation's benefit. The magnitude of this error is unlikely to be significant because this study is used in combination with other surface water valuation studies.
Baseline Value of Fishery	
Converting annual WTP values to per-trip values	(+) EPA converted annual WTP values reported in the three CV studies used in this analysis to per-trip values by dividing seasonal welfare gain per user reported in each CV study by the average number of fishing, boating, or viewing days in a given state. This calculation implies that every individual participates in only one activity, which may not be the case. This implication may result in an overestimation of the per-trip welfare gain, and, consequently, an overestimation of total recreational benefits from the final rule.

Table 15.14: Key Omissions, Biases, and Uncertainties in the Analysis for Improved Recreational and Nonuse Benefits

Assumption/Limitation	Direction of Impact on Benefit Estimates
This analysis estimates the baseline value of the fisheries at locations across the country using a range of values for all types of fisheries.	(?) Site-specific fisheries may have higher or lower baseline values, and thus, higher or lower benefits from reduced MP&M discharges.
The total number of recreational person-days in the counties abutting MP&M reaches is evenly distributed across all reach miles in these counties.	(+) This method for estimating the number of recreational users potentially affected by water quality improvements from the final regulation accounts for the quantity but not quality of potential recreational opportunities available to recreational users. There may be important substitute sites in or outside the counties abutting MP&M reaches. Ignoring recreationally important substitute sites may result in overestimation of benefits from the final regulation. Ideally the analysis would consider recreational importance of both sites affected by MP&M discharges and substitute sites.
Nonuse Values	
Nonuse values are estimated as one-half of recreational use benefits.	(?) It is unknown what bias estimating nonuse values based on recreational use values has on benefits.
Overall Impact on Benefits Estimates	**(?)**

\+ Potential overestimate.
? Uncertain impact.
\- Potential underestimate.

Source: U.S. EPA analysis.

GLOSSARY

1Q10: the lowest one-day average flow with a recurrence interval of ten years.

7Q10: the lowest consecutive seven-day average flow with a recurrence interval of ten years.

ambient water quality criteria (AWQC): published and periodically updated by the EPA under the Clean Water Act. The criteria reflect the latest scientific knowledge on the effects of specific pollutants on public health and welfare, aquatic life, and recreation. The criteria do not reflect consideration of economic impacts or the technological feasibility of reducing chemical concentrations in ambient water. The criteria serve as guides to states, territories, and authorized tribes in developing water quality standards and ultimately provide a basis for controlling discharges or releases of pollutants into our nation's waterways. AWQC are developed for two exposure pathways: ingestion of the pollutant via contaminated aquatic organisms only, and ingestion of the pollutant via both water and contaminated aquatic organisms.

benefiting reaches: reaches where the MP&M rule is expected to eliminate existing AWQC exceedences. These receiving waters are likely to experience significant water quality improvements as a result of the reduced MP&M discharges. A reach is considered to benefit if at least one AWQC exceedance is eliminated due to reduced MP&M discharges.

benefits transfer: involves the application of value estimates, functions, and/or models developed in one context to address a similar resource valuation question in another context. Often a meta-analysis is undertaken where benefits estimates based on existing studies are used to develop new estimates which are applicable to the scenario under consideration. This process accounts for relevant differences in study characteristics, such as the quality of environmental resource, the environmental change considered, and the user population being investigated.

contingent valuation (CV): directly asks people what they are willing to pay for a benefit and/or willing to receive in compensation for tolerating a cost through a survey or questionnaire. Personal valuations for increases or decreases in the quantity of some good are obtained contingent upon a hypothetical market. The aim is to elicit valuations or bids that are close to what would be revealed if an actual market existed.

conventional pollutants: biological oxygen demand (BOD), total suspended solids (TSS), oil and grease (O&G), pH, and anything else the Administrator defines as a conventional pollutant.

dissolved oxygen (DO): oxygen freely available in water, vital to fish and other aquatic life and for the prevention of odors. DO levels are considered a most important indicator of a water body's ability to support desirable aquatic life. Secondary and advanced waste treatment are generally designed to ensure adequate DO in waste-receiving waters. (http://www.epa.gov/OCEPAterms/dterms.html)

Metal Products and Machinery (MP&M): industry includes facilities that manufacture, rebuild, and maintain metal parts, products, or machines.

National Demand Study (NDS): U.S. EPA and the National Forest Service conducted the National Demand Survey for Water-Based Recreation in 1993. The survey collected data on demographic characteristics and water-based recreation behavior using a nationwide stratified random sample of 13,059 individuals aged 16 and over.

nonconventional pollutant: catch-all category that includes everything that is not classified as a priority pollutant or a conventional pollutant.

piscivorous: feeding preferably on fish.

priority pollutant (PP): 126 individual chemicals that EPA routinely analyzes when assessing contaminated surface water, sediment, groundwater, or soil samples.

toxic pollutants: EPA's Office of Water narrowly defines a toxic pollutant as one of 126 priority pollutants. This definition is not completely synonymous with pollutants that have a "toxic" effect. Many nonconventional pollutants may also be hazardous to aquatic life and human health.

"toxic" pollutant: any pollutant that has an adverse effect on aquatic life or human health.

travel cost (TC) model: derives values by evaluating expenditures of recreators. Travel costs are used as a proxy for price in deriving demand curves for the recreation site. (http://www.damagevaluation.com/glossary.htm)

U.S. Fish and Wildlife Service (FWS): the principal federal agency responsible for conserving, protecting, and enhancing fish, wildlife, and plants and their habitats for the continuing benefit of the American people. (http://www.fws.gov/r9extaff/pafaq/fwsfaq.html)

willingness-to-pay (WTP): maximum amount of money one would give to buy some good. (http://www.damagevaluation.com/glossary.htm)

ACRONYMS

1Q10: the lowest 1-day average flow with a recurrence interval of 10 years
7Q10: the lowest 7-day average flow with a recurrence interval of 10 years
AWQC: ambient water quality criteria
CV: contingent valuation
DO: dissolved oxygen
FWS: U.S. Fish and Wildlife Service
MP&M: Metal Products and Machinery
NDS: National Demand Study
TC: travel cost
WTP: willingness-to-pay

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Chapter 16: POTW Benefits

INTRODUCTION

The final rule only regulates direct dischargers. Therefore, the selected option does not affect POTW operations. For the alternative policy options that consider both direct and indirect dischargers, EPA evaluated two categories of productivity benefits for ***publicly-owned treatment works (POTWs)***:

- reduced ***interference*** with the operations of POTWs, and
- reduced contamination of sewage sludge (i.e., biosolids) at POTWs that receive discharges from MP&M facilities.

CHAPTER CONTENTS

Interference with POTW processes occurs when high levels of toxics, such as metals or cyanide, kill bacteria required for wastewater treatment processes. The removal of these pollutants would eliminate the need for extra labor and materials to maintain POTW operations.

Toxic priority and nonconventional pollutants may also pass through a POTW and contaminate sludge generated during primary and secondary wastewater treatment.[1] POTW treatment of wastewater with reduced pollutant concentrations translates into cleaner sludge, which can be disposed of using less expensive and more environmentally benign methods. In some cases, cleaner sludge may have agricultural applications, which would generate additional resource conservation benefits.

Some MP&M pollutants that pass through a POTW and contaminate sludge are not currently subject to sewage sludge pollutant concentration limits. The alternative policy options would reduce concentrations of these pollutants in sewage sludge as well, which may translate into reduced environmental and human health risks. EPA did not estimate the reduced risk attributable to the reduction of these pollutants.

Wastewater from MP&M facilities also contains ***hazardous air pollutants (HAPs)***. These pollutants may represent unacceptable health risks to POTW workers if released into the air at high enough concentrations during the wastewater treatment cycle. This reduction in pollutants may translate into health benefits to POTW workers and those living near POTWs.

The remaining sections of this chapter present methodology for estimating benefits to the receiving POTWs from reducing pollutants in the wastewater of indirect MP&M dischargers. As noted above, the final option does not affect POTW operations since it regulates direct dischargers only. For the alternative options that consider both direct and indirect dischargers, EPA evaluated two benefits measures associated with MP&M pollutants: (1) the reduction in pollutant interference at POTWs; and (2) pass-through of pollutants into the sludge, which limits options for POTW disposal of sewage sludge.

[1] The term sewage sludge, also called biosolids, is often shortened to sludge throughout this chapter for simplicity.

16.1 Reduced Interference with POTW Operations

High levels of some MP&M pollutants (such as metals, chlorobenzene, polyaromatic hydrocarbons, and oil and grease) can kill bacteria that are required for the wastewater treatment process (U.S. EPA, 1987). POTWs affected by such "inhibition problems" may incur extra labor and materials costs to maintain system operations. As a partial measure of the economic benefits resulting from the alternative regulatory options, EPA estimated the extent to which reduced MP&M discharges would decrease pollutant concentrations to below POTW ***pollutant inhibition values***, using the following steps:

- estimate the baseline and post-compliance ***influent concentrations*** for each POTW receiving discharges from MP&M facilities, based on annual pollutant loadings from the MP&M facility, the number of POTW operating days per year, and the gross volume of influent;
- compare baseline and post-compliance influent concentrations with available inhibition levels (see Table I.5 in Appendix I); and
- estimate the change in the number of POTWs in which influent concentrations of MP&M pollutants exceed POTW inhibition values.

Adverse effects on POTW operations, including inhibition of ***microbial degradation***, are likely when influent concentrations of one or more pollutants exceed an inhibition value. EPA estimated influent concentrations in excess of POTW inhibition values for the sample facilities for the baseline and the alternative regulatory options. Results of this analysis are presented in Appendix I of this report. Eliminating the exceedances will result in operating cost savings to POTWs. EPA has not estimated a monetary value for this benefit, however, due to data limitations.

The final rule only regulates direct dischargers. Therefore, the selected option does not affect POTW operation. For the alternative policy options that consider both direct and indirect dischargers, EPA estimated that 51 POTWs had influent concentrations in excess of biological inhibition values for one or more pollutants under the baseline conditions corresponding to the 433 Upgrade Options. This represents 0.3% of the over 16,000 POTWs operating nationwide. (Table I.12 in Appendix I provides detailed information on pollutants exceeding POTW inhibition criteria.) Both upgrade options would eliminate exceedances of POTW inhibition criteria in 21 POTWs.

EPA's analysis finds that influent concentrations in 293 POTWs exceed biological inhibition values for one or more pollutants under the Proposed/NODA Option. The Proposed/NODA Option would eliminate inhibition criteria exceedances in 156 of the affected POTW.[2]

POTWs may impose local limits to prevent inhibitions. If local limits are in place, the estimated reduction in potential inhibition problems at the affected POTWs may be overstated. In this case, however, the estimated social cost of the MP&M regulation is also overstated.

16.2 Assessing Benefits from Reduced Sludge Contamination

16.2.1 Data Sources

The analysis of POTW benefits from improved sludge quality draws on several data sources. The §308 POTW Surveys provide most of the required information. EPA collected information from 147 POTWs representing a 98 percent response rate to the 150 surveys that were mailed. EPA also used the §308 survey of MP&M facilities. The two data collection efforts were not designed to provide a match between the MP&M sample facilities and the POTWs to which they discharge. EPA obtained a significant amount of information from the POTW Surveys, but had substantially less information on the POTWs that receive discharges from the MP&M facilities. To address this data limitation, EPA used the POTW Survey data to infer

[2] The total number of facilities reported for the Proposed/NODA Option analysis differs from the facility count reported for the final rule and the upgrade options (Directs + 413 to 433 Upgrade Option, Directs + All to 433 Upgrade Option). After deciding in July 2002 not to consider the NODA option as the basis for the final rule, EPA did not perform any more analyses on the NODA option -- including not updating facility counts and related analyses for the change in subcategory and discharge status classifications.

information on the key factors that are likely to influence choice of sewage sludge use and disposal practices for the POTWs receiving discharges from the MP&M facilities.

The POTW Survey contains three sections. Section 1 provides general information on POTW location and size. Section 2 provides data on the cost of administering pre-treatment programs (see Appendix F). Section 3 contains data on the cost of treating and disposing of sewage sludge and provides new and more consistent data for analyzing the effect of reduced pollutant loadings on sewage sludge management costs.

The POTW Survey asked for the following information:

- current sludge disposal practices;
- sludge disposal costs for one or more disposal methods;
- reasons for not using a less expensive disposal method;
- number of MP&M facilities discharging to the POTW, by flow size (less than 1 million gal/year; 1-6.25 million gal/year; greater than 6.25 million gal/year);
- total metal loadings discharged to the POTW from all sources; and
- percentage of total metal loadings attributable to MP&M facilities.

The POTW Survey was intended to address data limitations encountered in the Phase 1 analysis, particularly the inadequacy of information about POTWs that receive discharges from the MP&M sample facilities. The only information available for the Phase I analysis was POTW geographic location, influent volume, and the metals content of the discharge received from the sampled MP&M facilities. Discharges to the POTW by non-sampled MP&M facilities and by non-MP&M facilities were not known. These discharges may significantly affect sewage sludge quality, however, resulting in a discrepancy between predicted and actual pollutant concentrations in sewage sludge and the corresponding disposal practices. In addition, lack of information on the factors that may influence a POTW's decisions about sludge management practices introduced additional uncertainty in the analysis.

EPA used the POTW Survey to calculate the following parameters:

- baseline percentage of the total metal loadings to POTWs by POTW flow category attributable to MP&M facilities;
- post-compliance loading reductions for non-sampled MP&M facilities discharging to the receiving POTWs;
- costs of sewage sludge disposal practices; and
- percentage of qualifying sludge that is not beneficially used for any of the following reasons: lack of land; lower cost alternative; inability to meet **vector** or **pathogen** requirements; poor weather; stricter state standards; and other reasons.

EPA also used the data provided by the Association of Metropolitan Sewerage Agencies (AMSA) to refine its analysis of POTW benefits for the final rule. AMSA provided EPA with comments on the proposed MP&M rule and supplemented these comments with a spreadsheet database (AMSA, 2000). The database contains data from an AMSA formulated survey and covers responses from 176 POTWs, representing 66 pretreatment programs. The AMSA survey was conducted to verify data from EPA's survey of POTWs and therefore included similar, although fewer, variables compared to EPA's survey.

EPA used the results of the AMSA survey to supplement information from the MP&M POTW Survey on percentage of metal loadings contributed by MP&M facilities and the number of MP&M facilities served by POTWs. Based on the results of the joint analysis of the EPA and AMSA surveys, EPA revised the following elements of the POTW benefits methodology: (1) the number of MP&M facilities served by small, medium, and large POTWs, (2) percentage of metal loadings contributed by MP&M facilities, and (3) percentage of qualifying sludge that is not land-applied.

Finally, EPA used other data sources in this analysis, including *Handbook for Estimating Sludge Management Costs* (EPA, 1985) and *Regulatory Impact Analysis of the Part 503 Sludge Regulation* (EPA, 1993b).

16.2.2 Sludge Generation, Treatment, and Disposal Practices

a. Sludge generation

POTWs generally treat wastewater from industrial indirect dischargers along with domestic wastewater. Sludge results from primary, secondary, and advanced wastewater treatment. The extent and type of wastewater treatment determine the chemical and physical character of the sludge. Sludge may be conditioned, thickened, stabilized, and dewatered to reduce its volume.

Sludge contains five classes of components: organic matter, pathogens, nutrients, inorganic chemicals, and organic chemicals. The mix and levels of these components ultimately determine the human health and environmental impact of sludge use/disposal, and so may also dictate the most appropriate uses and disposal practices (EPA, 1993b).

Organic matter (the primary constituent of sludge) comes from human waste, kitchen waste, and stormwater runoff. Organic and inorganic chemicals in sludge come from industrial processes that discharge to municipal sewers. The concentration of inorganic pollutants in sludge, including metals, depends upon the volume and type of industrial wastes discharged to the POTW, as well as the extent and character of stormwater runoff.

b. Sludge use/disposal practices

After treatment, sludge can be used in the following ways:

- *Land Application:* Spraying or spreading on the land surface, injection below the surface, or incorporation into the soil, for soil conditioning or fertilization of crops or vegetation. Agricultural lands (pasture, range land, crops), forest lands (***silviculture***), and drastically disturbed lands (land reclamation sites) may all receive sludge;

- *Bagged Application:* Collection of sludge in containers for application to land (i.e., distribution and marketing);

- *Surface Disposal:* Disposal on land specifically set aside for this use, including surface impoundments (also called lagoons), sludge monofills (i.e., sludge-only landfills), and dedicated sites (i.e., land on which sludge is spread solely for final disposal);

- *Co-disposal:* Disposal in a ***municipal solid waste landfill (MSWL)*** or ***hazardous waste landfill***; and

- *Incineration:* Combustion of organic and inorganic matter at high temperatures in an enclosed device.

Land application and bagged application are beneficial uses of sludge. Both methods can be categorized as being "high" or "low," depending on pollutant concentrations in sewage sludge. "High" applications meet stringent limits on the total concentration of a given pollutant at a given application site. "High" sludge is exempt from meeting pollutant loading rate limits and certain record-keeping requirements. "Low" applications meet less stringent "ceiling" limits for pollutants. Ceiling limits govern whether a sewage sludge can be applied to land at all. "Low" applications require more record-keeping because POTWs must track total (cumulative) loadings applied to each given site, in addition to tracking the concentration of sludge applied at any given time.

Many POTWs use more than one use/disposal practice, which helps to maintain flexibility and avoid the capacity limitations of a single practice. The practice chosen depends on several factors, including:

- cost to prepare sludge for use/disposal;

- pollutant concentrations;

- market demand for sludge;

- cost to transport sludge to use/disposal sites;

- availability of suitable sites for land application, landfilling, or surface disposal;

- weather and other local conditions;

- allowance of a safety factor to account for unplanned or unforseen conditions;

- state environmental regulations; and
- public acceptance (EPA, 1993b).

The choice of use/disposal method is restricted by the quality of the sludge generated by the POTW. Sludge for beneficial uses must meet more stringent standards for pollutant concentrations than sludge used or disposed of in other ways. Similarly, sludge that is surface-disposed in an unlined unit generally must meet more stringent standards than sludge surface-disposed in a lined unit, disposed in an MSWL, or incinerated. Sludge disposed in a MSWL must meet more stringent standards than incinerated sludge.

Table 16.1 summarizes sludge use/disposal methods according to the number and percent of dry metric tons ***(DMT)***, based on information provided in Section 3 of the §308 POTW Survey. The information presented in this table takes into account data provided by AMSA on POTW characteristics such as POTW flow and the total amount of sludge generated by each POTW. Because the AMSA data was collected five years after the EPA POTW Survey was administered and it does not correspond to the base year of the analysis (1996), EPA did not use AMSA data to adjust the allocation of sludge to each use/disposal method category.

Table 16.1: Sludge Use/Disposal (1996) by POTWs Discharging > 2 Million Gallons/Day[a]

Use/Disposal Sub-Class	Thousand DMT	Percent of DMT
Total Beneficial Use	**2,641.2**	**39.9%**
Land Application-High	1,017.4	15.4%
Bag Application-High	339.9	5.1%
Land Application-Low	1,283.9	19.4%
Bagged Application-Low	0	0%
Total Surface Disposal	**528.2**	**8.0%**
Surface Disposal: Unlined Unit	347.2	5.3%
Surface Disposal: Lined Unit	181.0	2.7%
Co-Disposal: Municipal Landfill	**1,768.8**	**26.8%**
Incineration	**1,129.9**	**17.1%**
Unknown: Other	**543.2**	**8.2%**
All	**6,611.2**	**100.0%**

[a] The §308 POTW Survey did not collect information from POTWs discharging < 2 million gallons per day.

Source: U.S. EPA, POTW Survey and AMSA Survey (2000) on Proposed MP&M Effluent Guidelines.

As Table 16.1 shows, 39.9 percent of total sludge tons reported by respondents is used beneficially (land application and bagged application). Co-disposal in a municipal landfill is the second most frequently used disposal method, accounting for 26.8 percent of all sludge disposed in the U.S. Surface disposal in unlined and lined units, incineration, and "other" disposal methods account for 5.3 percent, 2.7 percent, 17.1 percent, and 8.2 percent of all sludge tons, respectively. No sludge was sent to a hazardous waste landfill by the POTW Survey respondents.

c. Pollutant limits and disposal options

Section 405(d) of the Clean Water Act, as amended, requires EPA to specify acceptable management practices and numerical limits for certain pollutants in sludge. The Agency published *Standards for the Use/Disposal of Sludge* (40 CFR Part 503, February 1993) to protect public health and the environment from reasonably anticipated adverse effects of pollutants in sludge (U.S. EPA, 1993a). The standards include general requirements, pollutant limits, management practices, operational standards, monitoring frequency, record-keeping, and reporting for the final use and disposal of sludge in four circumstances:

- sludge co-disposed with household waste in a MSWL;

- sludge land-applied for beneficial purposes (including bagged sludge);
- sludge disposed on land or on surface disposal sites; and
- incinerated sludge.

With the exception of MSWLs, the standards for each practice include numerical limits on sludge pollutant concentrations. Part 503 sets limits on pollutant concentrations for land application at two levels:

- Land Application-Low limits, which govern whether sludge can be applied to land at all; and
- more stringent Land Application-High limits which define, in part, sludge that is exempt from meeting certain record-keeping requirements.

For sludge meeting only the Land Application-Low limits, Part 503 contains pollutant loading rate limits. These determine the amount of sludge and associated pollutant content that may be applied to a particular site.

EPA did not establish pollutant-specific, numerical criteria for toxic pollutants of concern in the sludge disposed in MSWLs, because the design standards applicable to MSWLs are considered adequate to protect human health and the environment. Also, MSWL sludge is co-disposed with household waste, making precise numerical criteria infeasible. The *Solid Waste Disposal Facility Criteria* (40 CFR Part 258, Federal Register 50978, October 9, 1991) specify that POTWs using an MSWL must ensure that their sewage is non-hazardous and passes the Paint Filter Liquid Test.

The pollutant limits for sludge land application, surface disposal, and incineration constrain a POTW's choice of sludge use/disposal practice. Table 16.2 presents numerical limits for the three sludge use/disposal practices for eight MP&M pollutants. The land application pollutant limits place restrictions on concentrations of metals in sludge; the surface disposal criteria cover a subset of the metals regulated for land application. The MP&M effluent limitations guideline covers five metals and causes incidental removal of the remaining three metals regulated under the Part 503 sludge regulation. The alternative policy options would improve the quality of sewage sludge generated by POTWs receiving discharges from MP&M facilities and, as a result, would increase sludge use/disposal options for the affected POTWs.

Table 16.2: Sludge Use/Disposal Pollutant Limits

Pollutant	Application Limits		Surface Disposal Limits (mg/kg dry weight)[a]	MP&M Pollutants of Concern
	Low Limits (Low) (mg/kg dry weight)	High Limits (High) (mg/kg dry weight)		
Arsenic	75	41	73	✔
Cadmium	85	39		✔
Copper	4,300	1,500		✔
Lead	840	300		✔
Mercury	57	17		✔
Nickel	420	420	420	✔
Selenium	100	100		✔
Zinc	7,500	2,800		✔

[a] Pollutant limits for active sludge unit whose boundary is greater than 150 meters from the surface disposal site property line.

Source: Standards for the Use or Disposal of Sludge; Final Rules. 40 CFR Part 257 et al. Federal Register February 19, 1993a.

d. Reasons for not land-applying qualifying sludge

POTW characteristics including location, state regulations, and community concerns also affect use/disposal methods for sludge. The POTW Survey provided information on the percentage of sludge that qualified for beneficial use but was not beneficially used. Survey data indicate that 57 percent of qualifying sludge was not land-applied, for the following reasons:

- land application is more expensive than another method;
- land is not available for sludge application;
- the cumulative pollutant loads at the land application site used had been exceeded;
- the vector or pathogen requirements to land apply could not be met at an acceptable cost; and
- inclement weather, concern over liability, stakeholder complaints, stricter state standards, desire to diversify practices, or technical problems.

Of the 57 percent of sludge that was not land-applied, only 11 percent of qualifying sludge was otherwise beneficially used (i.e., sold in bags). Therefore, only 50 percent of the total qualifying sludge is beneficially used.[3] In addition, POTW Survey data indicate that, on average, 7.5 percent of all sludge that qualifies for surface disposal is not surface disposed.

16.2.3 Overview of Improved Sludge Quality Benefits

This section discusses potential economic productivity benefits resulting from cleaner sludge, describes the methodology used to estimate benefits to POTWs directly affected by the regulation, and presents the results of the analysis.

EPA expected that the alternative regulatory options would reduce MP&M facility discharges of eight metals with Part 503 limits. The influent pollutant reductions to the receiving POTWs translate into sludge with reduced pollutant concentrations, allowing the sludge to meet the criteria for lower-cost use/disposal methods. The reduction in pollutants will then provide many POTWs with greater flexibility in the disposal of their sludge, and for some the opportunity to use less expensive methods of sludge use/disposal. In some cases, wastewater treatment systems may be able to use the cleaner sludge in agricultural applications, generating additional agricultural productivity benefits. Numerous benefits will result from reduced contamination of sludge, including the following:

- POTWs may have less expensive options for use/disposal of sludge. Methods involving stricter criteria are generally less expensive than the alternatives. In particular, land application usually costs substantially less than incineration or landfilling. As a result, under the alternative policy options sludge from some POTWs may meet more stringent criteria for less expensive use/disposal methods.
- Some sludge currently meeting only Land Application-Low concentration limits and pollutant loading rate limits would meet the more stringent Land Application-High concentration limits. Users applying sludge meeting Land Application-High pollutant limits would be exempt from meeting pollutant loading rate limits. They would have fewer record-keeping requirements than users of sludge meeting only Land Application-Low concentration and loading rate limits.
- By land-applying sludge, POTWs may avoid costly siting negotiations for more contentious sewage sludge use or disposal practices, such as incineration.
- POTW sludge provides supplemental nitrogen, which enhances soil productivity when land-applied. Sludge applied to agricultural land, golf courses, sod farms, forests, or residential gardens is a valuable source of nitrogen fertilizer.
- Non-point source nitrogen contamination of water may be reduced if sludge is used as a substitute for chemical fertilizers on agricultural land. Compared to nitrogen in most chemical fertilizers, nitrogen in sludge is relatively insoluble in water. The release of nitrogen from sludge occurs largely through continuous microbial activity, resulting in greater plant uptake and less nitrogen runoff than from conventional chemical fertilizers.

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[3] Percent of Qualifying Sludge Beneficially Used = (100% – 57%) +[(57% × 11%)/100%]=50%

- The organic matter in land-applied sludge can improve crop yields by increasing the ability of soil to retain water.

- Reduced concentrations of sludge pollutants not currently regulated may reduce human health and environmental risks. Human health risks from exposure to these unregulated sludge pollutants may occur from particulate inhalation, dermal exposure, ingestion of food grown in sludge-amended soils, ingestion of surface water containing sludge runoff, ingestion of fish from surface water containing sludge runoff, or ingestion of contaminated ground water.

- Land application of sludge satisfies an apparent public preference for this practice of sludge disposal, apart from considerations of costs and risk.

This analysis assumes that POTWs will choose the least expensive sludge use/disposal practice for which their sludge meets pollutant limits. POTWs with sludge pollutant concentrations exceeding the Land Application-High, Land Application-Low, or surface disposal pollutant limits in the baseline may be able to reduce sludge use/disposal costs after MP&M facilities have complied with the effluent limitations considered under alternative regulatory options.

As public entities, POTWs are not forced by the market to act as profit-maximizing or cost-minimizing agents, but rather are assumed to optimize their jurisdictional welfare function. POTWs take factors other than cost into consideration when determining their sludge use/disposal methods. These factors may include the desire to be perceived by the public as using sludge in an environmentally friendly way, or the desire to enhance relationships with clients by providing no-cost or low-cost fertilizer. Greater flexibility in disposal practices may therefore provide benefits beyond cost savings.

16.2.4 Sludge Use/Disposal Costs and Practices

This section summarizes the estimated cost differences of various use and disposal methods, based on the POTW Survey.

Alternative sludge use/disposal practices costs vary considerably among POTWs, based on several factors, the most important being the availability of local agricultural land or land suitable for surface disposal of sludge. Table 16.3 lists and ranks the use/disposal methods from least expensive to most expensive, according to the average qualitative ranking of each method in the POTW Survey.

Table 16.3: National Estimate of Qualitative Ranking of Use/Disposal Methods

	Mean Rankings
Least Expensive	Land Application-High
↕	Land Application-Low
	MSWL
↕	Bagged Application-High
	Surface Disposal in Unlined Unit
↕	Bagged Application-Low
	Surface Disposal in Lined Unit
↕	Incineration
Most Expensive	Hazardous Waste Landfill

Source: U.S. EPA, §308 POTW Survey.

Land Application-Low and Land Application-High were ranked as the two cheapest sewage sludge disposal options, supporting the assumption that beneficial use of sludge offers cost savings. The third least expensive option co-disposal in an MSWL costs less on average than either bagging sludge or surface disposing in an unlined unit.

EPA used the POTW Survey data as the primary source for estimating an average *difference* in costs among certain combinations of use/disposal practices (e.g., the cost savings achieved by switching from incineration to land application). Table 16.4 compares the cost savings realized by switching to sludge land application and surface disposal practices from less stringently regulated sludge use/disposal practices. While on average the estimates provided in Table 16.4 are expected to hold, the cost savings will vary for individual POTWs. POTWs whose sludge qualifies for beneficial use post-compliance but did not qualify for such use in the baseline may achieve cost savings in some, but not all, circumstances. For example, a POTW may not achieve cost savings from agricultural application due to sludge transportation costs or because there are less expensive alternatives for that particular facility. Switching from sewage sludge co-disposal in a MSWL to surface disposal offers no savings to a POTW.

Table 16.4: Cost Savings for Shifts in Sludge Use/Disposal Practices (2001$/DMT)

Switch From	Switch To:				
	Land Application[a] (High)	Land Application[a] (Low)	Sold in a Bag for Land Application	Surface Disposal on Unlined Unit	Surface Disposal on Lined Unit
Incineration	$103.82	$103.82	$95.91	$103.08	No Saving
Surface Disposal on Lined Unit	$126.39	$126.39	$71.89		
Surface Disposal on Unlined Unit	$6.44	$6.44	$0.59		
Co-disposal: MSWL	$100.44	$100.44	$69.96	No Saving	No Saving
Land Application-Low	$0.54-1.09				

[a] EPA assumes that the costs of land application to forests, public contact sites, and reclaimed land are similar to the costs of agricultural application.

Source: U.S. EPA analysis of the §308 POTW Survey data.

The cost section of the POTW Survey did not distinguish between low and high land application or low and high bagged application. Therefore, costs provided in the survey reflect the cost of both methods. To estimate the cost savings of avoiding these requirements by meeting Land Application-High limits, EPA used the compliance requirements for meeting Land Application-Low limits for bulk sludge (U.S. EPA, 1997). These cost savings provide a partial measure of the monetary benefit of improved sludge quality.

EPA estimates that the incremental record-keeping associated with the cumulative Land Application-Low limits requires two to four hours per application. Materials costs for meeting these requirements should be negligible. EPA estimated the record-keeping costs avoided from upgrading sludge quality from Land Application-Low to Land Application-High standards, using the following assumptions:

- a 40-acre site is a typical site size for land application (approximately 16 hectares) (US EPA, 1997);
- the typical application rate for land application is 7 DMT per hectare per application (US EPA, 1997); and
- labor at POTWs costs an average of $30.42 per hour (2001$), based on the §308 POTW Survey.[4]

Based on these assumptions, EPA estimated that $0.54 to $1.09 would be saved per DMT of sludge upgraded from Land Application-Low to Land Application-High.[5]

[4] See Appendix F for detail.

[5] Savings per DMT are calculated by dividing the estimated labor cost per application ($30.42 per Hour * Hours per Application) by the total amount of sludge disposed of per one application (16 Hectares * 7 DMT per hectare).

16.2.5 Quantifying Sludge Benefits

EPA estimated the number of POTWs receiving MP&M discharges and the associated quantity of sludge that would not meet Land Application-High pollutant limits, Land Application-Low pollutant limits, or surface disposal pollutant limits under both the baseline and regulatory options. EPA then assumed that, as a result of compliance with the MP&M effluent limitations guideline, a POTW meeting all pollutant limits for a less costly sludge use/disposal method would benefit from the reduced cost of that particular method. EPA estimated the reduction in sludge use/disposal costs using the steps described below:

1. Estimate total industrial baseline and post-compliance loadings of Part 503 regulated metals for each POTW with MP&M sample facility discharges;

2. Calculate the baseline and post-compliance sludge pollutant concentrations for all MP&M wastewater discharged to the POTW;

3. Compare POTW sludge pollutant concentrations with sludge pollutant limits for surface disposal and land application;

4. Estimate baseline and post-compliance sludge use/disposal practices based on the estimated pollutant concentrations in sewage sludge;

5. Identify POTWs that upgrade their sewage sludge disposal practices under the alternative policy options; calculate the economic POTW benefits by multiplying the cost savings for the shift in practices by the quantity of newly qualified sludge; adjust the estimate of benefits for the percentage of POTWs that cannot land apply sewage sludge due to transportation costs or other reasons, such as cold temperature; and

6. Estimate national benefits using MP&M sample facility weights.

a. Step 1: Estimate total industrial baseline and post-compliance loadings of Part 503 regulated metals

EPA estimated the quantities of Part 503 metals discharged to POTWs receiving wastewater from MP&M sample facilities and facilities operating in other metal discharging industries.[6] EPA used POTW Survey data to estimate the total metal loadings and percent of total loadings discharged to POTWs by MP&M facilities.

The POTW Survey provides the following information:

- number of known MP&M facilities discharging to the POTW,

- total loadings of each regulated metal received by the POTW, and

- percent of the total metal loadings attributable to MP&M industries.

[6] EPA did not include metals from residential wastewater due to lack of data. The effect on the analysis of omitting residential metal loadings is not known.

Table 16.5 summarizes this information by POTW flow volume.

Table 16.5: MP&M Contribution to Total Industrial Loadings Received by POTWs

MP&M Contribution	POTW size (million gallons per day)		
	2-10	11-50	>50
MP&M facilities	***Average number of MP&M facilities per POTW***		
small (<1 MG/year)	32.8	72.1	147.7
medium (1-6.25 MG/year)	2.5	8.0	24.5
large (>6.25 MG/year)	1.2	2.7	10.4
Chemicals	***MP&M percentage of total loadings by weight***		
Arsenic	7.4	14.0	7.0
Cadmium	16.1	23.4	12.8
Copper	18.9	21.6	10.9
Lead	13.8	19.8	10.3
Mercury	7.9	20.8	6.0
Nickel	25.1	24.4	15.8
Selenium	7.2	8.5	3.3
Zinc	20.2	16.0	8.2

Source: U.S. EPA, §308 POTW Survey.

EPA estimated total baseline metal loadings from all MP&M sources, as follows:

$$PLM_{k,i} = \frac{LMP_{small,k,i} \times AvgNumSm}{SampleSm} + \frac{LMP_{medium,k,i} \times AvgNumMed}{SampleMed} + \frac{LMP_{large,k,i} \times AvgNumLg}{SampleLg} \qquad (16.1)$$

where:

$PLM_{k,i}$ = baseline loadings of pollutant *k* to POTW; from all MP&M sources (µg/year);

$LMP_{small,k,i}$ = loadings of pollutant *k* from small (< 1 MG/year) sample MP&M facilities, discharging to POTW *i* (µg/year);

AvgNumSm = the average number of small MP&M facilities discharging to POTW *i*; EPA estimated the average number of MP&M facilities of a given size (small, medium, large) that discharge to POTWs in given flow categories, based on the §308 POTW Survey (see Table 16.5);[7,8]

SampleSm = number of MP&M small (< 1 MG/year) sample facilities discharging to POTW;

$LMP_{medium,k,i}$ = loadings of pollutant *k* from medium (1-6.25 MG/year) sample MP&M facilities, discharging to POTWs (µg/year);

AvgNumMed = the average number of medium MP&M facilities discharging to POTW *i* (based on the POTW flow category (see Table 16.5));

[7] EPA classified MP&M facilities as small, medium, and large flow in the POTW Survey, based on their discharge volume.

[8] This analysis considers the following POTW flow categories: (1) from 2 MG/day to10 MG/day; (2) from 11 to 50 MG/day; and (3) greater than 50 MG/day.

SampleMed = number of MP&M medium (1-6.25 MG/year) sample facilities discharging to POTW i;

$LMP_{large,k,i}$ = loadings of pollutant k from large (>6.25 MG/year) sample MP&M facilities discharging to POTW i (µg/year);

AvgNumLg = the average number of large MP&M facilities discharging to POTW i (based on the POTW flow category (see Table 16.5)); and

SampleLg = number of MP&M large (>6.25 MG/year) sample facilities discharging to POTW i.

EPA estimated total baseline metal loadings from all industrial sources using data from the POTW Survey, as follows:

$$PL_{k,i} = \frac{PLM_{k,i} \cdot 100\%}{\%MP_k} \qquad (16.2)$$

where:

$PL_{k,i}$ = total baseline loadings of pollutant k from all industrial sources to POTW i (µg/year),
$PLM_{k,i}$ = baseline loadings of pollutant k to POTW i from all MP&M sources (µg/year),
100% = the total reported POTW transfers of pollutant k from all industrial sources, and
$\%MP_k$ = the percentage of total reported POTW transfers of pollutant k from MP&M facilities in a given POTW flow category (see Table 16.5).

Post-compliance pollutant loadings to POTWs are calculated by subtracting the reduction in MP&M loadings due to the regulation from the estimated total baseline loadings.

b. Step 2: Calculate baseline and post-compliance sludge quality

First, for each metal with limits under the Part 503 regulation, EPA calculated POTW influent concentrations based on the pollutant loading and POTW flow rates, as follows:

$$IC_{k,i} = \frac{PL_{k,i}}{FL_i \times OD_i} \qquad (16.3)$$

where:

$IC_{k,i}$ = POTW influent concentration of pollutant k (µg/liter) for POTW i;
$PL_{k,i}$ = total loading of pollutant k to POTW i (µg/year) ;
Fl_i = POTW i flow (liters/day); and
OD_i = POTW i operation days (365 days/year).

Second, EPA calculated sludge pollutant concentrations for each pollutant:

$$PC_{k,i} = IC_{k,i} \times TRE_k \times PF_k \times SG \qquad (16.4)$$

where:

$PC_{k,i}$ = concentration of pollutant k in POTW i sludge (mg/kg or ppm),
$IC_{k,i}$ = POTW i influent concentration of pollutant k (µg/liter or ppb),
TRE_k = treatment removal efficiency for pollutant k (unitless),
PF_k = sludge partition factor for pollutant k (unitless), and
SG = sludge generation factor ((L-mg)/(µg-kg) or ppm/ppb).

The partition factor represents the fraction of the pollutant load expected to partition to sludge during wastewater treatment. This factor is chemical-specific. EPA uses a sludge generation factor of 5.96 (mg of chemical/kg sludge)/(g chemical/L of wastewater). The value of 5.96 is based on the "normal quantity of sludge produced" by a POTW with primary sedimentation/activated sludge/digestion/dewatering as reported in Wastewater Engineering (Metcalf & Eddy, 1972). The estimated sludge generation factor indicates that concentration in sludge is 5.96 ppb dry weight for every 1 ppb of pollutant removed and partitioned to sludge.

c. Step 3: Compare sludge pollutant concentrations at each POTW with limits for surface disposal and land application

EPA next compared sludge baseline and post-compliance pollutant concentrations to pollutant limits for land application and surface disposal using the following formula:

$$SE_p = 1 \ \ if \ \frac{PC_k}{CR_{k,p}} > 1 \tag{16.5}$$

where:

SE_p = sludge exceeds concentration limits for disposal or use practice, p;
PC_k = sludge pollutant, k, concentration; and
$CR_{k,p}$ = sludge pollutant, k, criterion for disposal or use practice, p.

If *any* sludge pollutant concentration at a POTW exceeds the pollutant limit for a sludge use/disposal practice in the baseline (i.e., PC/CR >1), then EPA assumed that the POTW cannot use that sludge use/disposal practice. If, as a result of compliance with the MP&M regulation, a POTW meets all pollutant limits for a sludge use/disposal practice (i.e., PC/CR ≤ 1), that POTW is assumed to benefit from an increase in sludge use/disposal options.

d. Step 4: Estimate baseline sludge use/disposal practices at POTWs that can meet land application or surface disposal pollutant limits post-compliance

Benefits from changes in sludge use/disposal practices depend on the baseline practices employed. EPA assumes that POTWs choose the least expensive sludge use/disposal practice for which their sludge meets pollutant limits. POTWs with sludge qualifying for land application in the baseline are assumed to dispose of their sludge by land application; likewise, POTWs with sludge meeting surface disposal pollutant limits (but not land application pollutant limits) are assumed to dispose of their sludge on surface disposal sites.

EPA assumed that the mix of surface disposal practices employed by POTWs in the baseline (e.g., surface disposal in a lined unit and surface disposal in an unlined unit) matches that of national surface disposal practices as calculated from the POTW Survey (see Table 16.1).

POTW Survey data indicate that 25 percent of total sludge meeting Land Application-High standards is sold in bags and 75 percent is land-applied. None of the sludge meeting Land Application-Low standards is sold in bags. Each POTW meeting Land Application-High standards in the post-compliance scenario is assumed to sell 25 percent of its sludge in bags and to land-apply the remainder.

The POTW Survey shows that 34 percent of total surface disposed sludge is disposed of in lined units and 66 percent in unlined units. This mix of surface disposal practices may not match the actual sludge disposal surface practices of any individual POTW. In aggregate, however, the assumed surface disposal practices are consistent with actual POTW sludge surface disposal practices. Survey data also showed that, on average, 7.5 percent of all sludge that qualifies for surface disposal was not surface disposed.

POTWs generating sludge exceeding land application and surface disposal pollutant limits in the baseline are assumed to either incinerate sludge or place sludge in a MSWL. The survey indicates that 39 percent of sludge not land-applied or deposited in surface disposal sites is incinerated and 61 percent is placed in MWSLs. Each POTW exceeding surface disposal and land application limits in the baseline is assumed to incinerate 39 percent of its sludge and co-dispose of the remainder. Again, this mix of sludge use/disposal practices may not match the actual sludge disposal practices of any single POTW; in aggregate, however, the assumed distribution corresponds to actual practices.

Using the sludge disposal cost differentials from Table 16.4, EPA estimated savings for shifts into land application and surface disposal from the assumed mix of baseline use/disposal practices (see Table 16.6). As previously discussed, EPA assumed that 50 percent of sludge could not be used beneficially (land-applied or sold in bags) and disposed less expensively through agricultural application of sludge due to transportation costs, land availability, or weather constraints. The Agency did not estimate benefits for this percentage of the sludge newly qualified for land application.

e. Step 5: Calculate economic benefits for POTWs receiving wastewater from sample MP&M facilities

Table 16.6 shows the cost savings for shifts from composite baseline sludge use/disposal practices to land application or surface disposal. Reductions in sludge use/disposal costs are calculated for each POTW receiving wastewater from an MP&M facility, using the following formula:

$$SCR_i = FL_i \times \frac{S}{2200} \times CD_i \qquad (16.6)$$

where:

- SCR_i = estimated sludge use/disposal cost reductions resulting from the regulation for POTW i (2001$);
- FL_i = POTW i wastewater flow (million gallons/year);
- S = sludge to wastewater ratio, assumed to be 1,127 lbs. (dry weight) per million gallons of water (lbs./million gallons) and divided by 2,200 to convert pounds to metric tons; and
- CD_i = estimated cost differential between least costly composite baseline use/disposal method for which POTW i qualifies and least costly use/disposal method for which POTW i qualifies post-compliance (2001$/DMT).

Table 16.6: Cost Savings from Shifts in Sludge Use/Disposal Practices from Composite Baseline Disposal Practices (2001$/DMT)

Baseline POTW Mix of Sludge Use/Disposal Practices	Post-Compliance POTW Sludge Use/disposal Practice			
	Agricultural Application-High (75% of sludge meeting Land Application-High pollutant limits)	Bagged Sludge (25% of sludge meeting Land Application-High pollutant limits)	Agricultural Application-Low	Surface Disposal[a] (Meet surface pollutant limits; do not meet land application pollutant limits)
Meets Land Application-Low pollutant limits, but not Land Application-High limits	$0.54-1.09	N/A[b]	N/A	N/A
Meets surface disposal pollutant limits, but not Land Application-Low limits Assumed disposal mix: 34% lined unit 66% unlined unit	 $126.39 $6.44	 $71.89 $0.59	 $126.39 $6.44	N.A.
Does not meet land application pollutant limits or surface disposal pollutant limits Assumed disposal mix: 39% incineration, 61% co-disposal	 $103.82 $100.44	 $95.91 $69.96	 $103.82 $100.44	 $0-$103.08 N/A

[a] Surface disposal includes monofills, surface impoundments, and dedicated sites.
[b] Not applicable (i.e., there is no cost savings).

Source: U.S. EPA, §308 POTW Survey.

EPA assumed that only 50 percent of the sludge qualified for land application is beneficially used (i.e., land-applied or sold in bags). The remaining 50 percent of the sludge newly qualified for land application will be disposed of by other methods; therefore, EPA assumed that no cost savings will be associated with 50 percent of the sludge qualified for land application. To ensure that these benefits are not overstated, this analysis includes an adjustment to the estimate of national sludge use/disposal cost benefits for POTWs that may be located at some distance from agricultural sites. This adjustment does not apply to benefits from shifts into surface disposal.

f. Step 6: Estimate national sludge benefits

EPA scaled the sludge use/disposal cost reductions to the national level as follows:

$$NSCR = \sum_{i=1}^{n} (FW_i \times SCR_i) \qquad (16.7)$$

where:

$NSCR$ = national estimated sludge use/disposal cost reductions resulting from the regulation (2001$);
n = number of POTWs estimated to shift into meeting surface disposal or land application pollutant limits as a result of MP&M effluent limitations;
FW_i = facility sample weights for facility or facilities discharging to POTW i; and
SCR_i = estimated sludge use/disposal cost reductions resulting from the regulation for POTW i (2001$).

16.3 Estimated Savings in Sludge Use/Disposal Costs

Of the POTWs receiving discharge wastewater from MP&M facilities, 1,020 POTWs exceed the Land Application-High pollutant limits and 856 exceed the Land Application-Low pollutant limits at baseline discharge levels under the alternative options considered for the final rule. This represents approximately 6 percent of the over 16,000 operating POTWs nationwide. The number of POTWs exceeding Land Application-High and Land Application-Low pollutant limits under the Proposed/NODA Option at baseline conditions is equal to 5,328 and 3,728, respectively.[9]

The final rule only regulates direct dischargers and, as a result, sewage sludge quality will not be affected by the selected option. EPA, however, did estimate savings in sludge disposal costs for the alternative options which consider both direct and indirect dischargers. EPA used the estimated sludge use/disposal cost differentials presented in Table 16.6 to calculate cost savings for the POTWs expected to upgrade their sludge disposal practices under alternative policy options. These results are presented in Table 16.7 below. The benefits are estimated at $11,319 to $22,539 (2001$) annually for both upgrade options. The Proposed/NODA Option would result in more substantial cost savings (i.e., $22.8 million (2001$)) to POTWs. However, the Proposed/NODA Option is not directly comparable to the two upgrade options due to inconsistent baselines.

[9] The total number of facilities reported for the Proposed/NODA Option analysis differs from the facility count reported for the final rule and the upgrade options (Directs + 413 to 433 Upgrade Option, Directs + All to 433 Upgrade Option). After deciding in July 2002 not to consider the NODA option as the basis for the final rule, EPA did not perform any more analyses on the NODA option -- including not updating facility counts and related analyses for the change in subcategory and discharge status classifications.

Table 16.7: National Estimate of Cost Savings from Shifts in Sludge Use/Disposal Under the Alternative Policy Options[a]

Shift	Category/Number of POTWs	Associated Sludge Quantity (DMT/Year)	Estimated Benefits (2001$)
Directs + 413 to 433 Upgrade			
Upgrade from minimum Land Application-Low limits to Land Application-High pollutant limits	15	16,548	$11,319 to $22,539
Upgrade from not meeting land application or surface disposal limits to Land Application-High pollutant limits	0	0	$0
Upgrade from not meeting land application or surface disposal limits to Land Application-Low pollutant limits	0	0	$0
Total	**15**	**16,548**	**$11,319 to $22,539**
Directs + All to 433 Upgrade			
Upgrade from minimum Land Application-Low limits to Land Application-High pollutant limits	15	16,548	$11,319 to $22,539
Upgrade from not meeting land application or surface disposal limits to Land Application-High pollutant limits	0	0	$0
Upgrade from not meeting land application or surface disposal limits to Land Application-Low pollutant limits	0	0	$0
Total	**15**	**16,548**	**$11,319 to $22,539**
Proposed/NODA Option			
Upgrade from minimum Land Application-Low limits to Land Application-High pollutant limits	45	88,389	$60,458 to $120,386
Upgrade from not meeting land application or surface disposal limits to Land Application-High pollutant limits	24	140,460	$6,725,273
Upgrade from not meeting land application or surface disposal limits to Land Application-Low pollutant limits	25	316,565	$16,009,889
Total	**93**	**545,414**	**$22,795,620 to $22,855,548**

[a] Based on the Traditional Extrapolation.

Source: U.S. EPA analysis.

16.4 Methodology Limitations

EPA used the POTW Survey to develop estimates of the cost-saving differentials for the various sludge use/disposal practices. Sludge use/disposal costs vary by POTW. The POTWs affected by the MP&M regulation may face costs that differ from those estimated. As a result, the analysis may over- or under-estimate the cost differentials.

POTW Survey data were also used to estimate metal loadings to POTWs in the baseline analysis. There are two major limitations associated with this approach:

- The baseline metal loadings from individual MP&M facilities of interest may differ from this estimate. The effect of using the §308 survey data to characterize the POTWs that receive MP&M discharges is therefore not known.

- The total share of metals coming from MP&M facilities is likely to be underestimated because lower flow MP&M facilities are not always known by the POTW. During the pretest of the MP&M POTW questionnaire, POTWs told EPA that they were not aware of many of the lower flow facilities that were discharging to them. The POTW would have to use the phone book in order to find and permit these facilities. EPA consequently considered exempting low flow facilities in the general metals and only oily wastes indirect discharge categories under some of the alternative regulatory options.

This analysis assumes that the mix of disposal practices estimated for a specific POTW may not match the actual sludge disposal practices used by that POTW. We know that the mix in the aggregate, as confirmed by the POTW Survey, is correct. The practices used in this analysis are therefore consistent with actual POTW sludge surface disposal practices. Because accurate assumptions for specific POTWs could not be made, the analysis may over- or underestimate the cost differentials.

EPA quantified, but did not monetize economic benefits from reducing interference with POTW operations for the alternative regulatory options. EPA did not estimate cost reductions that occur at POTWs with sludge inhibition problems caused by MP&M discharges. These omissions thereby underestimate the benefits of the regulation.

GLOSSARY

hazardous air pollutants (HAPs): air pollutants that are not covered by ambient air quality standards but which, as defined in the Clean Air Act, may present a threat of adverse human health effects or adverse environmental effects. Such pollutants include asbestos, beryllium, mercury, benzene, coke oven emissions, radionuclides, and vinyl chloride. MP&M pollutants include but are not limited to: chlorobenzene, dioxin,1,4-isophorone, and pyrene. (http://www.epa.gov/OCEPAterms/hterms.html)

hazardous waste landfill: an excavated or engineered site where hazardous waste is deposited and covered. (http://www.epa.gov/OCEPAterms/hterms.html)

influent concentrations: measure of a pollutant's concentration in wastewater being received by a POTW for treatment (see also: pollutant inhibition values).

interference: the obstruction of a routine treatment process of POTWs that is caused by the presence of high levels of toxics, such as metals and cyanide in wastewater discharges. These toxic pollutants kill bacteria used for microbial degradation during wastewater treatment (see: microbial degradation).

microbial degradation: the breakdown of organic molecules via biochemical reactions occurring in living microorganisms such as bacteria, algae, diatoms, plankton, and fungi. POTWs make use of microbial degradation for wastewater treatment purposes. This process is inhibited by the presence of toxics such as metals and cyanide because these pollutants kill microorganisms.

municipal solid waste landfill (MSWL): common garbage or trash generated by industries, businesses, institutions, and homes. Also known as municipal solid waste. (http://www.epa.gov/OCEPAterms/mterms.html)

pathogens: microorganisms (e.g., bacteria, viruses, or parasites) that can cause disease in humans, animals and plants. (http://www.epa.gov/OCEPAterms/pterms.html)

pollutant inhibition values: determined threshold concentration for a pollutant, which when exceeded by the pollutant's influent concentration in wastewater received for treatment will have adverse effects on POTW operations, such as inhibition of microbial degradation (see: microbial degradation).

publicly-owned treatment works (POTWs): a treatment works as defined by Section 212 of the Act, which is owned by a state or municipality. This definition includes any devices or systems used in the storage, treatment, recycling, and reclamation of municipal sewage or industrial wastes of a liquid nature. (http://www.epa.gov/owm/permits/pretreat/final99.pdf)

silviculture: management of forest land for timber. (http://www.epa.gov/OCEPAterms/sterms.html)

vector: 1. An organism, often an insect or rodent, that carries disease. 2. Plasmids, viruses, or bacteria used to transport genes into a host cell. A gene is placed in the vector; the vector then "infects" the bacterium. (http://www.epa.gov/OCEPAterms/vterms.html)

ACRONYMS

DMT: dry metric tons
HAPs: hazardous air pollutants
MSWL: municipal solid waste landfill
POTWs: publicly-owned treatment works

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Chapter 17: Environmental Justice & Protection of Children

INTRODUCTION

Executive Order 12898 requires that, to the greatest extent practicable and permitted by law, each federal agency must make achieving environmental justice part of its mission. Therefore, EPA examined whether the final regulation will promote environmental justice in areas affected by MP&M discharges.

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EPA concludes that discharges from MP&M facilities regulated under the final rule do not have a disproportional environmental impact on minority populations, based on the demographic characteristics of the populations residing in the counties affected by MP&M discharges.

The final rule is not subject to Executive Order 13045, "Protection of Children from Environmental Health Risks and Safety Risks" (62 FR 19885, April 23, 1997), because it is based on technology performance and not on health or safety risks. However, EPA analyzed the reduction of children's health impacts associated with the MP&M regulation, and determined that reductions in the baseline lead exposure are minimal.

The following section assesses whether MP&M discharges have a disproportionally high impact on minority populations.

17.1 DEMOGRAPHIC CHARACTERISTICS OF POPULATIONS LIVING IN THE COUNTIES NEAR MP&M FACILITIES

EPA assessed whether adverse environmental, human health, or economic effects associated with MP&M facility discharges are more likely to affect minorities and low-income populations. This analysis uses data on the race, national origin, and income level of populations residing in counties traversed by reaches receiving discharges from the 32 sample MP&M facilities considered in the final rule analysis. The 32 sample facilities are located in 46 counties in 12 states. The MP&M survey was designed to provide a representative coverage of various types of MP&M facilities, but not of their geographical location. EPA is therefore able to analyze only the location characteristics of the sample facilities, and not all 43,901 MP&M dischargers.[1]

EPA compared demographic data from the 1990 Population Census for the counties traversed by sample ***MP&M reaches*** with the corresponding state level indicators (U.S. Census Bureau, 1990). EPA considered several demographic characteristics to assess the environmental justice of the final regulation, including the relative proportions of African Americans, Native Americans, and Asian or Pacific Islanders, median income, the proportion of the population below the poverty level, unemployment percentage, and the proportion of the population that are children. Table 17.1 presents the results of this analysis, which show that the demographic characteristics of MP&M counties generally reflect state averages.

EPA calculated median income for the group of counties in each state receiving MP&M discharges as a weighted average of each county's median household income.[2] County's populations are used as weights in this analysis. EPA calculated this summary variable in place of the true median household income for MP&M counties because appropriate census data are not

[1] This estimate of MP&M facilities includes baseline closures.

[2] Average median income in MP&M counties =
Σ_i Median Income (i) × Number of Households (i)/Σ Number of Households (i), where (i) is a sample MP&M county.

available. The Agency notes that comparing this weighted average median income to the state-level median income may introduce uncertainty in the analysis.

Income data, as well as other characteristics examined to determine whether minority and/or low-income populations are subject to disproportionally high environmental impacts, show that the socioeconomic characteristics of populations residing in counties affected by MP&M discharges reflect corresponding state averages. Based on these findings, EPA expects that environmental benefits resulting from the MP&M rule will not accrue to populations disproportionally based on race or national origin and therefore will promote environmental justice.

Table 17.1: County Level Comparison of Demographic Data: Counties with Sample MP&M Facilities Versus Entire State

State	Counties	% White	% African-American	% Native Am., Eskimo, or Aleut	% Asian or Pacific Islander	Median Income	% Below Poverty Level	% Unemployed	% Children
California									
MP&M Only	3	58.64%	11.82%	0.53%	11.20%	$36,100	13.98%	7.04%	25.83%
Entire State	58	69.07%	7.39%	0.84%	9.57%	$35,798	12.51%	6.65%	26.01%
Indiana									
MP&M Only	3	95.38%	3.76%	0.23%	0.41%	$24,785	14.31%	7.42%	23.38%
Entire State	93	90.59%	7.75%	0.26%	0.66%	$28,797	10.68%	5.74%	26.29%
Kentucky									
MP&M Only	1	98.44%	0.54%	0.12%	0.74%	$34,485	7.40%	3.64%	29.38%
Entire State	120	92.06%	7.11%	0.19%	0.47%	$22,534	19.03%	7.37%	25.93%
Maryland									
MP&M Only	1	94.61%	4.47%	0.35%	0.34%	$36,019	7.50%	4.56%	26.86%
Entire State	24	71.03%	24.87%	0.30%	2.88%	$39,386	8.27%	4.30%	24.31%
Mississippi									
MP&M Only	3	56.88%	42.46%	0.09%	0.47%	$26,342	19.31%	6.93%	28.00%
Entire State	82	63.46%	35.59%	0.34%	0.49%	$20,136	25.21%	8.43%	29.04%
Missouri									
MP&M Only	1	99.45%	0.04%	0.44%	0.04%	$17,594	18.87%	4.00%	24.21%
Entire State	115	87.68%	10.69%	0.44%	0.77%	$26,362	13.34%	6.16%	25.71%
New York									
MP&M Only	2	92.64%	4.90%	0.34%	0.78%	$25,864	12.13%	10.57%	28.09%
Entire State	63	74.47%	15.90%	0.33%	3.83%	$32,965	13.03%	6.88%	23.66%
North Carolina									
MP&M Only	3	88.47%	10.71%	0.23%	0.33%	$26,189	10.75%	3.94%	24.10%
Entire State	100	75.60%	21.96%	1.25%	0.76%	$26,647	12.97%	4.79%	24.27%
Ohio									
MP&M Only	2	89.17%	9.69%	0.24%	0.74%	$28,527	11.70%	6.82%	24.76%
Entire State	89	87.81%	10.62%	0.21%	0.82%	$28,706	12.54%	6.60%	25.85%
Oklahoma									
MP&M Only	4	82.68%	8.48%	6.99%	1.06%	$26,456	13.63%	5.86%	26.20%
Entire State	77	82.26%	7.38%	8.03%	1.04%	$23,577	16.71%	6.87%	26.60%

Table 17.1: County Level Comparison of Demographic Data: Counties with Sample MP&M Facilities Versus Entire State

State	Counties	% White	% African-American	% Native Am., Eskimo, or Aleut	% Asian or Pacific Islander	Median Income	% Below Poverty Level	% Unemployed	% Children
Pennsylvania									
MP&M Only	22	92.89%	6.12%	0.12%	0.64%	$27,851	11.56%	6.46%	22.88%
Entire State	68	88.57%	9.15%	0.13%	1.14%	$29,069	11.13%	5.97%	23.54%
Washington									
MP&M Only	1	84.94%	4.97%	1.18%	7.90%	$36,179	7.96%	4.15%	22.56%
Entire State	40	88.64%	3.03%	1.71%	4.34%	$31,183	10.92%	5.72%	25.86%

Source: U.S. EPA analysis of 1990 Census Data (U.S. Bureau of Census 1990).

17.2 Protection of Children from Environmental Health and Safety Risks

EPA assessed whether the final regulation will benefit children, including reducing health risk from exposure to MP&M pollutants from consumption of contaminated fish tissue and drinking water and improving recreational opportunities. EPA was able to quantify only one category of benefits specific to children: avoided health damages to pre-school age children from reduced exposure to lead. This analysis considered several measures of children's health benefits associated with lead exposure for children up to age six. Avoided neurological and cognitive damages were expressed as changes in three metrics: (1) overall IQ levels; (2) the incidence of low IQ scores (<70); and (3) the incidence of blood lead levels above 20 mg/dL. EPA also assessed changes in the incidence of neonatal mortality from reduced maternal exposure to lead. EPA's methodology for assessing lead-related benefits to children is presented in Chapter 14 of this report.

The Ohio case study analysis showed that the final rule is expected to yield $422,000 (2001$) in annual benefits to children in the state of Ohio from reduced neurological and cognitive damages and reduced incidence of neonatal mortality. On the other hand, the national-level analysis shows that benefits to children from reduced lead discharges are negligible nationwide. As noted in Chapter 18, different findings from these two analyses are likely to be due to insufficient data and a more simplistic approach used in the national-level analysis.

Children over age seven are also likely to benefit from reduced neurological and cognitive damages from reduced exposure to lead. Giedd et al. (1999) studied brain development among 10 to 18 year-old children and found substantial growth in brain development, mainly in the early teenage years. This research suggests that older children may be hypersensitive to lead exposure, as are children aged 0 to 7.

Additional benefits to children from reduced exposure to lead not quantified in this analysis may include prevention of the following adverse health effects: slowed or delayed growth, delinquent and anti-social behavior, metabolic effects, impaired heme synthesis, anemia, impaired hearing, and cancer (see Chapter 14 of this report for details).

GLOSSARY

MP&M reach: a reach to which an MP&M facility discharges.

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Chapter 18: MP&M Benefit / Cost Comparison

INTRODUCTION

The preceding Chapters 12 through 16 provided quantitative and qualitative assessments of the expected benefits to society from reduced MP&M effluent discharges under the final regulation. Chapter 11 assessed the regulation's expected social costs. This chapter sums the estimated values for the benefit categories that EPA was able to monetize, and compares the aggregate benefits estimate with the estimate of social costs.

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18.1 ESTIMATING NATIONAL LEVEL BENEFITS AND COSTS

EPA traditionally estimates national level costs and benefits by extrapolating analytic results from sample facilities to the national level using sample facility weights. EPA's traditional sampling approach relies on information about the economic and technical characteristics of the regulated community. Although important for understanding the technical requirements and costs of a regulation, this sampling approach does not incorporate information that could significantly affect the occurrence and distribution of regulatory benefits, such as characteristics of the receiving water body and the size of population that may benefit from reduced pollutant discharges. As a result, the traditional sampling approach may yield benefit estimates that are less accurate than those that could be obtained by using a sampling framework that accounts for such benefit-receptor characteristics.

EPA recognizes that using a traditional extrapolation method to estimate national-level benefits may lead to a large degree of uncertainty in benefits estimates. Therefore, in addition to the traditional extrapolation method used in the proposed rule, EPA also estimated national-level benefits for the final rule using an alternative extrapolation method.[1]

Under this method, EPA used an alternative set of sampling weights, based on a post-sampling stratification method, to calculate alternative national estimates of benefits. EPA adjusted the original sample weights using two variables that are likely to affect the occurrence and size of benefits associated with reduced discharges from sample MP&M facilities: receiving water body type and size, and the size of the population residing in the vicinity of the sample facility. The Agency used a commonly used post-stratification method calling "raking" to adjust original sample weights to reflect these benefit pathway characteristics. EPA used data from three data sources – EPA's Permit Compliance System database (PCS), EPA's Reach File 1, and Census Data – to develop the adjusted weights. Because of data limitations, EPA restricted the re-weighting effort only to direct dischargers and excluded indirect dischargers that are not considered in the final MP&M rule. EPA therefore performed this alternative analysis for only the selected option. Appendix G details the post-sampling stratification method used to adjust the original sample weights.

EPA uses the post-stratification extrapolation benefit estimates to validate general conclusions that the Agency draws from its main analysis based on the traditional extrapolation method.

[1] EPA also conducted a sensitivity analysis of national benefits for the final MP&M regulation by extrapolating the results of the Ohio case study to the national level. The results of this analysis are presented in Appendix G.

18.2 SOCIAL COSTS

As discussed in Chapter 11, EPA estimated the cost to society from compliance with the final regulation. The components of social costs include the resource cost of compliance (e.g., labor, equipment, material, and other economic resources needed to comply with the rule), costs to governments administering the regulation, and the social costs of unemployment resulting from facility closures. EPA estimated that the final rule will cause no unemployment and thus impose no unemployment-related costs to society. EPA also estimated that governments will incur no additional costs from administering the regulation. EPA estimated the final rule's annual cost to society at $13.82 million (2001$). This value is based only on the estimated resource cost of compliance.

18.3 BENEFITS

EPA developed a partial monetary estimate of the final rule's expected benefits based on three benefit categories: human health, water-based recreation (including nonuse value), and economic productivity benefits (avoided sewage sludge disposal costs). The Agency estimated the total monetized benefits by summing the monetary values reported in the preceding chapters across all categories of benefits. As noted in Chapter 12, these benefits estimates are incomplete because they omit numerous mechanisms by which society is likely to benefit from reduced effluent discharges from the MP&M industry. Examples of benefit categories not reflected in these monetized estimates include:

- non-lead and non-cancer related health benefits,
- improved aesthetic quality of waters near discharge outfalls,
- benefits from improved wildlife habitat, including habitat for threatened or endangered species,
- tourism benefits, and
- reduced costs of drinking water treatment.

The Agency estimated the total national benefits based on three extrapolation approaches. Table 18.1 summarizes the monetary value of benefits to society from the final rule. Traditional extrapolation yields total benefit values of $0.88 to $2.36 million (2001$) annually, with a midpoint estimate of $1.45 million (2001$). Benefits estimates based on the post-stratification extrapolation method range from $0.57 to $1.54 million (2001$), with a midpoint estimate of $0.98 million.

The ranges of national benefit estimates from the two extrapolation methods substantially overlap, with each method confirming the value estimated by the other method. This finding provides confidence in the reasonableness of the estimates from the separate extrapolation methods, given the limitations of data and coverage of benefit categories underlying the analysis for both methods.

18.4 COMPARING MONETIZED BENEFITS AND COSTS

EPA cannot perform a complete cost-benefit comparison because not all of the benefits resulting from the final regulatory option can be valued in dollar terms. As reported in Table 18.1, combining the national estimates of benefits and costs yields the following value of net monetizable benefits under the traditional and post-stratification extrapolation methods:

- Under the traditional extrapolation technique, the estimated net monetizable benefits range from negative $11.5 million to negative $12.9 million annually (2001$). Comparing the midpoint estimate of social costs with the midpoint estimate of monetized benefits results in a net benefit of negative $12.3 million (2001$).
- The post-stratification extrapolation method, which does not affect the estimated costs of the rule, results in total net monetizable benefits ranging from negative $12.3 to negative $13.3 million (2001$), with a midpoint estimate of negative $12.8 million (2001$).

The lack of a comprehensive benefits valuation limits the assessment of the relationship between costs and benefits of the final rule. EPA believes that the benefits of regulation, even in the low-estimate case (post-stratification extrapolation), would be comparable to the social costs if all of the benefits of regulation could be quantified and monetized.

Table 18.1: Comparison of National Annual Monetizable Benefits to Social Costs: Final Rule (2001$)			
Benefit and Cost Categories	**Low**	**Mid**	**High**
Final Option -- Traditional Extrapolation			
Benefit Categories			
Reduced cancer risk from fish consumption	$90	$90	$90
Reduced cancer risk from water consumption	$0	$0	$0
Reduced risk from exposure to lead	$0	$0	$0
Enhanced water-based recreation	$586,503	$999,838	$1,574,380
Nonuse benefits	$293,252	$499,919	$787,190
Avoided sewage sludge disposal costs	N/A	N/A	N/A
Total Monetized Benefits[a]	**$879,845**	**$1,499,846**	**$2,361,660**
Cost Categories			
Resource costs of compliance	$13,824,563	$13,824,563	$13,824,563
Costs of administering the final regulation	$0	$0	$0
Social costs of unemployment	$0	$0	$0
Total Monetized Costs	**$13,824,563**	**$13,824,563**	**$13,824,563**
Net Monetized Benefits (Benefits Minus Costs)[b]	**($12,944,718)**	**($12,324,717)**	**($11,462,903)**
Final Option -- Post-Stratification Extrapolation			
Benefit Categories			
Reduced cancer risk from fish consumption	$134	$134	$134
Reduced cancer risk from water consumption	$0	$0	$0
Reduced risk from exposure to lead	$0	$0	$0
Enhanced water-based recreation	$382,105	$651,392	$1,025,705
Nonuse benefits	$191,053	$325,696	$512,852
Avoided sewage sludge disposal costs	N/A	N/A	N/A
Total Monetized Benefits[a]	**$573,292**	**$977,221**	**$1,538,691**
Cost Categories			
Resource costs of compliance	$13,824,563	$13,824,563	$13,824,563
Costs of administering the final regulation	$0	$0	$0
Social costs of unemployment	$0	$0	$0
Total Monetized Costs	**$13,824,563**	**$13,824,563**	**$13,824,563**
Net Monetized Benefits (Benefits Minus Costs)[b]	**($13,251,271)**	**($12,847,342)**	**($12,285,872)**

[a] EPA did not estimate low and high benefits estimates for reduced cancer risk or lead exposure because it used a single estimate for the value of a statistical life (VSL) to estimate mortality benefits in these categories. EPA calculated low and high estimates of total monetized benefits by adding midpoint benefits estimates for cancer risk and lead exposure to respective low and high estimates of recreation and nonuse benefits.

[b] EPA's estimate of social cost is based only on the estimated resource cost of compliance and was calculated as only a single value instead of a range. Low, mid, and high net benefit values were calculated by subtracting the total monetized cost estimate from low, mid, and high estimates of total monetized benefits.

Source: U.S. EPA analysis.

Chapter 19: Social Costs and Benefits of Regulatory Alternatives

INTRODUCTION

EPA considered three regulatory options as alternatives to the selected MP&M rule. These options (the Proposed/NODA Option, Directs + 413 to 433 Upgrade Option, Directs + All to 433 Upgrade Option) are described in Chapter 4. EPA estimated the social costs and benefits of these three options, using the same methods applied in the analyses of the final rule. This chapter summarizes the results of these benefit and cost analyses. The total number of facilities reported for the Proposed/NODA Option (Option II) analysis differs from the facility count reported for the final rule and Options III and IV. After deciding in July 2002 not to consider the NODA option as the basis for the final rule, EPA performed no more analysis on the NODA option, including not updating facility counts and related analyses for the change in subcategory and discharge status classifications.

CHAPTER CONTENTS

19.1 ESTIMATED SOCIAL COSTS

EPA estimated social costs for the final rule and alternative options in *Chapter 11: Social Costs*. This section provides a summary of those results.

19.1.1 Compliance Costs for MP&M Facilities

Table 19.1 presents the estimated resource value of compliance costs by discharge status under the final option and alternative regulatory options. These compliance costs are not adjusted for the effect of taxes or pass-through of compliance costs to customers, and therefore represent the social value of resources used for compliance. EPA annualized compliance costs using a 7 percent discount rate over a 15-year analysis period. A more detailed description as well as the results presented by subcategory can be found in *Chapter 11: Social Costs*. The total resource compliance costs of the final rule are equal to $13.8 million (2001$). The total annualized compliance costs under the Proposed/NODA Option are $1,620.3 million, or 117 times the final rule's compliance costs. The total annualized compliance costs under the Directs + 413 to 433 Upgrade Option are $96.8 million, or 7 times the final rule's costs. The total annualized compliance costs under the Directs + All to 433 Upgrade Option are $138.2 million, or 10 times the final rule's costs.

Table 19.1: Resource Value of Compliance Costs under Different Options (millions, 2001$)

Option	Indirect	Direct	Total
Option I: Selected Option (Directs Only)	$0.0	$13.8	$13.8
Option II: Proposed/NODA Option	$1,111.4	$508.9	$1,620.3
Option III: Directs + 413 to 433 Upgrade Option	$83.0	$13.8	$96.8
Option IV: Directs + All to 433 Upgrade Option	$124.4	$13.8	$138.2

Source: U.S. EPA analysis.

19.1.2 Government Administrative Costs

The final rule excludes all indirect dischargers from coverage. EPA therefore expects no POTW administrative costs for the final rule. Under the alternative options, which include indirect dischargers, EPA expects no increase in permitting costs for facilities that already hold a permit in the baseline. However, governments will incur additional permitting costs for unpermitted facilities (under the Proposed/NODA option only) and to accelerate repermitting for some indirect dischargers that currently hold permits. The alternative regulatory options may also cause some administrative costs to decrease. For example, control authorities will no longer have to repermit facilities that are estimated to close as a result of the MP&M rule.

EPA estimates that each of the three alternative options considered would result in *reduced* POTW regulatory costs. These cost savings result from regulatory closures (i.e., facilities that currently hold a permit and would have required repermitting in the baseline, but that will no longer require repermitting under the regulatory options). The cost savings as a result of regulatory closures outweigh the additional costs of issuing new permits (under the Proposed/NODA option only) and repermitting on an accelerated, three-year schedule.

Table 19.2 below presents the estimated permitting costs to governments of administering the final rule and alternative options. *Chapter 7: Government and Community Impact Analysis* describes the methodology used to estimate these administrative costs. Estimated annualized cost savings to POTWs for the three alternative regulatory options range between $0.05 and $1.0 million under the Proposed/NODA option, and between $0.03 and $0.2 million under the Directs + 413 to 433 Upgrade Option and the Directs + All to 433 Upgrade Option (all costs in (2001$).

Table 19.2: Annualized Government Administrative Costs by Regulatory Option (2001$)

Option	Low	Medium	High
I: Selected Option	n/a	n/a	n/a
II: Proposed/NODA Option	(46,000)	(198,000)	(1,027,000)
III: Directs + 413 to 433 Upgrade	(26,000)	(56,000)	(218,000)
IV: Directs + 433 to All Upgrade	(26,000)	(55,000)	(213,000)

Source: U.S. EPA analysis.

19.1.3 Cost of Unemployment

The loss of jobs associated with any facility closures would represent a social cost of the regulation. However, from its facility impact analysis, EPA estimates that no facilities will close as a result of the final rule. Accordingly, EPA estimates a zero cost of unemployment for the final regulation.

Table 19.3 presents the estimated social costs of unemployment for the alternative regulatory options, for which EPA estimated closures. These estimates include the estimated willingness-to-pay to avoid cases of involuntary unemployment, and the cost of administering the unemployment compensation system for unemployed workers. EPA annualized costs using a 7 percent discount rate over a 15-year analysis period.

The Agency based lower-bound estimates of the number of net job losses expected from compliance. Net job losses are estimated at 26,060 jobs under the Proposed/NODA Option, 7,319 under the 413 Upgrade Option, and 7,011 under the Local Limits Option. The gross estimate for lost employment, which does not consider increased employment from compliance activities and thus provides a conservative upper-bound of potential unemployment effects, is 32,729 jobs under the Proposed/NODA Option and 7,874 under both 433 Upgrade Options. From these estimates for lost employment, social costs of unemployment under the Proposed/NODA Option range from $344 million to $454 million (2001$). Social costs of unemployment under the 433 Upgrade Options range from $83 million to $109 million (2001$).

Table 19.3: Social Costs of Unemployment for Final Rule and Alternative Options (millions, 2001$)

Unemployment/ Cost Category	Option I: Selected Option (Directs Only)	Option II: Proposed/NODA Option			Option III: Directs + 413 to 433 Upgrade Option			Option IV: Directs + All to 433 Upgrade Option		
		Low	Mid	High	Low	Mid	High	Low	Mid	High
Net Unemployment (FTE-years)[a]	n/a		26,060			7,319			7,011	
Gross Unemployment (FTE-years)[a]	n/a		32,729			7,874			7,874	
Annualized Cost of Unemployment	n/a	$344.16	$399.22	$454.29	$82.80	$96.05	$109.30	$82.80	$96.05	$109.30
Annualized Administrative Cost	n/a	$0.44	$0.44	$0.44	$0.11	$0.11	$0.11	$0.11	$0.11	$0.11
Total Social Cost of Unemployment	**n/a**	**$344.60**	**$399.66**	**$454.73**	**$82.91**	**$96.16**	**$109.40**	**$82.91**	**$96.16**	**$109.40**

[a] Number of FTE positions multiplied by the duration of employment/unemployment. EPA assumed that workers losing jobs due to regulatory closures would be unemployed for one year. The timing and duration of employment gains due to compliance expenditures differ for employment associated with manufacturing and installing equipment (in the first year) and operating and maintaining equipment (all 15 years of the analysis period).

Source: U.S. EPA analysis.

19.1.4 Total Social Costs

EPA estimated that the final rule will not result in social costs of unemployment and that governments will not incur additional costs in administering the regulation. EPA estimates the total social cost of the final rule at $13.8 million (2001$). This cost results entirely from the estimated resource costs of compliance.

For the Proposed/NODA Option, EPA estimated social costs to range from $1.96 billion to $2.07 billion (2001$) annually based on the cost estimates presented above. The midpoint estimate, $2.02 billion is almost 150 times greater than the final rule's social cost. This increase results from the more stringent technology requirements for most subcategories under the Proposed/NODA Option compared to those under the final rule. In addition, this alternative option includes additional subcategories not covered by the regulation.

For the Directs + 413 to 433 Upgrade Option, EPA estimated social costs to range from $180 million to $206 million (2001$) annually. The midpoint estimate, $193 million, is 14 times greater than the final rule's social cost. This increase results from requiring facilities currently regulated under the Electroplating regulations (40 CFR 413) to comply with the Metal Finishing regulations (40 CFR 433).

For the Directs + All to 433 Upgrade Option, EPA estimated social costs to range from $221 million to $247 million (2001$) annually. The midpoint estimate, $234 million, is 17 times greater than the final rule's social cost. This increase results from requiring facilities currently regulated by local limits or general pretreatment standards to meet with the Metal Finishing regulations (40 CFR 433).

19.2 ESTIMATED BENEFITS

EPA estimated the benefits for the alternative options based on the methodologies described in Chapters 12 through 16.

19.2.1 Human Health Benefits

EPA used the methodology described in Chapter 13 to assess human health benefits from reduced incidence of cancer from consumption of contaminated fish tissue and drinking water under the three alternative options.

EPA estimated that the final rule, as well as both upgrade options, would reduce incidence of cancer from consumption of contaminated fish by 1.4E-5 cancer cases per year. The Proposed/NODA Option would eliminate an estimated 0.57 cancer cases per year from the baseline level. The estimated monetary value of reduced incidence of cancer from consumption of contaminated fish is $3.68 million under the Proposed/NODA Option, $90 (2001$) under the final rule and Directs + 413 to 433 Upgrade Option, and $169 (2001$) under the Directs + All to 433 Upgrade Option.

Under the final rule, as well as both upgrade options, EPA expects no reductions in cancer cases from consumption of contaminated drinking water. Under the Proposed/NODA Option, 0.001 fewer cancer cases are expected annually from the baseline level. Estimated annual monetary benefits resulting from fewer cancer cases caused by the consumption of contaminated drinking water are $6,536 (2001$) for the Proposed/NODA Option.

EPA used the methodology described in Chapter 14 to assess benefits to children and adults from reduced exposure to lead under the alternative options. EPA estimated that the final rule will yield no lead-related benefits to children from reduced consumption of contaminated fish. Annual lead-related benefits for children of $20.8 million (2001$) are expected for the Proposed/NODA Option. The Directs + 413 to 433 Upgrade Option and the Directs + All to 433 Upgrade Option would result in $1.3 and $1.5 million (2001$) in lead-related benefits for children, respectively.

EPA estimated that the Proposed/NODA Option would reduce neonatal mortality by 1.60 cases, and avoid an estimated loss of 1,078 IQ points. The Directs + 413 to 433 Upgrade Option and the Directs + All to 433 Upgrade Option would reduce cases of neonatal mortality by 0.15 and 0.17, and avoid the loss of 32 and 36 IQ points, respectively. EPA estimated lead-related benefits for adults at $7.0 million under the Proposed/NODA Option, and approximately $0.7 million (2001$) for both upgrade options. Combined lead-related benefits for children and adults total $27.8 million for the Proposed/NODA Option, and between $2.0 and $2.2 million (2001$) for both upgrade options. Table 19.4 summarizes all health-related benefits.

Table 19.4: Annual Human Health Benefits for the Alternative Options (2001$)

Regulatory Option	Reduced Cancer Risk from Fish Consumption		Reduced Cancer Risk from Water Consumption		Lead-Related Benefits		Total Monetized Human Health Benefits
	Number of Cancer Cases	Monetary Value	Number of Cancer Cases	Monetary Value	Children	Adult	
Proposed/NODA Option							
Baseline	0.920		3.117				
Proposed/NODA Option	0.353	$3,684,973	3.116	$6,536	$20,791,073	$7,048,025	$31,530,607
Final Option Alternatives							
Baseline	0.033		5.3E-07				
Selected Option	0.033	$90	5.3E-07	$0	$0	$0	$90
Directs + 413 to 433 Upgrade	0.033	$90	5.3E-07	$0	$1,303,590	$704,574	$2,008,254
Directs + 413 + 50% LL Upgrade	0.033	$169	5.3E-07	$0	$1,457,640	$785,304	$2,243,113

Source: U.S. EPA analysis.

19.2.2 Recreational Benefits

EPA used the methodology described in Chapter 15 to assess improvements in recreational benefits under the alternative options. The Agency found that the final option will reduce the occurrence of pollutant concentrations in excess of ***ambient water quality criteria (AWQC)*** limits by 2 percent (9 of 395 baseline occurrences) (see Table 19.5). EPA found that the Proposed/NODA Option would reduce pollutant concentrations in excess of AWQC limits by 2.6 percent (154 of 5,999 baseline occurrences), while both upgrade options would reduce such occurrences by 72 percent (285 of 395 baseline occurrences) from the baseline level.

EPA estimated the range of recreational value increases (including both use and nonuse value) for these reaches resulting from habitat improvements for each option. EPA expects recreational value of improved reaches to increase by $0.9 million to $2.4 million annually under the final rule, $406 million to $956 million annually under the Proposed/NODA Option, $182.7 million to $443.5 million under the Directs + 413 to 433 Upgrade Option, and by $183.5 million to $445.9 million under the Directs + All to 433 Upgrade Option (2001$) (see Table 19.7). The midpoint estimates of combined annual recreational and nonuse benefits under these options are $1.5 million, $649 million, $297.0 million, and $298.5 million (2001$). The midpoint estimates of recreational and nonuse benefits are approximately 200 times greater under the upgrade options than under the final rule.

Table 19.5: Number of MP&M Discharge Reaches with MP&M Pollutant Concentrations Exceeding AWQC Limits

Regulatory Status	Number of Reaches with Concentrations Exceeding			Number of Reaches with Concentrations Exceeding AWQC Limits[a]
	AWQC Acute Exposure Limits for Aquatic Species	AWQC Chronic Exposure Limits for Aquatic Species	AWQC Limits for Human Health	
Proposed/NODA Option				
Baseline	330	928	5,865	5,999
Proposed/NODA Option	86	539	5,803	5,845
Final Option Alternatives				
Baseline	18	353	78	395
Selected Option	9	344	78	386
Directs + 413 to 433 Upgrade	0	53	78	109
Directs + 413 + 50% LL Upgrade	0	31	78	109

[a] All reaches exceeding aquatic acute exposure limits also exceed chronic exposure limits. In order not to double count the number of reaches expected to benefit from the regulation, the total number of reaches exceeding AWQC limits is the sum of the number of reaches that exceed human health criteria and the number exceeding aquatic chronic criteria, which do not also exceed AWQC limits for human health.

Source: U.S. EPA analysis.

19.2.3 Avoided Sewage Sludge Disposal or Use Costs

The final rule will not regulate indirect dischargers and therefore will not reduce metals discharges to POTWs or the number of POTWs that exceed land application standards for sewage sludge disposal. However, reduced metals discharges to POTWs resulting from the Proposed/NODA Option would enable 48 additional POTWs to dispose of sewage sludge by land application, resulting in $22.8 million (2001$) in cost savings (see Table 19.6). The Directs + 413 to 433 Upgrade Option and the Directs + All to 433 Upgrade Option would not reduce the number of POTWs that exceed land application standards. However, under both upgrade options 15 POTWs would be able to improve their sludge quality from meeting the land application low standard to meeting the land application high standard, resulting in approximately $16,929 (2001$) in cost savings to POTWs.

Table 19.6: Cost Savings from Land Application

Regulatory Option	# of POTWs Exceeding Land Application (High) Standards	Cost Savings from Upgrading Sewage Sludge Disposal Methods (2001$)
Proposed/NODA Option		
Baseline	5,328	
Proposed/NODA Option	5,259	$22,825,584
Final Option Alternatives		
Baseline	856	
Selected Option	856	$0
Directs + 413 to 433 Upgrade	856	$16,929
Directs + All to 433	856	$16,929

Source: U.S. EPA analysis.

19.2.4 Total Monetized Benefits

EPA estimates total monetized benefits under the final option ranging from $879,845 to $2,361,660 (2001$), with a midpoint estimate of $1,499,846. Total monetized benefits for the Proposed/NODA Option range from $460 million to $1,010 million, with a midpoint estimate of $704 million (2001$). Total monetized benefits estimates for the Directs + 413 to 433 Upgrade Option and the Directs + All to 433 Upgrade Option are similar, with respective ranges of $185 million to $446 million, and $186 million to $448 million (2001$). Midpoint estimates of total monetized benefits for these options are $299 million and $301 million (2001$), respectively. Midpoint estimates for monetized benefits for the upgrade options are approximately 200 percent higher than the midpoint estimate of benefits for the final rule.

19.3 Comparison of Estimated Benefits and Costs

Combining the estimates of social benefits and social costs under the final option yields net monetized benefits ranging from negative $11.5 million to negative $12.9 million (2001$), with a midpoint estimate of negative $12.3 million (see Table 19.7).

Under the Proposed/NODA Option, net monetized benefits range from negative $1,505 million to negative $1,064 million (2001$) per year, with a midpoint estimate of negative $1,316 million. Annual net monetized benefits under the Directs + 413 to 433 Upgrade Option and the Directs + All to 433 Upgrade Option range from $5 million to $240 million, and negative $35 million to positive $201 million (2001$) per year, respectively. Midpoint estimates of net benefits for these options are $106 million and $66 million (2001$), respectively (see Table 19.7). As discussed in Chapter 12, the benefits assessment of regulatory options is necessarily incomplete due to the omission of numerous mechanisms by which society is likely to benefit from reduced effluent discharges.

Table 19.7: Comparison of Social Benefits and Costs of Alternative Options (2001$)

Benefit and Cost Categories[d]	Low	Mid	High
Selected Option			
Benefit Categories			
Reduced Cancer Risk from Fish Consumption	$90	$90	$90
Reduced Cancer Risk from Water Consumption	$0	$0	$0
Reduced Risk from Lead Exposure	$0	$0	$0
Enhanced Water-Based Recreation	$586,503	$999,838	$1,574,380
Nonuse Benefits	$293,252	$499,919	$787,190
Avoided Sewage Sludge Disposal Costs	N/A	N/A	N/A
Total Monetized Benefits[a]	**$879,845**	**$1,499,846**	**$2,361,660**
Cost Categories			
Resource Costs of Compliance	$13,824,563	$13,824,563	$13,824,563
Administration Costs to POTWs	$0	$0	$0
Social Costs of Unemployment	$0	$0	$0
Total Monetized Costs	**$13,824,563**	**$13,824,563**	**$13,824,563**
Net Monetized Benefits (Benefits Minus Costs)[b]	**($12,944,718)**	**($12,324,717)**	**($11,462,903)**
Proposed/NODA Option			
Benefit Categories			
Reduced Cancer Risk from Fish Consumption	$3,684,973	$3,684,973	$3,684,973
Reduced Cancer Risk from Water Consumption	$6,536	$6,536	$6,536
Reduced Risk from Lead Exposure	$27,839,098	$27,839,098	$27,839,098
Enhanced Water-Based Recreation	$270,366,433	$432,938,869	$637,360,014
Nonuse Benefits	$135,183,216	$216,469,435	$318,680,007
Avoided Sewage Sludge Disposal Costs	$22,795,620	$22,825,584	$22,855,548
Total Monetized Benefits[a]	**$459,875,876**	**$703,764,495**	**$1,010,426,176**
Cost Categories			
Resource Costs of Compliance	$1,620,252,136	$1,620,252,136	$1,620,252,136
Administration Costs to POTWs	($46,000)	($198,000)	($1,027,000)
Social Costs of Unemployment	$344,597,370	$399,662,865	$454,728,360
Total Monetized Costs	**$1,964,803,507**	**$2,019,717,002**	**$2,073,953,497**
Net Monetized Benefits (Benefits Minus Costs)[c]	**($1,504,927,631)**	**($1,315,952,507)**	**($1,063,527,321)**

Table 19.7: Comparison of Social Benefits and Costs of Alternative Options (2001$)

Benefit and Cost Categories[d]	Low	Mid	High
Directs + 413 to 433 Upgrade			
Benefit Categories			
Reduced Cancer Risk from Fish Consumption	$90	$90	$90
Reduced Cancer Risk from Water Consumption	$0	$0	$0
Reduced Risk from Lead Exposure	$2,008,254	$2,008,254	$2,008,254
Enhanced Water-Based Recreation	$121,808,075	$197,990,383	$295,661,071
Nonuse Benefits	$60,904,038	$98,995,192	$147,830,535
Avoided Sewage Sludge Disposal Costs	$11,319	$16,929	$22,539
Total Monetized Benefits[a]	**$184,731,776**	**$299,010,848**	**$445,522,489**
Cost Categories			
Resource Costs of Compliance	$96,779,134	$96,779,134	$96,779,134
Administration Costs to POTWs	($26,000)	($56,000)	($218,000)
Social Costs of Unemployment	$82,907,075	$96,155,345	$109,403,616
Total Monetized Costs	**$179,660,209**	**$192,878,479**	**$205,964,750**
Net Monetized Benefits (Benefits Minus Costs)[c]	**$5,071,567**	**$106,132,369**	**$239,557,739**
Directs + All to 433 Upgrade			
Benefit Categories			
Reduced Cancer Risk from Fish Consumption	$169	$169	$169
Reduced Cancer Risk from Water Consumption	$0	$0	$0
Reduced Risk from Lead Exposure	$2,243,113	$2,243,113	$2,243,113
Enhanced Water-Based Recreation	$122,360,444	$198,976,248	$297,272,287
Nonuse Benefits	$61,180,222	$99,488,124	$148,636,143
Avoided Sewage Sludge Disposal Costs	$11,319	$16,929	$22,539
Total Monetized Benefits[a]	**$185,795,267**	**$300,724,583**	**$448,174,251**
Cost Categories			
Resource Costs of Compliance	$138,237,664	$138,237,664	$138,237,664
Administration Costs to POTWs	($26,000)	($55,000)	($213,000)
Social Costs of Unemployment	$82,907,075	$96,155,345	$109,403,616
Total Monetized Costs	**$221,118,739**	**$234,338,009**	**$247,428,280**
Net Monetized Benefits (Benefits Minus Costs)[c]	**($35,323,472)**	**$66,386,574**	**$200,745,971**

[a] EPA did not estimate low and high benefits estimates for reduced cancer risk or lead exposure because a single estimate for the value of a statistical life (VSL) was used to estimate mortality benefits in these categories. EPA calculated low and high estimates of total monetized benefits by adding midpoint benefits estimates for cancer risk and lead exposure to respective low and high estimates of recreation and nonuse benefits.

[b] EPA's estimate of social costs for the final regulation is based only on the estimated resource costs of compliance and is a single value instead of a range. EPA calculated low, mid, and high net benefit values by subtracting the total monetized cost estimate from low, mid, and high estimates of total monetized benefits.

[c] EPA calculated the low net benefit value by subtracting the high value of costs from the low value of benefits, and calculated the high net benefit value by subtracting the low value of costs from the high value of benefits. The mid net benefit value is the mean value of benefits less the midpoint of costs.

[d] Category values may not sum to reported totals due to rounding of individual estimates for presentation purposes.

Source: U.S. EPA analysis.

GLOSSARY

ambient water quality criteria (AWQC): published and periodically updated by the EPA under the Clean Water Act. The criteria reflect the latest scientific knowledge on the effects of specific pollutants on public health and welfare, aquatic life, and recreation. The criteria do not reflect consideration of economic impacts or the technological feasibility of reducing chemical concentrations in ambient water. The criteria serve as guides to states, territories, and authorized tribes in developing water quality standards and ultimately provide a basis for controlling discharges or releases of pollutants into our nation's waterways. AWQC are developed for two exposure pathways: ingestion of the pollutant via contaminated aquatic organisms only, and ingestion of the pollutant via both water and contaminated aquatic organisms.

ACRONYM

AWQC: ambient water quality criteria

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Chapter 20: Baseline Conditions in Ohio

INTRODUCTION

Section IV of this EEBA focuses on the state of Ohio as a case study of the MP&M regulation's expected benefits and costs. Ohio has a diverse water resource base, a relatively large number of MP&M industry facilities, and a more extensive water quality ecological database than many other states. EPA gathered extensive data on MP&M facilities and on Ohio's baseline water quality conditions and water-based recreation activities to support the case study analysis. These data characterize current water quality conditions, water quality changes expected from the regulation, and the expected welfare changes from water quality improvements at water bodies affected by MP&M discharges.

The case study analysis supplements the national-level analysis performed for the MP&M regulation in two important ways. First, the case study used improved data and methods to determine MP&M pollutant discharges from both MP&M facilities and other sources. In particular, EPA administered 1,600 screener questionnaires in the state of Ohio to augment information on Ohio MP&M facilities. The Agency also used information from the sampled MP&M facilities to assign discharge characteristics to non-sampled MP&M facilities[1]. Second, the analysis used an original travel cost study to value four recreational uses of water resources affected by the regulation: swimming, fishing, boating, and near-water activities. The added detail provides a more complete and reliable analysis of water quality changes from reduced MP&M discharges. The case study analysis therefore provides more complete estimates of changes in human welfare resulting from reduced health risk, enhanced recreational opportunities, and improved economic productivity.

CHAPTER CONTENTS

The statewide case study of recreational benefits from the MP&M regulation combines water quality modeling with a ***random utility model (RUM)*** to assess how changes in water quality from the regulation will affect consumer valuation of water resources. The study addresses a wide range of pollutant types and effects, including water quality measures not often addressed in past recreational benefits studies. The estimated model supports a more complete analysis of recreational benefits from reductions in ***nutrients*** and "toxic" pollutants.[2]

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[1] Appendix H provides a detailed discussion on the approach used to estimate discharge characteristics for non-sampled MP&M facilities.

[2] The term "toxic" used here refers to the 126 ***priority or toxic pollutants*** specifically defined as such by EPA, as well as ***nonconventional pollutants*** that have a toxic effect on human health or aquatic organisms.

This and the next two chapters present the Ohio case study. This chapter provides background information on the state of Ohio, the following chapter presents the results from the recreational benefits analysis, and the last chapter summarizes social costs and benefits of the final regulation for the state of Ohio.

20.1 Overview of Ohio's Geography, Population, and Economy

Table 20.1 summarizes general information on Ohio. Ohio is large, heavily-industrialized, and densely-populated. The state covers a total surface area of 44,828 sq. mi. (106,607 sq. km.), of which water represents 3,875 sq. mi. (10,036 sq. km.). About 90 percent of the water surface area consists of Lake Erie; the remainder includes inland waters, such as lakes, reservoirs, and rivers (including the Ohio River). The state housed 11,353,140 people in 2000. The three largest metropolitan areas are located on Lake Erie (Toledo and Cleveland) and the Ohio River (Cincinnati).

<table>
<tr><th colspan="4">Table 20.1: Facts about the State of Ohio</th></tr>
<tr><td colspan="4">Geography</td></tr>
<tr><td>Location</td><td colspan="3">Midwest United States, northeast part:
south of Lake Erie
east of Indiana
north of the Ohio River</td></tr>
<tr><td>Total land area</td><td colspan="3">40,953 sq. mi. (106,607 sq. km.)

Of the 26,451,000 acres of terrestrial surface area in Ohio:
97 percent is non-federal land (National Resources Inventory (NRI))
3,558,000 acres, representing 13.5 percent of the total area of Ohio, are developed
The remaining non-federal lands are rural land, classified mostly as crop land, forest, and pasture lands. (USDA, 1992a)</td></tr>
<tr><td>Total water surface area</td><td colspan="3">3,875 sq. mi. (10,036 sq. km.)

Approximately 90 percent is represented by Lake Erie, and 10 percent are inland waters including rivers, lakes, and reservoirs.[a]</td></tr>
<tr><td>Total area</td><td colspan="3">44,828 sq. mi. (116,104 sq. km.)</td></tr>
<tr><td colspan="4">Demographics</td></tr>
<tr><td>Population</td><td colspan="3">11,353,140 in 2000, approximately 4 percent of total U.S. population (U.S. Census Bureau)
Population increase: 4.7 percent from 1990 to 2000, compared to a 13.1 percent increase in the U.S. population overall.
Most densely populated part of the state: northeastern Ohio, both urban and rural areas.
Largest cities: Cleveland, Cincinnati, and Toledo.</td></tr>
<tr><td colspan="4">Economics</td></tr>
<tr><td></td><td>Ohio</td><td>Midwest</td><td>U.S.</td></tr>
<tr><td>Per capita income (1996$)</td><td>$23,537
Rank in per capital income in the U.S.: 21</td><td>$24,166</td><td>$24,231</td></tr>
<tr><td>Percent of population below the poverty level (1995 Current Population Survey data, DOC 1996)</td><td>11.5%</td><td>N/A</td><td>13.8%</td></tr>
<tr><td></td><td colspan="3">Ohio per capita income increased by 16 percent from 1986 to 1996.
Income growth is consistent with other midwestern states and is 2 percent greater than overall U.S. per capita income growth.</td></tr>
<tr><td>Gross State Product (GSP)</td><td colspan="3">$303,569,000,000 (1996$), representing 4 percent of Gross Domestic Product (GDP) for the U.S. in 1996.</td></tr>
<tr><td rowspan="2">Percent increase in GSP/GDP from 1986 to 1996 (in adjusted 1996$)</td><td>Ohio GSP</td><td colspan="2">U.S. GDP</td></tr>
<tr><td>25%</td><td colspan="2">29%</td></tr>
</table>

[a] Total water surface areas are estimated by the USDA's National Resources Inventory (NRI) (USDA 1992b). (http://www.ftw.nrcs.usda.gov/nri_data.html)

Source: U.S. EPA analysis.

20.2 Profile of MP&M Facilities in Ohio

EPA selected Ohio as the case study state because MP&M industries account for a large share of the state's economy (see Table 20.2). Data from the 1997 Economic Censuses show that industries containing MP&M facilities employ 19.8 percent of Ohio's total industrial workers and produce 21.2 percent of industrial worker output by value. MP&M industries also account for 22.1 percent of payroll payments, indicating that jobs in MP&M industries are more highly paid than industrial jobs on average in Ohio. The discussion below explains the sources and methodology EPA used, and then presents detailed results and caveats.

Table 20.2: MP&M Share of Industrial Output and Employment in Ohio, 1997

	Total Employment	Payroll	Value of Output
MP&M	827,507	$23,233,857,000	$132,117,226,000
Total	4,087,393	$112,777,104,000	$677,978,137,000
MP&M Share	**19.8%**	**22.1%**	**21.2%**

Source: Department of Commerce 1992 Economic Censuses.

EPA obtained employment, payroll, and output data from the 1997 Economic Census CD-ROM, drawing from the eight economic censuses in Table 20.3. Employment and payroll numbers include all employees (i.e., production plus non-production workers). The measure of output differs according to the source, but in each case the output measures shown in Table 20.2 correspond conceptually to total revenue. EPA extracted the EMPLOYEE, PAYROLL, and VALUE fields for each 4-digit SIC industry in the MP&M category and for the entire state of Ohio. Industries include both in-scope and out-of-scope facilities.

Table 20.3: The Economic Censuses

Source	Measure of Output
Census of Retail Trade	Value of sales
Census of Wholesale Trade	Value of sales
Census of Service Industries[a]	Value of receipts
Census of Transportation, Communications, and Utilities	Value of revenue
Financial, Insurance, and Real Estate Industries	Value of receipts
Census of Manufacturers	Value of shipments
Census of Mineral Industries	Value of shipments
Census of Construction Industries	Value of construction work

[a] Includes both taxable and non-taxable establishments.

Source: Department of Commerce 1997 Economic Censuses.

The MP&M industries include facilities to which the MP&M rule may not apply. For example, MP&M industries include non-dischargers, but census data do not distinguish between in-scope and out-of-scope facilities. In addition, EPA substantially revised the scope of the final regulation by excluding from the final regulation all indirect dischargers and direct dischargers in all subcategories except for Oily Wastes. Definition of MP&M subcategories is provided in Section 4.1 of this report. The final rule applies to an estimated 172 direct discharging facilities in Ohio.

Also, the analysis examines only the industrial sectors for which the Department of Commerce compiles statistics in the Economic Censuses. Published industrial employment and output measures often exclude military and other government personnel and farm output and employment, whether those exclusions are noted or not. The analysis excludes $4.7 billion in value of agricultural products sold in 1997 by farms in Ohio, according to the U.S. Department of Agriculture's 1997 Census of Agriculture. The Ohio analysis also excludes the government sector, which employed approximately 760,000 people in

Ohio in 1997, according to the U.S. Bureau of Labor Statistics.[3] These exclusions are normal when economists compare the size of industrial groups.

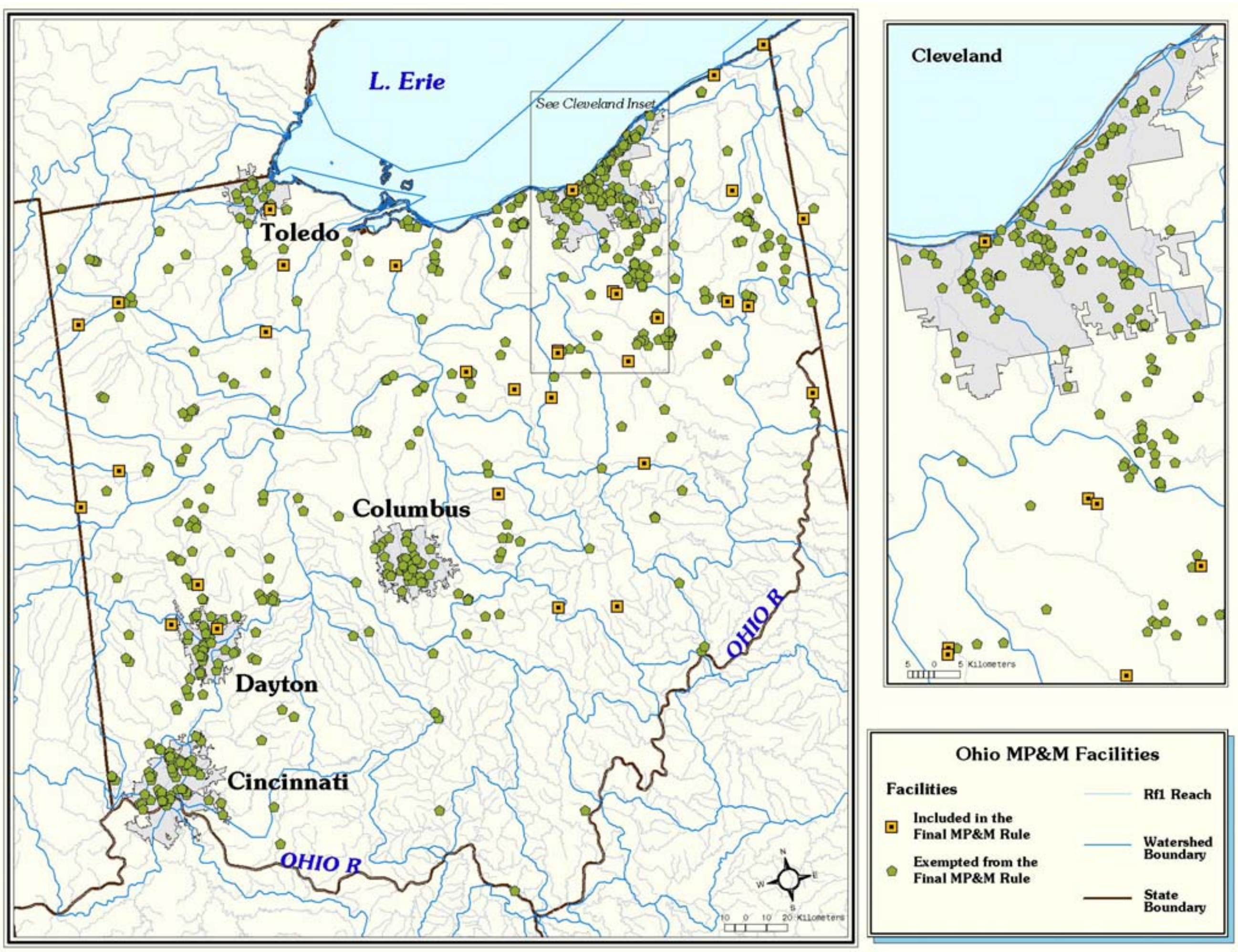
If total employment in Ohio includes the government sector, then MP&M industries account for only 16.7 percent, rather than 19.8, percent of employment. If total industrial manufacturing and non-manufacturing output in Ohio includes the agricultural sector, then MP&M industries account for only 21.0, rather than 21.1, percent of output. This said, data from the Bureau of Labor Statistics and USDA are not completely consistent with the Economic Census data.

EPA augmented information on MP&M facilities available from published data sources and the Section 308 survey by oversampling the state of Ohio with 1,600 screeners. The Agency used information from the Section 308 survey and the 1,600 screeners to characterize discharges from MP&M facilities in Ohio and to assess the economic impact of the final regulation at the state level. Figure 20.1 depicts locations of the Ohio facilities included in the case study analysis.

The map of facility locations shows that the additional information from 1,600 screeners enabled EPA to perform the benefits assessment with a greater level of detail than is possible at the national level. The added detail results in a more complete and reliable analysis of changes in human welfare resulting from reduced health risk and improved recreational opportunities.

[3] U.S. Bureau of the Census, *Statistical Abstract of the United States, 1993*, Washington, D.C., 1993.

Figure 20.1: Location of Sample MP&M Facilities in Ohio



Source: U.S. EPA analysis.

20.3 OHIO'S WATER RESOURCES

The benefits of enhanced water quality stem directly from enhancing water quality and/or quantity of services provided by water resources. To aid in understanding the analysis of benefits from the final rule in Ohio, this section summarizes environmental services provided by Ohio's water resources.

Ohio is a water-rich state:

- 24,000+ miles of named and designated rivers and streams;
- 451-mile border on the Ohio River;
- 200,000 acres among 450 lakes, ponds, rivers, and reservoirs; and
- 230+ miles of Lake Erie shoreline.

These water resources provide three broad categories of services: ***in-stream***, ***withdrawal***, and ***existence services***. Water resources provide in-stream services prior to the withdrawal of water from the water body. Major in-stream services include life support for animals and plants, water-based recreation, commercial fishing and navigation, water storage, and aesthetics. Withdrawal services include uses of water resources after the water is withdrawn from the water body. These uses include drinking water supply, irrigation, production and processing services, and sanitary services. Existence services are not linked to current uses of water bodies, and arise from knowing that species diversity or the natural beauty of a given water body is preserved.

The Ohio Environmental Protection Agency (Ohio EPA) assesses surface waters in their ***Ohio Water Resource Inventory (OWRI)*** report based on water resource services provided by the assessed water body. The main focus of this assessment is on beneficial uses associated with Ohio's water resources, including aquatic life use, recreation, and public water supply. Table 20.4 shows how Ohio surface waters fall into these use designations.

Table 20.4: Summary of Designated Life Uses for Ohio Surface Waters (1996)

Use Designation	Stream/River (Miles)[a]	Lakes / Reservoir (Acres)[a]	Lake Erie (Shore Miles)[a]
Total	43,917	200,000	236
Aquatic Life Use[a]	24,067	193,903	236
Exceptional Warmwater Habitat (EWH)	3,217	193,903	236
Warmwater Habitat (WWH)	18,318		
Other	2,532		
Recreation			
Primary Contact (PCR)[b]	224,96	200,000	236
Secondary Contact (SCR)	1,188		
Public Water Supply		118,801	

[a] Total river/stream miles are based on Ohio EPA estimates. U.S. EPA estimates 61,532 total river miles and 29,113 total perennial miles based on RF3, which includes many smaller undesignated streams.
[b] Note that some water bodies have more than one designated use (e.g., aquatic life and primary recreation).

Source: Ohio EPA, OWRI, 1996.

The aquatic life use category is further subdivided into seven categories. The most widely-applied aquatic use designation in Ohio is ***Warmwater Habitat (WWH)***, accounting for 18,318 (76 percent) stream and river miles (Ohio EPA, OWRI, 1996). The second most widely applied designation is ***Exceptional Warmwater Habitat (EWH)***, accounting for 3, 217 stream and river miles (13 percent), 236 Lake Erie shore miles (100 percent), and 193,903 acres of inland lakes (100 percent). Other aquatic life categories include:

- ***Modified Warmwater Habitat (MWH)***,
- ***Limited Resource Waters (LRW)***,
- ***Limited Warmwater Habitat (LWH)***,
- Seasonal Salmonid Habitat ***(SSH)***, and
- ***Coldwater Habitat (CWH)***.

Recreational uses are subdivided into ***Primary Contact Recreation (PCR)*** and ***Secondary Contact Recreation (SCR)***:

- Primary Contact Recreation (PCR) rivers and streams deep enough for full human body immersion activities, such as swimming.
- Secondary Contact Recreation (SCR) only deep enough to permit wading and incidental contact, such as boating.

Approximately half of the designated stream miles, all inland lakes, and all of the Lake Erie shore miles are designated for PCR (see Table 20.4). In addition, three percent of the designated stream miles (1,188 miles) are suitable for SCR.

The following sections detail each category of water resource use.

20.3.1 Aquatic Life Use

The Ohio water resources support hundreds of aquatic species and plants. Ohio water resources are also home to a number of endangered and threatened species. Suitable stream and lake habitat are essential for both resident and transient animal populations, including imperiled aquatic species. Habitats include specific ***biotic*** components (e.g., assemblages of plant and animal species) and physical (e.g., ***dissolved oxygen (DO)*** content and temperature range) components. Water quality impairments associated with siltation, excess nutrients, or low DO can adversely affect habitats that support important activities, such as reproduction, foraging, migration, and overwintering.

The following sections briefly introduce water-dependent biological resources in Ohio. Water quality effects on life support for animals and plants are discussed in Section 20.5

a. Ohio fish species

Fish are found throughout Ohio in almost every inland surface water body and Lake Erie. Many fish species serve important recreational or commercial functions, while others are important forage for birds, other fish, and land-based species. Ecosystem well-being therefore depends on the health of fish and other aquatic species populations. The Ohio EPA monitors biological data, especially those on sensitive aquatic species, to determine the aquatic life use attainment of surface waters. The state gives high priority to healthy aquatic ecosystem maintenance.

Ohio's rivers and lakes offer a variety of man-made and natural habitats that offer excellent fishing opportunities for numerous gamefish species. The state of Ohio spends significant resources on fishery management, trout stocking, and recreational area maintenance to enhance these fish populations. Table 20.5 below provides brief summaries of the habitat and diet of major recreational and commercial fish species in Ohio (Ohio DNR, 1999).

Table 20.5: Recreationally or Commercially Valuable Fish Species in Ohio

Fish	Native or introduced?	Habitat	Spawning season	Diet
Bass	Most native bass (e.g., largemouth, smallmouth, spotted, and sock)	Ponds, lakes, rivers, and streams in every county; Lake Erie	Mid-April to mid-June	Frogs, crayfish, insects, and other fish
Bullhead	Native	Throughout Ohio; concentrations in northern and west central Ohio	Mid-May to June	Insect larvae, crayfish, snails, dead animals
Burbot	Native	Lakes and rivers; prefer deep waters, but move inshore to spawn	Winter	Minnows and the young of other fish species
Carp	Introduced	Warm lakes, streams, and ponds with abundant organic matter, in every county	Late April to June	Insect larvae, mollusks, fish, crustaceans
Catfish (channel, flathead)	Native	Throughout Ohio's rivers and lakes; tolerate a wide range of conditions	When waters reach 70° F in temperature	Bottom feeders with a diet of insect larvae, mollusks, and fish both dead and alive

Table 20.5: Recreationally or Commercially Valuable Fish Species in Ohio

Fish	Native or introduced?	Habitat	Spawning season	Diet
Crappie, white		Larger ponds, reservoirs, and rivers, including near-shore habitats of Lake Erie, in most areas of Ohio	May and June	Insects and small fish
Crappie, black		Same general habitat as white crappie, slightly less widely distributed	May and June	Insects and small fish
Drum	Native	Lake Erie; drums support a commercial fishery	Spring into late summer	Mollusks, crayfish, fish, insects
Lamprey		Lake Erie and tributaries; Ohio River and larger tributaries		Some species parasitize other fish by attaching themselves to a larger host's flank and feeding on its flesh
Muskellunge (Muskie)	Native	Historically found in Lake Erie bays and tributaries and streams of Ohio River drainage; now also found in several impoundments	April and early May, when temperatures reach low- to mid-50s	Suckers, gizzard shard, and other soft-rayed fish
Perch, white	Introduced	Lake Erie and tributaries	April and May	Insects, crustaceans, other fish
Perch, yellow	Native	Lakes, impoundments, ponds, slow-moving rivers	April and May	
Pike	Native	Historically abundant in Lake Erie and tributaries; today distributed in a small portion of Lake Erie, Sandusky Bay, Maumee Bay, and their tributary streams in marshes, bays, and pools with abundant vegetation	As ice breaks in late February and early March Pike is a popular ice-fishing species	Mostly fish, but are opportunistic feeders; will occasionally eat frogs, muskrats, small ducks
Salmon (chinook and coho)	Introduced	Stocked in Lake Erie for both recreational and commercial fishing purposes		
Sauger	Native	Lake Erie and its tributaries; Ohio River	Spring, when water temperatures reach high 40s	Insects, crayfish, other small fish during low light (dawn and dusk)
Saugeye (cross between sauger and walleye)	Introduced	Stocked into many Ohio impoundments		
Sucker, white	Native	Every county; Lake Erie	April to May	Bottom feeders, consuming various plant and animal species
Sunfish	Bluegill, pumpkinseed, green, warmouth, and longear sunfish are native; redear sunfish are introduced	Rivers, streams, and lakes throughout Ohio, and Lake Erie	Between May and August	Adults feed mostly on smaller fish, insects, crustaceans

Table 20.5: Recreationally or Commercially Valuable Fish Species in Ohio

Fish	Native or introduced?	Habitat	Spawning season	Diet
Trout	Lake and brook trout are native; rainbow and brown trout are introduced and maintained by stocking	Lake trout populations are stocked in Pennsylvania and New York and are not highly prevalent in Ohio and Lake Erie waters; Brook trout are stocked in several locations throughout Ohio		
Walleye	Native	Historically found in Lake Erie, but has been stocked in the Ohio River and reservoirs throughout the state	April	Shiners, gizzard shad, alewives, rainbow smelt
Whitefish	Native	Shallow bays of Lake Erie's western basin		Bottom feeders with a diet of mollusks and insect larvae

Source: U.S. EPA analysis.

b. Other species dependent on aquatic resources

Resident and migratory bird species make extensive use of Ohio waters. Areas along the banks or shorelines of rivers, streams, lakes, ponds, and reservoirs provide high quality nesting areas; the waters themselves are an abundant source of food. Ohio waters also serve as important staging areas for birds migrating to or from points north or south. Wading or aquatic birds are generally unaffected by water quality impairments directly. They are affected indirectly, however, through feeding on fish or invertebrates whose populations may be affected by point and non-point pollution sources. The regulations aimed at protecting aquatic species will therefore benefit wading and aquatic bird species indirectly. More than 130 aquatic bird species rely on Lake Erie and its tributaries. Many species are also found near inland surface waters. Major classifications of birds in Ohio include (Ohio DNR, 1999):

- Waterfowl, residing year-round in Ohio waters, especially Lake Erie. Large groups of migrating and breeding birds are also found elsewhere in the state. More than 30 species are associated with the Great Lakes area alone. All species depend on fish and crustaceans or aquatic plants for feeding. Waterfowl include loons, grebes, swans, ducks and geese. The trumpeter swan is of particular interest to Ohio, which became one of several states involved in efforts to restore these birds to the Midwest beginning in 1996 (Ohio DNR, 1999).

- Wading birds, including bitterns, herons, and egrets. These species both reside in Ohio waters and use them as breeding grounds. They use "stand-and-wait" methods to catch fish or other aquatic organisms in shallow waters. Many wading birds, such as the great egret, black-crowned night heron, and American bittern, frequent Lake Erie and surrounding areas.

- Marsh birds, including rails, moorhens, coots, and gallinules. They may feed on insects, crustaceans, mollusks, frogs, invertebrates, and small fish. These bird populations suffer from excessive development and habitat destruction. Ohio surface waters, especially those around Lake Erie, can serve as important breeding grounds for these and other bird species.

- Shore birds, including 42 species of plovers, sandpipers, gulls, and terns, in the Lake Erie and other Ohio areas. Many of them feed on aquatic organisms from Lake Erie.

- Raptors, including the bald eagle and osprey. These birds of prey rely on fishing for a large part of their diet. Bald eagles are also a nationally-listed threatened species.

- The belted kingfisher, which relies on fish in Ohio waters as a main source of food.

Ohio's biological resources also includes reptiles. Several species of lizards, snakes, and turtles depend on aquatic habitats for food and breeding. These reptiles include:

- Lizards - The five-fined skink, reported in areas along Lake Erie, can be found throughout Ohio.

- Snakes - The eastern fox snake, Eastern massasasuga, eastern ribbon snake, copperbelly water snake, Lake Erie water snake, and northern water snake feed within aquatic habitats.

- Turtles - The midland smooth softshell turtle and eastern spiny softshell turtle, found in the Ohio River and tributaries, are among Ohio turtles requiring aquatic habitats.

20.3.2 Water Recreation in Ohio

EPA used the 1994 ***Survey of National Demand for Water-based Recreation (NDS)*** (U.S. EPA, 1994) to characterize recreational uses of Ohio's water resources. The 1994 survey collected data on demographic characteristics and water-based recreation behavior using a nationwide stratified random sample of 13,059 individuals aged 16 and over. Respondents reported on water-based recreation trips taken within the previous 12 months, including the primary purpose of their trips (e.g., fishing, boating, swimming, and viewing), total number of trips, trip length, distance to the recreation site(s), and number of participants. EPA estimated recreational water use in Ohio by taking the following steps:

- estimate the percentage of survey respondents that visited Ohio, by state;

- apply this percentage to the total number of state residents aged 16 and over, to yield the total number of participants from each state;

- estimate the total number of recreation trips during the 12-month period for in-state and out-of-state participants;

- estimate the total number of recreation trips for out-of-state participants by multiplying an average number of trips per Ohio water body visitor by the total number of participants from each state;

- estimate the average number of annual trips per out-of-state visitor based on the number of times the respondents visited the site of their last recreational trip (i.e., Ohio water body).[4] EPA assumed that Ohio residents whose last recreation trip was in-state used Ohio water bodies for all of their recreation trips during the 12-month period; and

- estimate the total number of in-state trips, summing the weighted number of recreation trips over all Ohio respondents.

EPA found that:

- An estimated one million individuals made about 6.3 million boating trips to Ohio waters in 1993. In-state residents made 90 percent of the boating trips.

- Approximately one million people visited Ohio water bodies for recreational fishing.[5] These visitors accounted for about 15.6 million fishing trips to the area. Recreational fishermen from Ohio were the most frequent users of the state water resources, representing approximately 97 percent of all visitors.

- Approximately 972,000 and 896,000 visitors used the Ohio water bodies for near-water viewing and swimming, respectively, in 1993. These visitors account for approximately 9.4 and 7.8 million viewing and swimming trips to the area. Ohio residents account for 89 percent of viewers and 93 percent of swimmers.

- Most out-of-state recreational users came from the states surrounding Ohio, such as Indiana, Michigan, and Pennsylvania.

[4] NDS collected information only on the last site visited. Its numbers do not reflect people whose last visit was to a different area, but who may have also visited an Ohio water body on a previous trip during the year. See Section 21.3 for detail on the NDS data.

[5] EPA compared the estimated number of participants with total fishing licenses issued by Ohio in 1996. Ohio issued a total of 895,770 licenses for resident and nonresident fishing. The NDS data therefore provide relatively accurate information on participation rates.

20.3.3 Commercial Fishing in Ohio

Commercial fishing is a minor activity in Lake Erie: 12 license holders share a total of 19 licenses (LECBA 2003). Commercial catch data compiled by the Great Lakes Fishery Commission are summarized in Table 20.6 (Baldwin et al. 2002).

Table 20.6: Commercial Catches for Ohio Lake Erie Waters (1990)

Fish	Catch (1990 lbs)
Yellow perch	1,559,000
Carp	1,190,000
White perch	786,000
Sheepshead	640,000
White bass	392,000
ChannelcCatfish	365,000
Quillback	134,000
Buffalo	132,000
Bullheads	59,000
Suckers	41,000
Goldfish	31,000
Gizzard shad	19,000
Lake whitefish	10,000
Rock bass	1000

Source: Baldwin et al. (2002)

Yellow perch represents about half of the dockside value for the entire commercial fishery in the Ohio waters of Lake Erie. The value of this fishery ranged from $1.3 million to $2.5 million between 1993 and 1998. Overfishing and pollution have decreased the yellow perch population throughout Lake Erie dramatically over the past 30+ years. Annual catches averaged around 20 million pounds during the 1960s and 70s. The Lake Erie Committee set the 1998 lakewide ***total allowable catch (TAC)*** quota for this species at 7.44 million pounds. The yellow perch fishery rebounded somewhat over the past couple of years, due to strong annual recruitment, strict commercial catch restrictions, and a strict creel limit of 30 fish per day for the sport angler (LECBA 2003).

20.3.4 Surface Water Withdrawals

Water resources provide a wide range of services upon being withdrawn (removed) from the water body. Once used, water can be returned to its original sources, returned to another water body, or consumed (e.g., for human drinking water). Water withdrawals from surface water averaged 9,615 mgd in 1995 (USGS 1995). The majority of this water is used in power generation, accounting for 85 percent of all surface water withdrawals. Public water supply accounts for ten percent of all withdrawals. Industrial and commercial water use account for one and four percent of the total, respectively. Water quality and quantity impairments can have substantial impacts on the key withdrawal services that water provides to a wide range of economic entities.

20.4 Surface Water Quality in Ohio

This section describes current water quality conditions in Ohio and the effects of water quality impairments on beneficial uses of Ohio's water resources. Ohio EPA assessed designated use attainment in approximately 42 percent of Ohio streams and rivers; approximately 64 percent of lakes, ponds, and reservoirs; and all of the Lake Erie shoreline (Ohio EPA, OWRI, 1996). The OWRI report summarizes the results of this assessment. This report provides information on designated use support by water type and use designation, identifies major pollutant/stressors that affect the quality of surface water bodies and prevent designated use attainment, and lists major sources of impairment. The following three sections summarize findings from the 1996 OWRI report.

20.4.1 Use Attainment in Streams and Rivers in Ohio

Most water bodies are designated for several uses and more than one use can be impaired at a time. The most commonly occurring sole impairment in fresh water bodies is to aquatic life support. The Ohio EPA used an ecosystem approach that relies on various tools to determine aquatic life use attainment. Water chemistry, physical and habitat assessment, and direct sampling of biota all contribute to determine whether a water body meets an attainment status. Field data yield biological indices that eventually determine a final attainment score.

Ohio EPA assessed 6,560 perennial river miles for aquatic life use attainment. Of the 6,560 river miles assessed for aquatic life use:

- 38.5 percent (2,536 miles) are in full attainment (i.e., all water quality indicators meet criteria for specific water bodies);
- 10.8 percent (708 miles) are in full attainment, but are threatened by pollution and other sources;
- 23.3 percent (1,528 miles) are in partial attainment (i.e., one of two, or two water quality indicators do not meet criteria); and
- 27.4 percent (1,797 miles) are in non-attainment (i.e., no criteria are met or the river experiences a severe toxic impact).

Fecal coliform bacteria counts determine recreational use attainment. Such counts are less stringent for Secondary Contact Recreation than for Primary Contact Recreation. Ohio EPA has assessed 2,402 river miles for recreation use since 1988 (Ohio EPA, OWRI, 1996). Of the 2,402 river miles assessed for recreation use:

- 57 percent (1,370.3 miles) of the sampled rivers and streams are in full attainment (i.e., a water body meets all chemical criteria for recreational use and human contact);
- 19.7 percent (474.1 miles) are in partial attainment (i.e., a water body only partially meets human contact criteria); and
- 23.2 percent (557.4 miles) are in non-attainment (i.e., a water body fails to meet human contact criteria).

20.4.2 Lake Erie and Other Lakes Use Attainment

Lake Erie, which has a history of pollution problems, currently has fish consumption advisories for carp and channel catfish (Ohio DNR, 1999). Ohio EPA assesses Lake Erie as having partial use attainment for aquatic life and fish consumption, and full attainment for recreation.[6] Ohio EPA used parameters specified by the ***Ohio EPA Lake Condition Index (LCI)*** to develop use attainment for other lakes. Only approximately two percent of all lakes are in full use attainment for aquatic life, recreation, and fish consumption. Approximately 82, 50, and 53 percent are in full attainment for aquatic life, recreation, and fish consumption, respectively, but are threatened by pollution for these categories. High percentages of lake acres are in partial attainment for recreation (38.8 percent) and public supply (43.8 percent) use designations. Table 20.7 shows use attainment for Lake Erie and other lakes, ponds, and reservoirs.

[6] Further methodologies to better assess use attainment in Lake Erie are still under development by the Ohio EPA.

Table 20.7: Use Attainment Summary for Lake Erie ane Other Lakes									
Use Category	% of Total Units Assessed	Full Attainment		Full Attainment, Threatened		Partial Attainment		Non-Attainment	
	%	Units	%	Units	%	Units	%	Units	%
Lake Erie (Unit: Shore Miles) [a]									
Aquatic Life (EWH)	100					236	100		
Recreation	100	231	98			5	2		
Fish Consumption	100					236	100		
Lakes, Ponds, & Reservoirs (Unit: Acres)									
Aquatic Life (EWH)	64.7	1,651	2.2	63,174	82.2	10,686	13.9	1,302	1.7
Recreation (PCR)	64.4	1,392	1.8	38,499	50.3	29,793	38.9	6,582	9.0
Public Water Supply	64.1	1,301	1.7	40,846	53.6	33,365	43.8	673	0.9

[a] Assessments are based on unit of measure presented in parentheses.

Source: Ohio EPA, OWRI 1996.

20.4.3 Causes and Sources of Use Non-Attainment in Ohio

Ohio EPA assessed the causes and sources of impairment to Ohio surface waters and examined trends in major causes and sources from previous assessment cycles. The following discussion summarizes findings from the 1996 OWRI report (Ohio EPA, 1996).

a. Causes

Causes are the agents responsible for damage and threats to aquatic life. The major causes of impairment in Ohio surface waters include:

- organic enrichment/low DO,
- habitat modifications,
- siltation,
- flow alteration,
- nutrients, and
- metals.

Ohio EPA examined trends in these major causes from previous assessment cycles through 1996. They found that point source-related causes declined, while non-point sources became major contributors. Ohio EPA concluded that this trend "reflects the relative effectiveness of the programs to control point sources compared to general lack of measures to control many [non-point sources]" (Ohio EPA, OWRI, 1996).

Organic enrichment, which alters DO levels and affects aquatic communities, is the main cause of impairment in Ohio's rivers and streams. Inadequate wastewater treatment from municipal and industrial point sources account for most of this impairment. Metals are a major cause of impairment to approximately 226 river miles, a moderate cause of impairment to 179 river miles, and a minor cause of impairment or threat to 165 river miles.

Nutrients, resulting mostly from agricultural non-point sources, are the main cause of impairment in lakes. Metals are a major cause for impairment in approximately 250 acres of Ohio's lakes, ponds, and reservoirs, and form the main cause of impairment in Lake Erie, the major water resource in Ohio (90 percent of the surface water volume). Highly developed areas bordering the lake contribute urban runoff, along with discharges from industrial and municipal sources. Other causes of impairment in Lake Erie include ***priority organics***, DO, and nutrients.[7]

b. Sources

Sources are the origins of the agents responsible for damage and threats to water resources. The major sources of impairment to Ohio surface waters include:

- municipal and industrial discharges,
- hydromodification,
- agricultural runoff,
- urban runoff, and
- mining.

Point source-caused impairment has declined over time, while that from non-point sources, such as agricultural and urban runoff, has increased. Point sources remain a major source of impairment in almost 900 miles, or 25 percent, of Ohio's affected rivers and streams. Point sources are the major source of impairment for Lake Erie. They form a major source of impairment for 24 shore miles, and a moderate source of impairment for an additional 281 shore miles of Lake Erie. In addition, point sources adversely affect 1,678 lake acres.

Non-point sources related to agricultural and urban runoff form the major source of impairment for some 9,000 acres, or two-thirds of Ohio's lakes, ponds, and reservoirs. In addition, 46 Lake Erie shore miles list non-point sources as their major impairment source.

20.5 Effects of Water Quality Impairments on Water Resource Services

Water resource services are negatively affected by pollutants that impair the aquatic ecosystems. Certain pollutants can adversely affect aquatic species directly by increasing species morbidity and/or impairing reproductive success, or indirectly by adversely altering food chain interactions. These direct and indirect impacts can change quantity and type of fish and other species in the aquatic ecosystem. In the worst case scenario, an impaired ecosystem no longer supports any aquatic life. High pathogen counts or excessive eutrophication in water bodies that are suitable for swimming may force swimmers to go elsewhere or forego swimming altogether. Any aesthetic degradation decreases the value of each individual's recreational experience. In severe cases, the affected water bodies become unsuitable for recreation. Water quality impairments also increase the cost of treating water to meet drinking water standards.

This section details the effects of water quality impairments on in-stream services provided by Ohio's water resources.

20.5.1 Effect of Water Quality Impairment on Life Support for Animals and Plants

Deficiencies in water quantity and quality can impair the health of aquatic ecosystems. In worst case scenarios, the ecosystem may no longer support aquatic life at all. The major causes of water quality impairment in Ohio include high ***biological oxygen demand (BOD)*** from organic enrichment, habitat and flow alterations, nutrients, ***siltation*** and ***turbidity***, ***metals***, ***pH***, ***ammonia***, and priority organics. Habitat, flow alterations, and thermal discharges are unrelated to MP&M effluents and are not discussed here. MP&M effluents contribute to the remaining major causes of water quality impairment, with the ecological effects outlined below.

a. BOD/COD

BOD and ***chemical oxygen demand (COD)*** are two methods to determine the oxygen requirements of pollutants in wastewater. Low oxygen level is the primary cause of impairment in Ohio's rivers and streams and a major source of

[7] Major, moderate, and minor impacts refer to the high, moderate, and slight magnitude codes specified by the U.S. EPA for the 301(b) report.

impairments in Ohio's lakes. When bacteria decompose excess organic matter, they consume DO in surface waters. Oxygen is needed to chemically (abiotically) oxidize the pollutants present in wastewater. When too much oxygen is needed to oxidize pollutants, hypoxic (oxygen deficient) or anoxic (oxygen depleted) conditions result. Sources of high oxygen demand include effluents from municipal treatment plants and certain industries, and runoff from feedlots or farms. Another source is ***eutrophication*** caused by excessive nutrient input. The nutrients stimulate algal blooms. Bacteria consume the algae when they die, decreasing DO in the water column. DO is a critical variable for fish and invertebrate survival. If oxygen concentrations drop below a minimum level, organisms suffocate and either move out or die (EPA, 1986). This effect can drastically reduce the amount of useable aquatic habitat.

b. Nutrients

Nutrients are the leading causes of impairment in Ohio lakes and comprise one of the major causes of impairment in rivers, streams, and Lake Erie. The overabundance of nitrogen and phosphorus is one of the most documented forms of aquatic ecosystem pollution. Although both compounds are essential nutrients for phytoplankton (free-floating algae) and periphyton (attached algae), which form the base of the aquatic food web, too much nutrient input overstimulates primary productivity and results in eutrophication. The impact of these compounds has contributed significantly to water quality decline in the United States (EPA, 1992). Phosphorus is a limiting nutrient in most freshwater systems (Wetzel, 1983), whereas nitrogen is typically limited in estuarine and marine systems.

In freshwater, excess phosphate (PO_4) has been linked to eutrophication and nuisance growth of algae and aquatic weeds (Wetzel, 1983), even though direct toxicity to fish and other aquatic species is not a major concern. DO in the water column decreases, however, when algae and other aquatic plants die off, and certain toxins may be produced, both of which can contribute to fish kills.

c. Siltation and turbidity

Siltation and turbidity are the third leading causes of impairments in Ohio rivers and lakes, except Lake Erie. Siltation is the most important factor in surface water degradation in the U.S. (EPA, 1992). Major sources include urban and stormwater runoff, mining and logging activities, and runoff from plowed fields (EPA, 1992). All these inputs create cloudy water with increased turbidity and decreased visibility and light penetration. High primary productivity by phytoplankton following excessive nutrient input can also increase turbidity. Excess suspended matter decreases the amount of light penetrating the water column, which can reduce primary productivity. This turbidity can eliminate or displace fish species requiring clear water to live, feed, or reproduce.

d. Metals

Metals are the leading cause of impairment in Lake Erie and comprise one of the major causes of impairment in inland lakes and rivers. Metals are naturally-occurring inorganic constituents of the earth's crust. Priority pollutant metals commonly found in the aquatic environment include antimony, arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium and zinc (EPA, 1998a). These compounds enter the aquatic environment via urban stormwater runoff, industrial and municipal effluents, and atmospheric deposition. As a group, metals can be highly toxic: ***water quality criteria (WQC)*** for acute toxicity range from around 1,100 ***µg/l*** (chromium VI in saltwater) to around 1 µg/l (mercury in freshwater); WQC for chronic toxicity range from 120 µg/l (zinc in freshwater) to <1.0 µg/l (mercury in salt- and freshwater) and are therefore an order of magnitude lower (EPA, 1998a).

Once metals reach the aquatic environment, they tend to associate with organic and inorganic particulates in the water column. Sediments become long-term sinks for metals, which accumulate in the bottom. Metals can enter the food chain when ingested by benthic invertebrates or other burrowing organisms. Most metals have ***bioconcentration factors (BCFs)*** ranging from 100 to 10,000 and can therefore bioaccumulate in aquatic organisms. A few, including selenium, lead, and mercury, may reach hazardous levels in fish or wildlife receptors and result in avian developmental or neurological abnormalities.

e. Organic chemicals

Priority organics are the second most frequent cause of impairment in Lake Erie and comprise one of the major causes of impairment in rivers and streams. Thousands of different compounds exist as organic chemicals, including petroleum hydrocarbons and myriad industrial chemicals. They enter the aquatic environments via municipal and industrial effluents, stormwater runoff, contaminated groundwater, atmospheric deposition, illegal dumping, or accidental releases. Aquatic toxicities vary by orders of magnitude depending on the compound. Factors influencing toxicity and long-term ecological effects include water solubility, volatility, biodegradation potential, and bioaccumulation potential.

Excessive amounts of organic chemicals degrade surface water quality by causing acute or (more typically) chronic toxicity. This toxicity impairs growth, development, and/or reproductive success in fish and aquatic invertebrates. Persistent and low water-soluble organic chemicals accumulate in sediments and are taken up into local aquatic food chains. They can reach dangerous concentrations in fish and avian receptors, resulting in reproductive failures or other avian health effects.

f. pH

Approximately 180 river miles are pH-impaired in Ohio. pH is a measure of acidity. Acid reaches surface waters via atmospheric deposition ("acid rain"), industrial effluents, and leachates from mine ***overburdens*** or spoils. Acidity by itself is a key variable shaping aquatic communities: it is a toxicant in its own right but also controls metal solubility, and the toxicity of several metals and ammonia.

Aquatic species vary widely in their sensitivity to pH: the most sensitive vertebrate and invertebrate species die off when average pH ranges between 6.0 and 6.5. Most fish species are eliminated when pH reaches 5.0. Only a few can survive at pH 4.5 (U.S. EPA, 1999). Macro invertebrates exhibit the same pattern, except that hardy species can survive down to a pH of about 3.5.

g. Ammonia

Large amounts of ammonia enter lakes and rivers via wastewater treatment plants and industrial effluents, atmospheric deposition, and non-point source surface runoff. Approximately 150 river miles in Ohio are ammonia-impaired. This compound, unique among regulated pollutants, is also produced naturally inside fish as a metabolic waste product. Excess ammonia usually diffuses rapidly out of the blood stream and into the surrounding water via the gills. High concentrations of external ***un-ionized*** ammonia (NH_3) reduce or reverse this diffusive gradient and allow ammonia to build up to toxic levels inside the organism (EPA, 1998c).

Ammonia in surface water exists in two major forms: un-ionized ammonia (NH_3), which is highly toxic to fish or invertebrates, and ammonium ion (NH_4^+), which is much less toxic. Which form prevails depends mainly upon the pH level; temperature and ionic composition play a smaller role. EPA calculated a WQC that becomes more severe with decreasing acidity. For example, the acute criteria for surface waters containing salmonids equals 36.7 mg/l at pH=6.0 but only 2.14 mg/l at pH=8.5. For surface waters without salmon, the acute criteria for the same pH equal 55.0 mg/l and 3.2 mg/l, respectively (EPA, 1998c).

20.5.2 Effect of Water Quality Impairment on Recreational Services

Healthy surface waters are essential to support a diversity of recreational uses, including viewing and other near-water activities. Industrial or other human activities impair surface water quality. Certain metals and chlorinated compounds can bioaccumulate in aquatic food chains and reach unhealthy levels in carnivorous fish or shellfish. Health advisories to limit or avoid their consumption may result. High concentrations of toxic compounds can also lead to human contact advisories. The release of untreated or poorly treated sewage can cause high levels of pathogenic bacteria in water and result in swimming advisories or beach closures. All of these actions limit the full use of surface waters and can have significant local economic impacts.

a. Fish consumption advisories

In 1997, the Ohio Department of Health ***(ODH)*** issued a statewide fish consumption advisory to protect women of childbearing age and children six years or younger against mercury's neurological and developmental effects. The advisory, which applies only to these two population groups, recommended that these women and children eat no more than one meal per week of any fish caught in Ohio waters. The advisory covers all state waters because most of the mercury measured in fish tissues originates from region-wide fossil fuel combustion processes. The mercury reaches surface waters via atmospheric deposition on the surrounding landscape (Ohio DNR, 1999).

Since 1983, the ODH has developed numerous water body-specific fish consumption advisories for approximately 174 water body segments (rivers and lakes) and Lake Erie. These water bodies represent a relatively small fraction of Ohio's 5,000 discrete water body segments, as determined by Ohio EPA. The contaminants of greatest concern include ***polychlorinated biphenyls (PCBs)***, mercury, ***polycyclic aromatic hydrocarbons (PAHs)***, lead, organometallics, Mirex, phthalate esters, Chlordane, and hexachlorobenzene. Of these, four mercury, PAHs, lead, and phthalates are included on the MP&M list of ***pollutants of concern (POCs)***. As a group, these contaminants are generally characterized as lipophilic (i.e., fat loving), resistant to biological degradation or cellular metabolism, and toxic. Once they reach surface water, they concentrate in sediments and bioaccumulate or biomagnify through aquatic food chains. These compounds can linger for decades in aquatic systems.

The kind of sports or recreational fish species affected by the consumption advisories varies by water body segment. More than 23 different species are covered by advisories, including walleye, common carp, sauger, saugeye, white crappie, freshwater drum, and various species of bass, perch, catfish, salmon, trout, suckers, and sunfish. Restrictions vary depending on the pollutant, the fish species concerned, and the concentrations measured in edible tissues. The ODH developed maximum recommended rates of fish consumption that include outright consumption bans, one meal every two months, one meal a month, or one meal a week. The same water body segments can commonly have different advisories for different fish species (Ohio DNR, 1999).

b. Contact advisories

The ODH also issued human contact advisories for nine water body segments in Ohio located on the Black River, Little Scioto River, Mahoning River, the middle fork of the Little Beaver Creek, and the Ottawa River. Swimming or wading is prohibited due to the presence of high levels of PAHs, PCBs, Mirex, phthalate esters, and/or Chlordane. Of these, PAHs and phthalates are included on the list of MP&M POCs. Fish consumption advisories also cover all of these segments (Ohio DNR, 1999).

c. Beach closures

Beach closures typically occur during the summer months when high levels of fecal coliform bacteria or other disease-causing organisms (e.g., *Escherichia coli*) proliferate in surface waters. Such waters can become contaminated from several sources, including: agricultural runoff, sewer overflows, boating wastes, and poor hygienic practices by some bathers. Excessive levels of indicator pathogens in surface waters can indicate a serious threat to human health and may cause health departments to post warnings, restrict access, or forbid swimming altogether. The MP&M regulation is not expected to reduce beach closures during summer months.

Numerous public bathing beaches dot Ohio's 262-mile shoreline along Lake Erie. The ODH has developed a composite metric based on *E. coli* counts in surface waters at 11 selected beaches along Ohio's north coast. The metric tracks the average number of days that swimming advisories are posted at the 11 beaches for a 15 week period beginning around Memorial Day and continuing through Labor Day. The most recent data available show that the 11 beaches were under advisement an average of 21 days during the summer months (minimum of 0 days and maximum of 49 days) in 1996.

The ODH developed a 4-tiered scale to score and track the average number of days that the 11 public beaches are under advisement from one year to the next. Between 1990 and 1996, the average (based on a five-year running average) number of beach advisories scored in the "fair" category consistently, meaning that the beaches were under advisement between 20 and 30 days in the summer (State of Ohio, 1998).

Ohio's lakes, ponds, and reservoirs (excluding Lake Erie) yielded no quantitative data on beach closures. The 1996 Ohio Water Resource Inventory of Public Lakes, Ponds and Reservoirs provides a breakdown of the portion of Ohio's 446 public lakes that are threatened or impaired as a result of high levels of fecal coliform bacteria.

20.6 Presence and Distribution of Endangered and Threatened Species in Ohio

Many factors can affect the survival of ***endangered and threatened (E&T)*** species. Some factors are species-specific; others result from one or more anthropogenic stressors. Inherent vulnerability factors include narrow geographic distribution, slow reproductive rates, or requirements for large areas. Major anthropogenic stressors include intentional taking (e.g., fishing), incidental taking, physically altering habitat (e.g., converting wetlands into agricultural land), water pollution, and introducing alien species. A single stressor or a set of stressors can contribute to a species' decline or extinction. Previous studies reported that more than 40 percent of endangered aquatic species were affected by five or more environmental stressors, and only seven percent of federally-listed species had a single threat to their survival. Although stressors seldom act alone, water pollution is one of the major hazards to E&T aquatic species, cited as responsible for the decline of 19 (54 percent) out of 35 E&T fish species in Ohio (Ohio DNR, 1998).

The following sections provide an overview of E&T species found in Ohio, their distribution, and the major hazards threatening their survival. Species discussed below include those listed under both the federal ***Endangered Species Act*** (50 CFR Part 17) and the Ohio Department of Natural Resources' ***(DNR)*** Division of Natural Areas and Preserves. The MP&M regulation concentrates on water-related benefits; these sections therefore describe only those species associated with aquatic environments.[8] The DNR list includes 90 E&T species with a total of 1,227 observations throughout Ohio. "Observations" refers to locations where species were observed; most species have multiple observations. This analysis includes observations spanning the years 1980 to 1988.

20.6.1 E&T Fish

E&T fish inhabit almost every major water body in Ohio, including Lake Erie and the Ohio River and its tributaries. The Ohio DNR lists 35 total state-listed E&T fish species, of which 13 are threatened and 22 endangered. The list includes only one federally-listed species, the scioto madtom.

Of the total E&T fish, approximately 12 species use Lake Erie as a possible habitat and nine use the Ohio River. Most of the species listed live in riverine habitats. Approximately 28 species were identified in a river system in Ohio, including the Ohio, Scioto, Muskingham, Miami, Walhondig, and Maumee River systems. MP&M facilities are found on all these major river systems.

The DNR lists 384 observations of E&T fish in Ohio, of which 240 observations of 30 different species have been reported since 1980. Figure 20.2 maps the observations of E&T fish in Ohio and shows the extent to which these observations were reported in the state. Multiple observations can occur for a single species. In southern Ohio, most observations come from the Muskingham and Scioto River systems and the Ohio River. Most observations in northern Ohio came from Lake Erie tributaries or the lake itself.

In addition to water pollution, cited above as major hazard to E&T aquatic species, other major hazards to E&T fish include siltation and impoundments. Approximately two-thirds of E&T fish species are threatened by siltation, and 17 percent are threatened by impoundments or dams. MP&M regulations can improve affected ecosystems or habitats by reducing discharges from MP&M facilities. These improvements can then help reduce siltation and restore some of the E&T fish populations.

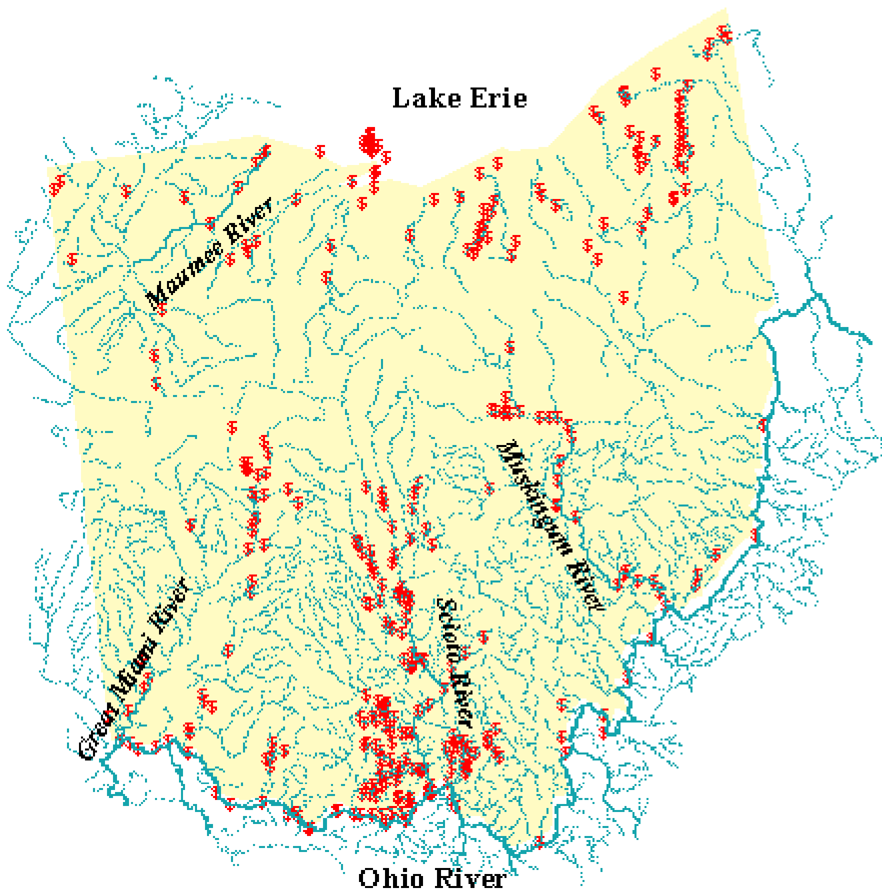
Many obscure E&T fish species have a pure existence value. Some E&T species, like brook trout and lake sturgeon, have high potential for consumptive uses. Restoring their populations and those of other commercial and recreational fish species may enhance recreational fishing opportunities. Table 20.8 lists E&T fish in Ohio, their habitat locations, and the cause for their E&T listing. The table lists species alphabetically by scientific name.

20.6.2 E&T Mollusks

Mollusks yield the largest number of reported observations of aquatic E&T species in Ohio, representing 48 percent of the total 1,227 observations. The Ohio DNR lists 29 E&T mollusk species, four threatened and 25 endangered. Of these, five mollusk species are on the federal endangered species list: catspaw, clubshell, fanshell, white catspaw, and pink mucket. Ohio's E&T mollusks concentrate in five major areas: Lake Erie and the Grand River tributary, Scioto River and Big Arby tributary, Muskingham River, Little Miami River, and the Ohio River. E&T mollusk populations reside mostly along the mainstems of large rivers and in Lake Erie, but are also found in the St. Joseph, Sandusky, and Cuyahoga Rivers.

[8] "Aquatic species" were identified by the Ohio Department of Natural Resources, Division of Natural Areas and Preserves. These species include any species that are "closely associated with aquatic habitats through their breeding or feeding requirements."

Figure 20.2: E&T Fish Observances in Ohio[a] (1980-1997)



[a] Each $ represents an observance.

Source: U.S. EPA analysis.

20.6.3 Other Aquatic E&T Species

Improved water quality resulting from the MP&M regulation may also benefit other aquatic E&T species. Unlike fish and mollusks, whose primary habitat is a surface water body at all times, these species may use surface water-related habitats only for breeding or feeding. Improved water quality may benefit these populations indirectly by enhancing the quality and quantity of aquatic biological resources.

Other aquatic-associated E&T species of Ohio include:

- Birds ten state-listed species, one threatened and nine endangered, include one federally-listed threatened species, the bald eagle. The state-listed species include: American and least bitterns, common and black terns, yellow- and black-Crowned night-herons, king rail, osprey, and snowy egret. These species are observed mostly along the Lake Erie coast. The bald eagle is observed mostly in Ohio's northeast corner.

- Amphibians three state-listed endangered species: blue-spotted salamander, observed in the very northwest section of the state along small streams and near the Maumee River; eastern spadefoot, found near the Ohio and Muskingham Rivers; and eastern hellbender, observed along the Muskingham and Scioto River systems and tributaries of the Ohio River.

- Reptiles two species: the copperbelly water snake, a state-listed endangered and federally-listed threatened species found in lakes and ponds in the northwest corner of Ohio; and the Lake Erie water snake, state-listed as threatened and a proposed threatened species for the federal list, found only along the edges of the Lake Erie islands.

- Mammals the river otter is state-listed as endangered. Sparse observations of the animal come from various small creeks and lakes in the eastern part of Ohio.

- Crustaceans the state-listed endangered Sloan's crayfish has been observed in several small tributaries of the Great Miami River system.

- Insects nine state-listed species, one threatened and eight endangered, are reported throughout the state.

Table 20.8: Endangered and Threatened Fish Species of Ohio

Common Name	Scientific Name	Number of Observations	Last Observed	Federal Status	State Status	Habitat	Causes for Listing
Lake sturgeon	*Acipenser fulvescens*	3	1979		E	Lake Erie, spawning in larger rivers such as Maumee and Auglaize	Pollution and dams
Longnose sucker	*Catostomus catostomus*	1	1950		E	Lake Erie	Pollution creating low oxygen levels
Rosyside dace	*Clinostomus funduloides*	53	1997		T	Small, upland streams of Teays and Little Scioto River systems	Runoff and siltation
Cisco	*Coregonus artedi*	1	1976		E	Lake Erie	Pollution and overfishing
Blue sucker	*Cycleptus elongatus*	2	1985		E	Ohio River and lower reaches of large tributaries	Pollution, dams, increased turbidity and siltation
Lake chubsucker	*Erimyzon sucetta*	28	1994		T	Lakes (not Erie) and larger streams	Increased turbidity and siltation
Bluebreast darter	*Etheostoma camurum*	19	1995		T	Scioto and Muskingham River systems, large streams	Pollution and siltation
Spotted darter	*Etheostoma maculatum*	8	1992		E	Large streams of Muskingham and Scioto systems	Pollution and siltation
Tippecanoe darter	*Etheostoma tippecanoe*	11	1994		T	Muskingham and Scioto River systems	
Tonguetied minnow	*Exoglossum laurae*	16	1996		T	Great Miami River system	Undetermined, likely pollution and siltation
Western banded killifish	*Fundulus diaphanus menona*	9	1994		E	Lake Erie and larger tributaries	Siltation
Goldeye	*Hiodon alosoides*	16	1989		E	Ohio River and lower reaches of large tributaries	Pollution
Mississippi silvery minnow	*Hybognathus nuchalis*	1	1983		E	Ohio River and tributaries	Siltation
Ohio lamprey	*Ichthyomyzon bdellium*	4	1992		E	Ohio River and lower reaches of large tributaries	Pollution and siltation
Northern brook lamprey	*Ichthyomyzon fossor*	25	1992		E	Small streams, tributaries of Grand and Scioto rivers	Pollution, siltation, and dams
Mountain brook lamprey	*Ichthyomyzon greeleyi*	6	1993		E	Mahoning River and tributaries	Pollution, siltation, and dams
Silver lamprey	*Ichthyomyzon unicuspis*	40	1993		T	Lake Erie and larger tributaries	Pollution, siltation, and dams
Blue catfish	*Ictalurus furcatus*	1	1987		E	Scioto River	
Spotted gar	*Lepisosteus oculatus*	1	1978		E	Lake Erie	Siltation and dredging

Table 20.8: Endangered and Threatened Fish Species of Ohio

Common Name	Scientific Name	Number of Observations	Last Observed	Federal Status	State Status	Habitat	Causes for Listing
Shortnose gar	*Lepisosteus platostomus*	9	1981		E	Scioto River and tributaries	Pollution and siltation
Speckled chub	*Macrhybopsis aestivalis*	1	1990		E	Ohio and Muskingham rivers, large rivers	Pollution and siltation
Greater redhorse	*Moxostoma valenciennesi*	12	1989		T	Maumee river system, large streams	Pollution and siltation
Popeye shiner	*Notropis ariommus*	4	1993		E	Extirpated from Ohio, creeks and small rivers of Maumee system	Siltation
Bigeye shiner	*Notropis boops*	22	1995		T	Great Miami River and Ohio River systems, upland streams	Siltation and impoundments
Bigmouth shiner	*Notropis dorsalis*	16	1994		T	Black and Rocky River systems, brooks and small streams	Competition with silver minnow
Blackchin shiner	*Notropis heterodon*	2	1983		E	Lake Erie and other lakes	Increased turbidity and siltation
Blacknose shiner	*Notropis heterolepis*	7	1983		E	Lake Erie and other lakes	Siltation
Mountain madtom	*Noturus eleutherus*	11	1991		E	Ohio River tributaries, larger streams and rivers	Pollution and siltation
Northern madtom	*Noturus stigmosus*	10	1989		E	Muskingham, Little Miami, Walhondig Rivers	
Scioto madtom	*Noturus trautmani*	1	1957	E	E	Big Darby Creek, tributary of Scioto	Pollution and siltation
Pugnose minnow	*Opsopoeodus emiliae*	6	1982		E	Lakes, canals, streams, and Lake Erie	Increased turbidity and siltation
Channel darter	*Percina copelandi*	18	1991		T	Lake Erie and Ohio River	Siltation
River darter	*Percina shumardi*	8	1989		T	Lake Erie and larger tributaries of Ohio River	Pollution and siltation
Paddlefish	*Polyodon spathula*	11	1996		T	Ohio River tributaries, larger streams and rivers	Pollution and siltation
Brook trout	*Salvelinus fontinalis*	1	1997		T	Tributaries of Lake Erie	Habitat destruction - timbering and non-native species

Source: Division of Natural Areas and Preserves, Ohio Department of Natural Resources, Natural Heritage Program 1998.

GLOSSARY

ammonia: a compound of nitrogen and hydrogen (NH_3). It is a colorless, pungent gas.

biological oxygen demand (BOD): the amount of dissolved oxygen consumed by microorganisms as they decompose organic material in polluted water.

bioconcentration factors (BCFs): indicators of the potential for chemicals dissolved in the water column to be taken up by aquatic biota across external surface membranes, usually gills.

biotic: pertaining to the characteristics of a naturally occurring assemblage of plants and animals that live in the same environment and are mutually sustaining and interdependent.

chemical oxygen demand (COD): the amount of oxygen consumed in the complete chemical oxidation of matter, both organic and inorganic, present in polluted water.

Coldwater Habitat (CWH): a designation assigned to a water body based on the potential aquatic assemblage.

dissolved oxygen (DO): oxygen freely available in water, vital to fish and other aquatic life and for the prevention of odors. DO levels are considered a most important indicator of a water body's ability to support desirable aquatic life. Secondary and advanced waste treatment are generally designed to ensure adequate DO in waste-receiving waters. (http://www.epa.gov/OCEPAterms/dterms.html)

endangered and threatened (E&T): animals, birds, fish, plants, or other living organisms threatened with extinction by anthropogenic (i.e., man-caused) or other natural changes in their environment. The Endangered Species Act contains requirements for declaring a species endangered.

Endangered Species Act: federal legislation enacted in 1973 that protects animals, birds, fish, plants, or other living organisms threatened with extinction by anthropogenic or other natural changes in their environment. For a species to be protected under this act it must be "listed" as either an "endangered" or "threatened" species.

eutrophication: process by which bodies of water receive increased amounts of dissolved nutrients, such as nitrogen and phosphorus, that encourage excessive plant growth and result in oxygen depletion.

Exceptional Warmwater Habitat (EWH): the aquatic life use designed to protect aquatic communities of exceptional diversity and biotic integrity. Such communities typically have a high species richness; often include strong populations of rare, endangered, threatened, and declining species; and/or are exceptional sport fisheries.

existence services: services that are not linked to current uses of water bodies. They arise from the knowledge that species diversity or the natural beauty of a given water body is being preserved.

in-stream services: water use taking place within the stream channel for purposes such as life support for animals and plants, water-based recreation, hydroelectric power generation, navigation, commercial fishing, water storage, and aesthetics.

Limited Resource Waters (LRW): an aquatic life use assigned to streams with very limited aquatic life potential, usually restricted to highly acidic mine drainage streams, or highly modified small streams (<3 sq. mi. drainage area) in urban or agricultural areas with little or no water during the summer months.

Limited Warmwater Habitat (LWH): see limited resource waters.

metals: inorganic compounds, generally non-volatile (with the notable exception of mercury), that cannot be broken down by biodegradation processes. They are of particular concern due to their prevalence in MP&M effluents. Metals can accumulate in biological tissues, sequester into sewage sludge in POTWs, and contaminate soils and sediments when released into the environment. Some metals are quite toxic even when present at relatively low levels.

μg/l: micrograms per liter.

Modified Warmwater Habitat (MWH): aquatic life use assigned to streams that have irretrievable, extensive, man-induced modifications that preclude attainment of the Warmwater Habitat use, but which harbor the semblance of an aquatic community. Such waters are characterized by poor chemical quality (low and fluctuating dissolved oxygen), degraded habitat conditions (siltation, habitat simplification), and species that are tolerant of these effects.

nonconventional pollutants: a catch-all category that includes everything not classified as either a priority or conventional pollutant.

nutrients: any substance, assimilated by living things, that promotes growth. The term is generally applied to nitrogen and phosphorus in wastewater, but is also applied to other essential and trace elements. (http://www.epa.gov/OCEPAterms/nterms.html)

Ohio EPA Lake Condition Index (LCI): an ecologically-based index that aggregates results across ten ecological metrics.

Ohio Water Resource Inventory (OWRI): a biennial report to U.S. EPA and Congress required by Section 305(b) of the Clean Water Act. The report is composed of four major sections: (1) inland rivers and streams, wetlands, Lake Erie, and water program description; (2) fish tissue contaminants; (3) inland lakes, ponds, and reservoirs; and (4) groundwater.

overburdens: rock and soil cleared away before mining. (http://www.epa.gov/OCEPAterms/oterms.html)

pH: an expression of the intensity of the basic or acid condition of a liquid. Natural waters usually have a pH between 6.5 and 8.5. (http://www.epa.gov/OCEPAterms/pterms.html)

pollutants of concern (POCs): the 131 contaminants identified by EPA as being of potential concern for this rule and that are currently being discharged by MP&M facilities. EPA used fate and toxicity data, in conjunction with various modeling techniques, to identify these pollutants and assess their potential environmental impacts on receiving water bodies and POTWs. MP&M pollutants of concern include 43 priority pollutants, 3 conventional pollutants, and 86 nonconventional pollutants.

polychlorinated biphenyls (PCBs): a group of toxic, persistent chemicals that are mixtures of chlorinated biphenyl compounds having various percentages of chlorine. PCBs are industrial chemicals formerly used in electrical transformers and capacitors for insulating purposes, and in gas pipeline systems as a lubricant.

polycyclic aromatic hydrocarbons (PAHs): a class of organic compounds with a fused-ring aromatic structure. PAHs result from incomplete combustion of organic carbon (including wood), municipal solid waste, and fossil fuels, as well as from natural or anthropogenic introduction of uncombusted coal and oil. PAHs include benzo(a)pyrene, fluoranthene, and pyrene.

Primary Contact Recreation (PCR): water recreation activities requiring full human body immersion, such as swimming, diving, water skiing, and surfing.

priority organics: prority pollutants that are organic chemicals.

priority pollutants: 126 individual chemicals that EPA routinely analyzes when assessing contaminated surface water, sediment, groundwater, or soil samples.

random utility model (RUM): a model of consumer behavior. The model contains observable determinants of consumer behavior and a random element.

Secondary Contact Recreation (SCR): water recreation activities requiring some direct contact with water but where swallowing of water is unlikely, such as paddling, wading, and boating.

siltation: deposition of finely divided soil and rock particles on the bottom of stream and river beds and in reservoirs.

Survey of National Demand for Water-based Recreation (NDS): a U.S. EPA survey of recreational behavior. The 1993 survey collected data on socioeconomic characteristics and water-based recreation behavior using a nationwide stratified random sample of 13,059 individuals aged 16 and over. (http://www.epa.gov/opei)

total allowable catch (TAC): amount of fish permitted to be removed under a fishery management regime in which the total catch allowed of a certain species for a fishing season has been fixed in advance.

"toxic" pollutants: refers to the 126 priority or toxic pollutants specifically defined as such by EPA, as well as nonconventional pollutants that have a toxic effect on human health or aquatic organisms.

turbidity: cloudy condition in water that interferes with the passage of light through the water column. It is caused by the presence of suspended silt or organic matter in the water body.

un-ionized: neutral form of an ionizable compound. With reference to ammonia, it is the neutral form of ammonia-nitrogen in water, usually occurring as NH_4OH. Un-ionized ammonia is the principal form of ammonia that is toxic to aquatic life. The relative proportion of un-ionized to ionized ammonia (NH^{4+}) is controlled by water temperature and pH.

Warmwater Habitat (WWH): a designation assigned to a water body based on the potential aquatic assemblage.

water quality criteria (WQC): specific levels of water quality that, if reached, are expected to render a body of water suitable for certain designated uses.

withdrawal services: services associate with water removed from the ground or diverted from a surface-water source for uses such as drinking water supply, irrigation, production and processing services, and sanitary services.

ACRONYMS

BCFs: bioconcentration factors
BOD: biological oxygen demand
COD: chemical oxygen demand
CWH: Coldwater Habitat
DO: dissolved oxygen
E&T: endangered and threatened
EWH: Exceptional Warmwater Habitat
LRW: Limited Resource Waters
LWH: Limited Warmwater Habitat
MWH: Modified Warmwater Habitat
ODH: Ohio Department of Health
DNR: Ohio Department of Natural Resources
LCI: Ohio EPA Lake Condition Index
OWRI: Ohio Water Resource Inventory
POCs: pollutants of concern
PCBs: polychlorinated biphenyls
PAHs: polycyclic aromatic hydrocarbons
PCR: Primary Contact Recreation
RUM: random utility model
SSH: Seasonal Salmonid Habitat
SCR: Secondary Contact Recreation
NDS: Survey of National Demand for Water-based Recreation
TAC: total allowable catch
WWH: Warmwater Habitat
WQC: water quality criteria

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Chapter 21: Modeling Recreational Benefits in Ohio with a RUM Model

INTRODUCTION

The recreational benefits analysis outlined in this chapter focuses on Ohio as a case study of the MP&M regulation's expected benefits. EPA combined water quality modeling and a ***random utility model*** of consumer behavior ***(RUM)*** to assess how changes in water quality from the MP&M regulation will affect consumer valuation of water resources for recreational uses. The RUM analysis provides a framework for estimating the effect of ambient water quality and other site characteristics on the total number of trips taken for different water-based recreation activities and the allocation of these trips among particular sites.

The Agency used this case study to address limitations inherent in the benefits transfer method used in the analysis of recreational benefits at the national level (see Chapter 15 for detail). The RUM model assesses water quality characteristics directly affected by the MP&M regulation, such as presence of ***ambient water quality criteria (AWQC)*** exceedances and nonconventional nutrient ***Total Kjeldahl Nitrogen (TKN)*** concentrations and their effect on recreation behavior. The direct link between the water quality measures included in the RUM model and the water quality measures affected by the regulation, as well as the site specific nature of the analysis reduce uncertainty in benefit estimates. In general, RUM models are well-regarded in the economic literature and when these models are appropriately applied, the results are thought to be quite reliable.

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Benefits transfer results are subject to uncertainty because water quality changes evaluated in available recreation demand studies are only roughly comparable with water quality measures considered in regulatory development. This case study analysis improves upon previous recreation demand studies that focused mainly on directly observable water quality effects, e.g., designated use support (i.e., whether a water body supports fishing), the presence of fish advisories, an oil sheen, or eutrophication. The Ohio case study includes unobservable water quality effects as well. The MP&M regulation affects a broad range of pollutants, many of which are toxic to human and aquatic life but are not directly observable (i.e., ***priority*** and ***nonconventional pollutants***. These unobservable toxic pollutants degrade aquatic habitats, decrease the size and abundance of fish and other aquatic species, increase fish deformities, and change watershed species composition. Water quality changes (i.e., changes in toxic pollutant concentrations) affect consumers' water resource valuation for recreation, even if consumers are unaware of changes in ambient pollutant concentrations.

This study allows for a more complete estimate of recreational benefits from reduced discharges of MP&M pollutants. In addition to estimates of recreational benefits from reduced frequency of AWQC exceedances, the Ohio case study evaluated changes in the water resource values from reduced discharges of TKN. The analysis also values additional recreational uses not addressed in the national analysis, such as swimming.

The study used data from the ***National Demand Survey for Water-Based Recreation (NDS)***, conducted by U.S. EPA and the National Forest Service, to examine the effects of in-stream pollutant concentrations on consumer decisions to visit a particular water body (U.S. EPA, 1994).

21.1 METHODOLOGY

21.1.1 Overview

The Ohio study combines direct simulation and ***inferential analyses*** to assess how changes in water quality will affect consumers' valuation of water resources.

The direct simulation analysis component estimates baseline and post-compliance *water quality* at recreation sites actually visited by the surveyed consumers *and* all other sites within the ***consumers' choice set***, visited or not.

The inferential analysis component, a RUM analysis of consumer behavior, estimates the effect of ambient water quality and other site characteristics on the total number of trips taken for different water-based recreation activities and the allocation of these trips among particular recreational sites. The RUM analysis is a ***travel cost model (TCM)***, in which the cost to travel to a particular recreational site represents the "price" of a visit.

The main advantage of the RUM model is inclusion of the effect of substitute sites on site values. For any particular site, assuming that it is not totally unique in nature, the availability of substitutes makes the value for that site lower than it would be without available substitutes.

EPA modeled two consumer decisions:

- how many water-based recreational trips to take during the recreational season (the ***trip participation model***); and
- conditional on the first decision, which recreation site to choose (the ***site choice model***).

The econometric estimation proceeded in two steps, each corresponding to the above decisions. The Agency estimated these decisions in reverse order (i.e., EPA modeled the second decision, site choice, first).

- *Modeling the Site Choice Decision.* Assuming that a consumer decides to take a water-based recreation trip, EPA estimated the likelihood that the consumer will choose a particular site as a function of site characteristics, the price paid per site visit, and household income. A consumer weighs the attributes for various "choice set" sites against the travel costs to each site. These travel costs include both the cost of operating a vehicle and the opportunity costs of time spent traveling. The consumer then weighs the value given to the site's attributes against the cost of getting to the site when making a site selection. The site choice model estimates how recreational users value access to specific sites, and estimates per trip economic values for changes in water quality at recreational sites in the study area.

  EPA estimated the site choice model using a two-level ***nested multinomial logit (NMNL)*** model, which groups sites with similar characteristics. The nested logit model assumes that individuals first choose the group of sites and then a site within that group. This study assumes that individuals first choose a water body type (Lake Erie, rivers, or small lakes) and then a specific site. EPA used the estimated site-choice model coefficients to estimate the value to the consumer of being able to choose among Ohio recreation sites on a given day. This measure is referred to as the "***inclusive value***."

- *Modeling Trip Frequency.* The site choice models estimated in the previous step treat the total number of recreational trips taken each season as ***exogenous*** to the site selection. The Agency estimated the expected number of trips taken during the recreation season using a ***Negative Binomial Poisson model*** (Hausman et al., 1995; Feather et al., 1995; and Creel and Loomis, 1992), which treats trip frequency as a pre-season decision regarding total participation in a given recreation activity.

  EPA estimated the total number of trips during the recreation season as a function of the ***expected maximum utility*** (inclusive value) from recreational activity participation on a trip, and socioeconomic characteristics affecting demand for recreation trips (e.g., number of children in the household). The coefficient of the individual's expected maximum utility of taking a trip) provided a means of estimating the seasonal **welfare effect** of water quality improvements, because changes in water quality change the value of available recreation sites.

Estimating the site choice and total trip participation models jointly is theoretically possible, but computational requirements make an integrated **utility-theoretic** model infeasible. EPA estimated separate site choice and trip frequency models for the four recreational activities: boating, swimming, fishing, and near-water recreation (e.g., viewing wildlife).[1]

The Agency used estimated coefficients of the **indirect utility function** with estimated changes in water quality to calculate per-trip changes in consumer welfare from improved water quality at recreation sites within each consumer choice set. Trip frequency per season increases if site water quality changes are substantial. A sample consumer's expected seasonal welfare gain is therefore a function of both welfare gain per trip and the estimated change in number of trips per season.

Combining the trip frequency model's prediction of trips under the baseline and post-compliance and the site choice model's corresponding per-trip welfare measure yields the **total seasonal welfare** measure.

EPA calculated each individual's seasonal welfare gain for each recreation activity from post-compliance water quality changes, and then used Census population data to aggregate the estimated welfare change to the state level. The sum of estimated welfare changes over the four recreation activities yielded estimates of total welfare gain.

To analyze water quality improvement benefits in the RUM framework, EPA used available discharge, ambient concentration, and other relevant data to measure baseline and post-compliance water quality at the impact sites. Appendix H provides detail on water quality modeling used in this analysis.

21.1.2 Modeling the Site Choice Decision

EPA used the RUM framework to estimate the probability of a consumer visiting a recreation site. This framework is based on the assumption that a consumer derives utility from the recreational activity at each recreation site. Each visit decision involves choosing one site and excluding others.

The consumer's decision involves comparing each site and choosing the site that produces the maximum utility. An observer cannot measure all potential determinants of consumer utility, so the indirect utility function will have a non-random element (V) and a random error term (ξ), such that the actual determinants of consumer utility $V' = V + \xi$. The probability (π_{jn}) that site *j* will be visited by an individual *n* is defined as:

$$\pi_{jn} = Pr(V_{jn} + \xi_{jn} > V_{sn} + \xi_{sn}) \quad (21.1)$$

where:

$V_{jn} + \xi_{jn}$ = utility of visiting site *j*, and

$V_{sn} + \xi_{sn}$ = utility of visiting a substitute site.

Estimating the model requires specifying the functional form of the indirect utility function, V, in which site choice is modeled as a function of site characteristics and the "price" to visit particular sites. For example, a set of conditional utility functions (one for each site alternative *j* in the choice set) can be determined as follows:

$$V_{jn} = \beta_M (M_{jn} - P_{jn}) + \beta X_{jn} \quad (21.2)$$

where:

V_{jn} = the utility realized from a conventional budget-constrained, utility maximization model conditional on choice of site *j* by consumer *n*;

β_M = marginal utility of income;

M_{jn} = the income of individual *n* available to visit site *j*;

[1] The Agency also attempted a model structure that allows for interaction among the choice of recreational activities. In this model, a person first chooses a recreational activity and then chooses a site. This model did not perform very well because less than ten percent of recreational users included in the dataset participate in all four activities.

P_{jn} = a composite measure of travel and time costs for consumer *n* on site alternative *j*;
β = a vector of coefficients representing the marginal utility of a specified site characteristic to be estimated along with β_M (e.g., size of the water body, presence of boating ramps); and
X_{jn} = a vector of site characteristics for site alternative *j* as perceived by consumer *n*. These characteristics include the actual monitored and/or modeled water quality parameters that are hypothesized to be determinants of consumer valuation of water-based recreation resources, and that may also be affected by the MP&M regulation.

The magnitude of the coefficients in Equation 21.2 reflects the relative importance of site characteristics when consumers decide which site to visit. The coefficients (β) of water quality characteristics of recreation sites are expected to be positive; that is, all else being equal, consumers of water-based recreation would prefer "cleaner" recreation sites. The coefficient on travel cost is expected to be negative, i.e., consumers prefer lower travel costs.

To estimate the site choice probabilities, EPA specified and estimated a nested multinomial logit model (NMNL) for fishing, boating, and swimming activities. The nested structure explicitly groups similar alternatives, which allows for a richer pattern of substitution among alternative sites. The NMNL is based on the assumption that an individual chooses first between groups of alternatives and then, within the chosen group, between individual alternatives. For this analysis, EPA grouped all recreational sites in Ohio by water body type based on site similarities. EPA tested various alternative site groupings, but the models presented here were most successful at explaining the probability of selecting a site. The best model used the following activity-specific site groupings:[2]

- Fishing model:
  - Group 1: Lake Erie sites;
  - Group 2: river sites;
  - Group 3: small lakes and reservoirs;

- Boating model:
  - Group 1: Lake Erie sites;
  - Group 2: inland sites, including rivers, small lakes, and reservoirs;

- Swimming model:
  - Group 1: Lake Erie sites;
  - Group 2: inland sites, including rivers, small lakes, and reservoirs;

- Viewing model: EPA used a non-nested model in which an individual compares all sites and chooses the one offering the highest utility level for each trip occasion.

First, the Agency attempted to estimate a nested model based on the three water body types lakes, rivers, and Lake Erie for all four recreational activities included in the analysis. This structure, however, performed well only for fishing. A two-nested model that included inland and Lake Erie sites seemed to perform better for the boating and swimming models. None of the nested structures performed well for participants in near-water/wildlife viewing activities.

This finding is not surprising because sites are grouped based on their similarities within a given nest. It is reasonable to assume that inland lakes, rivers, and Lake Erie sites are dissimilar from an angler's point of view, because each of the three water body types is likely to support different fish species. Lake sites may therefore not be close substitutes for rivers sites. For other activities, differences in fishery resources across water body types are unlikely to be important. Water body size and the presence of recreational amenities are likely to play a more important role than differences in fish species and the type of aquatic habitat. Lake and river sites may therefore be regarded as substitutes for each other by boaters and swimmers. Lake Erie, on the other hand, is a unique water resource that differs from inland water bodies because of its physical characteristics (e.g., size and water temperature); river and lake sites are therefore not likely to be considered substitutes for Lake Erie sites. Finally, participants in near-water recreation use water resources indirectly and are therefore more likely to regard recreational sites located on different water body types as close substitutes to each other. For this reason, the viewing model is a simple logit model without a nested structure.

[2] Three of the four models (fishing, boating, and swimming) passed specification tests for appropriateness of a nested structure (see Section 21.3 for detail). Test results showed that only two site groups are appropriate for the boating and swimming models inland sites (rivers, small lakes, and reservoirs) and Lake Erie sites in Ohio. The fourth activity, wildlife viewing, did not pass specification tests for a nested structure and was estimated as a flat ***multinomial logit (MNL)*** model.

The models assume that an individual first decides to visit a specific water body grouping (hereafter, region), then decides which site within that group to visit. An individual probability of visiting site *j*, given the choice of region *R*, is a simple multinomial logit. If the random terms ξ_{nj} for individual *n* at site *j* are independently and identically distributed and have an extreme value Weibull distribution, then π_{jn} takes the form (McFadden, 1981):

$$\pi_{jn|r} = \frac{e^{V_{jn}}}{\sum_{j \in r} e^{V_{jn}}} \tag{21.3}$$

where:

- $\pi_{jn|r}$ = probability of selecting site *j* in region *r*;
- $e^{V_{jn}}$ = the consumer's utility from visiting site *j*;
- r = regions -- "Lake Erie," "rivers," etc. as specified above for a given activity; and
- $\sum_{j \in r} e^{V_{in}}$ = the sum of the consumer's utility at each site *j* for all sites in the opportunity set for region *r*.

Estimated parameters of the indirect utility function are then used to estimate the inclusive value. For consumer *n*, the inclusive value measures the overall quality of recreational opportunities for each water-based activity and represents the expected maximum utility of taking a trip. Note that, although EPA used a random draw from the opportunity set for the purpose of estimating the model parameters, the Agency calculated the inclusive value (i.e., the expected maximum utility) using all recreation sites in the consumer's opportunity set in a given region.

The inclusive value is calculated as the log of the denominator in Equation 21.2 (McFadden, 1981).

$$I_r = \ln\left(\sum_{j=1}^{J} e^{V_{jn}(W)}\right) \tag{21.4}$$

where:

- I_r = inclusive value for sites associated with region *R*;
- $e^{V_{jn}}$ = individual *n*'s utility from visiting site *j*; and
- W = a vector of baseline water quality characteristics.

The probability of choosing a particular region is:

$$\pi_r = \frac{e^{I_r \gamma_r}}{\sum_{r=1}^{r=R} e^{I_r \gamma_r}} \tag{21.5}$$

where:

- π_r = probability of selecting region *r*;
- I_r = the inclusive values for a given region;
- γ_r = the coefficient on the inclusive value for a given region; and
- r = activity-specific regions (e.g., "Lake Erie," "rivers," and "small lakes" for fishing).

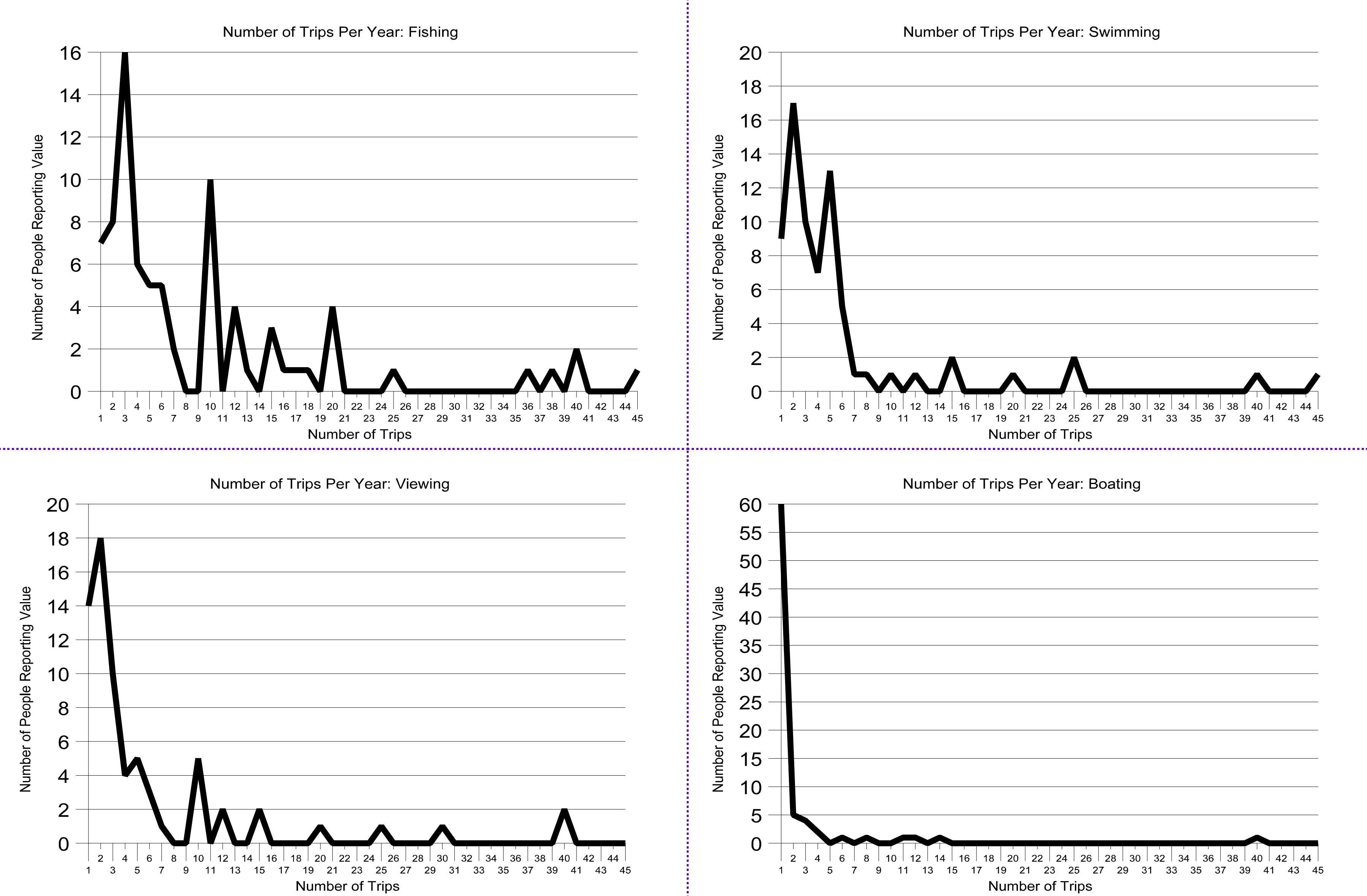
To estimate the model described by Equations 21.2 and 21.5, EPA used a standard statistical software package, ***LIMDEP***.

21.1.3 Modeling Trip Participation

After modeling the site choice decision, the next step modeled the determinants of the number of water-based recreation trips a consumer takes during a season. To link the quality of available recreation sites with consumer demand for recreation trips, EPA modeled the number of recreation trips taken during the recreation season as a function of the inclusive value estimated in the previous step and socioeconomic characteristics affecting demand for recreation activities. The dependent variable, the number of recreation trips taken by an individual during the recreation season, is an integer value greater than or equal to zero. To account for the non-negative property of the dependent variable, EPA used count data models based on probability densities that have the non-negative integers as their domain.

One of the simplest count data models is a ***Poisson estimation process***, which is commonly used with count data, such as number of recreation trips taken during the recreation season. Inherent in the model specification is the assumption that each observation of a number of trips is drawn from a ***Poisson distribution***. Such a distribution favors a large number of observations with small values (e.g., two trips, four trips) or zeros, resulting in its being skewed toward the lower end. Due to the nature of the observed number of trips, it is quite reasonable to assume that the underlying distribution can be characterized as a Poisson distribution. Figure 21.1 shows the number of recreation trips taken per year and the number of respondents who reported taking that number of trips.

Figure 21.1: Number of Trips Per Year By Activity Type



Source: U.S. EPA analysis of NDS data (U.S. EPA, 1994)

Estimating the Poisson model is similar to estimating a nonlinear regression. The single parameter of the Poisson distribution is λ, which is both the mean and variance of y_n. The probability that the actual number of trips taken is equal to the estimated number of trips is estimated as follows (Green, 1993):

$$Prob(Y_n = y_n) = \frac{e^{-\lambda_n}\lambda_n^{y_n}}{y_n!} \qquad (21.6)$$

where:

Y_n	=	the actual number of trips taken by an individual in the sample;
y_n	=	the estimated number of trips taken by an individual in the sample;
n	=	1, 2,..., N, the number of individuals in the sample; and
λ_n	=	$\beta'X$, expected number of trips for an individual in the sample, where X is a vector of variables affecting the demand for recreational trips (e.g., inclusive values and socioeconomic characteristics) and β is the vector of estimated coefficients.

From Equation 21.6, the expected number of water-based recreation trips per recreation activity season taken by an individual is given by:

$$E[y_n|x_n] = Var[y_n|x_n] = e^{\beta' x_n} \qquad (21.7)$$

where:

$E[y_n\|x_n]$	=	the expected number of trips, y_n, given x_n;
$Var[y_n\|x_n]$	=	the variance of the number trips, y_n, given x_n;
β	=	a vector of coefficients on x; and
x	=	a matrix of socioeconomic variables and inclusive values.

An empirical drawback of the Poisson model is that the variance of the number of trips taken must be equal to the mean number of trips, and this equality is not always supported by actual data. In particular, the NDS survey data exhibit ***overdispersion***, a condition where variance exceeds the mean. The estimated variance-to-mean ratios of the number of trips in the NDS data sample are 31, 27.9, 35.6, and 10.5 for fishing, swimming, viewing, and boating trips, respectively. Overdispersion is therefore present in the data set.

To address the problem of overdispersion, EPA used the ***negative binomial regression model***, an extension of the Poisson regression model, which allows the variance of the number of trips to differ from the mean. In the negative binomial model, λ is respecified so that (Green, 1993):

$$\ln \lambda_n = \beta X_n + \epsilon \qquad (21.8)$$

where the error term (ϵ) has a gamma distribution, $E[\exp(\epsilon_i)]$ is equal to 1.0, and the variance of ϵ is α.

The resulting probability distribution is:

$$Prob[Y = y_n|\epsilon] = \frac{e^{\lambda_n}\exp(\epsilon)\lambda_n^{y_n}}{y_n!} \qquad (21.9)$$

where:

y_n	=	0,1,2... number of trips taken by individual n in the sample;
n	=	1,2,..., N number of individuals in the sample; and
λ_n	=	expected number of trips for an individual in the sample.

Integrating ϵ from Equation 21.9 produces the unconditional distribution of y_n. The negative binomial model has an additional parameter, α, which is the overdispersion parameter, such that:

$$Var[y_n] = E[y_n](1 + \alpha E[y_n]) \tag{21.10}$$

The overdispersion rate is then given by the following equation:

$$\frac{Var[y_n]}{E[y_n]} = 1 + \alpha E[y_n] \tag{21.11}$$

EPA used the negative binomial model to predict the seasonal number of recreation trips for each recreation activity based on the inclusive value, individual socioeconomic characteristics, and the overdispersion parameter, α. If the inclusive value has the anticipated positive sign, then increases in the inclusive value stemming from improved ambient water quality at recreation sites will lead to an increase in the number of trips. The combined MNL model site choice and count data trip participation models allowed the Agency to account for changes in per-trip welfare values, and for increased trip participation in response to improved ambient water quality at recreation sites.

21.1.4 Calculating Welfare Changes from Water Quality Improvements

EPA estimated the welfare change associated with water quality improvements from the baseline to post-compliance conditions as a ***compensating variation (CV)***, which equates the expected value of realized utility under the baseline and post-compliance conditions. The expected seasonal change in welfare attributed to the quality improvements for an individual *n* in the sample consists of two components:

- per trip welfare gain, and
- increased number of trips under the post-compliance water quality condition.

The Agency first calculated the welfare gain from water quality improvement for each consumer on a given day by using a CV measure for consumer *n* (Kling and Thompson, 1996):

$$CV_n = \frac{\ln\left[\sum_{r=1}^{R}\left(\sum_{j=1}^{J_r} e^{V_{jn}(W^0)}\right)\right] - \ln\left[\sum_{r=1}^{R}\left(\sum_{j=1}^{J_r} e^{V_{jn}(W^1)}\right)\right]}{\beta_M} \tag{21.12}$$

where:

CV_n = the compensating variation for individual *n* at site *j* on a given day;
r = "Lake Erie," "inland," etc.
j = $1,...J_r$ represents a set of alternative sites for a given recreational activity in region *r*;

$\ln\left[\sum_{r=1}^{R}\left(\sum_{j=1}^{J_r} e^{V_{jn}(W)}\right)\right]$ = the inclusive value index (I);

W^0 = a vector of information describing baseline water quality;
W^1 = a vector of information describing post-compliance water quality; and
β_M = the implicit coefficient on income that influences recreation behavior.

In deriving Equation 21.12, EPA assumed that the marginal utility of income, β_M, is constant across alternatives (as well as across quality changes). If this assumption does not apply, the derivation of Eq. 21.12 is more complicated (Hausman et al., 1995).

EPA then estimated the low and high values of the seasonal welfare gain for individual n in the sample as follows: [3]

$$W_{low,\ n} = \frac{(I^1 - I^0) \times Y^0}{-\beta_\mu} \tag{21.13}$$

$$W_{high,\ n} = \frac{(I^1 - I^0) \times Y^1}{-\beta_\mu} \tag{21.14}$$

where:

$W_{low,\ n}$	=	lower bound estimate of the seasonal welfare gain for individual n;
$W_{high,\ n}$	=	upper bound estimate of the seasonal welfare gain for individual n;
I^1	=	the post-policy inclusive value;
Y^1	=	the estimated number of trips after water quality improvement;
I^0	=	the baseline inclusive value;
Y^0	=	the estimated number of trips in the baseline; and
β_Y	=	the implicit coefficient on income that influences recreation behavior.

These estimates are *per individual* in the population for those individuals meeting qualifications for inclusion in the NDS response set (i.e., respondents whose home state is Ohio and respondents from the neighboring states whose last trip was to Ohio's sites).[4] EPA extrapolated the estimates of value per individual to the Ohio state level based on Census data (U.S. Bureau of the Census, 2000). The following section details the extrapolation method used in the analysis.

21.1.5 Extrapolating Results to the State Level

EPA used a simplified extrapolation technique to estimate the state-level benefits. EPA first estimated the number of participants in fishing, swimming, boating, and wildlife viewing in Ohio, based on the estimated percentage of the NDS survey respondents residing in Ohio who participate in a given activity and the state adult population. The 2000 Census data provide information on the number of Ohio residents aged 16 and older. EPA then multiplied the estimated average seasonal welfare gain per participant in a given recreational activity by the corresponding number of recreational users. The total welfare gain to the users of water-based recreation in Ohio is the sum of fishing, swimming, boating, and wildlife viewing benefits.

21.2 DATA

This section describes the data and supporting analyses required to implement the RUM analysis. The following general categories of data and supporting analyses are required:

- information on the consumers of water-based recreation responding to the NDS in Ohio;
- recreation sites identified for the water quality and RUM analyses, including the sites visited by consumers of water-based recreational activity and supplemental sites in their choice sets;
- estimated price of visiting the sites. The "visit price" is estimated as a function of travel distance (and travel time) between each consumer's hometown and each site in the choice set; and
- information on site characteristics likely to be important determinants of consumer behavior. Of particular importance to this analysis are the water quality and related characteristics of sites in the choice set, and how those characteristics may be expected to change as a result of regulation.

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[3] EPA selected this approach for calculating seasonal welfare gain per individual based on Dr. Parsons' recommendation (G.R. Parsons, 1999).

[4] Section 21.2.1 provides a detailed description of the data sample used in the analysis.

The following sections discuss each category of data and/or supporting analysis below.

21.2.1 The Ohio Data

EPA obtained information on survey respondent socioeconomic characteristics and recreation behavior, including last trip profile and the annual number of trips associated with each water-based activity, from the NDS (U.S. EPA, 1994). The 1994 survey collected data on demographic characteristics and water-based recreation behavior using a nationwide stratified random sample of 13,059 individuals aged 16 and over. Respondents reported on water-based recreation trips taken within the past 12 months, including the primary purpose of their trips (e.g., fishing, boating, swimming, and viewing), total number of trips, trip length, distance to the recreation site(s), and number of participants. Where fishing was the primary purpose of a trip, respondents were also asked to state the number of fish caught. Table 21.1 shows the number of trips taken per year by primary recreation activity, as reported in the NDS.

EPA selected case study observations for Ohio residents who took trips within or outside of the state. Trips to Ohio recreation sites by residents of neighboring states were also included in the site choice models, but not in the trip participation models.[5] All four activity models included single-day trips only. EPA included only activity participants with valid hometown ZIP codes, whose destination site was uniquely identified. The Agency used data on both Ohio participants and Ohio non-participants to estimate total seasonal trips, but included only Ohio participants and several residents of nearby states in the site choice models. Although they could not be used in the site choice model, participant observations from Ohio with missing location information were used to analyze the number of trips. Tables 21.1 and 21.2 list valid observations by activity, residence, and model type. Figure 21.2 illustrates the distribution of the sample observations in relation to the location of MP&M facilities affected by the rule in Ohio.

Table 21.1: Classification of Sample Observations for Estimation of the Site Choice Models

	Total Ohio Residents	Ohio Residents with Last Trip In-State	Valid Ohio Residents with Last Trip In-State	Valid Ohio Residents with Last Trip Outside State	Valid Nonresidents with Last Trip in Ohio	Valid for Site Choice Model
Participants (Total)	609	408	237	35	11	297
Fishing	122	103	66	9	0	84
Swimming	147	100	58	14	2	76
Viewing	231	126	64	2	7	73
Boating	109	79	49	10	2	64

Source: U.S. EPA analysis.

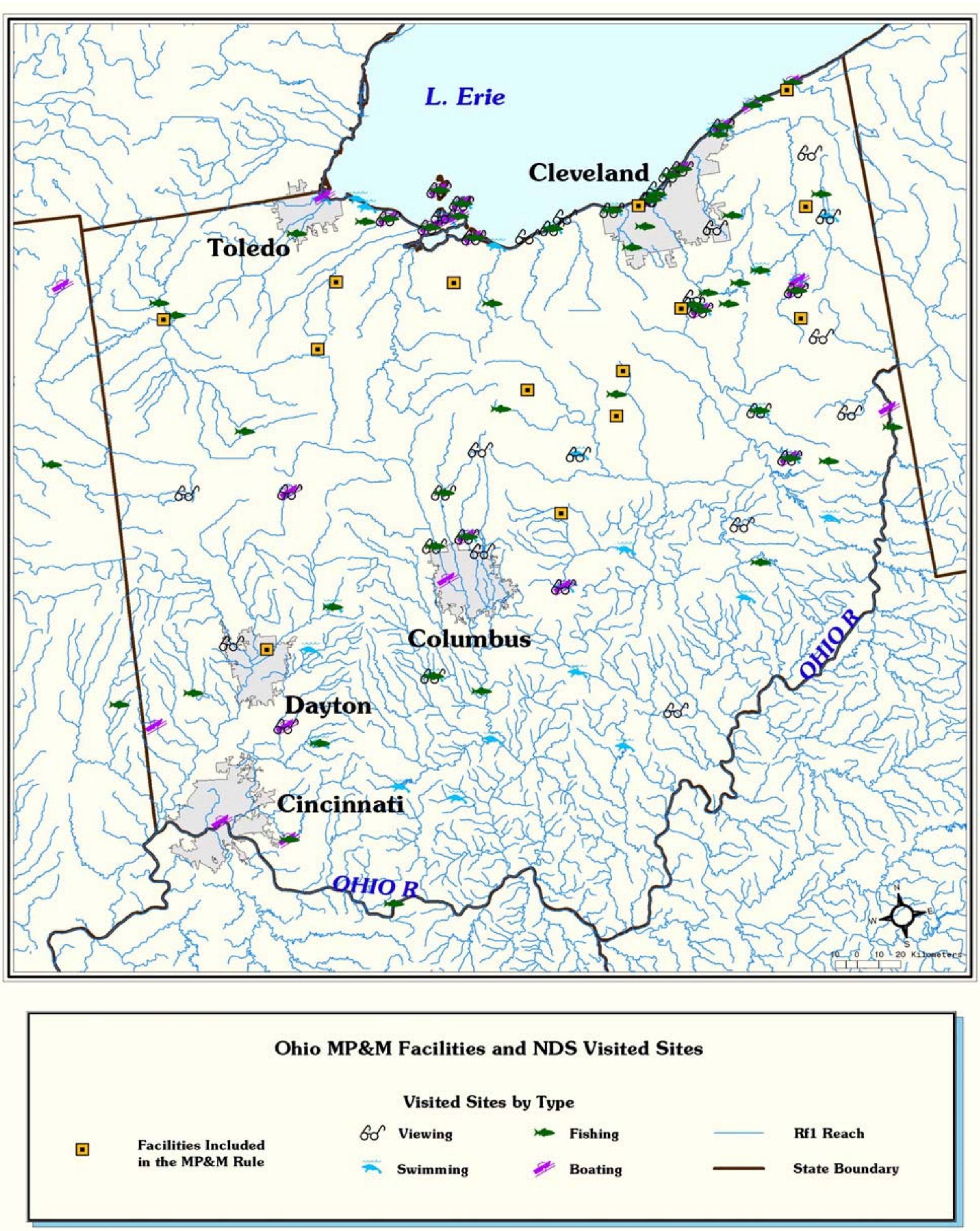
[5] These additional observations total 11 across the four activities and thus represent only a small fraction of total observations. Including only Ohio respondents in the trip participation models underestimates the benefits associated with water quality improvements, because the welfare gains to recreators from neighboring states are ignored.

Table 21.2: Classification of Sample Observations for Estimation of the Trip Participation Models

Ohio Residents	Total	Residents with Last Trip In-State	Residents with Last Trip Outside State	Valid for Trip Participation Model
Non-Participants	300			291
Participants (Total)	609	408	34	322
Fishing	122	103	4	84
Swimming	147	100	9	78
Viewing	231	126	7	75
Boating	109	79	14	85
Total Observations	909	408	34	613

Source: U.S. EPA analysis.

Figure 21.2: Location of MP&M Facilities in Relation to the Visited Sites



Source: *U.S. EPA analysis.*

21.2.2 Estimating the Price of Visits to Sites

EPA estimated trip "price" for each consumer of water-based recreation as the sum of travel costs plus the opportunity cost of time, following the procedure described in Haab et al. (2000). Based on Parsons and Kealy (1992), this study assumed that time spent "on-site" is constant across sites and can be ignored in the price calculation.

To estimate consumers' travel costs, EPA first used ZipFip software to calculate the one-way distance to each site for each participant.[6] The average estimated one-way distance to the site visited is 37.56 miles. EPA then multiplied round-trip distance by average motor vehicle cost per mile ($0.29, 1993 dollars).[7,8] The model adds the opportunity cost of travel time, measured in terms of wages lost, to the travel cost for those who would have lost income by taking the recreation trip. For these consumers the dummy variable LOSEINC equals one. Travel times equal the round-trip distance divided by a travel speed of 40 mph and multiplied by the individual's hourly wage as calculated below.

The travel cost variable in the model was calculated as follows:

$$Visit\ Price = \begin{cases} Round\ Trip\ Distance \times \$.29 + \dfrac{Round\ Trip\ Distance}{40\ mph} \times (Wage) & If\ LOSEINC = 1 \\ Round\ Trip\ Distance \times \$.29 & If\ LOSEINC = 0 \end{cases} \tag{21.15}$$

Individuals not losing income (e.g., individuals taking vacation or a weekend trip or individuals whose work schedule is not flexible) do not face lost wages as a result of the trip and inclusion of the opportunity cost of time would be inappropriate. These consumers still have an opportunity cost for their travel time, which could otherwise be spent doing something else, like fishing. In other words, a shorter distance traveled allows for a longer time spent at the recreation site. For these consumers, the analysis included an additional round-trip travel time variable calculated as:

$$Travel\ Time = \begin{cases} Round\ Trip\ Distance/40 & If\ LOSEINC = 0 \\ 0 & If\ LOSEINC = 1 \end{cases} \tag{21.16}$$

The average one-way estimated travel time to the visited site is 56.34 minutes.[9]

21.2.3 Site Characteristics

EPA identified 1,954 recreation sites on 1,631 reaches in the universal opportunity set. Of these, 580 observations are known recreational sites (e.g. parks); 1,366 observations are ***Reach File 1*** ***(RF1)*** reaches without a known recreational site; and eight observations are neither located in RF1 nor identified as known recreation sites but were visited by an NDS respondent.

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[6] The program was created by Daniel Hellerstein and is available through the USDA at http://usda.maunlib.cornell.edu/datasets/general/93014.

[7] Note that all expenditures are in 1993 dollars because the NDS trip choices and the associated expenditure occurred in 1993.

[8] The estimate of motor vehicle cost per mile was based on estimates compiled by the Insurance Information Institute.

[9] The average travel time to the visited site was fairly uniform across the activities. Average one-way time to the visited site was 51.38 minutes, 71.64 minutes, 43.76 minutes, and 58.57 minutes for fishing, boating, swimming, and viewing, respectively.

Each consumer choice set theoretically includes hundreds of substitutable recreation sites in Ohio and in the neighboring states. To prevent the recreation site analysis from becoming unmanageable, EPA analyzed a sample of recreation sites for each consumer observation. The Agency then created a randomly-drawn reduced choice set for each recreational activity as follows:[10]

- *Fishing.* The reduced choice set consists of 20 Lake Erie sites, 20 river sites, and 20 small lakes/reservoirs. Thus, a total individual choice set consists of 60 alternatives (including the chosen site);

- *Boating.* The reduced choice set consists of 20 Lake Erie sites and 20 inland recreation sites (including rivers and lakes/reservoirs). A total individual choice set consists of 40 alternative sites (including the chosen site);

- *Swimming.* Similar to boating, the reduced choice set consists of 20 Lake Erie sites and 20 inland recreation sites (including rivers and lakes/reservoirs). A total individual choice set consists of 40 alternative sites (including the chosen site);

- *Wildlife Viewing.* The reduced choice set consists of 40 sites, including Lake Erie, river, and small lake/reservoir sites.

Each participant choice set, by definition, includes the site actually visited by the respondent. For each consumer, EPA drew the additional sites from a geographic area defined by a distance constraint (and the water body types listed above). The Agency used a 120-mile distance limit for inland recreation sites (Ohio rivers, small lakes, or reservoirs). All Lake Erie sites are eligible for inclusion in the choice sets for all models. EPA assumed that consumers of water-based recreation would be willing to travel farther to visit Lake Erie sites, because this water resource presents unique recreational opportunities.[11] EPA used the resulting aggregate choice set of sites for all individuals participating in a given recreation activity to model consumer decisions regarding trip allocation across recreation sites.

The Agency used two classes of characteristics to estimate site choice:

- those unaffected by the MP&M regulation, but likely to determine valuation of water-based recreational resources; and

- those affected by the regulation *and* hypothesized to be significant in explaining recreation behavior and resource valuation.

Regulation-independent site characteristics include water body type and size, location characteristics, and the presence of site amenities (e.g., boat ramps, swimming beaches, picnic areas). Regulation-dependent site characteristics include regulation-affected water quality variables.

a. Regulation-independent site characteristics

Site characteristics that are likely to be important determinants of consumer valuation of water-based recreational resources but that are independent of the MP&M regulation include general site descriptors. These descriptors include the type and size of the water body and location characteristics, and the presence of site amenities. EPA obtained data on regulation-independent site characteristics from two main sources, RF1 and the Ohio Department of Natural Resources **(ODNR)**.

RF1 provided water body type (i.e., lake, river, or reservoir) and physical dimension (i.e., length, width, and depth). The dummy variables, LAKE ERIE, RIVER, and LAKE characterize water body types. If a site is located on Lake Erie, LAKE ERIE takes the value of 1; 0 otherwise. If a site is located on river, RIVER takes the value of 1; 0 otherwise. Finally, if a site is located on a small lake or reservoir, LAKE takes the value 1; 0 otherwise. Water body size was determined by the length of the reach segment in miles for rivers and Lake Erie sites. For small lakes and reservoirs, the appropriate water body size is the water body area in acres. The site choice models use the logarithm of water body size as a measure of site importance,

[10] McFadden (1981) has shown that estimating a model using random draws can give unbiased estimates of the model with the full set of alternatives.

[11] Travel distance from respondent's hometown to the Lake Erie sites did not exceed 250 miles.

because people are more likely to be aware of large water bodies.[12] Water body size data for sites not located in RF1 came from the ODNR.

ODNR, supplemented by the *Ohio Atlas and Gazetteer*, provided data on recreational amenities and site setting (e.g., presence/absence of boat ramps, swimming beaches, or picnic areas; public accessibility; and size of land available for recreation). EPA used land available for recreation, LN(LAND), (e.g., acreage of state park, fishing, hunting, and other recreation areas) to approximate site setting and attractiveness. Dummy variables represent the presence of three recreational amenities: BEACH is a swimming beach; RAMP is a boating ramp; and PARK indicates a park.

b. Regulation-dependent site characteristics

Selecting regulation-dependent site characteristic variables that are both policy-relevant and significant in explaining recreation behavior proved challenging. MP&M facilities discharge many pollutants, most of them unlikely to have visible indicators of degraded water quality (e.g., odor, reduced turbidity, etc). EPA hypothesized that pollutant loadings can, nonetheless, reduce the likelihood of selecting a recreation site. Reduced pollutant discharges improve water quality and aquatic habitat, thereby increasing fish populations and enhancing the recreational fishing experience. In addition, in-stream nutrient concentrations are good predictors of eutrophication, which causes aesthetic losses and may thus affect the utility of a water resource for all four recreational uses.

The connection between the policy variables (i.e., the change in concentrations of MP&M pollutants) and the effects perceived by consumers (e.g., increased catch rate, increased size of fish, greater diversity of species, or improved aesthetic qualities of the water body) are not modeled directly, but are captured implicitly in the differential valuation of water resources as reflected in the RUM analyses.

EPA considered two types of pollutant effects in defining water quality variables for model inclusion:

- visible or otherwise directly perceivable effects (e.g., water turbidity); and
- unobservable toxic effects likely to impact aquatic habitat and species adversely.

The Agency accounted for directly observable effects using the ambient concentrations of nutrients (e.g., TKN) as an explanatory variable.

Rather than include the concentrations of all toxic pollutants separately, EPA constructed a variable to reflect the adverse impact potential of toxic pollutants on aquatic habitat. EPA identified recreation sites at which estimated concentrations of one or more MP&M pollutants exceeds AWQC limits for aquatic life protection, to assess the likely adverse impacts on aquatic organisms. A dummy variable, AWQC_EX, takes the value of 1 if in-stream concentrations of at least one MP&M pollutant exceed AWQC limits for aquatic life protection, 0 otherwise. This approach accounts for the fact that adverse effects on aquatic habitat are not likely to occur below a certain threshold level.

c. Biological factors

Numerous biological parameters (e.g., abundance of sport fish) that are a function of the availability and quality of suitable habitat for breeding and feeding are also likely to affect recreation behavior. To account for biological parameters affecting the demand for water-based recreation, EPA used relative ***fish abundance (Biomass)*** obtained from the ***Ohio Water Resource Inventory (OWRI)*** database (OH EPA, 1996). Relative fish abundance is measured as the total fish weight (in kg) per 300 meters. Because this variable reflects presence of both tolerant and intolerant fish species, it is less correlated with the two regulation-dependent water quality variables (i.e., TKN and AWQC) included in the analysis compared to the index of well-being ***(IWB2)*** used in the proposed rule analysis.

Chemical properties of the waters (e.g., pollutant concentrations) are likely to affect the diversity and abundance of the fishery resources. Biological parameters may also be affected by numerous anthropogenic stressors unrelated to water quality, such as over-fishing, physical alteration of habitat, invasion of exotic species, etc. Although EPA used the baseline values of relative fish abundance to estimate the site choice models, the Agency did not estimate changes in biological parameters caused by the regulation analysis due to data limitations and the challenges posed by modeling population impacts of a broad spectrum of pollutants at hundreds of recreation sites.

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[12] EPA uses the logarithm of water body size because it expects the effect of water body size on utility to diminish as that size increases.

d. Presence of fish advisories

Another important factor that may affect a recreational consumer's decision to visit a particular site is presence of ***fish consumption or contact advisories (FCAs)***. EPA obtained information on fish consumption advisories and contact advisories at reaches in Ohio from the ODNR (Ohio DNR, 1999). Fish consumption advisories and contact advisories were listed by the name of the stream or river with the consumption advisory. An advisory that applied to only part of the river included the names of cities, towns, or highways to identify the stretch of the reach for which the advisory was relevant. The name of the river and the other geographic identifiers were used to assign reach numbers from RF1 to the consumption advisories. EPA created a dummy variable for each type of advisory (i.e., fish advisories and contact advisories). The variable takes the value of 1 if the relevant advisories are present; 0 otherwise.

21.3 Site Choice Model Estimates

EPA estimated four separate models of recreational demand: fishing, boating, swimming, and viewing. The Agency classified trips by the primary activity listed by the respondent. All four activity models cover single-day trips. EPA estimated the site choice model using the site actually visited and randomly-drawn sites from the choice set for each recreation activity as described in Section 21.2-3 above.

EPA estimated activity models for five alternative choice sets (i.e., five random draws from the universal choice set), producing five sets of estimated coefficients. Mean estimates from the five alternative draws represent EPA's best estimate of actual coefficient values. Table 21.3 lists the variables used as arguments in the utility function and presents the mean estimation results for the four models. In estimating site choice models for fishing, boating, swimming, and viewing, the Agency restricted the coefficient on travel cost to be equal across all four models to ensure a constant marginal utility of income across all four activities.

The following sections provide a short description of the results of the site choice model corresponding to each recreation activity.

Table 21.3: Site Choice Model Estimation Results (Mean parameter estimates from five random draws)[a]

Variable		Activity			
		Fishing	Boating	Swimming	Viewing
TRCOST [b]		-0.044 (-22.704)	-0.044 (-22.704)	-0.044 (-22.704)	-0.044 (-22.704)
TIME [c]		-1.474 (-7.482)	-0.362 (-4.27)	-0.436 (-7.007)	-0.719 (-12.647)
RAMP [d]		0.878 (7.509)	N/A	N/A	N/A
LN(LAND) [e]		N/A	N/A	0.058 (2.431)	0.162 (7.471)
PARK [f]		N/A	N/A	0.753 (3.79)	0.787 (4.638)
BEACH [g]		N/A	N/A	0.491 (2.96)	N/A
LN(SIZE) [h]	All	N/A	0.502 (5.777)	-0.273 (-6.083)	N/A
	Lake Erie	0.908 (6.639)	N/A	N/A	0.665 (10.474)
	River	0.171(1.993)	N/A	N/A	-0.261 (-4.937)
	Lake	0.050 (-0.348)	N/A	N/A	-0.429 (-4.329)
Biomass [i]	Lake Erie	N/A	-0.130 (-1.777)	N/A	N/A
	River	0.068 (2.328)	0.017 (0.4432)	N/A	N/A
TKN [j]		-0.584 (-3.763)	-1.187 (-6.863)	-0.660 (-4.631)	-0.711 (-4.401)
AWQC [k]		-0.573 (-3.698)	-0.172 (-1.179)	N/A	N/A
Inclusive Values					
ERIE		0.811(9.895)	0.296 (6.098)	0.730 (7.466)	N/A
Inland		N/A	0.088 (2.525)	0.275 (6.302)	N/A
RIVER		0.591 (6.945)	N/A	N/A	N/A
LAKE		0.429 (2.629)	N/A	N/A	N/A
Adj. R^2		0.467	0.280	0.408	

[a] EPA performed this analysis based on five alternative draws to assess sensitivity of the estimated coefficients with respect to random draws.
[b] Travel Cost is calculated as 0.29 * round-trip distance.
[c] Travel Time is (round-trip distance / 40)*Wage.
[d] 1 if a boating ramp is present, and 0 otherwise.
[e] Log of the number of land acres.
[f] 1 if the site is a park, and 0 otherwise.
[g] 1 if a swimming beach is present, and 0 otherwise.
[h] Log of the size of the water body. For rivers and Lake Erie, this is the log of the reach segment length or Lake Erie shore segment in miles. For lakes, this is log of the lake circumference.
[i] Biomass is measured as the total fish weight (in kg) per 300 meters.
[j] In-stream concentrations of TKN (mg/l).
[k] 1 for any reach if in-stream concentrations of at least one MP&M pollutant exceeds the AWQC limits for protection of aquatic life, and 0 otherwise.
Note: T-statistic for test that the estimated coefficient equals 0 is given in parentheses beside the coefficient estimates.
N/A indicates that the variable was not included in the estimation for this activity.

Source: U.S. EPA analysis.

21.3.1 Fishing Model

The estimated fishing model includes travel cost (TRCOST), time (TIME) spent traveling, and site characteristics. The Agency included the following site characteristics in the fishing model: boat ramp (RAMP), water body size (LN(SIZE)), relative fish abundance (Biomass), TKN concentrations, and presence of AWQC exceedances. Table 21.3 shows that most coefficients have the expected sign and are significantly different from zero at the 95th percentile. Travel cost and travel time have a negative effect on the probability of selecting a site, indicating that anglers prefer to visit sites closer to their homes (other things being equal).

Anglers who fish from a boat are likely to view the presence of a boat ramp as an important factor that may affect their site choice. However, the presence of a boat ramp is unlikely to be important for anglers who fish from shore. Thus, the Agency used an interaction variable (RAMP x USE_BOAT) such that the ramp variable was turned on only if the angler reported using a boat on his last fishing trip. A positive sign on the boat ramp indicates that anglers owning a boat are more likely to choose sites with a boat ramp.

The water body size has a different effect on the probability of selecting a site in the Lake Erie, river, and small lake/reservoir groups. The larger the river or the Lake Erie shore segment, the more likely that anglers visited the reach. The size of inland lakes and reservoirs does not have a significant effect on the probability of visiting the site.

The Agency used the square root of the fish weight per 300 meters as a measure of fish abundance (Biomass). The probability of a river site visit increases as the relative fish abundance at the site increases. However, inclusion of this variable in the Lake Erie nest was not significant, which indicates that relative fish abundance does not have a significant effect on choosing a Lake Erie site. This finding is counterintuitive and is likely to be due to the lack of variation in the relative fish abundance variable for the Lake Erie sites. This variable was excluded from the Lake Erie nest in the final model presented here. Data on relative fish abundance were not available for lakes.

Finally, higher ambient concentrations of TKN, which indicate potential eutrophication problems, and presence of AWQC exceedances negatively affect the probability of site selection. In other words, anglers prefer cleaner sites, all else being equal.

Estimated inclusive values on Lake Erie sites, rivers, and small lakes lie within a unit interval [0,1] and are significantly different from 0, indicating that the nested choice structure is appropriate.[13]

EPA found other variables, tested as explanatory variables, to be insignificant, including the presence of FCAs. It might be expected, *a priori*, that the presence of an FCA decreases a site's likelihood as a fishing choice. In fact, the existence of FCAs did not significantly affect a site's probability of being chosen; 59 percent of the sites actually chosen by NDS respondents had an FCA in place. Creel surveys provided by ODNR indicated that, on average, anglers released 70 percent of their catch (ODNR, 1997). This finding suggests that recreational anglers are aware of FCAs, and catch but do not consume fish in the affected areas.

21.3.2 Boating Model

The estimated boating model includes travel cost (TRCOST), time (TIME) spent traveling, and site characteristics. The Agency included the following site characteristics in the boating model: water body size (LN(SIZE)), relative fish abundance (Biomass), TKN concentrations, and presence of AWQC exceedances. Table 21.3 shows that most coefficients have the expected sign and are significantly different from zero at the 95th percentile.

Travel cost and travel time have a negative effect on the probability of selecting a site, indicating that boaters prefer to visit sites closer to their homes (other things being equal). However, the magnitude of the travel time coefficient indicates that boaters are willing to travel farther than participants in other recreational activities. This is not surprising, since motor-boating and sailing are restricted to the sites where these activities are allowed. The positive coefficient on the water body size variable (LN(SIZE)) indicates that the larger the water body the more likely the boaters visited it.

The coefficients on water quality variables (TKN and AWQC) are negative, indicating that boaters prefer to visit cleaner sites. The Biomass coefficient is positive, but insignificant for inland sites, and negative for Lake Erie sites. The negative coefficient on this variable is likely to be due to the fact that 88 percent of the sample trips used in this model were motorboating trips. Motorboating itself is likely to be a significant environmental stressor for biological communities due to noise and turbidity associated with this activity. Thus, lower fish abundance at popular boating sites may indicate that intensive motorboating may adversely affect species abundance. As was the case with the fishing model, the estimated

[13] Inclusive values equal to 1 cause the model to collapse to a flat multinomial logit.

inclusive value is significantly different from zero and lies within a unit interval [0.1], supporting the nested model framework.

21.3.3 Swimming Model

EPA included the travel cost and time variables (TRCOST, TIME), physical characteristics of the site, and ambient TKN concentrations in the swimming model. This model also includes the presence of recreational amenities that are likely to be important to swimmers: presence of a beach, the designation of the site as a park, and the natural log of the land acres. All estimated coefficients have the expected sign and are significantly different from zero at the 95th percentile.

Price, travel time, the presence of a park with a beach, and the size of the land area around the site all increase the probability of a particular site being chosen for swimming. Swimmers are less likely to visit large sites (referring to the size of the water body) or sites with visible water quality effects as indicated by higher in-stream concentrations of TKN. As for the fishing and boating models, the estimated inclusive value is significantly different from zero and lies within a unit interval [0,1] supporting the nested model framework.

Again, some variables expected to be significant, such the presence of contact advisories, are not. This variable's insignificance probably stems from its scarcity. Of 1,954 sites included in the universal opportunity set, contact advisories are in place for only 13. (None of the sites actually visited had contact advisories in place.) The probability that a chosen site has contact advisories in place is very small, because individual choice sets are randomly selected.

The fish Biomass variable representing biological characteristics of a water body also did not have a significant influence on consumer decisions to visit a particular site and was dropped from the model. This outcome is not surprising, since abundant aquatic life may, in fact, interfere with swimming activities.

21.3.4 Viewing (Near-water Activity) Model

EPA included the travel cost and time variables (TRCOST, TIME), physical site characteristics, and ambient TKN concentrations in the viewing model. In addition, the Agency included the natural log of the land acres and the designation of the site as a park. All estimated coefficients have the expected sign and are significantly different from zero at the 95th percentile.

The probability of choosing a site for near-water activities is most significantly related to visit price, travel time, land size, and in-stream concentrations of TKN. Similarly to the fishing model, the water body size has a different effect on the probability of selecting a site in the Lake Erie, river, and small lake/reservoir groups. The larger the Lake Erie shore segment, the more likely that viewers visited the site. The negative coefficients on river and inland lake size indicate that consumers prefer smaller inland water bodies for near-water and wildlife viewing activities.

21.4 Trip Participation Model

EPA estimated the determinants of individual choice concerning how many trips to take during a recreation season with a separate model for each of the four activities. These participation models rely on socioeconomic data, and on estimates of individual utility (the inclusive value) derived from the site choice models. Variables of importance include age, ethnicity, gender, education, and the presence of young or older children in the household. Whether or not the individual owns a boat is particularly important in boating participation, and is included in the model for that activity only. Variable definitions for the trip participation model are:

- IVBASE: inclusive value, estimated using the coefficients obtained from the site choice models;
- #TRIPS: number of trips taken by the individual;
- AGE: individual's age. If the individual did not report age, their age is set to the sample mean;
- MALE: equals 1 if the individual is a male, 0 otherwise;
- NOHS: equals 1 if the individual did not complete high school, 0 otherwise;

- COLLEGE: equals 1 if the individual completed college, 0 otherwise;
- AFAM: equals 1 if the individual is African American, 0 otherwise;
- YNGKIDS: equals 1 if there are kids 6 years or younger, 0 otherwise;
- OLDKIDS: equals 1 if there are kids 7 years or older, 0 otherwise;
- OWNBT: equals 1 if individual owns a boat, 0 otherwise;
- Constant: a constant term representing each individual's utility associated with not taking a trip; and
- α (alpha): overdispersion parameter estimated by the Negative Binomial Model.

Table 21.4 presents explanatory variables and a mean value for each.

Table 21.4: Mean Values for Explanatory Variables Used in the Participation Models

Variables (Mean)	Non-Participant (N=291)	Boating (N=85)	Fishing (N=84)	Swimming (N=78)	Viewing (N=75)
# TRIPS	0.00	7.71	10.07	9.46	9.59
AGE	43.99	39.06	38.53	34.76	36.91
MALE	0.33	0.49	0.65	0.47	0.47
NOHS	0.17	0.09	0.14	0.13	0.13
COLLEGE	0.15	0.32	0.20	0.32	0.35
AFAM	0.11	0.02	0.05	0.03	0.12
YNGKIDS	0.18	0.26	0.24	0.24	0.27
OLDKIDS	0.38	0.48	0.58	0.56	0.48
OWNBT	N/A	0.53	N/A	N/A	N/A

Source: U.S. EPA analysis.

Table 21.5 presents the results for the participation models of the four recreation activities.

Table 21.5: Trip Participation Negative Binomial Model Estimates

Variables/ Statistics	Boating	Fishing	Swimming	Viewing
IVBASE	0.12 (0.71)	0.82 (2.86)	0.72 (4.57)	0.47 (3.66)
AGE	-0.07 (-4.73)	-0.04 (-2.06)	-0.06 (-2.24)	-0.05 (-2.77)
MALE	1.23 (2.75)	2.22 (3.25)	1.15 (1.52)	0.91 (2.00)
NOHS	1.29 (2.37)	-1.09 (-1.56)	-0.92 (-0.96)	0.1 (0.17)
COLLEGE	-0.19 (-0.29)	-0.40 (-0.721)	0.53 (0.71)	1.22 (2.05)
AFAM	-3.74 (-1.81)	-1.44 (-1.53)	-4.07 (-2.68)	-1.16 (-1.34)
YNGKIDS	1.51 (2.96)	-0.95 (-1.26)	0.35 (0.42)	-0.17 (-0.38)
OLDKIDS	-1.67 (-3.58)	1.11 (2.78)	0.4 (0.65)	0.8 (1.81)
OWNBT	3.82 (5.26)	N/A	N/A	N/A
Constant	0.20 (0.11)	-5.74 (-3.01)	-0.1 (-0.06)	-1.98 (-1.6)
Alpha α	5.77 (5.85)	9.03 (7.16)	8.92 (6.78)	8.17 (6.03)

Note: T-statistic for test that coefficient equals 0 is given in parentheses below the coefficient estimates.
N/A indicates that the variable was not included in the estimation for this activity.

Source: U.S. EPA analysis.

Parameter estimates of the inclusive value index (IVBASE) in the swimming, fishing, and viewing models are positive and differ significantly from zero at the 95th percentile, indicating that water quality improvements have a positive effect on the number of trips taken during a recreation season.

The estimated coefficient on IVBASE in the boating model, while positive, was not statistically significant. Taking a boating trip often requires more preparation (e.g., taking a boat to the water body) than taking other trips. Therefore, although water quality improvements increase the value of a boating day, factors other than water quality are likely to have a stronger impact on the number of boating trips per season.

The AGE variable is negative and significant for all four recreation activities: younger people are likely to take more recreation trips. Ethnicity and gender (the AFAM and MALE variables) also have a significant impact on whether an individual participates in water-based recreation. African Americans living in Ohio are less likely to participate in any of the four recreation activities than representatives of other ethnic groups. Males are more likely than females to participate in any of the recreation activities.

Education also influences trip frequency significantly. People who did not complete high school (NOHS=1) tend to take fewer fishing or swimming trips. Those with a college degree (COLLEGE=1) are more likely to participate in swimming and viewing. Respondents who attended college are less likely, however, to participate in fishing and boating than those who completed only a high school education. For the boating model, the COLLEGE variable is not significantly different from zero.

The presence of older children (OLDKIDS) in the household is associated with greater participation in swimming, viewing (near-water recreation), and fishing activities, but is not a significant determinant in decisions to participate in boating. Younger children in the household (YNGKIDS) tends to lead to greater participation in boating and swimming, but leads to fewer fishing or viewing trips.

21.5 Estimating Benefits from Reduced MP&M Discharges in Ohio

21.5.1 Benefiting Reaches in Ohio

EPA identified reaches where it expects the MP&M rule to eliminate or reduce the number of existing AWQC exceedances (hereafter, benefiting reaches). The Agency first identified the reaches in which baseline discharges from industrial sources, including both MP&M and non-MP&M facilities, caused one or more pollutant concentrations to exceed AWQC limits for aquatic species. A reach is considered to benefit from the MP&M rule if at least one AWQC exceedance is eliminated due to reduced MP&M discharges. Although the method for identifying benefiting reaches is similar to the method used in the national analysis (see Chapter 15 for detail), there are three notable differences:

- Unlike the national analysis, the Ohio case study incorporates information on all industrial and municipal point source discharges and non-point sources to assess in-stream concentrations of toxic and nonconventional pollutants in the baseline and post-compliance. Appendix H provides information on the data sources and methods used to assess ambient water quality conditions in Ohio.

- The water quality model used in this analysis estimates ambient pollutant concentrations in the reaches receiving discharges from MP&M facilities and reaches below the initial discharge reach. Appendix H provides detail on the water quality model used in this analysis.

- The analysis of recreational benefits accounts for changes in TKN concentrations.

EPA's analysis indicates that pollutant concentrations at the baseline discharge levels from all industrial sources (including all MP&M facilities) exceed acute exposure criteria for aquatic life on 15 reaches, and exceed chronic exposure criteria for protection of aquatic species on 21 reaches. EPA estimates that reducing pollutant discharges from oily waste facilities directly discharging to the receiving streams would not eliminate all concentrations in excess of the acute aquatic life exposure criteria or the chronic exposure criteria on any reach under the final rule; it would reduce the number of acute and chronic exceedances on one reach.

In addition, baseline pollutant concentrations exceed human health-based AWQC for consumption of water and organisms on three reaches and exceed AQWC for consumption of organisms only on two reaches. EPA estimates that reducing pollutant discharges from oily waste facilities directly discharging to the receiving streams would reduce the number of pollutants exceeding the human health-based AWQC on one reach under the final rule; it would not eliminate all human health-based AQWC exceedances on any reach in Ohio. Table 21.6 summarizes these results. In addition, the final regulation is estimated to reduce in-stream concentrations of TKN in the affected reaches. The estimated average reductions are 0.54 percent in lakes and 0.45 percent in rivers and streams.

Table 21.6.: Estimated MP&M Discharge Reaches with MP&M Pollutant Concentrations in Excess of AWQC Limits for the Oily Wastes Subcategory for Protection of Aquatic Species or Human Health

Regulatory Status	Number of Reaches with Concentrations Exceeding AWQC Limits for Human Health		Number of Reaches with Concentrations Exceeding AWQC Limits for Aquatic Species		Number of Benefiting Reaches	
	H20 and Organisms	Org. Only	Acute	Chronic	All AWQC Exceedances Eliminated	Reaches with Some AWQC Exceedances Eliminated
Baseline	3	2	15	21	-	-
Final Regulation	3	2	15	21	0	1

Source: U.S. EPA analysis.

21.5.2 Estimating Recreational Benefits in Ohio

To estimate peoples' willingness-to-pay for water quality improvements, the Agency first calculated per-person seasonal welfare gain corresponding to the final regulation. Table 21.7 presents, for each recreation activity, the compensating variation per trip (the median value over all individuals in the sample) associated with the reduced MP&M discharges. Because the trip choices and the associated expenditures occurred in 1993, the welfare gain was calculated in 1993 dollars and then adjusted to 2001 dollars based on the Consumer Price Index (CPI).

The model indicates that the reductions in MP&M discharges from the final regulation result in a modest increase in per-trip values for three of the four recreation activities (fishing, viewing, and swimming). There is no welfare gain to boaters from improved water quality under the post-compliance scenario.[14] Table 21.7 provides the mean estimates of welfare gain per recreational user in Ohio.

Table 21.7: Welfare Gain per Recreational User in Ohio (2001$)

	Per Trip Welfare Gain	Average Number of Trips per Person per Year	Mean Seasonal Welfare Gain
Fishing	$0.02	13.6	$0.17
Boating	$0.00	6.22	$0.00
Viewing	$0.01	9.26	$0.11
Swimming	$0.01	8.72	$0.01

Source: U.S. EPA analysis.

Table 21.7 also reports seasonal compensating variation per individual. The reported seasonal welfare gain includes both the increase in the utility from better water quality at the available recreation sites receiving MP&M discharges and the increase in utility from greater recreational trip participation.

As noted above, the Ohio case study evaluated changes in the water resource values from both reduced discharges of TKN and reduced frequency of AWQC exceedances. Changes in TKN concentration in the Ohio water bodies resulting from reduced MP&M discharges from the Oily Wastes subcategory account for approximately 96 percent of the monetary value of benefits resulting from the final rule.

[14] The choice set of recreational sites available to boaters was restricted to the sites where motorboating and sailing is permitted because the majority of Ohio boaters included in this analysis used either motor or sail boats. Water quality improvements at the sites where boating is not allowed does not result in welfare gain to boaters.

Both the per-trip and seasonal welfare estimates are much lower than values reported in the existing studies of water-based recreation. This is not surprising, since the water quality changes expected from the final rule are very modest.

To calculate state-level recreational benefits from the final rule, EPA first calculated seasonal welfare gain from water quality improvements per individual in the sample. The Agency then multiplied the average welfare gain per individual by the corresponding number of participants in a given activity (see Section 21.1.5 above for detail). The resulting product is the annual benefit from the final MP&M rule to consumers of a given water-based recreation activity in Ohio. Table 21.8 summarizes state-level results.

Table 21.8: Estimated Recreational and Nonuse Benefits from Reduced MP&M Discharges from the Oily Wastes Subcategory in Ohio

Activity	Percentage of Ohio Residents Participating in Single-Day Trips (from NDS)	Number of Participants Aged 16 and older[a]	Total Annual Welfare Gain to Recreational Users in Ohio
Fishing	10.2%	892,283	$153,102
Boating	7.7%	676,026	$0
Viewing	9.1%	798,220	$88,047
Swimming	9.1%	798,220	$9,783
Total Recreational Use Benefit			$250,933
Nonuse Benefits			$125,466
Total Recreational Benefits (Use + Nonuse)			$375,859

[a] EPA estimated the number of participants in each recreation activity by multiplying the percent of NDS survey respondents from Ohio participating in a single day trip for each activity by the total adult population aged 16 an older (8,790,969). This analysis uses the 2000 Census data to estimate current population in Ohio.

Source: U.S. EPA analysis.

Under the final regulation, the extrapolation from the sample to the adult population in Ohio yields mean annual benefits estimates of $153,102, $9,783, $88,047, and $0 (2001$) for fishing, swimming, viewing, and boating, respectively. The total mean recreational use benefit is $250,932 (2001$). The Agency used the same approach as in the national analysis to estimate nonuse benefits (see Section 15.2.3, *Nonuse Benefits*, for detail). EPA estimated nonuse benefits as one-half of recreational use benefits for low, mid, and high estimates, respectively. The estimated mean nonuse benefit is $125,466 (2001$).

21.6 Limitations and Uncertainty

21.6.1 One-State Approach

Some benefits are likely to be missed by a state-level case study. For example, residents from neighboring states undoubtedly recreate in Ohio waters, and residents of Ohio undoubtedly recreate in neighboring states. A state-by-state approach that restricts its analysis to recreation activities within the state misses these categories of benefits.[15] This omission is likely to be more significant for unique locations of high quality (e.g., Lake Erie), where participants travel significant distances, and for sites very close to state boundaries.

[15] Note that EPA used a few observation on visitors from neighboring states to estimate site choice models. The analysis does not include these observations in calculating state-level benefits from water quality improvements.

21.6.2 Including One-Day Trips Only

Use of day-trips only tends to understate recreational benefits for swimming, fishing, boating, and viewing, since recreation as part of multi-day trips is excluded. Inclusion of multi-day trips, however, can be problematic. Multi-day trips are frequently multi-activity trips. An individual might travel a substantial distance, participate in several recreation activities and go shopping and sightseeing, all as part of one trip. Recreational benefits from improved recreational opportunities for the primary activity are overstated if all travel costs are treated as though they are associated with the one recreational activity of interest. The total benefits per trip from water quality improvements are not overstated, however, if individuals participated only in several water-based activities.

21.6.3 Nonuse Benefits

Estimating nonuse benefits using the 50 percent rule is less precise than using a more sophisticated benefits transfer approach. However, limiting the benefits of water quality improvements only to recreational benefits would significantly underestimate the benefits of the rule. The effects of using the simpler approach, e.g. either overestimation or underestimation of benefits, is unknown. Other benefits include aesthetic benefits for residents living near water bodies, habitat values for a variety of species (in addition to recreational fish), and nonuse values. To correct for this limitation of using only a travel cost model, EPA quantified nonuse values in proportion to recreation values. This approach provides only a rough approximation of the value of water resources to nonusers. For example, some natural resources have high use values but small or negligible nonuse values (e.g., cows), while other species have very high nonuse values but small or negligible use values (e.g., blue whales).

21.6.4 Potential Sources of Survey Bias

The survey results could suffer from bias, such as recall bias (e.g., Westat, 1989), nonresponse bias, and sampling effects.

a. Recall bias

Recall bias can occur when respondents are asked the number of days in which they recreated over the previous season, such as in the NDS survey. Some researchers believe that recall bias tends to lead to an overstatement of the number of recreation days, particularly for more avid participants. Avid participants tend to overstate the number of recreation days, since they count days in a "typical" week and then multiply them by the number of weeks in the recreation season.[16] They often neglect to consider days missed due to bad weather, illness, travel, or when fulfilling "atypical" obligations. Some studies also found that the more salient the activity, the more "optimistic" the respondent tends to be in estimating number of recreation days. Individuals also have a tendency to overstate the number of days they participate in activities that they enjoy and value. Taken together, these sources of recall bias may result in an overstatement of the actual number of recreation days.

b. Nonresponse bias

A problem with sampling bias may arise when extrapolating sample means to population means. This could happen, for example, when avid recreation participants are more likely to respond to a survey than those who are not interested in the forms of recreation, are unable to participate, assume that the survey is not meant for them, or consider the survey not worth their time.

c. Sampling effects

Recreational demand studies frequently face two types of observations that do not fit general recreation patterns: non-participants and avid participants:

Non-participants are those individuals who would not participate in the recreation activity under any conditions. This analysis assumes that an individual is a non-participant in a particular activity if he or she did not participate in that activity at *any* site. This assumption tends to understate benefits, since some individuals may not have participated during the sampling period simply by chance, or because price/quality conditions were unfavorable during the sampling period.
Avid participants can also be problematic because they claim to participate in an activity an inordinate number of times. This

[16] Westat (1989) uses ten or more activity-days per year as an indicator of an "avid" user.

reported level of activity is sometimes correct, but often overstated, perhaps due to recall bias (see Westat, 1989). Even where the reports are correct, these observations tend to be overly influential. EPA dropped observations of participants who reported more than 100 trips per year when estimating trip participation models, to correct for potential bias caused by these observations.

GLOSSARY

ambient water quality criteria (AWQC): levels of water quality expected to render a body of water suitable for its designated use. Criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, fish production, or industrial processes. (http://www.epa.gov/OCEPAterms/aterms.html)

compensating variation (CV): the amount of money a person would need to pay or receive in order to leave that person as well off as they were before a change.

consumer choice set: the set of alternatives (e.g., alternative recreation sites) from which a consumer may choose.

exogenous: external to the inner workings of a system or model; variables are exogenous to the extent that they are "given" and not the result of the operation of the system or anything going on in the model itself.

expected maximum utility: see "inclusive value."

fish biomass (Biomass): measure of biological factors in the water body represented by the total fish weight in kilograms per 300 meters.

fish consumption advisories (FCAs): an official notification to the public about specific areas where fish tissue samples have been found to be contaminated by toxic chemicals which exceed FDA action limits or other accepted guidelines. Advisories may be species specific or community wide.

inclusive value: the value to the consumer of being able to choose among X alternatives (e.g., among a number of recreational sites) on a given trip occasion.

indirect utility function: gives the maximum value of utility for any given prices and money income. The indirect utility function is obtained when the quantity of goods that maximizes consumer utility subject to a budget constraint are substituted into a utility function.

inferential analyses: based on interpretation.

multinomial logit (MNL): a utility maximization model. In this model, an individual is assumed to have preferences defined over a set of alternatives (e.g., recreation sites). The choice model takes the form of comparing utilities from different alternatives and choosing the one that produces the maximum utility. In this framework, observed data consist of attributes of the choices (e.g., available recreational amenities at different sites) and the choice actually made. Usually no characteristics of the individuals are observed beyond their actual choice.

National Demand Survey for Water-Based Recreation (NDS): a U.S. EPA survey of recreational behavior. The 1994 survey collected data on socioeconomic characteristics and water-based recreation behavior using a nationwide stratified random sample of 13,059 individuals aged 16 and over. (http://www.epa.gov/opei)

negative binomial regression model: an extension of the Poisson regression model that allows the variance of the process to differ from the mean (see also Poisson distribution and Poisson estimation process).

Negative Binomial Poisson model: (see negative binomial regression model).

nested multinomial logit model (NMNL): an extension of MNL (see above). In this model, an individual is assumed to choose among different groups of alternatives first (i.e., Great Lakes or inland recreation sites) and then to choose specific alternatives (e.g., a particular river reach, lake, or Great Lakes site) in the choice set for each group.

nonconventional pollutants: a catch-all category that includes all pollutants that are not classified as priority pollutants or conventional pollutants.

Ohio Water Resource Inventory (OWRI): a biennial report to U.S. EPA and Congress required by Section 305(b) of the Clean Water Act. The report is composed of four major sections: (1) inland rivers and streams, wetlands, Lake Erie, and water program description; (2) fish tissue contaminants; (3) inland lakes, ponds, and reservoirs; and (4) groundwater.

overdispersion: condition for a distribution where the variance exceeds the mean. It usually signifies a nonrandom dispersion, for example the case where a small minority of the population is responsible for the majority of recreational trips taken.

Poisson distribution: a random variable X is defined to have a Poisson distribution if the probability density of X is given by $f_x(X) = f_x(X;\lambda) = e^{-\lambda} \lambda^x / x!$ for x = 0,1,2.., and 0 otherwise. In this model, λ is both the mean and variance of X.

Poisson estimation process: used to model discrete random variables. Typically, a Poisson random variable is a count of the number of events that occur in a certain time interval or spatial area, for example, the number of recreational trips taken during a recreational season.

priority pollutants: 126 individual chemicals that EPA routinely analyzes when assessing contaminated surface water, sediment, groundwater, or soil samples.

random utility model (RUM): a model of consumer behavior. The model contains observable determinants of consumer behavior and a random element.

Reach File 1 (RF1): a database of approximately 700,000 miles of streams and open waters in the conterminous United States. The database contains information on stream flow, time travel velocity, reach length, width, depth, and other stream attributes.

site choice model: used to determine which recreational site is chosen by the consumer. EPA estimated the likelihood that the consumer will choose a particular site as a function of site characteristics, the price paid per site visit, and household income.

Total Kjeldahl Nitrogen (TKN): the total of organic and ammonia nitrogen. TKN is determined in the same manner as organic nitrogen, except that the ammonia is not driven off before the digestion step.

travel cost model (TCM): method to determine the value of an event by evaluating expenditures by participants. Travel costs are used as a proxy for price in deriving demand curves for recreation sites. (http://www.damagevaluation.com/glossary.htm)

total seasonal welfare: see "welfare effect."

trip participation model: used to estimate the number of water-based recreational trips taken during the recreation season. EPA estimated the total number of trips during the recreation season as a function of the expected maximum utility (inclusive value) from recreational activity participation on a trip and socioeconomic characteristics affecting demand for recreation trips (e.g., number of children in the household).

utility-theoretic: consistent with the behavioral postulate that individuals act to maximize their welfare (utility) that underlines the structure of models of consumer behavior.

welfare effect: gain or loss of welfare to the group of individuals (e.g., fishermen) as a whole.

ACRONYMS

AWQC: ambient water quality criteria
CV: compensating variation
FCAs: fish consumption advisories
IWB2: index of well-being
LIMDEP: Limited Dependent Variable
MNL: multinomial logit
NDS: National Demand Survey for Water-Based Recreation
NMNL: nested multinomial logit model
ODNR: Ohio Department of Natural Resources
OWRI: Ohio Water Resource Inventory
RUM: random utility model
RF1: Reach File 1
TKN: Total Kjeldahl Nitrogen
TCM: travel cost model

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Chapter 22: MP&M Benefit-Cost Analysis in Ohio

INTRODUCTION

This chapter presents estimated benefits and costs of the final MP&M regulation in Ohio. The preceding chapter summarized the methodology and results of the case study of the expected recreational benefits from water quality improvements in Ohio. This chapter first presents estimates of the remaining three benefit categories, including:

- reduced human health risk from exposure to carcinogens and systemic health toxicants,
- changes in health risk from exposure to lead for adults and children, and
- ***publicly-owned treatment works (POTW)*** benefits.[1]

CHAPTER CONTENTS

The chapter then presents the social costs of the final regulation for the state of Ohio and compares the aggregate benefits and social costs estimates. From this analysis, EPA estimates that the final regulation will have net monetizable benefits in Ohio of $868 thousand annually (2001$).

EPA estimated MP&M costs and benefits in Ohio using methodologies similar to those used for the national-level analysis but with greater detail and coverage of information. In addition to the RUM study of recreational benefits discussed in the previous chapter, other analytical improvements included the following:

- the use of more detailed data on MP&M facilities. EPA oversampled the state of Ohio with 1,600 screeners to obtain information on co-occurrence of MP&M discharges;
- the use of data on non-MP&M discharges to estimate current baseline conditions in the state; and
- the use of a first-order decay model to estimate in-stream concentrations in the Ohio water bodies. This model allows the assessment of the environmental effects of MP&M discharges on the reaches receiving MP&M discharges and downstream reaches.

Appendix H describes the water quality model used in this analysis and the approach and data sources used to estimate total pollutant loadings from all industrial and municipal sources to Ohio's water bodies. The Agency believes that the added level of detail results in more robust benefit-cost estimates.

22.1 BENEFITS OF THE FINAL REGULATION

EPA estimates that MP&M facilities in all subcategories in Ohio discharge approximately 127.6 million pounds of pollutants per year to POTWs, and approximately 83.6 million pounds of pollutants directly to surface water. EPA estimates that the final regulation will reduce direct discharges by approximately 0.5 million pounds of pollutants annually.

[1] The final rule regulates only direct dischargers. Therefore, the selected option does not affect POTW operations.

22.1.1 Human Health Benefits (Other than Lead)

EPA estimates total monetized human health benefits from the final regulation of $14,504 (2001$). Chapter 13 details the methodologies used to estimate human health benefits from reduced exposure to carcinogens and systemic health toxicants other than lead.

a. Reduced incidence of cancer cases from consumption of contaminated fish and drinking water

Table 22.1 shows the number of cancer cases avoided by the final regulation for both the drinking water and fish consumption pathways. EPA estimates that improved water quality resulting from the final regulation will reduce the incidence of cancer cases via the drinking water and fish consumption pathways from 0.11 cases in the baseline to 0.10 cases under the final regulation, with a total annual value of $14,504. Essentially all of the cancer avoidance occurs via the fish consumption pathway, which yields annual cancer avoidance benefits of $14,503. Monetized cancer avoidance benefits from reduced drinking water contamination are negligible.

Table 22.1: Estimated Annual Benefits from Avoided Cancer Cases from Fish and Drinking Water Consumption

	Cancer Cases	Benefits (2001$)
	Baseline[a]	
Drinking Water	0.1026421	
Fish Consumption	0.00331	
Total	**0.11**	
	Final Regulation	
Drinking Water	0.1026420	negligible[b]
Fish Consumption	0.00108	$14,503
Total	**0.10**	**$14,504**

[a] The baseline includes baseline loadings from dischargers in all subcategories.
[b] Monetized cancer avoidance benefits from reduced drinking water contamination are approximately $1.

Source: U.S. EPA analysis.

b. Systemic health effects

EPA's analysis of in-waterway pollutant concentrations indicates that baseline hazard ratios, for both the fish consumption and drinking water pathways, for the population associated with sample facilities only, are less than one on all reaches but one. For those reaches with a baseline hazard ratio of less than one, EPA's analysis finds shifts in populations from higher (but less than 1.0) to lower hazard ratio value between the baseline and post-compliance cases. For the single reach with a baseline hazard ratio greater than one, the hazard ratio declined but did not fall below one.

c. Reduced frequency of human health-based AWQC exceedances in Ohio's water bodies

Baseline in-waterway concentrations of MP&M pollutants exceed human health-based ***ambient water quality criteria (AWQC)*** limits for consumption of water or organisms in three reaches. Two reaches exceeded human health-based AWQC for consumption of organisms only. EPA estimates that the final regulation will not eliminate these exceedences of human health AWQC on any reach but will reduce the number of exceedences on one reach.

22.1.2 Lead-Related Benefits

Total monetized lead-related benefits in Ohio for children and adults under the final regulation are $422,113 (2001$). Chapter 14 of this report describes the methodology used to estimate these benefits.

a. Estimated benefits to Ohio's children

Table 22.2 presents lead-related benefits from the final regulation for preschool age children and pregnant women in Ohio. EPA estimates that the final regulation will reduce neonatal mortality by 0.024 cases annually, with an annual monetary value of $162,094 (2001$).

EPA estimates that the final regulation will avoid the loss of an estimated 26.96 IQ points among preschool children in Ohio, with an annual value of $253,934 (2001$). The annual avoided costs of compensatory education from reduced incidence of children with IQ below 70 and blood lead levels above 20 µg/dL amount to approximately $6,085. In total, the final regulation results in lead-related benefits for Ohio children of $422,113 annually (2001$).

Table 22.2: Ohio Child Lead Annual Benefits (2001$): Final Regulation

Category	Reduced Cases or IQ Points	Monetary Value of Benefits
Neonatal mortality	0.024	$162,094
Avoided IQ loss	26.96	$253,934
Reduced IQ < 70	0.09	$5,345
Reduced PbB > 20 µg/dL	0.04	$740
Total Benefits		**$422,113**

Source: U.S. EPA analysis.

b. Adult benefits

Table 22.3 presents benefit estimates for reduced lead-related health effects in adults. These health effects include increased incidence of hypertension, initial non-fatal ***coronary heart disease (CHD)***, non-fatal stokes (***cerebrovascular accidents [CBA]*** and ***brain infarction [BI]***), and premature mortality. The final regulation would reduce hypertension in Ohio by an estimated 9.4 cases annually among males, with annual benefits of approximately $10,670 (2001$). Reducing the incidence of initial CHD, strokes, and premature mortality among adult males and females in Ohio would result in estimated benefits of $963, $2,115, and $103,645, respectively. Overall, adult lead-related benefits total $117,393. This analysis does not include other lead-related health effects from elevated ***blood pressure (BP)*** or from effects such as nervous system disorders, anemia, and possible cancer effects.

Table 22.3: Ohio Adult Lead Benefits (2001$): Final Regulation

Category		Final Regulation	
		Reduced Cases	Monetary Value of Benefits
Men	Hypertension	8.697	$10,670
	CHD	0.011	$693
	CBA	0.005	$947
	BI	0.003	$535
	Mortality	0.015	$79,178
Women	CHD	0.003	$270
	CBA	0.002	$392
	BI	0.001	$241
	Mortality	0.004	$24,467
Total Benefits			**$117,393**

Source: U.S. EPA analysis.

22.1.3 Economic Productivity Benefits

The selected option does not affect POTW operations because the final rule regulates only direct dischargers. For the alternative policy options that consider both direct and indirect dischargers, EPA evaluated two categories of productivity benefits for POTWs:

- reduced ***interference*** with the operations of POTWs, and
- reduced contamination of sewage sludge (i.e., biosolids) at POTWs that receive discharges from MP&M facilities.

Chapter 16 presents the methodology for evaluating POTW benefits. EPA's analysis found that the alternative policy options did not yield POTW productivity benefits in Ohio.

22.1.4 Total Monetized Benefits

Summing the monetary values over all benefit categories (Chapters 21 and 22) yields total monetized benefits in Ohio of $930,408 (2001$) annually for the final regulation (see Table 22.4). As noted in Chapter 12, this benefit estimate is necessarily incomplete because it omits some mechanisms by which society is likely to benefit from reduced effluent discharges from the MP&M industry. Examples of benefit categories excluded from this estimate include: non-lead-related, non-cancer health benefits; improved aesthetic value of waters near discharge outfalls; benefits from improved habitat for wildlife, including threatened or endangered species; tourism benefits; and reduced costs for drinking water treatment.

Table 22.4: Estimated Annual Benefits in Ohio from Reduced MP&M Discharges under the Final Regulation 2001$)

Benefit Category	Low	Mid	High
1. Reduced Cancer Risk:			
Fish Consumption	$14,503	$14,503	$14,503
Water Consumption[a]	n/a	n/a	n/a
2. Reduced Risk from Exposure to Lead:			
Children	$422,113	$422,113	$422,113
Adults	$117,393	$117,393	$117,393
3. Enhanced Water-Based Recreation	$250,932	$250,932	$250,932
4. Nonuse benefits	$125,466	$125,466	$125,466
5. Avoided Sewage Sludge Disposal Costs	$0	$0	$0
Total Monetized Benefits	**$930,408**	**$930,408**	**$930,408**

[a] The monetized cancer avoidance benefits from reduced drinking water contamination are negligible.

Source: U.S. EPA analysis.

22.2 Social Costs of the Final Regulation

22.2.1 Baseline and Post-Compliance Closures

The methodology used to assess baseline and post-compliance closures differed from the methodology used for the national analysis presented in Chapter 5. The screener data collected for Ohio facilities did not provide financial data to perform an after-tax cash flow or net present value test. EPA therefore used data from the national analysis to estimate the percentage of facilities that close in the baseline and post-compliance. EPA assumed that the frequency of Ohio facility closures would be the same as that found in the national analysis for facilities with the same discharge status, subcategory, and flow category. For example, 2 percent of Oily Wastes facilities discharging less than one million gallons per year close in the baseline in the national analysis, and this same percentage is assumed for Ohio screener direct dischargers in that flow size category.

Table 22.5 summarizes the numbers of facilities in Ohio closing or excluded from the final regulation by discharge status. All indirect dischargers operating post-regulation are excluded from requirements by subcategory exclusions. Of the 198 direct dischargers operating post-regulation, 85 (or 43 percent) are excluded from requirements by subcategory exclusions. A total of 113 direct discharging facilities in the Oily Wastes subcategory are therefore subject to requirements under the final regulation.

Table 22.5: Regulatory Impacts for Ohio MP&M Facilities by Discharge Type			
	Indirect	Direct	Total
Number of MP&M facilities operating in the baseline	1,682	198	1,880
Number of MP&M facilities with subcategory exclusions	1,682	85	1,767
Number of MP&M facilities operating in the baseline estimated subject to regulatory requirements	0	113	113
Number of regulatory closures	0	0	0
Percent of MP&M facilities operating in the baseline and subject to regulatory requirements that are regulatory closures	0.0%	0.0%	0.0%

Source: U.S. EPA analysis.

22.2.2 Compliance Costs for MP&M Facilities

The calculation of annualized compliance costs in Ohio uses the methodology presented in Chapter 11. These compliance costs are not adjusted for the effect of taxes or for recovery of costs through price increases, and therefore represent the social value of resources used for compliance. EPA annualized compliance costs using a social discount rate of seven percent over an estimated 15-year useful life of compliance equipment.

In calculating compliance costs for Ohio facilities, EPA combined the compliance cost estimates developed for the "detailed questionnaire" Ohio facilities included the national analysis with compliance costs estimated for the additional "screener questionnaire" facilities included in the Ohio analysis. The Agency estimated compliance costs for each Ohio screener facility and then calculated an annualized compliance cost by subcategory, flow range, and discharge status for the Ohio facilities. These costs included facilities that might be assessed as baseline closures and thus would overstate expected compliance costs to the extent that some facilities are expected to close and not incur compliance costs. Because EPA estimated closures among Ohio screener facilities based on the closure rates from the national analysis, it was not possible to identify specific Ohio screener facilities as baseline or post-regulation closures and to remove their compliance costs from the total compliance cost estimates on a facility-specific basis. Instead, EPA reduced the total compliance costs, by facility category, by the estimated fraction of facilities assessed as baseline closures from the national analysis. EPA added these costs for the "screener questionnaire" facilities to the estimated compliance costs for the "detailed questionnaire" facilities to calculate total compliance costs for Ohio MP&M facilities.

Table 22.6 reports the estimated resource value of compliance costs by discharge status and subcategory. The total estimated annualized compliance costs are $62 thousand.

Table 22.6: Resource Value of Compliance Costs in Ohio (2001$)			
Subcategory	Indirect	Direct	Total
General Metals	$0	$0	$0
MF Job Shop	$0	$0	$0
Non Chromium Anodizer	$0	$0	$0
Oily Wastes	$0	$62,232	$62,232
Printed Wiring Boards	$0	$0	$0
Railroad Line Maintenance	$0	$0	$0
Steel Forming & Finishing	$0	$0	$0
Total	**$0**	**$62,232**	**$62,232**

Source: U.S. EPA analysis.

22.2.3 Total Social Costs

As discussed in Chapter 11, the regulation's social costs include the resource cost of compliance (e.g., labor, equipment, material, and other economic resources needed to comply with the rule), costs to governments administering the regulation, and the social costs associated with unemployment resulting from facility closure. EPA estimated that the final rule will not result in social costs of unemployment and that governments will not incur additional costs in administering the regulation. Accordingly, as shown in Table 22.7, EPA's estimate of the final rule's social costs in Ohio is the same as that reported for the resource cost of compliance, $62 thousand (2001$) annually.

Table 22.7: Annual Social Costs for the Final Regulation in Ohio (2001$, costs annualized at 7%)

Component of Social Costs	Final Rule
Resource value of compliance costs	$62,232.0
Government administrative costs	$0.0
Social cost of unemployment	$0.0
Total Social Cost	$62,232.0

Source: U.S. EPA analysis.

22.3 Comparison of Monetized Benefits and Costs in Ohio

EPA cannot perform a complete cost-benefit comparison because not all of the benefits resulting from the final rule can be valued in dollar terms. As reported above, for Ohio, EPA estimated the final rule's social cost at $62 thousand annually (2001$) and estimated monetizable benefits of $930 thousand annually (2001$). Subtracting the social costs from social benefits yields a net monetizable benefit of $868 thousand annually (2001$).

In contrast to the national estimates of costs and benefits for the final regulation, the Ohio case study shows substantial net positive benefits even for the lower-bound benefits estimate. This difference results mainly from the more complete assessment of benefits from reduced MP&M pollutant discharges and more detailed water quality modeling. In addition to estimating recreational benefits from reduced frequency of AWQC exceedences, the Ohio case study estimated changes in water resource values from reduced discharges of TKN. Changes in TKN concentration in Ohio water bodies account for approximately 96 percent of the monetary value of recreational and nonuse benefits from the final rule. EPA also included an additional recreational benefit category in the Ohio analysis: swimming. Although the estimated per-trip welfare gain to swimmers is less than the gain for participants in other water-based recreational activities, this benefit category accounts for a sizable portion of the state-level benefits. Other factors that affect the Ohio benefit-cost comparison include: the presence of unique water resources such as Lake Erie; use of a more sophisticated water quality model, which estimates water quality changes in reaches downstream from the discharge reach; and a more accurate account of baseline water quality conditions. The presence of unique water resources, such as Lake Erie, and other numerous recreational opportunities (e.g., inland lakes, rivers, and reservoirs), suggest that the estimated benefits for Ohio are likely to be higher than the average of benefits for other states.

GLOSSARY

ambient water quality criteria (AWQC): levels of water quality expected to render a body of water suitable for its designated use. Criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, fish production, or industrial processes. (http://www.epa.gov/OCEPAterms/aterms.html)

blood pressure (BP): the pressure of the blood on the walls of the arteries.

brain infarction (BI): stroke.

cerebrovascular accidents (CBA): stroke.

coronary heart disease (CHD): disorder that restricts blood supply to the heart; occurs when coronary arteries become narrowed or clogged due to the build up of cholesterol and fat on the inside walls and are unable supply enough blood to the heart.

interference: the obstruction of a routine treatment process of POTWs that is caused by the presence of high levels of toxics, such as metals and cyanide in wastewater discharges. These toxic pollutants kill bacteria used for microbial degradation during wastewater treatment (see: microbial degradation).

publicly-owned treatment works (POTW): a treatment works as defined by Section 212 of the Act, which is owned by a state or municipality. This definition includes any devices or systems used in the storage, treatment, recycling, and reclamation of municipal sewage or industrial wastes of a liquid nature. (http://www.epa.gov/owm/permits/pretreat/final99.pdf)

ACRONYMS

AWQC: ambient water quality criteria
BI: brain infarction
BP: blood pressure
CBA: cerebrovascular accidents
CHD: coronary heart disease
POTW: publicly-owned treatment works

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Appendix A: Detailed Economic Impact Analysis Information

INTRODUCTION

This appendix provides information to support the economic analyses of MP&M industries evaluated for the final rule and presented in Chapter 3 through Chapter 11 of the EEBA. The first section below provides the SIC and NAICS codes that define the MP&M industrial sectors. The second section presents information on the annual turnover of establishments ("births" and "deaths") in the industrial sectors. The third section provides a description of the MP&M surveys that supported the economic impact and benefits analyses presented in the EEBA (see Section 3 of the TDD).

CHAPTER CONTENTS

A.1 MP&M SIC AND NAICS CODES

Standard Industrial Classification (SIC) codes and North American Industrial Classification System (NAICS) codes are hierarchical systems that allow for detailed classification of industries using numerical codes. This section lists and describes the SIC codes that make up the MP&M industry sectors. It also describes the process by which data organized by NAICS code was converted to SIC code format.

A.1.1 SIC Codes by Sector

Table A.1 lists and describes the 4-digit SIC codes that make up the MP&M industry sectors. These codes were used until recently to define industries for reporting of Federal Census data, and are the framework for the part of the industry profile (Chapter 3) based on publicly available material.

Table A.1: MP&M Sectors and SIC Codes Evaluated for the Final Rule[a]

SIC Code	Standard Industrial Classification Groups
	Aerospace
3761	Guided Missiles and Space Vehicles
3764	Guided Missile and Space Vehicle Propulsion
3769	Other Space Vehicle and Missile Parts
	Aircraft
3721	Aircraft
3724	Aircraft Engines and Engine Parts
3728	Aircraft Parts and Auxiliary Equipment
4581	Airports, Flying Fields, Airport Terminal Services
	Bus And Truck
3713	Truck and Bus Bodies
3715	Truck Trailers

Table A.1: MP&M Sectors and SIC Codes Evaluated for the Final Rule[a]	
SIC Code	**Standard Industrial Classification Groups**
4111	Local And Suburban Transit
4119	Local Passenger Transit, N.E.C.
4131	Intercity And Rural Bus Transportation
4141	Local Bus Charter Service
4142	Bus Charter Service, Except Local
4173	Bus Terminal And Service Facilities
4212	Local Trucking without Storage
4213	Trucking, Except Local
4214	Local Trucking with Storage
4215	Courier Services, Except by Air
4231	Trucking Terminal Facilities
Electronic Equipment	
3661	Telephone and Telegraph Apparatus
3663	Radio and Television Broadcast and Communications Equipment
3669	Communications Equipment, N.E.C.
3671	Electron Tubes
3675	Electronic Capacitors
3677	Electronic Coils and Transformers
3678	Connectors for Electronic Applications
3679	Electronic Components, N.E.C.
3699	Electrical Machinery, Equipment, And Supplies, N.E.C.
Hardware	
2796	Platemaking and Related Services
3398	Metal Heat Treating
3412	Metal Shipping Barrels, Drums, Kegs, Pails
3421	Cutlery
3423	Hand And Edge Tools, Except Machine Tools and Handsaws
3425	Hand Saws and Saw Blades
3429	Hardware, N.E.C.
3433	Heating Equipment, Except Electric and Warm Air Furnace
3441	Fabricated Structural Metal
3443	Fabricated Plate Work (Boiler Shops)
3444	Sheet Metal Work
3446	Architectural and Ornamental Metal Work
3448	Prefabricated Metal Buildings And Components
3449	Miscellaneous Metal Work
3451	Screw Machine Products
3452	Bolts, Nuts, Screws, Rivets, and Washers
3462	Iron and Steel Forgings
3466	Crowns and Closures
3469	Metal Stamping, N.E.C.
3492	Fluid Power Valves and Hose Fittings
3493	Steel Springs
3494	Valves And Pipe Fittings, Except Brass

Table A.1: MP&M Sectors and SIC Codes Evaluated for the Final Rule[a]	
SIC Code	**Standard Industrial Classification Groups**
3495	Wire Springs
3496	Miscellaneous Fabricated Wire Products
3498	Fabricated Pipe and Fabricated Pipe Fitting
3499	Fabricated Metal Products, N.E.C.
3541	Machine Tools, Metal Cutting Types
3542	Machine Tools, Metal Forming Types
3544	Special Dies and Tools, Die Sets, Jigs and Fixtures, and Industrial Molds
3545	Machine Tool Access and Measuring Devices
3546	Power Driven Hand Tools
3965	Fasteners, Buttons, Needles, Pins
Household Equipment	
2514	Metal Household Furniture
2522	Office Furniture, Except Wood
2531	Public Building and Related Furniture
2542	Partitions and Fixtures, Except Wood
2591	Drapery Hardware and Window Blinds/shades
2599	Furniture and Fixtures, N.E.C.
3431	Metal Sanitary Ware
3432	Plumbing Fittings and Brass Goods
3442	Metal Doors, Sash, and Trim
3631	Household Cooking Equipment
3632	Household Refrigerators and Home and Farm and Freezers
3633	Household Laundry Equipment
3634	Electric Housewares and Fans
3635	Household Vacuum Cleaners
3639	Household Appliances, N.E.C.
3641	Electric Lamps
3643	Current-carrying Wiring Devices
3644	Noncurrent-carrying Wiring Devices
3645	Residential Electrical Lighting Fixtures
3646	Commercial, Industrial, and Institutional
3648	Lighting Equipment, N.E.C.
3651	Radio/television Sets Except Communication Types
7623	Refrigeration and Air-conditioning Service and Repair Shops
Instruments	
3812	Search, Detection, Navigation, Guidance, Aeronautical, Nautical Systems and Instruments
3821	Laboratory Apparatus and Furniture
3822	Automatic Environmental Controls
3823	Process Control Instruments
3824	Fluid Meters and Counting Devices
3825	Instruments to Measure Electricity
3826	Laboratory Analytical Instruments
3827	Optical Instruments and Lenses
3829	Measuring and Controlling Devices, N.E.C.

Table A.1: MP&M Sectors and SIC Codes Evaluated for the Final Rule[a]	
SIC Code	**Standard Industrial Classification Groups**
3841	Surgical and Medical Instruments and Apparatus
3842	Orthopedic, Prosthetic and Surgical Suppl.
3843	Dental Equipment and Supplies
3844	X-ray Apparatus and Tubes
3845	Electromedical Equipment
3851	Ophthalmic Goods
7629	Electric Repair Shop
	Iron and Steel
3315	Steel Wiredrawing and Steel Nails and Spikes
3316	Cold-Rolled Steel Sheet, Strip, and Bars
3317	Steel Pipe and Tubes
	Job Shop
3471	Plating and Polishing
3479	Metal Coating and Allied Services
	Mobile Industrial Equipment
3523	Farm Machinery and Equipment
3524	Garden Tractors and Lawn and Garden Equipment
3531	Construction Machinery and Equipment
3532	Mining Machinery and Equipment, Except Oil Field
3536	Hoists, Industrial Cranes and Monorails
3537	Industrial Trucks, Tractors, Trailers
3795	Tanks and Tank Components
	Motor Vehicle
3465	Automotive Stampings
3592	Carburetors, Piston Rings, Valves
3647	Vehicular Lighting Equipment
3694	Electrical Equipment for Motor Vehicles
3711	Motor Vehicle and Automobile Bodies
3714	Motor Vehicle Parts and Accessories
3716	Mobile Homes
3751	Motorcycles
3792	Travel Trailers and Campers
3799	Miscellaneous Transportation Equipment
4121	Taxicabs
5013	Motor Vehicle Supplies and New Parts
5511	Motor Vehicle Dealers (New and Used)
5521	Motor Vehicle Dealers (Used Only)
5561	Recreational Vehicle Dealers
5571	Motorcycle Dealers
5599	Automotive Dealers, N.E.C.
7514	Passenger Car Rental
7515	Passenger Car Lease
7519	Utility Trailer and Recreational Vehicle Rental
7532	Top, Body, and Upholstery Repair and Paint Shops

Table A.1: MP&M Sectors and SIC Codes Evaluated for the Final Rule[a]	
SIC Code	**Standard Industrial Classification Groups**
7533	Auto Exhaust Systems
7537	Auto Transmission Repair
7538	General Automotive Repair
7539	Auto Repair Shop, N.E.C.
7549	Auto Services, Except Repair and Carwashes
	Office Machine
3571	Electronic Computers
3572	Typewriters
3575	Computer Terminals
3577	Computer Peripheral Equipment, N.E.C.
3578	Calculating, Accounting Machines Except Computers
3579	Office Machines, N.E.C.
7378	Computer Maintenance and Repairs
7379	Computer Related Services, N.E.C.
	Ordnance
3482	Small Arms Ammunition
3483	Ammunition, Except for Small Arms
3484	Small Arms
3489	Ordnance and Accessories, N.E.C.
	Miscellaneous Metal Products
3497	Metal Foil and Leaf
3861	Photographic Equipment and Supplies
3931	Musical Instruments
3944	Games, Toys, Children's Vehicles
3949	Sporting and Athletic Goods, N.E.C.
3951	Pens and Mechanical Pencils
3953	Marking Devices
3993	Signs and Advertising Displays
3995	Burial Caskets
3999	Manufacturing Industries, N.E.C.
7692	Welding Repair
7699	Repair Shop, Related Service
	Precious Metals and Jewelry
3873	Watches, Clocks, and Watchcases
3911	Jewelry, Precious Metal
3914	Silverware, Plated Ware and Stainless
3915	Jewelers' Materials and Lapidary Work
3961	Costume Jewelry
7631	Watch, Clock, Jewelry Repair
	Printed Circuit Boards
3672	Printed Circuit Boards
	Railroad
3743	Railcars, Railway Systems
4011	Railroad Transportation

Table A.1: MP&M Sectors and SIC Codes Evaluated for the Final Rule[a]	
SIC Code	**Standard Industrial Classification Groups**
4013	Railroad Transportation
Ships and Boats	
3731	Ship Building and Repairing
3732	Boat Building and Repairing
4412	Deep Sea Foreign Transportation
4424	Deep Sea Domestic Transportation
4432	Freight Transportation Great Lakes
4449	Water Transportation of Freight, N.E.C.
4481	Deep Sea Passenger Transportation
4482	Ferries
4489	Water Passenger Transportation, N.E.C.
4491	Marine Cargo Handling
4492	Towing and Tugboat Service
4493	Marinas
4499	Water Transportation Services, N.E.C.
Stationary Industrial Equipment	
3511	Steam, Gas, Hydraulic Turbines, Generating Units
3519	Internal Combustion Engines, N.E.C.
3533	Oil Field Machinery and Equipment
3534	Elevators and Moving Stairways
3535	Conveyors and Conveying Equipment
3543	Industrial Patterns
3547	Rolling Mill Machinery and Equipment
3548	Electric and Gas Welding and Soldering
3549	Metal Working Machinery, N.E.C.
3552	Textile Machinery
3553	Woodworking Machinery
3554	Paper Industries Machinery
3555	Printing Trades Machinery and Equipment
3556	Food Products Machinery
3559	Special Industry Machinery, N.E.C.
3561	Pumps and Pumping Equipment
3562	Ball and Roller Bearings
3563	Air and Gas Compressors
3564	Blowers and Exhaust and Ventilation Fans
3565	Industrial Patterns
3566	Speed Changers, High Speed Drivers and Gears
3567	Industrial Process Furnaces and Ovens
3568	Mechanical Power Transmission Equipment, N.E.C.
3569	General Industrial Machinery, N.E.C.
3581	Automatic Merchandising Machines
3582	Commercial Laundry Equipment
3585	Refrigeration and Air and Heating Equipment
3586	Measuring and Dispensing Pumps

Table A.1: MP&M Sectors and SIC Codes Evaluated for the Final Rule[a]

SIC Code	Standard Industrial Classification Groups
3589	Service Industry Machines, N.E.C.
3593	Fluid Power Cylinders and Actuators
3594	Fluid Power Pumps and Motors
3596	Scales and Balances, Except Laboratory
3599	Machinery, Except Electrical, N.E.C.
3612	Transformers
3613	Switchgear and Switchboard Apparatus
3621	Motors and Generators
3629	Electric Industrial Apparatus, N.E.C.
7353	Heavy Construction Equip Rental, Leasing
7359	Equipment Rental, Leasing, N.E.C.

[a] EPA evaluated options for these industrial sectors but did not regulate them all under the final rule.

N.E.C. = Not Elsewhere Classified

Source: Executive Office of the President, Office of Management and Budget, Standard Industrial Classification Manual 1987.

A.1.2 Bridge Between NAICS and SIC codes

In 1997, the Census Bureau switched from using SIC codes to using NAICS codes. NAICS codes allow for greater comparability with the International Standard Industrial Classification System (ISIC), which is developed and maintained by the United Nations. NAICS codes also better reflect the structure of today's economy, including the growth of the service sectors and new technologies, than do the decades-old SIC codes. Because EPA chose to create regulatory subgroups for the MP&M industries based on aggregated four-digit SIC codes, it was necessary for EPA to convert some data based on NAICS codes into SIC code format.

The SIC-NAICS conversion is not always straightforward because NAICS and SIC codes often don't map on a one-to-one basis. Specific industries that were grouped together in one SIC code sometimes map to several NAICS codes, and sometimes several SIC codes were aggregated together in one NAICS code.

To address this conversion problem, EPA created a "bridge" that converts the NAICS classification structure to the SIC structure using share values computed from Economic Census data. This bridge is based on data from the 1997 Census, which reported the share of number of establishments and value of output that each SIC code that contributed to each NAICS code, and vice versa.

The first step in creating the bridge was to obtain a table that listed the value of shipments (VOS) that each NAICS code contributed to each SIC code. Since the total VOS for each NAICS code was known, EPA computed share values for each NAICS, which were equal to the percent of total VOS in that NAICS code that was classified in a certain SIC code. The equation is:

$$\text{Share of } NAICS_x \text{ going to } SIC_y = (\text{VOS that } NAICS_x \text{ contributed to } SIC_{y}) / (\text{total VOS for } NAICS_x) \quad \text{(A-1)}$$

Using these share values, EPA converted data classified by NAICS to SIC format, simply by multiplying VOS for each NAICS by its share value, for each SIC, and then summing up the totals for each SIC. For example, if NAICS codes 333121, 332456, and 332457 all contributed a portion of their output to SIC 3322, then:

$$\begin{aligned}\text{VOS for } SIC_{3322} = &(\text{share of } NAICS_{333121} \text{ going to } SIC_{3322}) * (\text{VOS for } NAICS_{333121}) \\ &+ (\text{share of } NAICS_{332456} \text{ going to } SIC_{3322}) * (\text{VOS for } NAICS_{332456}) \quad \text{(A-2)} \\ &+ (\text{share of } NAICS_{332457} \text{ going to } SIC_{3322}) * (\text{VOS for } NAICS_{332457})\end{aligned}$$

Occasionally it was not possible to compute share values because the Census Bureau withheld some 1997 VOS data because of disclosure issues[1]. In those cases, EPA estimated 1997 VOS based on 1992 Census data and then used those estimates to compute share values. First, EPA calculated the average VOS per establishment in 1992 for each relevant SIC code:

$$\text{VOS per establishment for } SIC_y = (\text{VOS for } SIC_y \text{ in 1992}) / (\text{number of establishments for } SIC_y \text{ in 1992}) \quad \text{(A-3)}$$

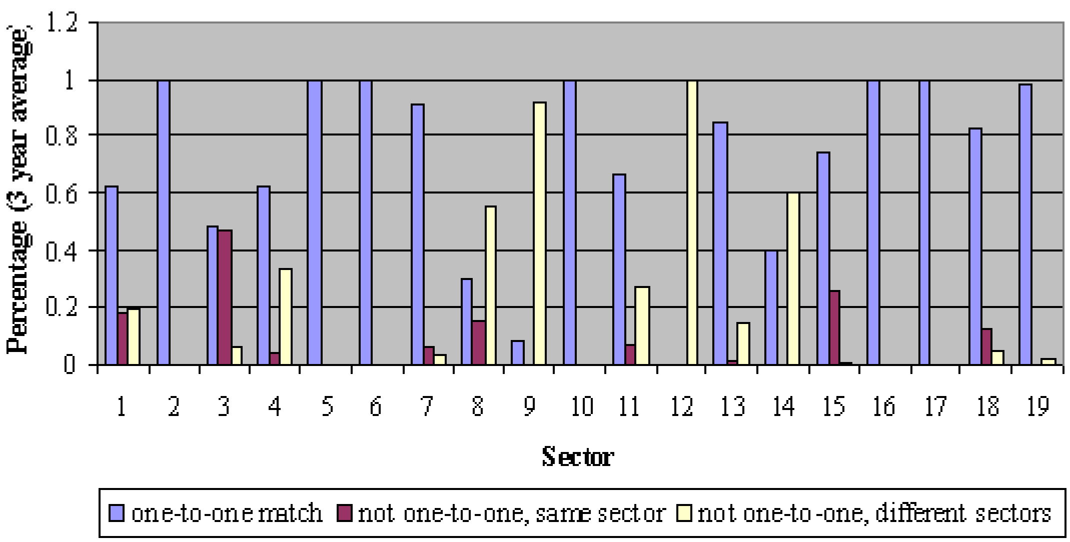
EPA then multiplied this average VOS per establishment for a certain SIC by the number of establishments that each NAICS contributed to that SIC in 1997:

$$\text{Estimated VOS that } NAICS_x \text{ contributed to } SIC_y \text{ in 1997} = (\text{VOS per establishment for } SIC_y) * (\text{number of establishments } NAICS_x \text{ contributed to } SIC_y \text{ in 1997}) \quad \text{(A-4)}$$

EPA used this estimated VOS to compute an estimated share value.

To gain a rough measure of how accurately the NAICS codes could be broken into sectors, EPA calculated, by sector: (1) the percentage of NAICS codes that matched "one-to-one" with an SIC code, (2) the percentage that did not match one-to-one but were contained in a single sector, and (3) the percentage that didn't match one to one and were contained in multiple sectors (Figure A.1, Table A.2).

Figure A.1: Percentage of VOS 1997 to 1999 Attributable to One-to-One NAICS-SIC Match, Not One-to-One but in the Same Sector, and Not One-to-One but in Different Sectors



Sectors: 1 Hardware; 2 Aircraft; 3 Electronic Equipment; 4 Stationary Industrial Equipment; 5 Ordnance; 6 Aerospace; 7 Mobile Industrial Equipment; 8 Instruments; 9 Precious Metals and Jewelry; 10 Ships and Boats; 11 Household Equipment; 12 Railroad; 13 Motor Vehicle; 14 Bus and Truck; 15 Office Machine; 16 Printed Circuit Boards; 17 Job Shop; 18 Miscellaneous Metal Products; 19 Iron and Steel

Source: Department of Commerce, Bureau of the Census, Manufacturing Industry Series; U.S. EPA analysis.

[1] The Bureau of the Census does not release any data that could reveal data about a specific firm. In cases when a NAICS or SIC code is so specific that it includes only a few firms, information about VOS is not released. However, the number of establishments in a specific industry is not considered private information.

Table A.2: Percentage of Input One-to-One, Not One-to-One but in the Same Sector, and Not One-to-One and in Different Sectors

Sector	VOS One-to-One	Employment One-to-One	VOS Same Sector	Employment Same Sector	VOS Different Sectors	Employment Different Sectors
YEAR: 1997						
1	62.5%	64.3%	18.2%	16.5%	19.3%	19.2%
2	100.0%	100.0%	0.0%	0.0%	0.0%	0.0%
3	46.7%	47.2%	47.2%	43.2%	6.2%	9.7%
4	63.3%	68.1%	3.9%	4.4%	32.8%	27.6%
5	100.0%	100.0%	0.0%	0.0%	0.0%	0.0%
6	100.0%	100.0%	0.0%	0.0%	0.0%	0.0%
7	91.8%	88.1%	5.5%	7.8%	2.7%	4.1%
8	30.4%	30.2%	14.4%	14.4%	55.2%	55.4%
9	10.2%	8.3%	0.0%	0.0%	89.8%	91.7%
10	100.0%	100.0%	0.0%	0.0%	0.0%	0.0%
11	67.5%	60.6%	6.3%	4.5%	26.3%	34.9%
12	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%
13	85.3%	69.5%	1.1%	3.1%	13.6%	27.4%
14	39.1%	42.8%	0.0%	0.0%	60.9%	57.2%
15	73.1%	59.9%	26.4%	38.6%	0.5%	1.5%
16	100.0%	100.0%	0.0%	0.0%	0.0%	0.0%
17	99.9%	99.9%	0.0%	0.0%	0.1%	0.1%
18	83.1%	76.5%	12.2%	17.8%	4.6%	5.7%
19	98.1%	95.3%	0.0%	0.0%	1.9%	4.7%
YEAR: 1998						
1	62.8%	64.9%	17.9%	16.3%	19.3%	18.8%
2	100.0%	100.0%	0.0%	0.0%	0.0%	0.0%
3	47.6%	47.3%	46.0%	42.7%	6.4%	10.0%
4	62.0%	68.3%	3.8%	4.4%	34.2%	27.3%
5	100.0%	100.0%	0.0%	0.0%	0.0%	0.0%
6	100.0%	100.0%	0.0%	0.0%	0.0%	0.0%
7	91.8%	88.0%	5.5%	8.0%	2.7%	4.1%
8	29.4%	29.3%	15.1%	14.7%	55.5%	55.9%
9	8.4%	8.7%	0.0%	0.0%	91.6%	91.3%
10	100.0%	100.0%	0.0%	0.0%	0.0%	0.0%
11	66.2%	60.0%	6.9%	4.8%	26.9%	35.2%
12	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%
13	84.2%	68.0%	1.3%	3.4%	14.6%	28.6%
14	40.7%	43.4%	0.0%	0.0%	59.3%	56.6%
15	73.5%	58.9%	26.0%	39.7%	0.5%	1.4%
16	100.0%	100.0%	0.0%	0.0%	0.0%	0.0%
17	99.9%	99.9%	0.0%	0.0%	0.1%	0.1%
18	82.1%	76.1%	12.9%	18.2%	4.9%	5.8%
19	97.9%	95.3%	0.0%	0.0%	2.1%	4.7%

Table A.2: Percentage of Input One-to-One, Not One-to-One but in the Same Sector, and Not One-to-One and in Different Sectors

Sector	VOS One-to-One	Employment One-to-One	VOS Same Sector	Employment Same Sector	VOS Different Sectors	Employment Different Sectors
YEAR: 1999						
1	62.3%	64.3%	18.3%	16.4%	19.4%	19.3%
2	100.0%	100.0%	0.0%	0.0%	0.0%	0.0%
3	48.7%	47.9%	45.4%	42.3%	5.9%	9.8%
4	61.6%	67.8%	3.6%	4.3%	34.7%	27.9%
5	100.0%	100.0%	0.0%	0.0%	0.0%	0.0%
6	100.0%	100.0%	0.0%	0.0%	0.0%	0.0%
7	89.6%	87.0%	7.4%	8.8%	3.0%	4.2%
8	29.9%	29.8%	15.2%	15.2%	54.9%	55.1%
9	7.1%	7.5%	0.0%	0.0%	92.9%	92.5%
10	100.0%	100.0%	0.0%	0.0%	0.0%	0.0%
11	65.5%	57.8%	7.7%	5.4%	26.9%	36.8%
12	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%
13	84.6%	68.3%	1.3%	3.9%	14.1%	27.9%
14	40.5%	45.8%	0.0%	0.0%	59.5%	54.2%
15	75.6%	56.6%	23.8%	41.9%	0.6%	1.6%
16	100.0%	100.0%	0.0%	0.0%	0.0%	0.0%
17	99.9%	99.9%	0.0%	0.0%	0.1%	0.1%
18	82.0%	76.8%	13.0%	17.1%	5.0%	6.1%
19	97.7%	95.0%	0.0%	0.0%	2.3%	5.0%

Sectors: 1 Hardware; 2 Aircraft; 3 Electronic Equipment; 4 Stationary Industrial Equipment; 5 Ordnance; 6 Aerospace; 7 Mobile Industrial Equipment; 8 Instruments; 9 Precious Metals and Jewelry; 10 Ships and Boats; 11 Household Equipment; 12 Railroad; 13 Motor Vehicle; 14 Bus and Truck; 15 Office Machine; 16 Printed Circuit Boards; 17 Job Shop; 18 Miscellaneous Metal Products; 19 Iron and Steel

Source: Department of Commerce, Bureau of the Census, Manufacturing Industry Series; U.S. EPA analysis.

Table A.3 presents the data that was used to calculate the relationship between NAICS and SIC codes. The table lists the MP&M sector to which each SIC code belongs, gives a short description of each SIC, and lists NAICS codes that encompass similar industries. The table also lists the number of establishments, the value of shipments, and the number of employees that are contributed to each SIC by each NAICS, as well as the share values, i.e. the portion of its total value of shipments that a given NAICS code contributes to a given SIC code.

Table A.3: Relationships between SIC and NAICS Codes Based on 1997 Economic Census for MP&M Industries Evaluated for the Final Rule[a] (thousands, 1997$)

SIC	SIC Industry	NAICS Code	1997 NAICS Industry	Number of Establishments	Sales, Shipments or Receipts	Share Value
			Aerospace			
3761	Guided Missiles and Space Vehicles	336414	Guided Missile and Space Vehicle Manufacturing	22	14,791,466	100.0%
3764	Guided Missile and Space Vehicle Propulsion	336415	Guided Missile and Space Vehicle Propulsion Unit and Propulsion Unit Parts Manufacturing	28	3,239,033	100.0%
3769	Other Space Vehicle and Missile Parts	336419	Other Guided Missile and Space Vehicle Parts and Auxiliary Equipment Manufacturing	49	898,758	100.0%
			Aircraft			
3721	Aircraft	336411	Aircraft Manufacturing	204	56,273,651	100.0%
3724	Aircraft Engines and Engine Parts	336412	Aircraft Engine and Engine Parts Manufacturing	369	22,617,284	100.0%
3728	Aircraft Parts and Auxiliary Equipment	336413	Other Aircraft Parts and Auxiliary Equipment Manufacturing	1,138	20,073,061	100.0%
4581	Airports, Flying Fields, Airport Terminal Services	488111	Air Traffic Control	114	43,450	100.0%
		488119	Other Airport Operations	1,699	3,243,149	99.8%
		488190	Other Support Activities for Air Transportation	2,400	5,859,631	100.0%
		561720	Janitorial Services	127	203,918	1.0%
			Bus & Truck			
3713	Truck and Bus Bodies	336211	Motor Vehicle Body Manufacturing	715	8,719,326	96.2%
3715	Truck Trailers	336212	Truck Trailer Manufacturing	390	5,507,768	100.0%
4111	Local And Suburban Transit	485111	Mixed Mode Transit Systems	28	51,567	100.0%
		485113	Bus and Other Motor Vehicle Transit Systems	542	1,152,525	100.0%
		485999	All Other Transit and Ground Passenger Transportation	534	601,988	89.9%
4119	Local Passenger Transit, N.E.C.	485320	Limousine Service	3,234	1,873,924	100.0%
		485410	School and Employee Bus Transportation	158	158,947	3.6%
		485991	Special Needs Transportation	1,789	1,141,413	100.0%
		485999	All Other Transit and Ground Passenger Transportation	232	67,395	10.1%
		487110	Scenic and Sightseeing Transportation, Land	307	462,186	82.9%
		621910	Ambulance Services	3,275	4,443,174	88.4%
4131	Intercity And Rural Bus Transportation	485210	Interurban and Rural Bus Transportation	407	1,147,432	100.0%
4141	Local Bus Charter Service	485510	Charter Bus Industry	482	459,953	26.0%
4142	Bus Charter Service, Except Local	485510	Charter Bus Industry	1,049	1,308,246	74.0%
4173	Bus Terminal And Service Facilities	488490	Other Support Activities for Road Transportation	26	15,253	3.9%

Table A.3: Relationships between SIC and NAICS Codes Based on 1997 Economic Census for MP&M Industries Evaluated for the Final Rule[a] (thousands, 1997$)

SIC	SIC Industry	NAICS Code	1997 NAICS Industry	Number of Establishments	Sales, Shipments or Receipts	Share Value
4212	Local Trucking without Storage	484110	General Freight Trucking, Local	14,545	11,108,345	90.5%
		484210	Used Household and Office Goods Moving	3,259	1,198,983	9.5%
		484220	Specialized Freight (except Used Goods) Trucking, Local	34,935	18,932,851	96.0%
		562111	Solid Waste Collection	7,083	18,211,495	100.0%
		562112	Hazardous Waste Collection	414	1,095,553	100.0%
		562119	Other Waste Collection	827	837,625	100.0%
4213	Trucking, Except Local	484121	General Freight Trucking, Long-Distance, Truckload	23,111	51,142,148	100.0%
		484122	General Freight Trucking, Long-Distance, Less Than Truckload	6,210	25,010,091	100.0%
		484210	Used Household and Office Goods Moving	3,555	9,111,477	72.4%
		484230	Specialized Freight (except Used Goods) Trucking, Long-Distance	14,439	20,500,392	100.0%
4214	Local Trucking with Storage	484110	General Freight Trucking, Local	915	1,164,931	9.5%
		484210	Used Household and Office Goods Moving	2,286	2,273,241	18.1%
		484220	Specialized Freight (except Used Goods) Trucking, Local	543	782,939	4.0%
4215	Courier Services, Except by Air	492110	Couriers	2,362	19,289,602	53.1%
		492210	Local Messengers and Local Delivery	5,384	3,519,100	100.0%
4231	Trucking Terminal Facilities	488490	Other Support Activities for Road Transportation	14	12,989	3.3%
			Electronic Equipment			
3661	Telephone and Telegraph Apparatus	334210	Telephone Apparatus Manufacturing	598	38,300,044	100.0%
		334416	Electronic Coil, Transformer, and Other Inductor Manufacturing	7	8,904	0.6%
		334418	Printed Circuit Assembly (Electronic Assembly) Manufacturing	20	1,364,671	5.2%
3663	Radio and Television Broadcast and Comm Eq	334220	Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing	1,091	37,042,241	94.2%
3669	Communications Eq, N.E.C.	334290	Other Communications Equipment Manufacturing	497	4,233,288	100.0%
3671	Electron Tubes	334411	Electron Tube Manufacturing	159	3,858,499	100.0%
3675	Electronic Capacitors	334414	Electronic Capacitor Manufacturing	129	2,482,163	100.0%
3677	Electronic Coils and Transformers	334416	Electronic Coil, Transformer, and Other Inductor Manufacturing	426	1,512,232	97.9%
3678	Connectors for Electronic Applications	334417	Electronic Connector Manufacturing	347	5,598,906	100.0%

Table A.3: Relationships between SIC and NAICS Codes Based on 1997 Economic Census for MP&M Industries Evaluated for the Final Rule[a] (thousands, 1997$)

SIC	SIC Industry	NAICS Code	1997 NAICS Industry	Number of Establishments	Sales, Shipments or Receipts	Share Value
3679	Electronic Components N.E.C.	334220	Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing	126	2,265,873	5.8%
		334418	Printed Circuit Assembly (Electronic Assembly) Manufacturing	695	24,704,154	94.8%
		334419	Other Electronic Component Manufacturing	1,851	10,547,090	100.0%
		336322	Other Motor Vehicle Electrical and Electronic Equipment Manufacturing	253	1,420,996	8.4%
3699	Electronic Mach., Equipment, & Suppl. N.E.C.	332212	Hand and Edge Tool Manufacturing	4	140,811	2.1%
		333293	Printing Machinery and Equipment Manufacturing	5	0	0.9%[b]
		333314	Optical Instrument and Lens Manufacturing	5	7,320	0.2%
		333319	Other Commercial and Service Industry Machinery Manufacturing	57	934,728	10.0%
		333512	Machine Tool (Metal Cutting Types) Manufacturing	8	151,363	2.8%
		333618	Other Engine Equipment Manufacturing	2	0	0.7%[b]
		333992	Welding and Soldering Equipment Manufacturing	6	11,101	0.2%
		334510	Electromedical and Electrotherapeutic Apparatus Manufacturing	11	52,855	0.5%
		334511	Search, Detection, Navigation, Guidance, Aeronautical, and Nautical System and Instrument Manufacturing	7	77,832	0.2%
		334516	Analytical Laboratory Instrument Manufacturing	10	36,473	0.5%
		334519	Other Measuring and Controlling Device Manufacturing	5	6,174	0.1%
		335129	Other Lighting Equipment Manufacturing	4	859	0.0%
		335999	All Other Miscellaneous Electrical Equipment and Component Manufacturing	567	4,051,267	58.8%
Hardware						
2796	Platemaking and Related Services	323122	Prepress Services	1,276	2,663,020	53.2%
3398	Metal Heat Treating	332811	Metal Heat Treating	808	3,485,459	100.0%
3412	Metal Shipping Barrels, Drums, Kegs, Pails	332439	Other Metal Container Manufacturing	151	1,310,595	57.8%
3421	Cutlery	332211	Cutlery and Flatware (except Precious) Manufacturing	164	2,198,365	99.6%
3423	Hand & Edge Tools, Except Mach. Tools, Saws	332212	Hand and Edge Tool Manufacturing	1,069	5,677,903	86.0%
3425	Hand Saws and Saw Blades	332213	Saw Blade and Handsaw Manufacturing	176	1,452,540	100.0%

Table A.3: Relationships between SIC and NAICS Codes Based on 1997 Economic Census for MP&M Industries Evaluated for the Final Rule[a] (thousands, 1997$)

SIC	SIC Industry	NAICS Code	1997 NAICS Industry	Number of Establishments	Sales, Shipments or Receipts	Share Value
3429	Hardware N.E.C.	332439	Other Metal Container Manufacturing	117	402,378	17.7%
		332510	Hardware Manufacturing	952	10,359,952	96.0%
		332919	Other Metal Valve and Pipe Fitting Manufacturing	16	0	3.9%[b]
3433	Heatg. Equip. Except Elec. & Warm Air Frnc.	333414	Heating Equipment (except Warm Air Furnaces) Manufacturing	453	3,387,391	91.1%
3441	Fabricated Structural Metal	332312	Fabricated Structural Metal Manufacturing	2,900	14,200,270	86.8%
3443	Fabricated Plate Work (Boiler Shops)	332313	Plate Work Manufacturing	1,035	2,806,913	100.0%
		332410	Power Boiler and Heat Exchanger Manufacturing	472	3,849,100	100.0%
		332420	Metal Tank (Heavy Gauge) Manufacturing	614	4,764,118	100.0%
		333415	Air-Conditioning and Warm Air Heating Equipment and Commercial and Industrial Refrigeration Equipment Manufacturing	9	43,264	0.2%
3444	Sheet Metal Work	332322	Sheet Metal Work Manufacturing	4,479	15,957,992	100.0%
		332439	Other Metal Container Manufacturing	126	275,440	12.1%
3446	Architectural and Ornamental Metal Work	332323	Ornamental and Architectural Metal Work Manufacturing	1,744	3,536,413	88.2%
3448	Prefabricated Metal Buildings & Components	332311	Prefabricated Metal Building and Component Manufacturing	604	4,199,550	100.0%
3449	Miscellaneous Metal Work	332114	Custom Roll Forming	401	3,074,662	100.0%
		332312	Fabricated Structural Metal Manufacturing	152	2,166,021	13.2%
		332321	Metal Window and Door Manufacturing	33	364,564	3.6%
		332323	Ornamental and Architectural Metal Work Manufacturing	6	91,939	2.3%
3451	Screw Machine Products	332721	Precision Turned Product Manufacturing	2,745	8,326,077	100.0%
3452	Bolts, Nuts, Screws, Rivets, and Washers	332722	Bolt, Nut, Screw, Rivet, and Washer Manufacturing	1,040	8,134,661	100.0%
3462	Iron and Steel Forgings	332111	Iron and Steel Forging	421	4,924,426	100.0%
3466	Crowns and Closures	332115	Crown and Closure Manufacturing	67	969,982	100.0%
3469	Metal Stamping N.E.C.	332116	Metal Stamping	2,166	12,041,638	100.0%
		332214	Kitchen Utensil, Pot, and Pan Manufacturing	77	1,369,914	100.0%
3492	Fluid Power Valves and Hose Fittings	332912	Fluid Power Valve and Hose Fitting Manufacturing	424	6,602,909	100.0%
3493	Steel Springs	332611	Spring (Heavy Gauge) Manufacturing	129	761,711	100.0%
3494	Valves & Pipe Fittings, Except Brass	332919	Other Metal Valve and Pipe Fitting Manufacturing	222	2,753,397	94.4%
		332999	All Other Miscellaneous Fabricated Metal Product Manufacturing	23	73,983	0.7%
3495	Wire Springs	332612	Spring (Light Gauge) Manufacturing	394	2,481,151	100.0%
		334518	Watch, Clock, and Part Manufacturing	2	0	2.5%[b]

Table A.3: Relationships between SIC and NAICS Codes Based on 1997 Economic Census for MP&M Industries Evaluated for the Final Rule[a] (thousands, 1997$)

SIC	SIC Industry	NAICS Code	1997 NAICS Industry	Number of Establishments	Sales, Shipments or Receipts	Share Value
3496	Miscellaneous Fabricated Wire Products	332618	Other Fabricated Wire Product Manufacturing	1,253	4,587,656	87.3%
3498	Fabricated Pipe and Fabricated Pipe Fitting	332996	Fabricated Pipe and Pipe Fitting Manufacturing	856	4,024,999	100.0%
3499	Fabricated Metal Products N.E.C.	332117	Powder Metallurgy Part Manufacturing	128	1,317,301	100.0%
		332439	Other Metal Container Manufacturing	98	273,541	12.1%
		332510	Hardware Manufacturing	58	435,815	4.0%
		332919	Other Metal Valve and Pipe Fitting Manufacturing	7	0	1.7%[b]
		332999	All Other Miscellaneous Fabricated Metal Product Manufacturing	2,592	7,558,137	71.9%
		337215	Showcase, Partition, Shelving, and Locker Manufacturing	78	123,057	1.5%
		339914	Costume Jewelry and Novelty Manufacturing	82	49,953	3.9%
3541	Machine Tools, Metal Cutting Types	333512	Machine Tool (Metal Cutting Types) Manufacturing	393	5,183,521	97.2%
3542	Machine Tools, Metal Forming Types	333513	Machine Tool (Metal Forming Types) Manufacturing	225	2,255,011	100.0%
3544	Special Dies & Tools, Die Sets, Jigs, Etc.	333511	Industrial Mold Manufacturing	2,529	5,116,635	100.0%
		333514	Special Die and Tool, Die Set, Jig, and Fixture Manufacturing	4,746	8,244,855	100.0%
3545	Machine Tool Access & Measuring Devices	332212	Hand and Edge Tool Manufacturing	185	714,277	10.8%
		333515	Cutting Tool and Machine Tool Accessory Manufacturing	1,920	5,347,173	100.0%
3546	Power Driven Hand Tools	333991	Power-Driven Handtool Manufacturing	217	3,609,779	100.0%
3965	Fasteners, Buttons, Needles, Pins	339993	Fastener, Button, Needle, and Pin Manufacturing	249	0	99.2%[b]
Household Equipment						
2514	Metal Household Furniture	337124	Metal Household Furniture Manufacturing	420	2,422,853	100.0%
2522	Office Furniture, Except Wood	337214	Office Furniture (except Wood) Manufacturing	359	8,230,935	100.0%
2531	Public Buildng & Relatd Furniture	336360	Motor Vehicle Seating and Interior Trim Manufacturing	184	6,060,320	57.1%
		337127	Institutional Furniture Manufacturing	267	1,697,870	41.9%
		339942	Lead Pencil and Art Good Manufacturing	17	110,985	9.0%
2542	Partitions & Fixtures, Exc Wood	337215	Showcase, Partition, Shelving, and Locker Manufacturing	926	5,249,474	65.6%
2591	Drapery Hardware and Window Blinds/Shades	337920	Blind and Shade Manufacturing	488	2,393,564	100.0%
2599	Furniture and Fixtures, N.E.C.	337127	Institutional Furniture Manufacturing	727	2,305,770	57.0%
		339113	Surgical Appliance and Supplies Manufacturing	16	645,688	4.2%

Table A.3: Relationships between SIC and NAICS Codes Based on 1997 Economic Census for MP&M Industries Evaluated for the Final Rule[a] (thousands, 1997$)

SIC	SIC Industry	NAICS Code	1997 NAICS Industry	Number of Establishments	Sales, Shipments or Receipts	Share Value
3431	Metal Sanitary Ware	332998	Enameled Iron and Metal Sanitary Ware Manufacturing	88	1,575,505	100.0%
3432	Plumbing Fittings and Brass Goods	332913	Plumbing Fixture Fitting and Trim Manufacturing	116	3,590,128	100.0%
		332999	All Other Miscellaneous Fabricated Metal Product Manufacturing	5	118,059	1.1%
3442	Metal Doors, Sash, and Trim	332321	Metal Window and Door Manufacturing	1,384	9,876,049	96.4%
3631	Household Cooking Equipment	335221	Household Cooking Appliance Manufacturing	84	3,543,231	100.0%
3632	Household Refrig. & Home & Farm & Freezers	335222	Household Refrigerator and Home Freezer Manufacturing	27	4,887,364	100.0%
3633	Household Laundry Equipment	335224	Household Laundry Equipment Manufacturing	17	3,723,375	100.0%
3634	Electric Housewares and Fans	333414	Heating Equipment (except Warm Air Furnaces) Manufacturing	16	329,270	8.9%
		335211	Electric Housewares and Household Fan Manufacturing	138	3,488,251	100.0%
3635	Household Vacuum Cleaners	335212	Household Vacuum Cleaner Manufacturing	34	2,399,206	100.0%
3639	Household Appliances N.E.C.	333298	All Other Industrial Machinery Manufacturing	4	0	0.2%[b]
		335228	Other Major Household Appliance Manufacturing	36	3,300,662	100.0%
3641	Electric Lamps	335110	Electric Lamp Bulb and Part Manufacturing	82	3,306,009	100.0%
3643	Current-Carrying Wiring Devices	335931	Current-Carrying Wiring Device Manufacturing	519	5,877,522	100.0%
3644	Noncurrent-Carrying Wiring Devices	335932	Noncurrent-Carrying Wiring Device Manufacturing	219	4,451,186	100.0%
3645	Residential Electrical Lighting Fixtures	335121	Residential Electric Lighting Fixture Manufacturing	497	2,177,355	96.6%
3646	Commercial, Industrial, and Institutional	335122	Commercial, Industrial, and Institutional Electric Lighting Fixture Manufacturing	356	4,047,437	100.0%
3648	Lighting Equipment N.E.C.	335129	Other Lighting Equipment Manufacturing	327	3,054,806	100.0%
3651	Radio/Television Sets Except Commun. Types	334310	Audio and Video Equipment Manufacturing	554	8,454,194	100.0%
7623	Refrig, air condition	811310	Commercial and Industrial Machinery and Equipment (except Automotive and Electronic) Repair and Maintenance	2,343	1,890,237	10.8%
		811412	Appliance Repair and Maintenance	1,671	789,622	19.9%
			Instruments			
3812	Search, Det, Nav, Ggnc, Aero, Naut Sys/Inst	334511	Search, Detection, Navigation, Guidance, Aeronautical, and Nautical System and Instrument Manufacturing	680	32,497,776	99.8%
3821	Laboratory Apparatus and Furniture	339111	Laboratory Apparatus and Furniture Manufacturing	385	2,471,153	100.0%

Table A.3: Relationships between SIC and NAICS Codes Based on 1997 Economic Census for MP&M Industries Evaluated for the Final Rule[a] (thousands, 1997$)

SIC	SIC Industry	NAICS Code	1997 NAICS Industry	Number of Establishments	Sales, Shipments or Receipts	Share Value
3822	Automatic Environmental Controls	334512	Automatic Environmental Control Manufacturing for Residential, Commercial, and Appliance Use	317	2,935,692	100.0%
3823	Process Control Instruments	334513	Instruments and Related Products Manufacturing for Measuring, Displaying, and Controlling Industrial Process Variables	1,002	7,890,923	100.0%
3824	Fluid Meters and Counting Devices	334514	Totalizing Fluid Meter and Counting Device Manufacturing	222	3,765,769	100.0%
3825	Instruments to Measure Electricity	334416	Electronic Coil, Transformer, and Other Inductor Manufacturing	17	24,303	1.6%
		334515	Instrument Manufacturing for Measuring and Testing Electricity and Electrical Signals	826	13,852,897	100.0%
3826	Laboratory Analytical Instruments	334516	Analytical Laboratory Instrument Manufacturing	664	7,157,038	99.5%
3827	Optical Instruments and Lenses	333314	Optical Instrument and Lens Manufacturing	495	3,174,652	99.8%
3829	Measuring and Controlling Devices N.E.C.	334519	Other Measuring and Controlling Device Manufacturing	853	5,114,547	99.9%
		339112	Surgical and Medical Instrument Manufacturing	6	62,148	0.3%
3841	Surgical & Medical Instruments & Apparatus	339112	Surgical and Medical Instrument Manufacturing	1,598	18,450,024	99.7%
3842	Orthopedic, Prosthetic & Surgical Suppl.	322121	Paper (except Newsprint) Mills	2	0	1.4%[b]
		322291	Sanitary Paper Product Manufacturing	16	651,398	6.7%
		334510	Electromedical and Electrotherapeutic Apparatus Manufacturing	74	807,427	7.1%
		339113	Surgical Appliance and Supplies Manufacturing	1,636	14,743,779	95.8%
3843	Dental Equipment and Supplies	339114	Dental Equipment and Supplies Manufacturing	877	2,699,867	100.0%
3844	X-Ray Apparatus and Tubes	334517	Irradiation Apparatus Manufacturing	155	3,942,256	100.0%
3845	Electromedical Equipment	334510	Electromedical and Electrotherapeutic Apparatus Manufacturing	460	10,567,566	92.5%
3851	Ophthalmic Goods	339115	Ophthalmic Goods Manufacturing	575	3,607,813	100.0%
7629	Electric repair shop	811212	Computer and Office Machine Repair and Maintenance	1,538	913,258	10.7%
		811213	Communication Equipment Repair and Maintenance	201	231,458	14.4%
		811219	Other Electronic and Precision Equipment Repair and Maintenance	2,033	2,509,452	86.1%
		811411	Home and Garden Equipment Repair and Maintenance	579	185,507	18.5%
		811412	Appliance Repair and Maintenance	4,327	3,125,853	78.6%

Table A.3: Relationships between SIC and NAICS Codes Based on 1997 Economic Census for MP&M Industries Evaluated for the Final Rule[a] (thousands, 1997$)

SIC	SIC Industry	NAICS Code	1997 NAICS Industry	Number of Establishments	Sales, Shipments or Receipts	Share Value
Iron and Steel						
3315	Steel Wiredrawing and Steel Nails and Spikes	331222	Steel Wire Drawing	273	4,920,798	100.0%
		332618	Other Fabricated Wire Product Manufacturing	31	370,492	7.0%
3316	Cold-Rolled Steel Sheet, Strip, and Bars	331221	Rolled Steel Shape Manufacturing	186	6,343,466	100.0%
3317	Steel Pipe and Tubes	331210	Iron and Steel Pipe and Tube Manufacturing from Purchased Steel	235	7,565,377	100.0%
Job Shop						
3471	Plating and Polishing	332813	Electroplating, Plating, Polishing, Anodizing, and Coloring	3,404	5,979,405	100.0%
3479	Metal Coating & Allied Services	332812	Metal Coating, Engraving (except Jewelry and Silverware), and Allied Services to Manufacturers	2,156	8,460,896	100.0%
		339911	Jewelry (except Costume) Manufacturing	22	5,798	0.1%
		339914	Costume Jewelry and Novelty Manufacturing	16	2,257	0.2%
		339912	Silverware and Hollowware Manufacturing	12	6,296	0.7%
Mobile Industrial Equipment						
3523	Farm Machinery and Equipment	332212	Hand and Edge Tool Manufacturing	1	0	0.1%[b]
		332323	Ornamental and Architectural Metal Work Manufacturing	140	380,152	9.5%
		333111	Farm Machinery and Equipment Manufacturing	1,339	15,921,455	100.0%
		333922	Conveyor and Conveying Equipment Manufacturing	28	33,377	0.5%
3524	Garden Tractors & Lawn & Garden Equipment	332212	Hand and Edge Tool Manufacturing	3	0	0.3%[b]
		333112	Lawn and Garden Tractor and Home Lawn and Garden Equipment Manufacturing	145	7,454,511	100.0%
3531	Constr Mach and Eq	333120	Construction Machinery Manufacturing	785	21,965,455	100.0%
		333923	Overhead Traveling Crane, Hoist, and Monorail System Manufacturing	87	1,805,198	57.4%
		336510	Railroad Rolling Stock Manufacturing	25	346,760	4.2%
3532	Mining Mach. & Equip., Except Oil Field	333131	Mining Machinery and Equipment Manufacturing	292	2,710,923	100.0%
3536	Hoists, Industrial Cranes & Monorails	333923	Overhead Traveling Crane, Hoist, and Monorail System Manufacturing	220	1,340,561	42.6%
3537	Industrial Trucks, Tractors, Trailers	332439	Other Metal Container Manufacturing	4	6,775	0.3%
		332999	All Other Miscellaneous Fabricated Metal Product Manufacturing	19	27,488	0.3%
		333924	Industrial Truck, Tractor, Trailer, and Stacker Machinery Manufacturing	461	5,538,326	100.0%
3795	Tanks and Tank Components	336992	Military Armored Vehicle, Tank, and Tank Component Manufacturing	37	0	86.0%[b]

Table A.3: Relationships between SIC and NAICS Codes Based on 1997 Economic Census for MP&M Industries Evaluated for the Final Rule[a] (thousands, 1997$)

SIC	SIC Industry	NAICS Code	1997 NAICS Industry	Number of Establishments	Sales, Shipments or Receipts	Share Value
			Motor Vehicle			
3465	Automotive Stampings	336370	Motor Vehicle Metal Stamping	810	23,668,110	100.0%
3592	Carburetors, Piston Rings, Valves	336311	Carburetor, Piston, Piston Ring, and Valve Manufacturing	141	2,755,311	100.0%
3647	Vehicular Lighting Equipment	336321	Vehicular Lighting Equipment Manufacturing	106	3,282,824	100.0%
3694	Electrical Equipment for Motor Vehicles	336322	Other Motor Vehicle Electrical and Electronic Equipment Manufacturing	569	9,074,335	53.6%
3711	Motor Vehicle and Automobile Bodies	336111	Automobile Manufacturing	194	95,385,563	100.0%
		336112	Light Truck and Utility Vehicle Manufacturing	112	110,400,169	100.0%
		336120	Heavy Duty Truck Manufacturing	84	14,490,344	100.0%
		336211	Motor Vehicle Body Manufacturing	76	82,633	0.9%
		336992	Military Armored Vehicle, Tank, and Tank Component Manufacturing	6	0	14.0%[b]
3714	Motor Vehicle Parts and Accessories	336211	Motor Vehicle Body Manufacturing	23	265,552	2.9%
		336312	Gasoline Engine and Engine Parts Manufacturing	881	25,974,369	100.0%
		336322	Other Motor Vehicle Electrical and Electronic Equipment Manufacturing	193	6,446,681	38.1%
		336330	Motor Vehicle Steering and Suspension Components (except Spring) Manufacturing	212	10,750,312	100.0%
		336340	Motor Vehicle Brake System Manufacturing	269	10,033,288	100.0%
		336350	Motor Vehicle Transmission and Power Train Parts Manufacturing	523	33,288,093	100.0%
		336399	All Other Motor Vehicle Parts Manufacturing	1,508	34,193,298	99.6%
3716	Mobile Homes	336213	Motor Home Manufacturing	88	3,943,709	100.0%
3751	Motorcycles	336991	Motorcycle, Bicycle, and Parts Manufacturing	385	0	99.0%[b]
3792	Travel Trailers and Campers	336214	Travel Trailer and Camper Manufacturing	315	3,076,049	67.4%
3799	Miscellaneous Transportation Equipment	332212	Hand and Edge Tool Manufacturing	1	0	0.1%[b]
		336214	Travel Trailer and Camper Manufacturing	498	1,485,367	32.6%
		336999	All Other Transportation Equipment Manufacturing	378	4,557,989	100.0%
4121	Taxicabs	485310	Taxi Service	3,184	1,280,597	100.0%
5013	Motor Vehicle Supplies and New Parts	421120	Motor Vehicle Supplies and New Parts Wholesalers	12,620	83,214,728	100.0%
		441310	Automotive Parts and Accessories Stores	16,253	22,093,428	51.2%
5511	Motor Vehicle Dealers (New and Used)	441110	New Car Dealers	25,897	518,971,824	100.0%
5521	Motor Vehicle Dealers (Used Only)	441120	Used Car Dealers	23,340	34,680,468	100.0%
5561	Recreational Vehicle Dealers	441210	Recreational Vehicle Dealers	3,014	10,069,749	100.0%

Table A.3: Relationships between SIC and NAICS Codes Based on 1997 Economic Census for MP&M Industries Evaluated for the Final Rule[a] (thousands, 1997$)

SIC	SIC Industry	NAICS Code	1997 NAICS Industry	Number of Establishments	Sales, Shipments or Receipts	Share Value
5571	Motorcycle Dealers	441221	Motorcycle Dealers	3,635	7,369,260	100.0%
5599	Automotive Dealers, N.E.C.	441229	All Other Motor Vehicle Dealers	1,678	2,517,267	100.0%
7514	Passenger Car Rental	532111	Passenger Car Rental	4,367	14,783,704	100.0%
7515	Passenger Car Lease	532112	Passenger Car Leasing	879	3,800,424	100.0%
7519	Utility Trailer and Recreational Vehicle Rental	532120	Truck, Utility Trailer, and RV (Recreational Vehicle) Rental and Leasing	360	256,119	2.5%
7532	Top, Body, and Upholstery Repair and Paint Shops	811121	Automotive Body, Paint, and Interior Repair and Maintenance	35,569	17,755,296	100.0%
7533	Auto Exhaust Systems	811112	Automotive Exhaust System Repair	5,251	1,985,377	100.0%
7537	Auto Transmission Repair	811113	Automotive Transmission Repair	6,768	2,431,584	100.0%
7538	Gen Automotive Repair	811111	General Automotive Repair	77,751	25,598,455	100.0%
7539	Auto Repair Shop, N.E.C.	811118	Other Automotive Mechanical and Electrical Repair and Maintenance	9,674	3,494,643	100.0%
7549	Auto Services, Except Repair and Carwashes	488410	Motor Vehicle Towing	5,893	2,295,188	100.0%
		811191	Automotive Oil Change and Lubrication Shops	7,413	2,787,318	100.0%
		811198	All Other Automotive Repair and Maintenance	1,646	798,626	73.5%
			Office Machine			
3571	Electronic Computers	334111	Electronic Computer Manufacturing	563	66,331,909	100.0%
3572	Typewriters	334112	Computer Storage Device Manufacturing	211	13,907,367	100.0%
3575	Computer Terminals	334113	Computer Terminal Manufacturing	142	1,483,460	100.0%
3577	Computer Peripheral Eq N.E.C.	334119	Other Computer Peripheral Equipment Manufacturing	1,006	25,130,308	93.1%
3578	Calculating, Accounting Machines Except Computers	333313	Office Machinery Manufacturing	35	144,380	4.5%
		334119	Other Computer Peripheral Equipment Manufacturing	61	1,870,426	6.9%
3579	Office Machines, N.E.C.	333313	Office Machinery Manufacturing	134	3,047,549	95.5%
		334518	Watch, Clock, and Part Manufacturing	16	0	19.6%[b]
		339942	Lead Pencil and Art Good Manufacturing	13	257,020	20.8%
7378	Computer Maintenance and Repairs	811212	Computer and Office Machine Repair and Maintenance	6,087	7,565,169	89.0%
7379	Computer Related Services, N.E.C.	334611	Software Reproducing	124	1,258,435	100.0%
		541512	Computer Systems Design Services	20,233	15,942,861	31.1%
		541519	Other Computer Related Services	8,405	4,339,989	100.0%
			Ordnance			
3482	Small Arms Ammunition	332992	Small Arms Ammunition Manufacturing	113	938,818	100.0%
3483	Ammunition, Except for Small Arms	332993	Ammunition (except Small Arms) Manufacturing	53	1,497,045	100.0%
3484	Small Arms	332994	Small Arms Manufacturing	198	1,251,792	100.0%

Table A.3: Relationships between SIC and NAICS Codes Based on 1997 Economic Census for MP&M Industries Evaluated for the Final Rule[a] (thousands, 1997$)

SIC	SIC Industry	NAICS Code	1997 NAICS Industry	Number of Establishments	Sales, Shipments or Receipts	Share Value
3489	Ordnance and Accessories, N.E.C.	332995	Other Ordnance and Accessories Manufacturing	70	1,750,485	100.0%
Miscellaneous Metal Products						
3497	Metal Foil and Leaf	322225	Laminated Aluminum Foil Manufacturing for Flexible Packaging Uses	43	1,546,143	100.0%
		332999	All Other Miscellaneous Fabricated Metal Product Manufacturing	64	1,711,600	16.3%
3861	Photographic Equipment & Supplies	325992	Photographic Film, Paper, Plate, and Chemical Manufacturing	311	12,895,637	100.0%
		333315	Photographic and Photocopying Equipment Manufacturing	428	8,410,124	100.0%
3931	Musical Instruments	339992	Musical Instrument Manufacturing	576	1,356,651	100.0%
3944	Games, Toys, Children's Vehicles	336991	Motorcycle, Bicycle, and Parts Manufacturing	4	0	1.0%[b]
		339932	Game, Toy, and Children's Vehicle Manufacturing	785	4,534,497	100.0%
3949	Sporting and Athletic Goods, N.E.C.	339920	Sporting and Athletic Goods Manufacturing	2,571	10,591,160	100.0%
3951	Pens and Mechanical Pencils	339941	Pen and Mechanical Pencil Manufacturing	112	1,590,770	100.0%
3953	Marking Devices	339943	Marking Device Manufacturing	634	643,007	100.0%
3993	Signs and Advertising Displays	339950	Sign Manufacturing	5,709	7,910,809	100.0%
3995	Burial Caskets	339995	Burial Casket Manufacturing	177	1,271,184	100.0%
3999	Manufacturing Industries, N.E.C.	314999	All Other Miscellaneous Textile Product Mills	52	173,353	2.8%
		316110	Leather and Hide Tanning and Finishing	26	24,625	0.7%
		325998	All Other Miscellaneous Chemical Product and Preparation Manufacturing	9	80,624	0.6%
		326199	All Other Plastics Product Manufacturing	140	319,241	0.5%
		332212	Hand and Edge Tool Manufacturing	7	0	0.6%[b]
		332999	All Other Miscellaneous Fabricated Metal Product Manufacturing	185	285,362	2.7%
		335121	Residential Electric Lighting Fixture Manufacturing	53	69,864	3.1%
		337127	Institutional Furniture Manufacturing	5	28,296	0.7%
		339999	All Other Miscellaneous Manufacturing	2,284	7,183,815	85.4%
7692	Welding Repair	811490	Other Personal and Household Goods Repair and Maintenance	4,840	1,640,808	36.8%

Table A.3: Relationships between SIC and NAICS Codes Based on 1997 Economic Census for MP&M Industries Evaluated for the Final Rule[a] (thousands, 1997$)

SIC	SIC Industry	NAICS Code	1997 NAICS Industry	Number of Establishments	Sales, Shipments or Receipts	Share Value
7699	Repair Shop, Related Service	488390	Other Support Activities for Water Transportation	12	4,737	0.7%
		561622	Locksmiths	3,799	1,081,317	100.0%
		561790	Other Services to Buildings and Dwellings	1,254	0	22.4%[b]
		562991	Septic Tank and Related Services	2,538	0	81.8%[b]
		811212	Computer and Office Machine Repair and Maintenance	104	23,844	0.3%
		811219	Other Electronic and Precision Equipment Repair and Maintenance	838	404,627	13.9%
		811310	Commercial and Industrial Machinery and Equipment (except Automotive and Electronic) Repair and Maintenance	16,404	13,600,413	77.7%
		811411	Home and Garden Equipment Repair and Maintenance	3,032	816,008	81.5%
		811412	Appliance Repair and Maintenance	181	59,338	1.5%
		811430	Footwear and Leather Goods Repair	82	18,294	7.0%
		811490	Other Personal and Household Goods Repair and Maintenance	3,946	1,362,271	30.6%
3873	Watches, Clocks, and Watchcases	334518	Watch, Clock, and Part Manufacturing	128	718,191	77.9%
			Precious Metals and Jewelry			
3911	Jewelry, Precious Metal	339911	Jewelry (except Costume) Manufacturing	2,272	5,416,836	99.9%
3914	Silverware, Plated Ware & Stainless	332211	Cutlery and Flatware (except Precious) Manufacturing	11	8,032	0.4%
		339912	Silverware and Hollowware Manufacturing	151	899,684	99.3%
3915	Jewelers' Materials & Lapidary Work	339913	Jewelers' Material and Lapidary Work Manufacturing	394	919,066	100.0%
3961	Costume Jewelry	339914	Costume Jewelry and Novelty Manufacturing	826	1,223,475	95.9%
7631	Watch, Clock, Jewelry Repair	811490	Other Personal and Household Goods Repair and Maintenance	1,716	345,774	7.8%
			Printed Circuit Boards			
3672	Printed Circuit Boards	334412	Bare Printed Circuit Board Manufacturing	1,401	9,787,576	100.0%
			Railroad			
3743	Railcars, Railway Systems	336510	Railroad Rolling Stock Manufacturing	207	7,916,635	95.8%
			Ships and Boats			
3731	Ship Building and Repairing	336611	Ship Building and Repairing	700	10,571,810	100.0%
3732	Boat Building and Repairing	336612	Boat Building	1,043	5,622,040	100.0%
		811490	Other Personal and Household Goods Repair and Maintenance	1,739	821,273	18.4%
4412	Deep Sea Foreign Transportation	483111	Deep Sea Freight Transportation	487	11,570,718	100.0%
4424	Deep Sea Domestic Transportation	483113	Coastal and Great Lakes Freight Transportation	292	3,114,639	66.6%

Table A.3: Relationships between SIC and NAICS Codes Based on 1997 Economic Census for MP&M Industries Evaluated for the Final Rule[a] (thousands, 1997$)

SIC	SIC Industry	NAICS Code	1997 NAICS Industry	Number of Establishments	Sales, Shipments or Receipts	Share Value
4432	Freight Transportation Great Lakes	483113	Coastal and Great Lakes Freight Transportation	32	519,863	11.1%
4449	Water Transportation of Freight, N.E.C.	483211	Inland Water Freight Transportation	222	2,821,121	83.3%
4481	Deep Sea Passenger Transportation	483112	Deep Sea Passenger Transportation	80	3,908,143	100.0%
4481	Deep Sea Passenger Transportation	483114	Coastal and Great Lakes Passenger Transportation	64	89,597	49.2%
4482	Ferries	483114	Coastal and Great Lakes Passenger Transportation	61	92,493	50.8%
4482	Ferries	483212	Inland Water Passenger Transportation	76	121,992	41.6%
4489	Water Passenger Transportation, N.E.C.	483212	Inland Water Passenger Transportation	154	171,135	58.4%
4489	Water Passenger Transportation, N.E.C.	487210	Scenic and Sightseeing Transportation, Water	654	861,001	76.3%
4491	Marine Cargo Handling	488310	Port and Harbor Operations	168	889,125	100.0%
4491	Marine Cargo Handling	488320	Marine Cargo Handling	623	4,456,243	100.0%
4492	Towing & Tugboat Service	483113	Coastal and Great Lakes Freight Transportation	292	1,043,440	22.3%
4492	Towing & Tugboat Service	483211	Inland Water Freight Transportation	161	566,027	16.7%
4492	Towing & Tugboat Service	488330	Navigational Services to Shipping	361	1,014,026	67.0%
4493	Marinas	713930	Marinas	4,217	2,541,481	100.0%
4499	Water Transporation Services, N.E.C.	488330	Navigational Services to Shipping	504	499,176	33.0%
4499	Water Transporation Services, N.E.C.	488390	Other Support Activities for Water Transportation	640	444,499	67.7%
4499	Water Transporation Services, N.E.C.	532411	Commercial Air, Rail, and Water Transportation Equipment Rental and Leasing	126	454,392	7.1%
			Stationary Industrial Equipment			
3511	Steam, Gas, Hydraulic Turbines, Generator Units	333611	Turbine and Turbine Generator Set Units Manufacturing	86	5,783,057	100.0%
3519	Internal Combustion Engines, N.E.C.	333618	Other Engine Equipment Manufacturing	297	0	99.3%[b]
3519	Internal Combustion Engines, N.E.C.	336399	All Other Motor Vehicle Parts Manufacturing	7	123,954	0.4%
3533	Oil Field Machinery and Equipment	333132	Oil and Gas Field Machinery and Equipment Manufacturing	563	6,240,079	100.0%
3534	Elevators and Moving Stairways	333921	Elevator and Moving Stairway Manufacturing	196	1,607,066	100.0%
3535	Conveyors and Conveying Equipment	333922	Conveyor and Conveying Equipment Manufacturing	871	6,346,525	99.5%
3543	Industrial Patterns	332997	Industrial Pattern Manufacturing	673	623,927	100.0%
3547	Rolling Mill Machinery and Equipment	333516	Rolling Mill Machinery and Equipment Manufacturing	100	700,084	100.0%
3548	Electric and Gas Welding and Soldering	333992	Welding and Soldering Equipment Manufacturing	244	4,433,877	99.8%
3549	Metal Working Machinery, N.E.C.	333518	Other Metalworking Machinery Manufacturing	474	3,463,811	100.0%

Table A.3: Relationships between SIC and NAICS Codes Based on 1997 Economic Census for MP&M Industries Evaluated for the Final Rule[a] (thousands, 1997$)

SIC	SIC Industry	NAICS Code	1997 NAICS Industry	Number of Establishments	Sales, Shipments or Receipts	Share Value
3552	Textile Machinery	333292	Textile Machinery Manufacturing	478	1,779,034	100.0%
3553	Woodworking Machinery	333210	Sawmill and Woodworking Machinery Manufacturing	327	1,321,752	100.0%
3554	Paper Industries Machinery	333291	Paper Industry Machinery Manufacturing	366	3,438,235	100.0%
3555	Printing Trades Machinery and Equipment	333293	Printing Machinery and Equipment Manufacturing	546	0	99.1%[b]
3556	Food Products Mach	333294	Food Product Machinery Manufacturing	597	2,877,841	100.0%
3559	Special Industry Machinery, N.E.C.	333220	Plastics and Rubber Industry Machinery Manufacturing	455	3,584,992	100.0%
		333295	Semiconductor Machinery Manufacturing	257	11,158,627	100.0%
		333298	All Other Industrial Machinery Manufacturing	1,677	0	99.8%[b]
		333319	Other Commercial and Service Industry Machinery Manufacturing	78	644,019	6.9%
3561	Pumps and Pumping Equipment	333911	Pump and Pumping Equipment Manufacturing	489	6,826,043	100.0%
3562	Ball and Roller Bearings	332991	Ball and Roller Bearing Manufacturing	185	6,120,940	100.0%
3563	Air and Gas Compressors	333912	Air and Gas Compressor Manufacturing	314	5,633,008	100.0%
3564	Blowers and Exhaust and Ventilation Fans	333411	Air Purification Equipment Manufacturing	370	2,174,729	100.0%
		333412	Industrial and Commercial Fan and Blower Manufacturing	204	1,901,196	100.0%
3565	Industrial Patterns	333993	Packaging Machinery Manufacturing	689	4,858,270	100.0%
3566	Speed Changers, High Speed Drivers & Gears	333612	Speed Changer, Industrial High-Speed Drive, and Gear Manufacturing	268	2,402,392	100.0%
3567	Industrial Process Furnaces and Ovens	333994	Industrial Process Furnace and Oven Manufacturing	404	2,871,475	100.0%
3568	Mechanical Power Transmission Equipment, N.E.C.	333613	Mechanical Power Transmission Equipment Manufacturing	299	3,301,091	100.0%
3569	General Industrial Machinery, N.E.C.	333999	All Other Miscellaneous General Purpose Machinery Manufacturing	1,257	7,991,746	87.5%
3581	Automatic Merchandising Machines	333311	Automatic Vending Machine Manufacturing	121	1,325,960	100.0%
3582	Commercial Laundry Equipment	333312	Commercial Laundry, Drycleaning, and Pressing Machine Manufacturing	68	604,966	100.0%
3585	Refrigeration & Air and Heating Equipment	333415	Air-Conditioning and Warm Air Heating Equipment and Commercial and Industrial Refrigeration Equipment Manufacturing	792	22,846,865	99.8%
		336391	Motor Vehicle Air-Conditioning Manufacturing	60	5,626,596	100.0%
3586	Measuring and Dispensing Pumps	333913	Measuring and Dispensing Pump Manufacturing	71	1,316,899	100.0%
3589	Service Industry Machines, N.E.C.	333319	Other Commercial and Service Industry Machinery Manufacturing	1,165	7,596,253	81.3%

Table A.3: Relationships between SIC and NAICS Codes Based on 1997 Economic Census for MP&M Industries Evaluated for the Final Rule[a] (thousands, 1997$)

SIC	SIC Industry	NAICS Code	1997 NAICS Industry	Number of Establishments	Sales, Shipments or Receipts	Share Value
3593	Fluid Power Cylinders and Actuators	333995	Fluid Power Cylinder and Actuator Manufacturing	320	3,528,906	100.0%
3594	Fluid Power Pumps and Motors	333996	Fluid Power Pump and Motor Manufacturing	170	2,712,058	100.0%
3596	Scales and Balances, except Laboratory	333997	Scale and Balance (except Laboratory) Manufacturing	122	682,940	100.0%
3599	Machinery, Except Electrical, N.E.C.	332710	Machine Shops	23,619	27,143,131	100.0%
		332999	All Other Miscellaneous Fabricated Metal Product Manufacturing	132	506,611	4.8%
		333319	Other Commercial and Service Industry Machinery Manufacturing	50	172,536	1.8%
		333999	All Other Miscellaneous General Purpose Machinery Manufacturing	836	1,146,348	12.5%
3612	Transformers	335311	Power, Distribution, and Specialty Transformer Manufacturing	318	4,716,162	100.0%
3613	Switchgear and Switchboard Apparatus	335313	Switchgear and Switchboard Apparatus Manufacturing	583	7,609,164	100.0%
3621	Motors and Generators	335312	Motor and Generator Manufacturing	528	11,788,281	96.3%
3629	Electric Industrial Apparatus, N.E.C.	335999	All Other Miscellaneous Electrical Equipment and Component Manufacturing	413	2,838,366	41.2%
7353	Heavy Construction Equip Rental, Leasing	234990	All Other Heavy Construction	2,295	2,734,732	8.7%
		532412	Construction, Mining, and Forestry Machinery and Equipment Rental and Leasing	3,286	5,339,163	77.4%
7359	Equip Rental, Leasing, N.E.C.	532210	Consumer Electronics and Appliances Rental	3,011	1,790,890	100.0%
		532299	All Other Consumer Goods Rental	3,133	2,133,450	99.1%
		532310	General Rental Centers	6,509	3,910,618	100.0%
		532411	Commercial Air, Rail, and Water Transportation Equipment Rental and Leasing	498	0	74.3%[b]
		532412	Construction, Mining, and Forestry Machinery and Equipment Rental and Leasing	671	1,555,089	22.6%
		532420	Office Machinery and Equipment Rental and Leasing	400	436,178	7.1%
		532490	Other Commercial and Industrial Machinery and Equipment Rental and Leasing	3,408	6,775,140	69.7%
		562991	Septic Tank and Related Services	563	0	18.2%[b]

[a] EPA evaluated options for these industrial sectors but did not regulate them all under the final rule.

[b] Share values were calculated using estimated value of shipments data.

N.E.C. = Not Elsewhere Classified

Source: Department of Commerce, Bureau of the Census, 1997 Economic Census, Bridge Between NAICS and SIC; and EPA analysis.

A.2 Annual Establishment "Births" and "Deaths" in MP&M Industries Evaluated for the Final Rule

EPA used the Statistics of U.S. Businesses (SUSB) dynamic data to estimate the rate at which MP&M facilities evaluated for the final rule enter and leave the industry each year. The SUSB dynamic data report numbers of facilities starting up, closing, expanding employment and contracting employment each year from 1989 through 1997 (the latest currently available.)

Table A.4 shows the average number of facilities (establishments) operating at the beginning of each year for the period 1989 through 1997, the number of facility "births" and "deaths", and the average "birth rate" and "death rate" for each of the major 3-digit manufacturing SIC codes that include MP&M 4-digit SIC codes evaluated for the final rule.[2] This table shows that, over the period 1989-1997, annual closure rates ranged from 6 to over 12 percent in the different industries, with an overall average of almost 8 percent.

Table A.4: Annual Births and Deaths for MP&M Establishments Evaluated for the Final Rule by 3 Digit SIC Codes (1989-1997)

SIC	SIC Description	Average # Establishments at the Beginning of the Year	Average Establishment Births	Average Establishment Deaths	% Births	% Deaths
3410	Metal Cans And Shipping Containers	464	22	35	4.7%	7.5%
3420	Cutlery, Handtools, And Hardware	2,294	143	139	6.2%	6.1%
3430	Plumbing And Heating, Except Electric	687	45	53	6.6%	7.8%
3440	Fabricated Structural Metal Products	12,268	853	908	7.0%	7.4%
3450	Screw Machine Products, Bolts, Etc.	2,436	84	111	3.4%	4.6%
3460	Metal Forgings And Stamping	3,812	199	226	5.2%	5.9%
3470	Metal Services, N.E.C.	5,028	341	340	6.8%	6.8%
3480	Ordnance & Accessories, N.E.C.	390	39	40	10.0%	10.2%
3490	Misc. Fabricated Metal Products	7,084	606	531	8.6%	7.5%
3510	Engines And Turbines	346	26	24	7.5%	6.8%
3520	Farm And Garden Machinery	1,711	133	129	7.8%	7.5%
3530	Construction And Related Machinery	3,165	217	230	6.9%	7.3%
3540	Metalworking Machinery	11,072	672	660	6.1%	6.0%
3550	Special Industry Machinery	4,427	307	317	6.9%	7.1%
3560	General Industrial Machinery	3,961	243	225	6.1%	5.7%
3570	Computer And Office Equipment	2,025	262	246	12.9%	12.1%
3580	Refrigeration And Service Machinery	2,104	154	165	7.3%	7.9%
3590	Industrial Machinery, N.E.C.	21,972	1,996	1,659	9.1%	7.5%
3610	Electric Distribution Equipment	764	53	51	6.9%	6.6%
3620	Electrical Industrial Apparatus	2,024	117	130	5.8%	6.4%
3630	Household Appliances	461	44	41	9.5%	8.9%

[2] The data are disaggregated only to the 3-digit SIC level, and EPA therefore was unable to calculate closure rates for the specific 4-digit SICs that comprise the MP&M industries evaluated for the final rule. The analysis does not include 3-digit SICs that may include large numbers of non-metal products producers, for example SIC 241 (furniture, both wood and metal.)

Table A.4: Annual Births and Deaths for MP&M Establishments Evaluated for the Final Rule by 3 Digit SIC Codes (1989-1997)

SIC	SIC Description	Average # Establishments at the Beginning of the Year	Average Establishment Births	Average Establishment Deaths	% Births	% Deaths
3640	Electric Lighting And Wiring Equipment	1,905	123	143	6.5%	7.5%
3650	Household Audio & Video Equip	766	96	87	12.5%	11.4%
3660	Communications Equipment	1,794	169	159	9.4%	8.9%
3670	Electronic Components And Accessories	6,068	614	522	10.1%	8.6%
3690	Misc. Electrical Equipment & Supplies	1,890	136	157	7.2%	8.3%
3710	Motor Vehicles And Equipment	4,477	387	372	8.6%	8.3%
3720	Aircraft And Parts	1,633	122	127	7.5%	7.8%
3730	Ship And Boat Building And Repairing	2,669	343	339	12.9%	12.7%
3740	Railroad Equipment	189	15	15	7.9%	7.7%
3750	Motorcycles, Bicycles, & Parts	256	38	25	14.8%	9.7%
3760	Guided Missiles, Space Vehicles, Parts	127	7	11	5.5%	8.4%
3790	Miscellaneous Transportation Equipment	962	106	109	11.0%	11.3%
3810	Search & Navigation Equipment	758	34	60	4.5%	7.9%
3820	Measuring And Controlling Devices	4,209	275	295	6.5%	7.0%
3840	Medical Instruments And Supplies	3,770	334	289	8.9%	7.7%
3850	Ophthalmic Goods	536	40	48	7.5%	8.9%
3860	Photographic Equip & Supplies	784	71	72	9.1%	9.1%
3870	Watches, Clocks, Watchcases & Parts	159	12	20	7.5%	12.7%
3910	Jewelry, Silverware, And Plated Ware	2,606	246	275	9.4%	10.6%
3930	Musical Instruments	434	46	35	10.6%	8.0%
3940	Toys And Sporting Goods	2,843	384	345	13.5%	12.1%
3950	Pens, Pencils, Office, & Art Supplies	975	62	70	6.4%	7.2%
3960	Costume Jewelry And Notions	1,010	105	128	10.4%	12.7%
3990	Miscellaneous Manufactures	7,338	784	740	10.7%	10.1%
TOTAL		**136,653**	**11,103**	**10,698**	**8.1%**	**7.8%**

N.E.C. = Not Elsewhere Classified

Source: Small Business Administration, Statistics of U.S. Businesses.

A.3 Description of MP&M Surveys

EPA used two screener and seven detailed questionnaires (surveys) issued between 1989 and 1996 to collect financial and technical data from a sample of facilities that were evaluated for regulation under the final MP&M rule (see Section 3 of the TDD). The responses to these surveys provided the basic financial and economic information used in the facility and firm impact analyses. In addition, the POTW Survey provided information on facility permitting costs associated with regulatory options considered by EPA. The various surveys are described below as they relate to the financial and economic analyses. The MP&M rulemaking docket provides copies of the survey instruments and detailed information on the conduct of the surveys.

A.3.1 Screener Surveys

In 1990, EPA distributed 8,342 screener surveys to sites believed to be engaged in the original seven Phase I MP&M sectors. In 1996, EPA distributed 5,325 screener surveys to sites believed to be engaged in the eleven Phase II MP&M sectors. The screener surveys helped EPA to identify sites to receive the more detailed follow-up surveys and to make a preliminary assessment of the MP&M industry evaluated for the final rule. EPA identified the SIC codes applicable to the respective MP&M sectors evaluated for the final rule and randomly selected names and addresses in those SICs to receive the screener surveys based on Dun & Bradstreet databases.

A.3.2 Ohio Screener Surveys

EPA also sent the 1996 screener survey to 1,600 randomly selected sites in Ohio to support the Ohio case study.

A.3.3 Detailed MP&M Industry Surveys

Based on responses to the screener surveys, EPA sent a more detailed survey to a selected group of water-using MP&M facilities evaluated for the final rule. EPA collected financial and technical data from sample facilities in two phases.

Based on responses to the 1990 screener, EPA sent the Phase I detailed survey to a select group of water-using facilities. The Agency designed this survey to collect detailed technical and financial information. EPA selected 1,020 detailed survey recipients from water-discharging screener respondents, water-using screener respondents that did not discharge process water, and a non-randomly selected group of known water-discharging facilities that did not receive the screener.

EPA used information from the first two groups of survey recipients to develop pollutant loadings and reductions and to develop compliance cost estimates. Because EPA did not randomly select the third group of recipients, EPA did not use the data to develop national estimates.

To reduce burden on survey recipients for Phase II of the data collection effort, EPA developed two similar detailed surveys. Based on the development of the 1995 MP&M proposal, EPA chose to collect more detailed information from sites with annual process wastewater discharges greater than one million gallons per year (1 MGY). EPA sent the "long" detailed survey to all 353 1996 screener respondents evaluated for the final rule who indicated they discharged one million or more gallons of process wastewater annually and performed MP&M operations. The Agency sent the "short" detailed survey to 101 randomly selected 1996 screener respondents evaluated for the final rule who indicated they discharged less than one million gallons of process wastewater annually and performed MP&M operations.

The detailed survey responses provide financial, economic, and employment information about the site or the company owning the facility. In addition, the 1996 long detailed questionnaire included a section that requested supplemental information on other facilities owned by the company. EPA included this voluntary section to measure the impact of the final MP&M effluent guidelines on companies with multiple facilities that discharge process wastewater. This section requested the same information collected in the 1996 MP&M screener survey. Responses to questions in this section provided information on the size, industrial sector, revenue, unit operations, and water usage of the company's other facilities.

The 1996 short survey included the identical general facility and economic information collected in the long detailed survey, with one exception. Short survey recipients were not asked to provide information on the liquidation value of their plant.

A.3.4 Iron and Steel Survey

EPA also developed a detailed survey, under a separate rulemaking effort, to collect detailed information from facilities covered by the Iron and Steel Manufacturing effluent guidelines (40 CFR Part 420). Following field sampling of iron and steel sites and review of the completed industry surveys, EPA decided at proposal that some iron and steel operations would be more appropriately covered by the MP&M rule because they were more like MP&M operations. EPA relied on the Iron & Steel survey for financial and economic information on 47 iron and steel facilities. Commenters on the proposed rule stated that these operations and resulting wastewaters are comparable to those at facilities subject to the Iron and Steel Manufacturing effluent guidelines and that these discharges should remain subject to Part 420 rather than the final MP&M rule. Also at NODA, EPA considered including in the Steel Forming and Finishing subcategory wastewater discharges resulting from continuous electroplating of flat steel products (e.g., strip, sheet, and plate). EPA also relied on the Iron & Steel survey for financial and economic information on these 24 iron and steel facilities. EPA re-examined its database for facilities that perform continuous steel electroplating, and found that, contrary to its initial finding, continuous electroplaters do not perform operations similar to other facilities in this subcategory (i.e., steel forming and finishing facilities performing cold forming on steel wire, rod, bar, pipe, and tube). Thus, EPA included continuous electroplaters performing electroplating and coating operations in the General Metals subcategory for analyses supporting the final rule. As described in Section VI of the preamble to the final rule, EPA is not revising limitations or standards for any of these facilities. Such facilities will continue to be regulated by the General Pretreatment Standards (Part 403), local limits, permit limits, and Iron & Steel effluent limitations guidelines (Part 420), as applicable.

A.3.5 Municipality Survey

EPA distributed surveys in 1996 to city and county facilities that might operate facilities engaged in MP&M operations evaluated for the final rule. The Agency designed this survey to measure the rule's impact on municipalities and other government entities that perform maintenance and rebuilding operations on MP&M products (e.g., bus and truck, automobiles). The Agency sent the municipality survey to 150 city and county facilities randomly selected from the *Municipality Year Book-1995* based on population and geographic location. EPA allocated sixty percent of the sample to municipalities and 40 percent to counties. The 60/40 distribution was approximately proportional to their aggregate populations in the frame. EPA divided the municipality sample and the county sample into three size groupings as measured by population. The surveys collected information on costs of service and on the financial and economic characteristics of the governments operating these facilities.

A.3.6 Federal Facility Survey

EPA designed this survey to assess the impact of the MP&M effluent limitations guidelines and standards on federal agencies that operate MP&M facilities. EPA distributed the survey to federal agencies likely to perform industrial operations on metal products or machines. The Agency requested that the representatives of the seven chosen federal agencies voluntarily distribute copies of the survey to sites they believed performed MP&M operations. The information collected in the 1996 federal survey was identical to the long survey. After engineering review and coding, EPA entered data from 44 federal surveys into the database. Because EPA did not randomly select the survey recipients, data from these questionnaires were not used to develop national estimates.

A.3.7 POTW Survey

EPA distributed the Publicly-Owned Treatment Works (POTW) survey in November 1997. The Agency designed this survey to estimate possible costs and burden that POTWs might incur in administering MP&M permits or other control instruments and to estimate benefits from implementation of the options considered for the final rule. The Agency sent the POTW Survey to 150 POTWs with flow rates greater than 0.50 million gallons per day. EPA randomly selected the recipients from the 1992 Needs Survey Review, Update, and Query System Database (RUQus), and divided the POTW sample into two strata by daily flow rates: 0.50 to 2.50 million gallons, and 2.50 million gallons or more.

In addition to the total volume of wastewater treated at the site, the POTW Survey requested the number of industrial permits written, the cost to write the permits, the permitting fee structure, the percentage of industrial dischargers covered by National Categorical Standards (i.e., effluent guidelines), and the percentage of permits requiring specific administrative activities. EPA used this information to estimate administrative burden and costs. In addition, EPA requested information on the use or disposal of sewage sludge generated by the POTW. The Agency only required POTWs that received discharges from an MP&M facility to complete those questions. The POTW Survey requested the following sewage sludge information: amount generated, use or disposal method, metal levels, use or disposal costs, and the percentage of metal loadings from MP&M facilities. The Agency used this information to assess the potential changes in sludge handling resulting from the MP&M rule and to estimate economic benefits of these options to the POTW.

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Appendix B: Cost Pass-Through Analysis

INTRODUCTION

This appendix presents the methodology and results from the analysis of **cost pass-through (CPT)** potential for 19 MP&M sectors.[1] This analysis consists of two parts:

1. an econometric analysis of the historical relationship of output prices to changes in input costs, and

2. an analysis of market structure characteristics.

These two analyses together provide a numerical estimate of how much of compliance-related cost increases a sector can be expected to pass on to its consumers.

The rest of this appendix is organized into the following six sections:

- B.1: Rationale for developing sector-specific CPT coefficients as opposed to firm-specific CPT coefficients;
- B.2: Econometric analysis of CPT potential, based on the historical changes in output prices relative to changes in input costs;
- B.3: Analysis of the market structure factors expected to affect cost recovery;
- B.4: Validation of econometric estimates of the CPT coefficients;
- B.5: Adjustment of estimated CPT coefficients to reflect the portion of an MP&M sector that will incur compliance costs; and
- B.6: Attachment: Findings from a review of the CPT literature.

APPENDIX CONTENTS

B.1 THE CHOICE OF SECTOR-SPECIFIC CPT COEFFICIENTS

EPA believes the use of sector-specific CPT coefficients instead of firm-specific CPT coefficients in the impact analysis is an appropriate and practical way of analyzing compliance CPT. The sector-wide rate provides an estimate of the change in each facility's output prices as a function of the regulation-induced increase in its production costs, *assuming that the same cost increase is experienced by all establishments competing with the facilities in question*. For MP&M sectors in which a large fraction of establishments will be affected by the regulation, it is reasonable to assume that the MP&M compliance cost acts

[1] The analysis of cost pass-through potential presented here refines in several places the methodology developed for the Phase I MP&M analysis. These refinements are highlighted at the appropriate stages of the discussion that follows.

like an industry-wide cost shock. As noted below in section five, EPA applies an additional adjustment to the estimated CPT rate to reflect the fraction of total sector output that is estimated to incur regulation-induced production cost increases.

In contrast to the concept of a sector-specific CPT adjustment, a firm-specific CPT rate relates a change in the prices charged by a specific firm to a change in its production costs, *assuming no change in the production cost for rival producers of that product*. Not surprisingly, previous studies have found that the CPT rate for changes on an individual firm's costs differs from the rate at which a firm would pass through cost changes that are common to all, or a substantial fraction of, firms in an industry (e.g., Ashenfelter et al., 1998). It is true, however, that firms in an industry will have differing CPT among each other to some extent for reasons such as, differentiated products (e.g., products of different firms are not commodities and are not perfectly substitutable); imperfectly competitive markets (e.g., markets in which individual firms possess different degrees of market power); and segmented markets (e.g., geographically segmented markets). In the presence of such imperfections, individual firms will very likely respond differently in their ability to pass on cost increases in higher output prices *even when the production cost increase applies to all, or a substantial fraction, of an industry's production.* Nonetheless, estimating the CPT ability of individual firms or sub-sector groups of firms within the MP&M sectors would require a detailed analysis of market segments and substitutability of MP&M products. While this effort may be theoretically possible, it would be highly expensive and an overall daunting challenge given the breadth of the MP&M industry sectors.

Therefore, this analysis of CPT potential in the MP&M industry is undertaken at the sector-specific level under the assumption of perfect competition in these sectors -- including product homogeneity (i.e., products produced by one firm are perfect substitutes for products produced by other firms), and homogeneity of production technology and cost across firms (i.e., pricing is at marginal cost).[2] Under these conditions, the price response to a general industry-wide change in production costs is likely to be industry-wide and similar across all firms.

B.2 Econometric Analysis

EPA performed an econometric analysis of input costs and output prices to estimate historical CPT elasticities for 18 of the 19 Phase I and Phase II MP&M Sectors. EPA could not estimate historical CPT coefficients for Aerospace due to data limitations. These elasticities indicate the changes in output prices by sector that have occurred historically in relation to changes in the cost of production inputs. Two factors determine the share of a cost increase that a facility can pass through to its customers: the elasticity of demand and the elasticity of supply in the facility's market. Both factors are difficult to measure accurately; among other reasons, observed changes in price are due to simultaneous changes in demand and supply. In view of this difficulty, this pass-through analysis does not decompose cost pass-through into the separate effects stemming from elasticity of demand and elasticity of supply.

An additional analytic challenge involves joint consideration of quantity and price effects. Specifically, the amount of cost increase that a firm may recover through a revenue increase may generally be decomposed into a change in price and a change in quantity sold. In most markets, increased prices (in response to increased costs) translate into reduced quantity of sales. The interaction of supply and demand elasticities determines whether or not total revenue increases.

For practical reasons, this analysis focused on *the change in equilibrium price* due to a change in input costs and furthere assumes that the sale quantities of businesses complying with the regulation do not change. The analysis determined changes in market quantities from closures rather than by estimating output changes in non-closing facilities. The analysis assumed that the quantity of shipments or sales does not vary with the increase in fixed and average costs unless the facility closes. The following grounds support this restriction:

- ***The cost model for the individual facility reflects a constant marginal cost relationship.*** The change in quantity of output at a facility is a function of the change in equilibrium price and the marginal cost relationship at the facility. For instance, in the case in which marginal cost increases with output, an upward shift in the marginal cost relationship due to compliance costs will generally cause a facility to reduce its production quantity. The extent of changes in production quantity will vary across facilities based on the shift in marginal cost and the rate at which marginal cost changes with production. Engineering analysis of facilities provides no information, however, about any change in the marginal cost relationship for a given facility, providing only lump-sum costs. In lieu of this information, the analysis uses constant marginal costs, which in turn means that

[2] These assumptions likely approximate the real world for those MP&M sectors that consist of a large number of small, highly competitive firms such as Job Shops or Printed Wiring Boards.

profit-seeking facilities will tend not to change their output quantities in response to added costs resulting from regulation. As a result, the only quantity-related decision that can be meaningfully analyzed at the facility level is whether to terminate production completely.

- ***An estimate of quantity response would be based on the aggregate industry response and would not be logically applicable to the facility-level analysis.*** An analysis can estimate quantity elasticity response to changes in input costs, but this value would represent the aggregate quantity response in the particular MP&M sector. The aggregate response encompasses a diversity of responses across facilities: a few facilities may eliminate production entirely while others may reduce, keep the same, or even increase output. Applying the aggregate quantity response to individual facilities while simultaneously allowing for terminated production would exaggerate the likely facility-level quantity response and the likelihood of facility closures. The current analysis simulates the aggregate response from a micro-analytic perspective: exiting facilities that found compliance to be an uneconomic proposition affect the industry-wide quantity response.

B.2.1 Framework

The analysis measured the sensitivity of equilibrium prices to changes in input costs. The "cost elasticity of price," denoted E_p, measured the percentage change in output price per percent change in unit input costs.[3] EPA estimated the cost elasticity of price by regressing annual output price indices on annual input price indices**.** The methodology's direct estimation measured actual changes in output price with respect to changes in input costs. This practice took into account the full range of possible mechanisms by which input costs affect output prices, including technical changes, substitution, non-competitive pricing mechanisms, imperfect information phenomena, and any other shifts or irregularities in the supply and demand functions.

The 19 MP&M industry sectors encompass 224 industrial 4-digit SIC codes. EPA, however, could estimate the cost elasticity of price based on historical data for only 170 manufacturing SIC codes. EPA could not estimate the cost elasticity of price for Aerospace and non-manufacturing industries due to data limitations, but assigned a CPT coefficient to the aerospace sector based on the market structure analysis (see Section 2 for details, below).[4] EPA assumed zero CPT for non-manufacturing industries because these industries tend to be very competitive.

For each MP&M sector, EPA estimated a relationship for the k = 1 to10 yearly observations (from 1987 to 1996) by least-squares linear regression, as follows:

$$\ln(P_{out,k}) = \alpha + E_p \times \ln(P_{in,k-1}) + \epsilon \qquad \text{(B-1)}$$

where:

$P_{out,k}$	=	price index for the bundle of goods produced by the MP&M sector, year *k*;
E_p	=	elasticity of output price with respect to input costs for a given MP&M sector;
$P_{in,k-1}$	=	price index of inputs (labor and non-labor) to a given sector, year *k*-1;
b	=	elasticity of output price with respect to employment costs;
ϵ	=	error term; and
ln(x)	=	natural log of *x*

Specifying the key regression variables as logarithms permitted EPA to estimate the elasticities of output prices with respect to the independent variables directly. That is:

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[3] The elasticity measure also applies to revenue because quantity of production is assumed constant.

[4] Output Price Index data for the Aerospace sector were unavailable. EPA attempted to use proxy data for missile manufacturing,, a component of the defense sector, to estimate a CPT coefficient for the Aerospace sector. This analysis did not produce meaningful results. The missile manufacturing industry witnessed a sharp decline in producer prices during the 1987-1996 time period, therefore yielding a negative CPT coefficient for the Aerospace sector. Since the Aerospace sector and the missile manufacturing industry are sufficiently different from each other, EPA decided not to use the estimated CPT coefficient and instead derive a coefficient for the Aerospace sector based solely on the market structure analysis.

$$E_p = \frac{d\ln(P_{out,k})}{d\ln(P_{in,k-1})} = \frac{d(P_{out,k})/P_{out,k}}{d(P_{in,k-1})/P_{in,k-1}}, \quad \text{(B-2)}$$

which is the elasticity of output price with respect to input cost changes in the previous year.

EPA's use of the logarithmic transformations also eliminated any linear trend over time; in effect, the individual yearly observations become cross-sectional variables. The model therefore required no specific time-series structure.

EPA considered additional independent variables that might aid in explaining output price changes. For example, EPA included some measures of aggregate income, but these measures did not contribute significantly to the estimated relationships.

The coefficients E_p from this regression are the estimated cost-elasticities of price for each MP&M sector. The estimated coefficients address the question: over the period of analysis, by how much did output prices change as input costs increased? The value of E_p for each sector, linked with other information on market structure, yielded a composite measure of cost pass-through potential by MP&M sector. As discussed below, EPA used the results of the market structure analysis to validate the estimated values of E_p, which represent the expected CPT potential for the different MP&M sectors. The validated E_p values are the CPT coefficients ultimately assigned to sectors for the economic/financial impact analysis.

B.2.2 Data Used to Estimate the Regression Equation

Estimating E_p required a measure of the change over time in input costs and a measure of the change in output price for each MP&M sector. EPA lagged output prices by a year because the market takes time to respond to price changes (i.e., input prices from 1988 would predict output prices in 1989). For example, exchange rate pass-through studies found the lags associate with price pass-through can extend from 5 to 8 quarters (J. Menon, 1995). EPA used data on changes of annual output price indices from 1987 to 1996 and input price indices from 1986 to 1995. The final data set contains ten years of data for each of the 18 industrial sectors of concern. The analysis estimated the relationship between change in output price index (dependent variable) and change in input cost index. The input cost index (independent variables) combines a wide range of non-labor cost values, including energy, with employment cost values.

a. Dependent variable

The dependent variable is the output price index. The ***Producer Price Index (PPI)***, an appropriate measure of output price, measures changes in the price that the producer receives at the plant gate and is therefore the relevant price for the producer's production decisions. MP&M products are often intermediate goods whose market prices are producer prices. EPA estimated the dependent variable as the weighted average of PPIs for the goods produced by the industries in each sector.

EPA calculated the output price index for the sectors as follows:

$$P_{out,\,k} = \frac{\sum_i^N q_{i,\,k} \times PPI_{i,\,k}}{\sum_i^N q_{i,\,k}} \quad \text{(B-3)}$$

where:

$P_{out,k}$ = average output price index value for a given MP&M sector in year k;
$q_{i,k}$ = value of shipments for SIC industry i, year k; and
$PPI_{i,k}$ = Producer Price Index for the output of SIC industry i, year k.

EPA used the following information to fill in data gaps for all output prices when the PPI series had missing data:

- Information at the 3-digit SIC code level if data were unavailable at the 4-digit SIC code level;
- The percentage change in price at the 3-digit level, applied to the 4-digit level to calculate missing values, if data at the 4-digit level were available for several years; and

- A best-fit line to extrapolate data for years with missing data when at least five years worth of data were available.

b. Independent variables

The independent variable is the input cost index. The input cost index averages the producer price index values for commodity inputs to the sector in question, weighted by the share of each input to sector output. The weighted average calculation involves two steps: (1) estimating input cost indices at the 4-digit SIC level and (2) developing the input cost index at the MP&M sector level. These steps are discussed in detail below.

❖ *Estimating Input Cost Indices at the 4-digit SIC level*

EPA first identified the composition of production inputs required to produce output from a given industry by obtaining direct requirement coefficients from the *1992 Benchmark Input-Output Tables of the United States*.[5] The direct requirement coefficients are defined as follows: for each dollar of output from industry *i*, the direct requirements coefficient *rj* indicates the value of input *j* required to achieve one dollar of output from industry *i*. The sum of all requirements coefficients *rj* for industry *i* equals one. Note that the direct requirements coefficients from the input-output table include information on the purchase of capital goods. Changes in the cost of capital goods are therefore reflected in the PPI series for the associated industries. Because only one set of direct requirements coefficients were available for and are used in the analysis, this analysis assumes that the input mix remains constant over the ten-year period considered in the analysis.

EPA then used yearly PPI values and the ***Employment Cost Index (ECI)*** from the Bureau of Labor Statistics to estimate changes in the labor and non-labor components of production cost over time. The Agency used ECI for private manufacturers to estimate changes in labor cost for all sectors except for aircraft manufacturing, for which a sector-specific ECI is available.

EPA calculated the input cost index for a 4-digit SIC group as a weighted average of prices for (a) all non-labor inputs for which the PPI series data were available and (b) labor input. The percentage of inputs accounted for in our regression model ranges from 39 percent to 100 percent, with an average of 66 percent.

To summarize, EPA calculated the input cost index as follows. For each 4-digit SIC industry, *i*, that uses non-labor inputs, *j*, the average input price for the year *k* is:

$$P_{i,k} = \frac{\sum_j r_j \times PPI_{j,k} + r_l \times ECI_k}{\sum_j r_j + r_l} \qquad \text{(B-4)}$$

where:

$P_{i,k}$ = average input price index for SIC industry *i*, year *k*;
r_j = direct requirements coefficient for input commodity *j* by industry *i*; and
$PPI_{j,k}$ = Producer Price Index, commodity *j*, year *k*.
r_l = direct requirements coefficient for wages and salaries by industry *i*; and
ECI_k = Employement Cost Index in year *k*.

❖ *Developing the input cost index at the MP&M sector level*

EPA developed the input cost index at the MP&M sector level by weighting the individual 4-digit SIC group cost index values by 4-digit SIC value of shipments from the *Census of Manufactures* and various *Annual Surveys of Manufactures* for the corresponding years. This analysis assumes that weights by production value are constants over time.

The resulting values provided an aggregate measure of input costs over the ten-year period 1986-1995 for each MP&M sector. For each MP&M industry sector, containing *N* 4-digit SIC industries, the average input price in each year *k* is:

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[5] The Bureau of Economic Analysis' Input-Output Table uses its own industry classification system, which is similar to the Standard Industrial Classification (SIC) used in the Economic Censuses. This discussion refers to that classification system as the BEA classification. Although the BEA classification has more categories than the SIC system, EPA grouped and mapped the BEA classification codes to the more aggregate SIC codes that form the MP&M sectors. EPA calculated an average price when one BEA input classification code corresponded to more than one SIC code.

$$P_{in,k} = \frac{\sum_{i}^{N} q_{i,k} \times P_{i,k}}{\sum_{i}^{N} q_{i,k}} \qquad \text{(B-5)}$$

where:

$P_{in,k}$ = average input price index value for a given MP&M sector in year *k*;
$P_{i,k}$ = input price index value for SIC industry *i*, year *k* ; and
$q_{i,k}$ = value of shipments for SIC industry *i*, year *k*.

B.2.3 Regression Results

Table B.1 below gives the estimated parameter values (corrected for autocorrelation) and t-statistics for each of the sectors. Most of the estimated parameters have the expected sign and are statistically significant at 95th percentile. The estimated parameters show that 16 of the 18 MP&M sectors have been able to increase prices, at the margin, between 42 percent and 121 percent for every one percent increase in non-labor input costs. The estimated input cost coefficients are negative for two industrial sectors: Printed Circuit Boards and Office Machines. This finding suggest that additional market factors such strong domestic and global competition drive output prices down.

Figure B.1 below depicts output price and input cost trends from 1987 to 1996 for these two industries. It shows that in both sectors, output prices decreased faster than input costs. This difference indicates that significant competition in these sectors drives output prices down, undoubtedly through rapid technology innovation. An inverse relationship between labor cost and output prices also indicates presence of strong competition in these two sectors. Based on these findings, it is reasonable to assume that the printed circuit board and office machine sectors have zero CPT ability.

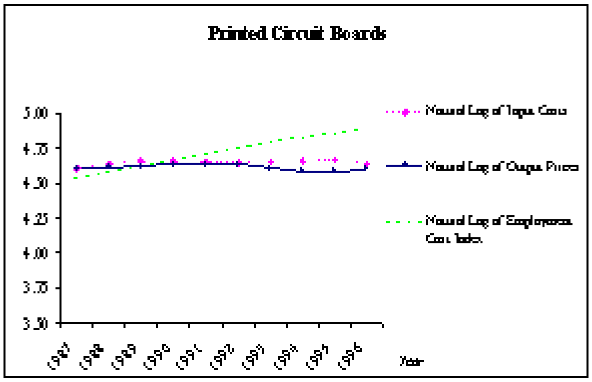
Table B.1: CPT Regression Results By Sector

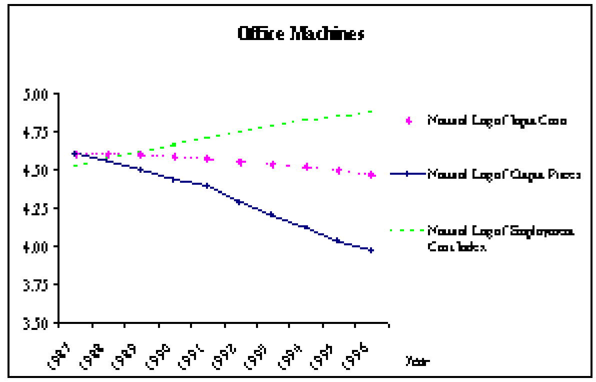
MP&M Sector	Regression Coefficients (t-statistics in parenthesis)			
	Phase 1 Proposed Rule (1982 to 1991)		Phase 2 Model (1987 to 1996)	
	Non-Labor Input Costs	Labor Input Costs	Intercept	Total Input Costs (Labor+Non-Labor)
Aerospace	.774 (12.73)	.001 (4.21)	N/A	N/A
Aircraft	.924 (37.22)	.003 (3.32)	-0.9280 (-1.45)	1.20 (8.90)
Bus & Truck	.930 (30.91)	.003 (2.46)	0.629 (1.00)	0.864 (6.52)
Electronic Equipment	.899 (25.28)	.005 (3.46)	2.79 (4.06)	0.395 (2.72)
Hardware	.889 (27.02)	.005 (3.68)	1.06 (1.80)	0.772 (6.22)
Household Equipment	.921 (43.03)	.003 (4.16)	1.69 (2.91)	0.636 (5.22)
Instruments	.923 (46.44)	.003 (4.34)	1.06 (1.79)	0.771 (6.18)
Iron and Steel	N/A	N/A	1.12 (1.57)	0.767 (5.14)
Job Shop	N/A	N/A	1.97 (3.33)	0.575 (4.61)
Mobile Industrial Equipment	.901 (23.94)	.004 (2.68)	0.546 (0.92)	0.884 (7.05)
Motor Vehicle	.898 (27.85)	.004 (3.36)	0.833 (1.03)	0.820 (4.76)
Office Machines	.920 (35.05)	.004 (3.52)	47.5 (17.2)	-9.33 (-15.6)
Ordnance	.907 (29.05)	.004 (3.18)	1.89 (3.63)	0.591 (5.41)
Other Metal Products	N/A	N/A	1.71 (3.04)	0.631 (5.34)
Precious Metals & Jewelry	.938 (24.82)	.002 (1.68)	1.69 (2.47)	0.640 (4.42)
Printed Circuit Boards	n/a	n/a	6.23 (9.07)	-0.337 (-2.31)
Railroad	.911 (30.52)	.004 (3.23)	0.548 (0.914)	0.881 (6.98)
Ships and Boats	.970 (34.68)	.001 (0.93)	0.817 (1.53)	0.823 (7.32)
Stationary Industrial Equipment	.909 (28.09)	.004 (3.06)	0.973 (1.78)	0.791 (6.88)

N/A = Not available from the Phase I analysis.

Source: U.S. EPA analysis

Table B.2: Output Prices and Unit Input Cost Trends in the Printed Circuit Board and Office Machine Sectors





Source: EPA Analysis.

Table B.1 also presents Phase 1 results for comparison. Note the following differences in the Phase 1 and Phase 2 analyses:

1. Time period:
   - Phase 1 analysis covers 1982 to 1991;
   - Phase 2 analysis covers 1987 to 1996.
2. Explanatory variables:
   - Phase 1 analysis included non-labor and labor cost variables separately. The model has no intercept term. Note that EPA then used only the non-labor input cost coefficient to estimate a CPT potential for a given sector;
   - Phase 2 analysis combines labor and non-labor input costs because compliance costs are associated with both. The intercept term captures additional market trends (e.g., increased import penetration) not reflected in the input cost indices.
3. Industrial sectors:
   - Phase 1 analysis included 15 industrial sectors. It excluded iron and steel, job shops, other metal products, and printed circuit boards industries;
   - Phase 2 analysis includes 18 of the 19 industrial sectors and excludes the aerospace industry. The Phase 1 analysis included aerospace, but EPA used proxies from the aircraft industries to estimate output price indices for the aerospace-related 4-digit SICs. EPA now estimates the CPT potential for this sector based on the market structure analysis alone.

EPA assigned MP&M sectors to low, average, and high CPT categories based on the natural breaks in the estimated parameter values. The estimated parameter values exhibit two distinct breaks in their distribution, between Precious Metals and Jewelry (65.89 percent) and Hardware (78.17 percent) and between Motor Vehicle (82.45 percent) and Railroad (88.49 percent). EPA added the Aerospace sector to the high CPT category based on results from the market structure analysis. Table B.3 summarizes results from this analysis.

Table B.3: Classification of MP&M Sectors by CPT Ability

Low CPT	Average CPT	High CPT
Office Machine	Hardware	Railroad
Printed Circuit Boards	Instruments	Mobile Industrial Equipment
Electronic Equipment	Iron & Steel	Bus & Truck
Job Shop	Stationary Industrial Equipment	Aircraft
Ordnance	Ships & Boats	Aerospace[a]
Other Metal Products	Motor Vehicle	
Household Equipment		
Precious Metals & Jewelry		

[a] Aerospace assigned to *High* category based on results from the market structure analysis (discussed in the next section).

Source: U.S. EPA analysis

B.3 Market Structure Analysis

The second part of the analysis of cost pass-through potential is based on an analysis of the current market structure of the MP&M industry sectors. Information on the competitive structure and market characteristics of an industry provide insight into the likely ranges of supply and demand elasticities and the sensitivity of output prices to input costs. For example, when input costs increase, the profit-maximizing firm attempts to maintain its profits by increasing output prices accordingly. The amount of the cost increase that the firm can pass on as higher prices depends on the relative market power of the firm and its customers. The market structure analysis described in this section attempts to measure the relative market power enjoyed by firms in each MP&M sector and provides ordinal rankings used to validate the CPT coefficients estimated by the econometric analysis. The analysis represents the current market structure and CPT ability of firms in the MP&M sectors and in no way attempts to forecast the future market structure of these sectors.

B.3.1 Measures Descriptions

The following discussion describes five indicators of market power used to assess cost pass-through potential for the 19 MP&M sectors. Only manufacturing firms have been considered; non-manufacturing firms have been excluded due to data limitations. As noted above, EPA assigned zero CPT ability to non-manufacturing firms. The five indicators of market power analyzed are : the eight-firm concentration ratio, import competition, export competition, long term growth, and competition barriers. Each of these factors are discussed in detail below.

a. Concentration

The extent of concentration among a group of market participants is an important determinant of that group's market power. A group of many small firms typically has less market power than a group of a few large firms, because the latter are in a more advantageous position to collude with each other. All else being equal, highly-concentrated industries are therefore expected to pass-through a higher proportion of the compliance costs that will result from this regulation.[6]

This analysis uses the eight-firm concentration ratio, which measures the percentage of the value of shipments concentrated in the top eight firms in each four-digit SIC category, as an indicator of market concentration. The analysis estimates sector concentration ratios as the weighted averages of component industry concentration ratios, weighted by SIC value of shipments.[7] An increase in the sector concentration ratio makes firms in an industry better able to pass on larger portions of their input cost increases without adversely affecting quantities sold to a significant extent.

[6] A substantial body of empirical research exists that has addressed the relationship between industry concentration and market power. Eg., see Waldman & Jensen, 1997.

[7] The eight-firm concentration ratio and value of shipments data used are for the year 1992.

This analysis is potentially limited by the necessity to aggregate component industries into sectors. The accuracy of any analysis to characterize market power originating from industry concentration depends to a great extent on defining the relevant market. A well-defined market requires including all competitors and excluding all non-competitors. Defining the relevant market too narrowly overstates market power, while defining the market too broadly would underestimate it. Aggregating concentration ratios for the four-digit SIC categories into a sector concentration ratio results in a sector average that may overstate market power for some portions of the sector and understate market power for other portions. This analysis would likely estimate concentration ratios for markets that in general are too broadly-defined.[8] Even so, the sectoral concentration ratios estimated should provide meaningful information that will assist in determining relative market power for each sector, because firms producing similar or related products are still classified within the same sector and each sector produces a distinctly different family of products (e.g., motor vehicles, aircrafts, ships and boats).

Another important determinant of the relevant market is its geographical extent. Given the nature of the MP&M industry, however, this factor is not important because it pertains more to industries dealing with perishable commodities and those with high transportation costs.

b. Import competition

Theory suggests that imports as a percent of domestic sales are negatively associated with market power because competition from foreign firms limits domestic firms' ability to exercise such power. Firms belonging to sectors in which imports make up a relatively large proportion of domestic sales will therefore be at a relative disadvantage in their ability to pass-through costs compared to firms belonging to sectors with lower levels of import penetration, a measure of import competition. Import penetration, the ratio of imports in a sector to the total value of domestic consumption in that sector, is particularly significant because foreign producers will not incur costs as a result of this regulation.

In the market structure analysis, higher import penetration generally means that firms are exposed to greater competition from foreign producers and will thus possess less market power to increase prices in response to regulation-induced increases in production costs. The Census Bureau provides import data at the four-digit SIC level. EPA estimated sector import penetration ratios as the ratio of the sum of component industry imports divided by the sum of component industry value of domestic consumption[9].

c. Export competition

The MP&M regulation will not increase the production costs of foreign producers with whom domestic firms must compete in export markets. As a result, sectors that rely to a greater extent on export sales will have less latitude in increasing prices to recover cost increases resulting from regulation-induced increases in production costs. They will therefore have a lower CPT potential, all else being equal.

This analysis uses export dependence, defined as the percentage of shipments from a sector that is exported, to measure the degree to which a sector is exposed to competitive pressures abroad in export sales. EPA used export data at the four-digit SIC level and derived sector export dependence ratios: the sum of component industry exports divided by the sum of component industry value of shipments.

That domestic producers export a substantial share of their product does not necessarily imply that they are subject to greater competitive pressures abroad compared to what they face in domestic markets. Such would be the case in sectors where U.S. producers are the dominant suppliers worldwide. To account for this possibility, EPA analyzed in more detail those sectors showing high export dependence to see if domestic firms in those sectors appear to dominate the world market.[10] Based on information presented in the profile of MP&M industry profile, EPA determined that firms in all four of these sectors (i.e., precious metals and jewelry, ordnance, office machine, and aircraft) operate in highly competitive international markets. The conventional theory that higher export dependence results in relatively lower market power is therefore assumed to hold true for all MP&M sectors.

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[8] The four-digit SIC category, while not a perfect delineation, is most often used by industrial organization economists in their studies because, among publicly available data sources, these industries appear to correspond most closely to economic markets (Waldman & Jensen, 1997).

[9] Census data on imports, exports, and value of shipments for the year 1996 were used for estimating this and the next market structure indicator.

[10] EPA considered sectors with export dependence exceeding 30 percent for this part of the analysis.

A substantial body of literature studies the link between environmental regulation and competitiveness in international trade. Overall, little empirical evidence seems to support the hypothesis that environmental regulations have had a significant adverse effects on the international competitiveness of domestic firms (Jaffe et al., 1995). Nonetheless, export dependence as an important independent factor in assessing the validity of the estimated CPT coefficients. If historical changes in input costs have affected both domestic and foreign firms more or less uniformly, then the econometrically estimated E_p would not address situations in which only domestic firms face higher costs. Determining the exact extent to which changes in input costs have affected both domestic and foreign producers uniformly is beyond the scope of this analysis. Such changes, however, can affect a significant proportion of cost changes related to the non-environmental aspect of inputs, such as those for energy, imported raw materials, and imported manufactured inputs.

Given the above, European and other developed countries have also implemented strict environmental regulations comparable to U.S. regulations; even changes in environmental costs have therefore often been relatively uniform across domestic and foreign firms. This uniformity may account for the fact that past studies do not show substantial impacts of U.S. environmental regulation on the balance of trade.

Because this regulation will affect only domestic firms, and the analysis assumes that no similar regulatory response is expected in foreign countries at least in the short term, domestic firms will face relatively higher production costs compared to their international competitors as a result of regulation. To study the impact of *this* regulation on the change in MP&M industry competitiveness in international markets, the market structure analysis must therefore include measures that assess the effect of each sector's dependence on export markets on its ability to pass through costs.

d. Long-term industry growth

An industry's competitiveness and the ability of firms to engage in price competition are likely to differ between declining and growing industries. Most studies have found that recent growth in revenue is positively related to profitability (Waldman & Jensen, 1997), which suggests a greater ability to recover costs fully.

Based on Census Bureau data, EPA estimated the average growth rate in the value of shipments between 1988 and 1996 for each sector, with the value of shipments for each component industry also serving as the weights for deriving average sector growth rates. EPA expects firms in sectors with higher growth rates to be better positioned to pass through compliance costs rather than being forced to absorb such cost increases in order to retain market share and revenues.

e. Competition barriers

Barriers to entry and exit help a concentrated industry exert market power by deterring potential competitors from entering the market. Without these barriers, a firm that tries to pass through compliance costs by raising its prices risks losing its market share to new firms that see an opportunity to compete at higher prices.

- **Entry barriers** are the fixed costs of beginning business in an industry. Entry barriers include high capital costs, brand name reputations that require a large advertising expense to overcome, a long learning curve, and any other factors that make the costs for new entrants higher than the costs of existing firms.

- **Exit barriers** are the fixed costs that cannot be salvaged upon leaving the industry. They are sometimes called **sunk costs** and are measured as the difference between the replacement value of a facility's capital and its liquidation value. Exit barriers include factors that make it difficult for a firm to liquidate its assets, such as specialized machinery that cannot be sold or converted to alternative uses, brand names that cannot transfer well to other products, or substantial shutdown liabilities that would offset the value of assets in liquidation. The capital valuations are typically needed to measure exit barriers.

An analysis measuring entry and exit barriers can avoid problems of data availability by identifying directly the presence of above-normal profits that such barriers would permit. This analysis uses a sector's ***risk-normalized return on assets (ROA)*** as an indicator of profit rates and the likely presence of entry and exit barriers. A popular measure used by managers for measuring firm performance, the ROA is used an indicator of firm profitability. This analysis estimates an ROA before interest payments and taxes to compare firms with different capital structures. Using the pre-tax ROA results in the *adding back* of the interest tax shield and permits comparing ROAs among firms assumed to be entirely equity-financed. The analysis measures firm riskiness by the Asset Beta, which is the firms' Equity Beta (i.e., measure of the firm's riskiness as an investment relative to the market for equity investments as a whole), adjusted to remove their financing decision from the beta calculation. With this adjustment, the analysis can compare firms with different capital structures because the Asset Beta represents the beta of common stock had the firm been entirely equity-financed.

The ***Capital Asset Pricing Model*** ***(CAPM)*** states that the expected risk premium on an investment (return earned over and above the risk-free rate) reflect investment's riskiness relative to the market (beta). The Treynor Ratio, a commonly used performance measure that uses betas as a measure of risk, embodies this principle of the CAPM:

Treynor Ratio = (Return from Investment - Risk Free Interest Rate) / (Beta of Investment)

For this analysis, however, the Treynor Ratio, or any other performance measure requiring estimation of the risk premium on an investment, could not be used. More than 60 percent of the firms in the analysis had five year, pre-tax ROAs that were lower than the risk-free interest rate of 5.21 percent (return on the three-month U.S. Treasury Bill for the five-year period 1996-2000). The analysis using the Treynor Ratio yielded results that did not permit a meaningful comparison of risk-normalized ROAs among sectors. This analysis therefore used a modified form of the Treynor Ratio that adjusts the total return and not just the risk premium by the riskiness of an investment. Applying this modification, the analysis estimated the risk-normalized ROAs as follows:

Risk-Normalized ROA = ROA / Asset Beta

The analysis estimated risk-normalized ROAs for sectors using firm level data as opposed to data at the 4-digit SIC level, and identified firms belonging to each MP&M sector using a two step process:

- First, EPA assigned facilities (and their parent firms) responding to the MP&M facilities survey to the sector from which they received the largest portion of their revenues.
- Second, EPA identified additional facilities belonging to each sector using a financial information Web site (marketguide.com), which provides a classification of publicly-traded firms by the 4-digit SIC code of their largest business segment based on revenues.

EPA estimated ROA and Beta values for a five-year time period, and estimated sector risk-normalized ROAs by weighting each firm's risk-normalized ROA by its market capitalization.[11]

The use of the risk-normalized ROA measure only assigns MP&M sectors relative rankings and does not imply that they face high or low barriers to competition in absolute terms. The analysis assumes that higher risk-adjusted profits in general indicate potential entry and exit barriers and above average market power.

[11] EPA further studied the business activities of firms belonging in the MP&M facilities survey that were identified as conglomerates or found to own multiple facilities belonging to more than one MP&M sector, and of firms in the broader sample having a market capitalization exceeding $25 billion. This additional step ensured that the market capitalization weight used in the analysis represented only the fraction of revenues that the firm receives from its business activities in the MP&M sector(s) of interest.

B.3.2 Results

EPA used these five indicators to assign each sector a cost pass-through score. Higher numerical values indicate greater CPT potential for some indicators (e.g., industry concentration) and lesser CPT potential for others (e.g., import competition). Table B.4 summarizes the specific ranking definitions for each indicator.

Table B.4: Summary of Ranking Rules for Assessing Relative Pass-Through Potential Based on Market Structure Considerations[a]

	Variable Indicates Greater Pass-Through Potential (High Rank)	Variable Indicates Lesser Pass-Through Potential (Low Rank)
8-Firm Concentration Ratio	Greater than median	Lesser than median
Ratio of Imports to Shipments	Lesser than median	Greater than median
Ratio of Exports to Shipments	Lesser than median	Greater than median
Average Growth Rate of Shipments	Greater than median	Lesser than median
Risk-Normalized Pre-Tax Return on Assets	Greater than median	Lesser than median

[a] All assessments of pass-through potential are relative among the 19 MP&M Sectors.

Source: U.S. EPA analysis.

For each of the five indicators, EPA ranked sectors from 1 to 19, with 1 assigned to the sector assessed to have the lowest CPT potential and 19 assigned to the sector assessed to have the highest CPT potential.[12] Based on this scoring system, the possible score for a sector when all five of its ranks are summed ranges from 5 to 95. Table B.5 presents a summary of the results for the market structure analysis.

[12] This ranking scale differs from the scale used to assign scores in the market structure analysis undertaken for the Phase I MP&M analysis. In the Phase I analysis, depending on the variable under consideration, a sector received a value of +1 if it indicated a greater CPT potential relative to the median and a value of -1 if it indicated a lesser CPT potential relative to the median . The sector at the median received a value of 0. The use of the median value as the threshold for determining relatively higher or lower (+1 or -1) market power was somewhat arbitrary, especially for values closely centered around the median. The new scale, since it considers individual sector ranks, is superior because it explicitly recognizes that extreme values are more likely to be indicative of high or low market power, and accordingly assigns them a higher or lower score. For example, the old scale would assign a sector with industry concentration just above the median (e.g., other metal products) the same score of +1 as a very highly-concentrated industry, such as aerospace. The new scale, however, recognizes the difference in industry concentration between the two sectors and therefore assigns the first sector a rank close to 10 and aerospace a rank close to 19.

Table B.5: Results of the Market Structure Analysis[a]

Overall Rank	Sector	8-firm Concentration Ratio		Import Penetration (%)		Export Dependence (%)		Avg. Annual Growth Rate (%)		Risk-Normalized ROA (%)		Aggregate Score
		Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank	
1	Precious Metals and Jewelry	35.0	4	77.36	1	49.85	2	-1.9	3	14.43	10	20
2	Printed Circuit Boards	35.0	3	21.99	8	17.07	10	1.5	8	7.50	2	31
3	Ordnance	76.90	16	18.92	10	50.17	1	-7.3	2	12.30	6	35
4	Household Equipment	54.22	10	33.18	3	17.02	11	1.5	9	12.02	5	38
4	Office Machine	61.38	14	51.85	2	43.41	4	3.1	15	9.58	3	38
6	Electronic Equipment	47.27	9	24.55	6	24.04	6	5.1	18	7.21	1	40
7	Aircraft	85.3	18	22.74	7	46.43	3	-1.7	4	16.15	13	45
8	Iron and Steel	41.87	6	4.54	16	1.32	17	0.4	6	11.38	4	49
9	Other Metal Products	54.27	11	32.40	4	17.57	9	1.1	7	26.60	19	50
10	Stationary Industrial Equipment	41.16	5	17.71	11	23.64	7	3.7	16	16.78	14	53
11	Hardware	24.52	2	14.31	14	11.37	13	2.1	11	17.18	15	55
12	Instruments	44.2	8	15.33	12	23.07	8	1.8	10	19.64	18	56
13	Mobile Industrial Equipment	58.56	13	21.42	9	29.62	5	2.8	13	18.13	17	57
14	Ships and Boats	58.20	12	6.49	15	6.48	15	-1.5	5	16.11	12	59
15	Job Shop	19.26	1	0.00	19	0.00	19	3.1	14	13.44	9	62
15	Motor Vehicle	77.30	17	27.56	5	15.74	12	2.6	12	18.10	16	62
17	Aerospace	92.29	19	0.75	18	0.75	18	-7.6	1	13.19	8	64
17	Bus & Truck	42.51	7	2.86	17	3.04	16	4.8	17	12.31	7	64
19	Railroad	71.00	15	15.16	13	10.26	14	7.6	19	14.62	11	72

[a] Shaded values are the medians for each market structure indicator.

Source: U.S. EPA analysis

This rank scoring system has some important limitations:

1. This grading scale implicitly assigns equal weights to each of the five market structure indicators. Clearly, the impact of each of these five indicators on market power will vary from sector to sector, and some indicators are likely to dominate others within each sector.

2. Although the ranking scale distinguishes between sectors with extreme values and those that are close to the median, it does not permit an accurate judgement about how significant a particular value may be in determining market power. For each indicator, sectors are simply ranked from 1 to 19 based on the lowest to highest market power potential. The change in market power expected as one moves from sector 1 to sector 5 is not likely to be equal, however, to the change in market power expected as one moves from sector 6 to sector 10.

In general, the market structure analysis revealed that a discernable gap exists in the estimated parameters around rank 4/5 and around rank 14/15 for most indicators (see Table B.6). For each indicator, two small groups, each containing about four to five sectors, therefore seem to have relatively low and high market power. A much larger group of about nine to ten sectors exhibit average market power.

Table B.6: Distribution of Estimated Parameters for Market Structure Variables

Rank	8-firm Concentration Ratio	Import Penetration	Export Dependence	Average Annual Growth Rate	Risk-Normalized ROA
1	19.26	77.36%	50.17%	-7.6%	7.21
2	24.52	51.85%	49.85%	-7.3%	7.50
3	35.00	33.18%	46.43%	-1.9%	9.58
4	35.07	32.40%	43.41%	-1.7%	11.38
[a]	41.16	27.56%	29.62%	-1.5%	12.02
6	41.87	24.55%	24.04%	0.4%	12.30
7	42.51	22.74%	23.64%	1.1%	12.31
8	44.22	21.99%	23.07%	1.5%	13.19
9	47.27	21.42%	17.57%	1.5%	13.44
10[a]	54.22	18.92%	17.07%	1.8%	14.43
11	54.27	17.71%	17.02%	2.1%	14.62
12	58.20	15.33%	15.74%	2.6%	16.11
13	58.56	15.16%	11.37%	2.8%	16.15
14	61.38	14.31%	10.26%	3.1%	16.78
15[a]	71.00	6.49%	6.48%	3.1%	17.18
16	76.90	4.54%	3.04%	3.7%	18.10
17	77.30	2.86%	1.32%	4.8%	18.13
18	85.32	0.75%	0.75%	5.1%	19.64
19	92.29	0.00%	0.00%	7.6%	26.60

[a] Highlighted rows mark the natural gaps in the various indicators.

Source: U.S. EPA analysis

The aggregate market structure scores for all sectors range from a low of 19 to a high of 71. Apart from the lowest score (precious metals and jewelry) and the highest score (railroad), all the other scores are uniformly distributed with no clear breaks in their distribution that can be used for classifying sectors by their CPT potential (see Table B.5). EPA therefore used an alternative classification system for the market structure analysis. Based on the average aggregate score of 50 (average rank of 10), EPA assigned sectors with an aggregate score of 40 or below (average rank of 8 or less) to the low CPT category, and assigned sectors with an aggregate score of 60 or above (average rank of 12 or more) to the high CPT category. EPA assigned sectors with aggregate scores between these cutoffs to the average CPT category. Table B.7 shows the categorization of all 19 sectors by their CPT potential based on this classification system. In total, EPA classified six, eight, and five sectors in the low, average, and high CPT categories, respectively. The classification cutoffs, though somewhat arbitrary, result in a sector classification similar to the trends witnessed for most individual indicators, such that about five sectors are classified in the low and high CPT categories and the remaining sectors are classified as having average CPT potential.

Table B.7: Classification of MP&M Sectors by CPT Ability

Low CPT	Average CPT	High CPT
Precious Metals & Jewelry	Aircraft	Job Shop
Printed Circuit Boards	Iron & Steel	Motor Vehicle
Ordnance	Other Metal Products	Aerospace
Household Equipment	Stationary Industrial Equipment	Bus & Truck
Office Machine	Hardware	Railroad
Electronic Equipment	Instruments	
	Mobile Industrial Equipment	
	Ships & Boats	

Source: U.S. EPA analysis

Although recognizing the limitations of the ranking scale, EPA believes that it is useful for presenting the results succinctly and provides a basis for validating the estimated CPT coefficients. Analyzing the relative importance of each indicator for each of the sectors is beyond the scope of this analysis.

B.4 VALIDATION OF ECONOMETRICALLY-ESTIMATED CPT COEFFICIENTS

The econometric analysis provides a quantitative assessment of what the cost pass-through ability of each sector *appears* to be. The market structure analysis yields a judgment of what the pass-through ability of each sector *ought* to be. In this section the two analyses are brought together, with the results of the market structure analysis used to validate the CPT coefficients estimated by the econometric analysis.

Table B.8 shows a comparison of each sector's CPT classification based on the econometric analysis and the market structure analysis. The two analyses classify 13 of the 19 sectors in the same CPT category. For these sectors, the market structure analysis appears to validate the CPT coefficient derived using the econometric analysis. No econometric estimate is available for one sector (aerospace); for this sector, EPA used only the market structure analysis. For the remaining five sectors, however, the two analyses assign sectors to different CPT categories. EPA undertook a more detailed analysis of these sectors' market structure to validate their CPT coefficient. Specifically, EPA examined the following two factors affecting firm's market power in a given industrial sector:

- Whether any (i.e., one or more) of the five structural indicators may be extremely important or irrelevant for a particular sector, and therefore whether its effect on market power is being under-weighted or over-weighted, respectively.

- Whether other factors affecting market power for these sectors have not been included in the market structure analysis, but which possibly have substantial effects on market power/CPT ability in particular sectors.

The discussion below summarizes EPA's review and conclusions for each of these six sectors.

Table B.8: Comparison of Sectoral Classification Based on Econometric and Market Structure Analysis

Sector	Econometric Analysis	Market Structure Analysis
CPT Categorization Matches		
Electronic Equipment	Low	Low
Household Equipment	Low	Low
Office Machine	Low	Low
Ordnance	Low	Low
Precious Metals and Jewelry	Low	Low
Printed Circuit Boards	Low	Low
Hardware	Average	Average
Instruments	Average	Average
Iron and Steel	Average	Average
Ships and Boats	Average	Average
Stationary Industrial Equipment	Average	Average
Bus & Truck	High	High
Railroad	High	High
CPT Categorization Does Not Match		
Other Metal Products	Low	Average
Job Shop	Low	High
Motor Vehicle	Average	High
Aircraft	High	Average
Mobile Industrial Equipment	High	Average
CPT Comparison Not Possible		
Aerospace	N/A	High

Source: U.S. EPA analysis.

B.4.1 Other Metal Products

This sector is assigned to the *low* category by the econometric analysis and the *average* category by the market structure analysis. EPA believes that the estimated CPT coefficient for this sector is accurate and that the market structure score for this sector is somewhat misleading because of the exceptionally high risk-normalized ROA derived for it. A priori, there appears to be no reason why firms in this sector should be able to earn significantly higher returns than in other sectors, and the high risk-normalized ROA estimated is likely an artifact of the small sample of firms for which financial data were available to estimate risk-normalized returns for this sector. The other four indicators of market power suggest below-average CPT for this sector, which agrees with the CPT coefficient estimated from the econometric analysis.

B.4.2 Job Shops

EPA assigned this sector to the *low* category by the econometric analysis and the *high* category by the market structure analysis. EPA believes that the market structure analysis may be misleading due to the high CPT ranks assigned to the Import Penetration and Export Dependence indicators of market power for this sector. These two indicators of market power are not relevant for this sector, however, because the sector is not trade-oriented. EPA expects the level of domestic competition among job shops to be the single most important factor that determines market power and the ability of firms to pass through costs in the sector. The Job Shop sector has the lowest concentration ratio among all the sectors, suggesting that the sector is characterized by a substantial number small firms (see Table 3.8 in the MP&M Industry Profile) that are most likely engaged in intense competition among each other. The estimated, *low*, CPT coefficient for this sector therefore appears to be appropriate.

B.4.3 Motor Vehicle

This sector is assigned to the *average* category by the regression analysis and the *high* category by the market structure analysis. EPA believes that this sector is characterized by average cost pass-through potential due to the extremely competitive nature of the motor vehicle industry both domestically and in international markets. In recent years, in a bid to remain or become more competitive, the trend in this industry has been towards the continual consolidation of firms into globalized manufacturers. In fact, motor vehicle manufacturers are no longer constrained within national boundaries, as mergers and joint ventures include some of the largest firms from different countries. In addition, manufacturers have increasingly standardized the design of motor vehicles and their parts, changes that have resulted in much less product differentiation (but greater product quality) among manufacturers. The increasing intensity of global competition and the move towards decreasing product differentiation are likely to limit the ability of domestic producers to pass-through significant portions of their cost increases associated with this regulation. Therefore, the finding of an average cost pass-through coefficient appears to be justified.

B.4.4 Aircraft

This sector is assigned to the *high* category by the econometric analysis and the *average* category by the market structure analysis. Based on the unique nature of the global aircraft industry, EPA believes that the estimated CPT coefficient for this sector is appropriate. Not only is the industry concentrated domestically (concentration ratio of 85.3), but this is also true of the global aircraft manufacturing industry. In recent years, the industry has witnessed substantial restructuring through mergers and consolidation, both nationally and internationally (see section 3.2.2 in the MP&M Industry Profile). The highly concentrated nature of the industry, combined with the sizeable share of the domestic market that is controlled by domestic aircraft manufacturers, suggests that firms in this sector have the ability to pass through a significant portion of their cost increases.

B.4.5 Mobile Industrial Equipment

EPA assigned this sector to the *high* category by the econometric analysis and the *average* category by the market structure analysis. EPA believes that this sector is more appropriately characterized by *average* CPT because the sector has witnessed certain trends in recent years that suggest that firms in this sector do not have a *high* ability to pass through cost increases. Specifically, growth rates in the construction and the farm and machinery equipment industries started to level off or even declined in recent years after a sustained period of growth (see section 3.2.10 in the MP&M Industry Profile). These declining trends are not fully represented in the regression analysis because the last year of analysis is 1996. EPA therefore revised the CPT coefficient for this sector to equal the average CPT value for all sectors classified in the *average* category based on the regression analysis.

B.4.6 Aerospace

Since the market structure analysis categorizes the Aerospace sector in the *high* CPT category, EPA estimated the CPT coefficient for this sector as the average CPT value for all sectors classified in the *high* category based on the regression analysis (excluding Mobile Industrial Equipment whose CPT coefficient was revised based on the market structure analysis).

B.5 Adjusting Estimates of Compliance CPT Potential

The CPT values estimated above reflect sector level CPT potential. The methodology must consider that ability to pass on cost increases through price increases will differ at the industry level versus the facility level. Cost increases that affect all facilities in an industry are more likely to be recovered through industry-wide price increases, whereas cases where only a few facilities in an industry incur cost increases are less likely to result in price increases. This analysis must therefore take into account the proportion of an industry that will experience cost increases when applying industry-level cost pass-through coefficients.

For the final MP&M rule, EPA will use the method used in the Phase I analysis where EPA adjusted the industry-level cost pass-through coefficient downward in proportion to the percentage of sector output bearing compliance cost. The ratio of the revenues in water-discharging facilities affected by the rule divided by total revenues in the MP&M sector provided a measure of the fraction of production in the MP&M sector likely to be affected by cost increase. That is, a cost pass-through percentage of 90 percent would be reduced to 72 percent if 80 percent of the sector output was subject to the regulation (.80 × .90 = .72). EPA applied this adjusted pass-through percentage to the percentage cost increase experienced by the regulated facilities only (i.e., sum of compliance costs divided by the sum of baseline costs for the facilities subject to the rule). Table B.9 presents the adjusted CPT coefficients estimated for each sector.

Table B.9: Adjusted Estimates of Compliance Cost Pass-Through Potential by MP&M Sector

Sector	Unadjusted Cost Pass-Through Potential	Estimated Fraction of Sector's Revenue Subject to Regulation (%)	Adjusted Cost Pass-Through Potential
Aerospace[a]	0.98	100.00	1.00
Aircraft[b]	1.20	100.00	1.00
Bus & Truck	0.86	100.00	0.96
Electronic Equipment	0.39	100.00	0.42
Hardware	0.77	33.50	0.26
Household Equipment	0.64	100.00	0.64
Instruments	0.77	100.00	0.77
Iron and Steel	0.77	100.00	0.77
Job Shop	0.57	43.70	0.25
Mobile Industrial Equipment[c]	0.79	100.00	0.79
Motor Vehicle	0.82	44.10	0.36
Office Machines[d]	(9.33)	34.50	0.00
Ordnance	0.59	100.00	0.59
Other Metal Products	0.63	100.00	0.63
Precious Metals & Jewelry	0.64	42.90	0.27
Printed Circuit Boards	(0.34)	53.60	0.00
Railroad	0.88	100.00	0.88
Ships and Boats	0.82	100.00	0.82
Stationary Industrial Equipment	0.79	32.20	0.25

[a] CPT coefficient for the Aerospace sector estimated based on the market structure analysis.
[b] For the Aircraft sector, the cost-pass through potential is capped at 100%.
[c] CPT coefficient for the Mobile Industrial Equipment sector revised based on the market structure analysis.
[d] For the Office Machine and Printed Circuit Boards sectors, the cost-pass through coefficients are set to zero based on both the estimated negative regression coefficient and the results of the market structure analysis.

Source: U.S. EPA analysis

ATTACHMENT B.A: SELECTED REVIEW OF CPT LITERATURE

To support the CPT analysis, EPA undertook a selected review of previous CPT analyses. The two most studied areas in the literature deal with exchange rate pass-through and tax pass-through. Unfortunately, neither of these study types is useful in assessing the reliability of the MP&M CPT results. Sections B.A.2 and B.A.3 provide a brief summary of this studies. One study (Ashenfelter et al,1998) estimates the pass-through rate for cost changes faced by an individual firm and compares it with passes-through of cost changes common to all firms in an industry. This appears to be the most relevant to the analysis of compliance costs pass through. Section B.A.1 provides a brief summary of findings from this study.

B.A.1 Ashenfelter et al. (1998), "Identifying the Firm-Specific Cost Pass-Through Rate."

As noted above, Ashenfelter et al. (1998) examines the pass-through rate for cost changes faced by only an individual firm (Staples, an office superstore chain), and distinguishes that rate from the rate at which a firm passes through cost changes common to all firms in an industry. Based on their analysis, they find the combined firm-specific and industry-wide pass-through rate (i.e., with no distinction between cost changes specific to the individual firm and those applicable to the entire industry) to be 57 percent. Conversely, the pass-through rate estimated for only firm-specific cost changes is about 15 percent and the pass-through rate for only industry-wide cost changes is close to 85 percent. The finding of a high CPT rate for industry-wide cost changes lends support to EPA's finding of similarly high historical CPT rates for many of the MP&M sectors.

B.A.2 Exchange Rate Pass-Through

The exchange rate pass-through literature examines the response of local currency import prices to variation in the exchange rate between exporting and importing countries. Based on seven studies covering the period 1970 to the mid-1980s, Menon (1995) finds that the estimated aggregate pass-through of exchange rate changes to import prices ranges from a low of 48.7 percent to a high of 91 percent. The mean value for pass-through for the sample of studies he considered is 69.9 percent. In contrast, Feinberg (1989) considers the impacts of exchange rate movements on U.S. domestic prices and finds an average pass-through of 16 percent in real terms. The pass-through is close to complete for industries that are heavily reliant on imported inputs and producing goods highly substitutable for imports. Pass-through rates are much lower for capital-intensive and concentrated industries and those protected by barriers to entry. The exchange rate pass-through scenario, however, is not comparable to the nature of compliance cost changes expected under the MP&M regulation and the resultant pass-through responses from domestic producers because the studies focus primarily on the impact of exchange rate changes on prices of imported goods and not on prices of domestically produced goods. Feinberg's study appears to be more relevant, but he does not present pass-through rates for individual industries, and does not explain why pass-through rates are much lower for capital-intensive and concentrated industries and those protected by barriers to entry.

B.A.3 Tax Pass-Through

The literature on tax pass-through examines the impact of excise tax changes on prices. Of the several studies that addressed the issue of tax pass-through, the majority report pass-through rates slightly in excess of a 100 percent (Ashenfelter et al., 1998). This literature is not entirely relevant to the CPT scenario being analyzed for this rule because most of these studies analyze changes in excise tax rates in the cigarette industry. In addition, excise tax changes on final goods do not affect manufacturing costs, and they have a uniform impact on the entire industry. Excise taxes do affect domestic producers, however, by altering final demand and therefore revenues received.

B.A.4 Studies Cited

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ACRONYMS

CAPM: Capital Asset Pricing Model
CPT: cost pass-through
ECI: Employment Cost Index
PPI: Producer Price Index
ROA: risk-normalized return on assets

Appendix C: Summary of Moderate Impact Threshold Values by Sector

INTRODUCTION

APPENDIX CONTENTS

Facilities subject to *moderate impacts* from the rule are expected to experience financial stress short of closure. This analysis uses two financial indicators: (1) Pre-Tax Return on Assets (PTRA) and (2) Interest Coverage Ratio (ICR). These threshold values were compared to pre- and post-compliance PTRA and ICR values for sample facilities to determine if facilities choosing to remain in business after promulgation of effluent guidelines would experience moderate impacts on their ability to attract and finance new capital. The remainder of this appendix describes the sources and methodology used to derive sector-specific moderate impact threshold values.

EPA calculated the thresholds using income and financial structure information by 4-digit SIC code from the Risk Management Association (RMA) *Annual Statement Studies* for eight years 1994-2001 (RMA, 2001; RMA 1998). This source provides quartile values derived from statements of commercial bank borrowers and loan applicants for firms having less than $250 million in total assets. These criteria may introduce bias, since firms with particularly poor financial statements might be less likely to apply to banks for loans, and some types of firms may be more likely to use bank financing than others. However, the RMA data offers the advantage of being available by 4-digit SIC codes and for quartile ranges.

RMA did not provide data for all 4-digit SIC codes associated with an MP&M sector. Out of 174 manufacturing SIC codes and 50 non-manufacturing SIC codes, 52 manufacturing SIC codes (30 percent) and 13 non-manufacturing SIC codes (26 percent), had no years of data available. RMA did not compile data for any SIC codes in two manufacturing sectors, Ordnance and Aerospace and one non-manufacturing sector, Precious Metals and Jewelry. When data were not available for any SIC codes within the sector, EPA calculated an average manufacturing or non-manufacturing threshold to use as a proxy.

The 4-digit SIC code data were consolidated into weighted sector averages, weighted by 1997 value of shipments from the Economic Censuses (U.S. DOC, 1997). For each sector and impact measure, a separate threshold was calculated for manufacturing and non-manufacturing SIC codes. The use of the RMA data for calculating the threshold values for pre-tax return on assets and interest coverage ratio is outlined below.

C.1 DEVELOPING THRESHOLD VALUES FOR PRE-TAX RETURN ON ASSETS (PTRA)

Pre-tax return on total assets measures the effectiveness of management in employing the resources available to it. A low ratio may indicate that a borrower would have difficulty financing treatment investments and continuing to attract investment.

The following data from Risk Management Association *Annual Statement Studies* were used to calculate PTRA:

- *% Profit Before Taxes / Total Assets*$_{25th}$ Ratio of profit before taxes divided by total assets and multiplied by 100 for the lowest quartile of values in each 4-digit SIC code.
- *Operating Profit* Gross profit minus operating expenses.
- *Profit Before Taxes* Operating profit minus all other expenses (net).

RMA provides a measure of pre-tax return on assets that approximates the measure that EPA defined for the moderate impact analysis. As defined by RMA, this measure is the ratio of pre-tax *income* to assets, designated ROA_{RMA}:

ROA_{RMA} = Pre-Tax Income (EBT) / $ASSETS_{25th}$

However, as defined by EPA for its analysis, the numerator of the PTRA measure requires the use of earnings before interest and taxes (EBIT) instead of pre-tax income (EBT). Defined as EBIT, the PTRA numerator will capture all return from assets, whether going to debt or equity. To derive a pre-tax, total return value, EPA adjusted RMA's measure of PTRA using the median percentage values of EBIT and EBT available from RMA. This adjustment yields the PTRA measure that EPA used in the moderate impact analysis, designated $ROA_{MP\&M}$:

$ROA_{MP\&M} = ROA_{RMA} * EBIT / EBT$

Negative values are included in the weighted-sector PTRA averages but a different method is used to adjust the ROA values reported in RMA to the value used in the moderate impact analysis. Specifically, using only those observations (i.e., 4-digit SIC code and year combinations) with positive values for % Profit Before Taxes / Total Assets, Operating Profit, and Profit Before Taxes, EPA calculated an adjustment factor by subtracting the difference between $ROA_{MP\&M}$ and ROA_{RMA} as follows:

$ROA_{MP\&M} - ROA_{RMA}$ = adjustment factor.

Those values were consolidated into sector-specific adjustment factors, weighted by 1997 value of shipments from the Economic Censuses (U.S. DOC, 1997). Each negative PTRA observation from RMA was adjusted by its sector specific adjustment factor to approximate the measure used in the moderate impact analysis:

ROA_{RMA} + sector-specific adjustment factor = $ROA_{MP\&M}$

The sector-specific adjustment factors average 0.47 for manufacturing sectors and range from 0.13 for the Office Machines sector to 0.60 for the Aircraft and Motor Vehicle sectors. The sector-specific adjustment factors average 0.22 for non-manufacturing sectors and range from 0.15 for the Motor Vehicle sector to 0.74 for the Railroad sector.

C.2 Developing Threshold Values for Interest Coverage Ratio (ICR)

Interest coverage ratio is a measure of a firm's ability to meet current interest payments and, on a pro-forma basis, to meet the additional interest payments under a new loan. A high ratio may indicate that a borrower would have little difficulty in meeting the interest obligations of a loan. This ratio also serves as an indicator of a firm's capacity to take on additional debt.

The following data from Risk Management Association *Annual Statement Studies* were used to calculate ICR:

- *EBIT/Interest*$_{25th}$ — Ratio of earnings (profit) before annual interest expense and taxes (EBIT) divided by annual interest expense for the lowest quartile of values in each 4-digit SIC code.
- *% Depr., Dep., Amort./Sales*$_{med}$ — Median ratio of annual depreciation, amortization and depletion expenses divided by net sales and multiplied by 100.
- *Operating Profit* — Gross profit minus operating expenses.

RMA provides a measure of interest coverage that approximates the measure that EPA defined for the moderate impact analysis. As defined by RMA, this measure is the ratio of earnings before interest and taxes to interest, designated ICR_{RMA}:

$ICR_{RMA} = EBIT / INTEREST_{25th}$

However, as defined by EPA for its analysis, the numerator of the ICR measure requires the use of earnings before interest, taxes, depreciation, and amortization (EBITDA) instead of earnings before interest and taxes (EBIT). Defined this way, the ICR numerator will include all operating cash flow that could be used for interest payments. To derive the desired ICR value (designated $ICR_{MP\&M}$), EPA adjusted the RMA value as outlined below:

$ICR_{MP\&M} = EBITDA / INTEREST$

Therefore, $ICR_{MP\&M} = ICR_{RMA} * (EBIT + DA) / EBIT$
or $ICR_{MP\&M} = ICR_{RMA} * \{1 + [(DA / SALES) / (EBIT / SALES)]\}$

For consistency of calculation, EPA used the median values available from RMA for the adjusting both the numerator (DA / SALES) and denominator (EBIT / SALES) terms.[1]

EPA used the same method as described above to adjust the negative ICR values reported in RMA to the value used in the moderate impact analysis. Including only those observations with positive values for EBIT/Interest, % Depr., Dep., Amort./Sales, and Operating Profit, an adjustment factor was calculated by subtracting the difference between $ICR_{MP\&M}$ and ICR_{RMA} as follows:

$ICR_{MP\&M} - ICR_{RMA}$ = adjustment factor.

A sector-specific adjustment factor was calculated for ICR values similar to the PTRA. Each negative ICR observation from RMA was adjusted by its sector specific adjustment factor to approximate the measure used in the moderate impact analysis:

ICR_{RMA} + sector-specific adjustment factor = $ICR_{MP\&M}$

The sector-specific adjustment factors average 0.59 for manufacturing sectors and range from 0.28 for the Precious Metals and Jewelry sector to 0.79 for the Printed Circuit Board sector. The sector-specific adjustment factors average 0.50 for non-manufacturing sectors and range from 0.24 for the Office Machines sector to 1.85 for the Aircraft sector.

[1] Numerator (% Depr., Dep., Amort./Sales) is available for quartile values; denominator (Operating Profit) only for median values.

C.3 Summary of Results

Table C.1 shows the resulting threshold values for PTRA and ICR by sector. The PTRA values for manufacturers range from zero percent for the Office Machine sector to 2.8 percent for the Aircraft and Household Equipment sectors and for the non-manufacturers the values range from 0.3 percent for the Office Machine sector to 3.1 percent for the Railroad sector. The ICR values for manufacturers range from 1.4 for the Office Machine and Railroad sectors to 2.3 for the Hardware, Household Equipment, and Printed Circuit Board sectors and for the non-manufacturers the values range from 1.2 for the Office Machine sector to 2.9 for the Aircraft sector.

In assessing moderate impacts, EPA used the non-manufacturing threshold for facilities that reported 100 percent of their revenues came from rebuilding and maintenance; otherwise, EPA used the manufacturing threshold.

Table C.1: Summary of Moderate Impact Thresholds by Sector

Sector	Pre-Tax Return on Assets (PTRA)		Interest Coverage Ratio (ICR)	
	Manufacturing	Non-Manufacturing	Manufacturing	Non-Manufacturing
Hardware[b]	2.6%	1.6%	2.3	1.9
Aircraft	2.8%	0.4%	2.2	2.9
Electronic Equipment[b]	2.1%	1.6%	2.2	1.9
Stationary Industrial Equipment	2.1%	2.5%	2.1	2.8
Ordnance[a]	2.2%	1.6%	2.1	1.9
Aerospace[a]	2.2%	1.6%	2.1	1.9
Mobile Industrial[b]	2.6%	1.6%	2.1	1.9
Instrument	2.2%	2.0%	2.1	2.0
Precious and Non-Precious[a]	1.8%	1.6%	1.7	1.9
Ships and Boats	1.7%	1.0%	1.6	2.0
Household Equipment	2.8%	2.6%	2.3	2.0
Railroad[b]	1.1%	3.1%	1.4	2.7
Motor Vehicle	2.4%	1.5%	2.0	1.7
Bus and Truck	2.3%	1.7%	2.0	2.8
Office Machine	0.0%	0.3%	1.4	1.2
Printed Circuit Board[b]	2.5%	1.6%	2.3	1.9
Job Shop[b]	2.3%	1.6%	2.2	1.9
Other Metal Products	1.0%	1.7%	1.6	1.8
Iron and Steel	2.4%	N/A	2.2	N/A
Unknown Sector[a]	2.2%	1.6%	2.1	1.9

[a] When data were not available for any SIC codes within the sector, EPA calculated an average manufacturing or non-manufacturing threshold to use as a proxy.

[b] There are no non-manufacturing SIC codes in several sectors, but in these sectors there are some facilities who reported that all of their revenue came from rebuilding and maintenance. In these cases, EPA used the average non-manufacturing thresholds in that sector as a proxy for the non-manufacturing threshold.

Source: RMA, 2001; RMA, 1998; U.S. Economics Census, 1997; U.S. EPA Analysis, 2002.

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Appendix D: Estimating Capital Outlays for MP&M Discounted Cash Flow Analyses

INTRODUCTION

APPENDIX CONTENTS

The economic impact analysis for the Metal Products & Machinery Industry (MP&M) final regulation involved calculation of the business value of sample facilities on the basis of a discounted cash flow (DCF) analysis of operating cash flow as reported in facility questionnaires. Business value is calculated on a pre- and post-compliance basis and the change in this value serves as an important factor in estimating regulatory impacts in terms of potential facility closures. For proposal, the business value calculation was based only on cash flow from operations and did not recognize cash outlays for capital acquisition as a component of cash flow. EPA Office of Water (OW) previously identified that the omission of capital acquisition cash outlays from the DCF analysis may lead to overstatement of the business value of sample facilities and, as a consequence, understatement of regulatory impacts in terms of estimated facility closures.

In response to this omission, the Office of Management and Budget suggested the adoption of depreciation as a surrogate for cash outlays for capital replacement and additions. However, for several reasons EPA believes depreciation is a poor surrogate. First, depreciation is meant to capture the consumption/use of previously acquired assets, *not* the cost of replacing, or adding to, the existing capital base. Therefore, depreciation is fundamentally the wrong concept to use as a surrogate for capital outlays for capital replacement and additions. Second, depreciation is estimated based on the historical asset cost, which may understate or overstate the real replacement cost of assets. Third, both book and tax depreciation schedules generally understate the assets' useful life. Thus, reported depreciation will overstate real depreciation value for recently acquired assets that are still in the depreciable asset base, and conversely, understate the real depreciation value of assets that have expired from the depreciable asset base but still remain in valuable use. Finally, depreciation does not capture the important variations in capital outlays that result from differences in revenue growth and financial performance among firms. Businesses with real growth in revenues will need to expand both their fixed and working capital assets to support business growth, and all else being equal, growing businesses will have higher ongoing outlays for fixed and working capital assets. Similarly, the ability of businesses to renew and expand their asset base depends on the financial productivity of the deployed capital as indicated by measures such as return on assets or return on invested capital. As a result, businesses with "strong" asset productivity will attract capital for renewal and expansion of their asset base, while businesses with "weak" asset productivity will have difficulty attracting the capital for renewal and expansion of the business' asset base. All else being equal, businesses with strong asset productivity will have higher ongoing outlays for capital assets; businesses with weak asset productivity will have lower ongoing outlays for capital assets.

As an approach to addressing the omission of capital acquisition cash outlays from the DCF analysis, EPA undertook to estimate a regression model of capital outlays using capital expenditure and relevant explanatory financial and business environment information for public-reporting firms in the MP&M industry sectors. The estimated model was then used to estimate capital outlays for facilities in the MP&M sample dataset. The estimated capital outlay values were used in the DCF analyses to calculate business value of sample facilities and estimate regulatory impacts in terms of facility closures.

This appendix reports the results of this effort, including: an overview of the analytic concepts underlying the analysis of capital outlays; specific variables included in the regression analysis; summary of data selection and preparation; general specification of regression models to be tested; and the findings from the regression analyses.

D.1 ANALYTIC CONCEPTS UNDERLYING ANALYSIS OF CAPITAL OUTLAYS

On the basis of general economic and financial concepts of investment behavior, EPA began its analysis by outlining a framework relating the level of a firm's capital outlays to explanatory factors that:

- can be observed for public-reporting firms either as firm-specific information or general business environment information and thus be included in a regression analysis; and
- for firm-specific information, are also available from the MP&M sample facility dataset.

To aid in identifying the explanatory concepts and variables that might be used in the analysis and as well in specifying the models for analysis, EPA reviewed recent studies of the determinants of capital outlays. EPA's review of this literature generally confirmed the overall approach in seeking to estimate capital outlays and helped to identify additional specific variables that other analysts found to contribute important information in the analysis of capital outlays (e.g., the decision to test capacity utilization as an explanatory variable, see below, resulted from the literature review). Articles reviewed are listed in Attachment D.A to this appendix.

Table D.1 beginning below and continuing the following two pages summarizes the conceptual relationships between a firm's capital outlays and explanatory factors that EPA sought to capture in this analysis. In the table, EPA outlines the concept of influence on capital outlays, the general explanatory variable(s) that EPA identified to capture the concept in a regression analysis, and the hypothesized mathematical relationship (sign of estimated coefficients) between the concept and capital outlays. Table D.2 identifies the specific variables included in the analysis, including any needed manipulations and the correspondence of the variables to MP&M survey information.

Table D.1: Summary of Factors Influencing Capital Outlays

Explanatory Factor/Concept To Be Captured in Analysis	Translation of Concept to Explanatory Variable(s)	Expected Relationship
Availability of attractive opportunities for additional capital investment. A firm's owners, or management acting on behalf of owners, should expend cash for capital outlays only to the extent that the expected return on the capital outlays whether for replacement of, or additions to, existing capital stock are sufficient to compensate providers of capital for the expected return on alternative, competing investment opportunities, taking into account the risk of investment opportunities.	Historical ***Return On Assets*** of establishment as a indicator of investment opportunities and management effectiveness, and, hence, of desirability to expand capital stock and ability to attract capital investment. Use of a historical variable implicitly assumes past performance is indicative of future expectations.	Positive
Business growth and outlook as a determinant of need for capital expansion and attractiveness of investment opportunities. All else equal, a firm is more likely to have attractive investment opportunities and need to expand its capital base if the business is growing and the outlook for business performance is favorable.	***Revenue Growth***, from the prior time period(s) to the present, provides a *historical* measure of business growth and is a potential indicator of need for capital expansion. Use of a historical variable implicitly assumes past performance is indicative of future expectations.	Positive
	Clearly, the theoretical preference is for a forward-looking indicator of business growth and need for capital expansion. Options EPA identified include ***Index of Leading Indicators*** and current ***Capacity Utilization***, by industry. Higher current *Capacity Utilization* may presage need for capital expansion.	Positive

Table D.1: Summary of Factors Influencing Capital Outlays

Explanatory Factor/Concept To Be Captured in Analysis	Translation of Concept to Explanatory Variable(s)	Expected Relationship
Importance in capital in business production. All else equal, the more capital intensive the production activities of a business, the greater will be the need for capital outlay to replenish, and add to, the existing capital stock. More capital intensive businesses will spend more in capital outlays to sustain a given level of revenue over time.	The ***Capital Intensity*** of production as measured by the production capital required to produce a dollar of revenue provides an indicator of the level of capital outlay needed to sustain and grow production. As an alternative to a firm-specific concept such as Capital Intensity of production, differences in business characteristics might be captured by an ***Industry Classification*** variable.	Positive
Life of capital equipment in the business. All else equal, the shorter the useful life of the capital equipment in a business, the greater will be the need for capital outlay to replenish, and add to, the existing capital stock.	No information is available on the actual useful life of capital equipment by business or industry classification. However, the ***Capital Turnover Rate***, as calculated by the ratio of book depreciation to net capital assets, provides an indicator of the rate at which capital is depleted, according to book accounting principles: the higher the turnover rate, the shorter the life of the capital equipment. However, the measure is imperfect for reasons of both the inaccuracies of book reporting as a measure of useful life, and as well the confounding effects of growth in the asset base due to business expansion which will tend to lower the indicated turnover rate, all else equal, without a real reduction in life of capital equipment. As above, an alternative to a firm-specific concept, differences in business characteristics might be captured by an ***Industry Classification*** variable.	Positive, generally, but with recognition of the potential for counter-trend effects
The cost of financial capital. The cost at which capital both debt and equity is made available to a firm will determine which investment opportunities can be expected to generate sufficient return to warrant use of the financial capital for equipment purchases. All else equal, the higher the cost of financial capital, the fewer the investment/capital outlay opportunities that would be expected to be profitable and the lower the level of outlays for replacement of, or additions to, capital stock.	Preferably, measures of cost-of-capital would be developed separately for debt and equity. The ***Cost of Debt Capital***, as measured by an appropriate benchmark interest rate, provides an indication of the terms of debt availability and how those terms are changing over time. Preferably, the debt cost/terms would reflect the credit condition of the firm, which could be based on a credit safety rating (e.g., S&P Debt Rating). While such information would be available for public firms, EPA judged that developing a comparable concept for MP&M sample facilities would not be possible within the scope of this analysis.	Negative
	The cost of equity capital is more problematic than the cost of debt capital since it is not directly observable for either public-reporting firms or, in particular, private firms in the MP&M dataset. However, a readily available surrogate such as ***Market-to-Book Ratio*** provides insight into the terms at which capital markets are providing equity capital to *public-reporting firms*: the higher the Market-to-Book Ratio, the more favorable the terms of equity availability. Although such information would *not* be available for private firms in the MP&M sample, EPA judged that it would be possible to develop a industry-level value for use with the MP&M facility analysis.	Negative

Table D.1: Summary of Factors Influencing Capital Outlays

Explanatory Factor/Concept To Be Captured in Analysis	Translation of Concept to Explanatory Variable(s)	Expected Relationship
The price of capital equipment. The price of capital equipment in particular, how capital equipment prices are changing over time will influence the expected return from capital outlays. All else equal, when capital equipment prices are increasing, the expected return from incremental capital outlays will decline and vice versa. However, although the generally expected effect of higher capital equipment prices is to remove certain investment opportunities from consideration, the potential effect on *total capital outlay* may be mixed. If expected returns are such that the demand to invest in capital projects is relatively inelastic, the effect of higher prices for capital equipment may be to raise, instead of lower, the total capital outlay for a firm.	Index provides an indicator of the change in capital equipment prices.	Negative, generally, but with recognition of the potential for counter-trend effects

Source: U.S. EPA analysis.

D.2 Specifying Variables for the Analysis

Working from the general concepts of explanatory variables outlined above, EPA defined the specific explanatory variables to be included in the analysis. A key requirement of the regression analysis is that the firm-specific explanatory variables included in the regression analysis later be able to be used as the basis for estimating capital expenditures for facilities in the MP&M dataset. As a result, in defining the firm-specific variables, it was necessary to ensure that the definition of variables selected for the regression analysis using data on public-reporting firms be consistent with the data items available for facilities in the MP&M dataset.

Also, EPA's selection of firm-specific variables was further constrained by an earlier decision to use the Value Line Investment Survey (VL) as the source of firm-specific information for the regression analysis. The decision to use VL as the source of firm-specific data for the analysis was driven by several considerations:

- *Considerably lower price than alternatives.* VL data were available at a price of $95 for a one-time data purchase; the price for other data sources such as Bloomberg and Standard & Poor's ranged from $7,000 to $11,000.

- *Reasonable breadth of public-reporting firm coverage.* The VL dataset includes 7,500 firms.

- *Reasonable breadth of temporal coverage.* VL provides data for the most recent 10 years i.e., 1991-2000. Although ideally EPA would have preferred a longer time series to include more years not in the "boom" investment period of the mid- to late-1990s.

- *Timeliness of access.* The VL data are provided as a standard package and thus could be available within a week of ordering while other data sources (e.g., Bloomberg) would have required more time because data would have provided as a custom purchase.

- *Reasonable coverage of concepts/data needed for analysis.* The VL data includes a wide range of financial data that are applicable to the analysis (VL provides 37 data items over the 10 reporting years; see Attachment DB). However, because of the pre-packaged nature of the VL data, it was not possible to customize any data items to support more precise definition of variables in the analysis. In particular, EPA found that certain balance sheet items were not reported to the level of specificity preferred for the analysis. Overall, though, EPA expects the consequence of using more aggregate, less-refined concepts should be minor.

The decision to use VL data for the analysis constrained, in some instances, EPA's choice of variables for the analysis.

Table D.2 reports the specific definitions of variables included in the analysis (both the dependent variable and explanatory variables), including any needed manipulations, the data source, the MP&M estimation analysis equivalent (either the corresponding variable(s) in the MP&M questionnaire or other source outside the questionnaire), and any issues in variable definition.

Table D.2: Variables For Capital Expenditure Modeling Analysis

Variables for Regression Analysis			MP&M Analysis Equivalent	Comment / Issue
Variable	**Source**	**Calculation**		
Dependent Variable				
***Gross* expenditures on fixed assets: CAPEX**, includes outlays to replace, and add to, existing capital stock	Value Line	Obtained from VL as **Capital Spending per Share**. **CAPEX** calculated by multiplying by **Average Shares Outstanding**.	None: to be estimated based on estimated coefficients.	*This value and all other dollar values in the regression analysis were deflated to 1996 (base year for MP&M regulatory analysis) using 2-digit SIC PPI values.*
Explanatory Variables				
Firm-Specific Variables				
On Assets: ROA	Value Line	**ROA = Operating Income / Total Assets**. Both **Operating Income**, defined as Revenue less Operating Expenses (CoGS+SG&A), and **Total Assets** were obtained directly from VL.	From Survey: **Revenue** *less* **Total Operating Expenses** (**Material & Product Costs** + **Production Labor** + **Cost of Contract Work** + **Fixed Overhead** + **R&D** + **Other Costs & Expenses**)	Would have preferred a post-tax concept in numerator *and* a deployed production capital concept in denominator. However, VL provides no tax value *per se* and would require calculation of tax using an estimated tax rate, which could introduce error. Also neither VL nor MP&M survey data provide sufficient information to get at deployed production capital.

Table D.2: Variables For Capital Expenditure Modeling Analysis				
Variables for Regression Analysis			MP&M Analysis Equivalent	Comment / Issue
Variable	**Source**	**Calculation**		
Revenue Growth: RVGR	Value Line	Primary formulation tested for *linear* models was percentage change in revenue over two years prior to current year: **RVGR = (REV$_t$ – REV$_{t-2}$) / REV$_{t-2}$**. VL provides 10 years of financial statement values 1991-2000, including **Revenue** by year. For *log-linear* models, the growth concept was dropped and **REV** was used as the explanatory variable (see below and also see later discussion under model specification).	No equivalent needed. Analysis proposed to set this value to zero in estimating capital outlay values for MP&M facilities. The use of a zero growth value is consistent with estimating the replacement capital expenditures in a no-growth steady-state.	Using a revenue growth term in the analysis defined over the prior two years requires three years of revenue data (e.g., current year plus trailing two years) and effectively eliminates two observation years from the analysis (1991 and 1992). Given that these data years occurred at the end of a recession period and before the mid- to late-90s economic boom period, EPA was very concerned about the potential loss of these years from the analysis dataset. In the end, the use of a log-linear model eliminated the need to construct the lagged difference variables and thus mooted the concern over loss of early year observations. The use of the log-linear model, however, also eliminated the potential to set the growth term to zero in estimating baseline capital outlays for MP&M facilities.
Revenue: REV	Value Line	In the linear models, **REV** included as a scale variable together with **REVGR**, as outlined above. For log-linear models, retained only **REV** as the explanatory variable. The simple variable, **REV**, captures the percent change/growth concept in the log-linear formulation.	From Survey: **Revenue**	Using **REV** only *and not **REVGR*** in the log-linear model restored the two data years at the beginning of the analysis period (1991 and 1992) to the analysis dataset. EPA believes including data for the first two observation period years is important for the generality of the analysis. Also tested **Total Assets** as a scale variable, which provided good, but not as strong, an explanation, as **REV**.
Capital Turnover Rate: CAPT	Value Line	**CAPT = Depreciation / Total Assets. Depreciation** and **Total Assets** directly available from VL.	From Survey: **Depreciation / Total Assets**	Would have preferred denominator of *net fixed assets* instead of *total assets.* However, VL provides detailed balance sheet information for only the four most recent years. Not possible to separate current assets and intangibles from total assets.
Capital Intensity: CAPI	Value Line	**CAPI = Total Assets / Revenue. Total Assets** and **Revenue** directly available from VL	From Survey: **Total Assets / Revenue**	As above, would have preferred *net fixed assets* instead of *total assets*, but needed data are not available from VL for the full analysis period.
Market-to-Book Ratio: MV/B	Value Line	**MV/B** = average market price of common equity (**Price**) divided by book value of common equity (**Book Value per Share**). **Price** and **Book Value per Share** directly available from VL.	Use average of **MV/B** for firms by MP&M industry group in regression analysis dataset; calculated at time of MP&M industry survey.	Ultimately found **MV/B** highly correlated with other, more important explanatory variables, which makes sense, given that equity terms would be derived from more fundamental factors, such as **ROA**. Omitting **MV/B** from the analysis eliminated the need to define an approach to use this variable with MP&M survey data.

Table D.2: Variables For Capital Expenditure Modeling Analysis

Variables for Regression Analysis			MP&M Analysis Equivalent	Comment / Issue
Variable	**Source**	**Calculation**		
General Business Environment Variables				
Interest on 10-year, A-rated industrial debt: DEBTCST	Bloomberg Financial Services	**DEBTCST** = annual average of rates for each data year	Use average of **DEBTCST** rates at time of MP&M industry survey.	10-year maturity, industry debt selected as reasonable benchmark for industry debt costs. 10 years became "standard" maturity for industrial debt during 1990s.
Index of Leading Indicators: ILI	Conference Board	Monthly index series available from Conference Board. For linear models, **ILI** = percent change from beginning to end of current year. For log-linear models, **ILI** = geometric mean of current year values.	For linear formulation, use average of year-to-year percent change in **ILI** at time of MP&M industry survey. For log-linear formulation, use average of **ILI** values at time of MP&M industry survey.	
Capacity Utilization by Industry: CAPUTIL	Federal Reserve Board (Dallas Federal Reserve)	Monthly index series available from Federal Reserve. For linear models, **CAPUTIL** = percent change in annual average values from prior year to current year. For log-linear models, **CAPUTIL** = current year average value.	For linear formulation, use average of year-to-year percent change in **CAPUTIL** at time of MP&M industry survey. For log-linear formulation, use average of **CAPUTIL** values at time of MP&M industry survey.	
Producer Price Index series for capital equipment: CAPPRC	Bureau of Labor Statistics	Annual average values available from BLS. For linear models, **CAPPRC** = percent change from prior year to current year. For log-linear models, **CAPPRC** = current year average value as reported by BLS.	For linear formulation, use average of year-to-year percent change in **CAPPRC** at time of MP&M industry survey. For log-linear formulation, use average of **CAPPRC** values at time of MP&M industry survey.	BLS reports PPI series for capital equipment based on "consumption bundles" defined for manufacturing and non-manufacturing industries. For this analysis, EPA used the PPI series based on the manufacturing industry bundle.

Source: U.S. EPA analysis.

D.3 Selecting the Regression Analysis Dataset

In addition to specifying the variables to be used in the regression analysis, EPA also needed to select the public firm dataset on which the analysis would be performed.

As noted above, EPA used the Value Line Investment Survey as the source for public firm data. VL includes over 7,500 publicly traded firms and identifies firms' principal business both by a broad industry classification (e.g., Electrical Equipment, Machinery) and by an SIC code assignment. In most instances, the SIC codes assignment is only at the 2-digit level. To build the public firm dataset corresponding to the MP&M industry sectors, EPA initially selected all firms included in the following 2-digit SIC code families:

- 2500: Furniture and fixtures,
- 3300: Primary metal industries,
- 3400: Fabricated metal products,
- 3500: Industrial machinery and equipment,
- 3600: Electrical and electronic equipment,
- 3700: Transportation equipment, and
- 3800: Instruments and related products.

From manual inspection, EPA deleted firms in four-digit SIC code 3579, which, in the VL classification, was comprised only of software manufacturers. In addition, in SIC code group 3300, EPA included firms only in the ferrous metal processing sectors: SIC codes 3311, 3312, 3315, 3316, 3317, and 3398.[1]

As a result of this selection, EPA developed an initial dataset of 1,015 firms. On inspection, EPA found that a substantial number of firms did not have data for the full 10 years of the analysis period. The general reason for the omission of some years of data is that the firms did not become publicly listed in their current operating structure whether through an initial public offering, spin-off, divestiture of business assets, or other significant corporate restructuring that renders earlier year data inconsistent with more recent data until after the beginning of the 10-year data period.[2] As a result, the omission of observation years for a firm always starts at the beginning of the data analysis period. This systematic front-end truncation of firm observations in the dataset could be expected to bias the analysis in favor of the capital expenditure behavior nearer the end of the 1990s decade. To avoid this problem, EPA removed all firm observations that have fewer than 10 years of data. As a result, the dataset used in the analysis has a total of 3,900 yearly data observations and represents 390 firms.

Table D.3 presents the number of firms by industry classifications.

Table D.3: Number of Firms by Industry Classifications

SIC Industry Classification	Number of Firms
2500: Furniture and fixtures	13
3300: Primary metal industries	27
3400: Fabricated metal products	24
3500: Industrial machinery and equipment	119
3600: Electrical and electronic equipment	101
3700: Transportation equipment	65
3800: Instruments and related products	41

D.4 SPECIFICATION OF MODELS TO BE TESTED

On the basis of the variables listed above and their hypothesized relationship to capital outlays, EPA specified a time-series, cross sectional model to be tested in the regression analysis. EPA's dataset consisted of 390 cross sections observed at 10 years (1991 through 2000). The general structure of this model was as follows:

$$\text{CAPEX}_{i,t} = f(\text{ROA}_{i,t}, \text{REV}_{i,t}, \text{CAPT}_{i,t}, \text{CAPI}_{i,t}, \text{DEBTCST}_{i,t}, \text{CAPPRC}_{t}, \text{CAPUTIL}_{j,t})$$

[1] These 4-digit SIC codes include all MP&M sectors in SIC 2-digit code 33 *plus* 4-digit SIC code 3311, to capture information for the steel manufacturing industry.

[2] When VL adds a firm to its dataset, it fills in the public-reported data history for the firm for the lesser of 10 years or the length of time that the firm has been publicly listed and thus subject to SEC public reporting requirements.

Where:

$CAPEX_{i,t}$	=	capital expenditures of firm i, in time period t;[1]
t	=	year (year = 1991, . . . , 2000);
i	=	firm i (i=1, . . . , 390);
j	=	industry classification j
$ROA_{i,t}$	=	return on total assets for firm i in year t;
$REV_{i,t}$	=	revenue ($ millions) for firm i in year t;
$CAPT_{i,t}$	=	capital turnover rate for firm i in year t;
$CAPI_{i,t}$	=	capital intensity for firm i in year t;
$DEBTCST_{t}$	=	financial cost of capital in year t;
$CAPPRC_{t}$	=	price of capital goods in year t;
$CAPUTIL_{j,t}$	=	the Federal Reserve Board's Index of Capacity utilization for a given industry j in year t.

EPA tested both linear and log-linear model specifications. Both models fit quit well, achieving overall correlation (R^2) in the upper 80 percent/low 90 percent range. However, the pattern of coefficient significance was better in the log-linear model. In addition, the log-linear model offered advantages in terms of retention of early time period observations and variable specification, as discussed below. Therefore, EPA selected a log-linear specification as the final model. The following paragraphs briefly discuss testing of both linear and log-linear forms of the model. Parameter estimates are presented for the final log-linear model only because this specification appeared to be superior to a linear model.

D.4.1 Linear Model Specification

EPA first tested linear models of CAPEX as a function of the proposed explanatory variables. In testing linear models of CAPEX, EPA tested a number of structural modifications within the overall hypothesized framework of explanatory variables. These included:

- Testing the influence of industry classification on the estimation of the coefficients for certain of the explanatory variables: e.g., using the product of an industry classification dummy variable and CAPPRC to test whether certain industries in particular, "high-tech" vs. "traditional" industries responded differently to change in price of capital equipment over time.

- Testing contemporary vs. lagged specification of certain explanatory variables: e.g., using prior, instead of current, period revenue, REV, as an explanatory variable.

- Testing scale-normalized specification of the dependent variable: e.g., using CAPEX/REV as the dependent variable instead of simple CAPEX.

- Testing flexible functional forms that included quadratic terms.

- Testing additional explanatory variables including the index of 10 leading economic indicators (ILI) and market-to-book ratio (MV/B).

EPA also tested the data for autocorrelation, heteroscedasticity, and multicollinearity.

Cross-sectional, time-series datasets typically exhibit both autocorrelation and group-wise heteroscedasticity characteristics. Autocorrelation is frequently present in economic time series data as the data display a "memory" with the variation not being independent from one period to the next. Heteroscedasticity usually occurs in cross-sectional data where the scale of the dependent variable and the explanatory power of the model vary across observations. Not surprisingly, the dataset used in this analysis had both characteristics.

The collinearity diagnostic showed that several independent variables are collinear. In particular, EPA found that the index of leading economic indicators (ILI) and the price of capital equipment (CAPPRC) variables are highly correlated. EPA further found that the market-to-book ratio variable (MV/B) was highly correlated with both capital turnover (CAPT) and return-on-assets (ROA) variables. To address the multicollinearity issue, EPA substituted capacity utilization (CAPUTIL) for the index of leading economic indicators (ILI) and dropped the market-to-book ratio (MV/B) variable in the final model.

[1] All dollar values were deflated to 1996 (base year for MP&M regulatory analysis) using 2-digit SIC PPI values.

D.4.2 Log-Linear Model Specification

The main advantage of the log-linear model is that it incorporates directly the concept of percent change in the explanatory variables. Specifying the key regression variables as logarithms permitted us to estimate directly as the coefficients of the model, the elasticities of capital expenditures with respect to firm financial characteristics and general business environment factors. In addition, by eliminating the need to use percent change variables, EPA was able to avoid losing early year observations in the analysis dataset. Finally, the logarithmic transformations helped to reduce outlier effects in the model.

EPA specified a log-linear model, as follows:

$$\ln(\mathrm{CAPEX}_{i,t}) = \alpha + \Sigma[\beta_x \ln(\mathrm{X}_{i,t})] + \Sigma[\gamma_y \ln(\mathrm{Y}_t)] + \epsilon$$

Where:

$\mathrm{CAPEX}_{i,t}$	=	capital expenditures of firm *i*, year *t*;
β_x	=	elasticity of capital expenditures with respect to firm characteristic X;
$\mathrm{X}_{i,t}$,	=	a vector of financial characteristics of firm *i*, year *t*;
γ_y	=	elasticity of capital expenditures with respect to economic indicator Y;
Y_t	=	a vector of economic indicators, year *t*; for CAPUTIL, Y is also differentiated by industry classification
ϵ	=	an error term; and
$\ln(x)$	=	natural log of *x*

Based on this model, the elasticity of capital expenditures with respect to an explanatory variable, for example, return on assets is calculated as follows:

$$E(CAPEX) = \frac{d\ln(CAPEX)}{d\ln(ROA)} = \frac{d(CAPEX)/CAPEX}{d(ROA)/ROA}$$

Because the log-linear specification incorporates directly the concept of percent change in the explanatory variables, EPA dropped the "change" specification variables i.e., revenue growth (REVGR), year-to-year change in the Index of Leading Indicators (ILIGR), and year-to-year change in the Capital Equipment Price Index (CAPPRC) from the analysis. For these variables, EPA used the logarithm of the simple, unadjusted values in the log-linear specification.

One disadvantage of the specified log-linear model is that the logarithmic transformation is not feasible for negative and zero values. This means that negative and zero values require linear transformation to be included in the analysis. The following variables in the sample required transformation:

- CAPEX: four firms in the sample reported zero capital expenditures at least in one time period. EPA set these expenditures to $1.

- REVENUE: one firm reported negative revenue (-$1,018) in one time period. Because this is likely due to accounting adjustments from prior period reporting, EPA set the firm's revenue in the current time period to $1.

- ROA: the values for return on assets in the public firm sample range from -1.1 to 0.6. Approximately 25 percent of the firms in the dataset reported negative ROAs in at least one year. To address this issue while reducing potential effects of data transformation on the modeling results, EPA used the following data transformation approach:

  - EPA excluded 12 firms with *any* annual ROA values below the 99th percentile of the ROA distribution (i.e., ROA $\leq$ - 0.31).

  - EPA used an additive data transformation to ensure that remaining negative ROA values were positive in the logarithm transformation. The additive transformation was performed by adding 0.31 to all ROA values.

The analysis tested several specifications of a log-linear model, including models with slope dummies for different industrial sectors and models with the intercept suppressed. The model presented below was most successful at explaining firms' investment behavior.

EPA estimated the specified model using the generalized least squares procedure. This procedure involves the following two steps:

- First, EPA estimated the model using simple OLS, ignoring autocorrelation for the purpose of obtaining a consistent estimator of the autocorrelation coefficient (ρ);

- Second, EPA used the generalized least squares procedure, where the analysis is applied to transformed data. The resulting autocorrelation adjustment is as follows:

$$Z_{i,t} = Z_{i,t} - \rho Z_{i,t-1}$$

where Z_{it} is either dependent or independent variables.

EPA was unable to correct the estimated model for group-wise heteroscedasticity due to computational difficulties. The statistical software used in the analysis (LIMDEP) failed to correct the covariance matrix due to the very large number of groups (i.e., 390 firms) included in the dataset. Application of other techniques to correct for group-wise heteroscedasticity was not feasible due to time constraints. The estimated coefficients remain unbiased; however, they are not minimum variance estimators.

Table D.4 presents model results. The model has a fairly good fit, with adjusted R^2 of 0.89. All coefficients have the expected sign and all but two (constant and capital price) are significantly different from zero at the 95th percentile.

Table D.4: Time Series, Cross-Sectional Model Results

Variable	Coefficient	t-Statistics
Constant	-2.077	-0.97
Ln(ROA)	0.618	9.353
Ln(REV)	1.025	113.867
Ln(CAPT)	0.6	20.285
Ln(CAPI)	0.976	27.342
Ln(DEBTCST)	-0.205	-2.653
Ln(CAPPRC)	-0.478	-0.939
Ln(CAPUTIL)	0.904	3.176
Autocorrelation Coefficient		
r	0.413	27.842

The empirical results show that the output variable (REV) is a dominant determinant of firms' investment spending. A positive coefficient on this variable means that larger firms invest more, all else equal, which is clearly a simple expected result. Very important for the MP&M analysis, as expected, firms with higher financial performance and better investment opportunities (ROA) invest more, all else equal: for each one percent increase in ROA, a firm is expected to increase its capital outlays by 0.62 percent. Other firm-specific characteristics were also found important and will aid in differentiating the expected capital outlay for MP&M facilities according to firm-specific characteristics. Firms that require more capital to produce a given level of business activity (i.e., firms that have high capital intensity, CAPI) tend to invest more: a one percent increase in capital intensity leads to a 0.98 increase in capital spending. Higher capital turnover/shorter capital life (CAPT) also has a positive effect on investment decisions: a one percent increase in capital turnover rate translates to a 0.60 percent in capital outlays.

The model also shows that current business environment conditions play an important role in firms' decision to invest. The most influential factor is capacity utilization in manufacturing facilities. A one percent increase in the Federal Reserve Index of Capacity Utilization for the relevant industrial sector (CAPUTIL) leads to a 0.90 percent increase in capital investment. Negative signs on the debt cost (DEBTCST) and capital price (CAPPRC) variables match expectations, indicating that less costly credit and falling (either relatively or absolutely) capital equipment prices are likely to have a positive effect on firms' capital expenditures. That these systematic variables are significant in the regression analysis means that EPA will be able to control for economy- and industry-wide conditions in estimating capital outlays for MP&M facilities.

D.4.3 Sensitivity Analysis

To examine the degree to which the estimated model was affected by transformation of ROA values and inclusion/exclusion of firms with the lowest ROA values, EPA ran two additional models. First, EPA estimated a model based on a subset of data that includes only firms with positive ROA values. Second, EPA estimated a model based on a complete dataset that includes the 12 firms with the lowest ROA values. Although all three models produced compatible results, the first model shows some notable differences in the estimated coefficients compared to the model presented in the preceding section. EPA found that when firms with the lowest negative ROAs are excluded from the analysis:

- The magnitude of the ROA effect on capital expenditures decreases;
- The magnitude of the debt cost effect on capital expenditures decreases slightly;
- The coefficient on the capital price term becomes significant.

These differences can be expected since firms with negative ROAs are weak performers and therefore are less likely to have large capital outlays. Not surprisingly, general economic indicators that affect firms' decisions to invest can be less or more important if a firm's financial performance/asset productivity is weak. For financially weaker firms, the financial cost of capital is a more important factor compared to firms that are strong financially. This finding indicates a strong "threshold of adequate financial performance" effect: capital outlays fall off severely at the lowest financial performance levels but the marginal effect of financial performance becomes more moderate as asset productivity moves into a more acceptable i.e., positive return range. Price of capital goods appears to be an insignificant factor in firms' decision to invest when weak firms are included in the analysis. At first, this finding seems to be counterintuitive: previous studies of investment behavior found a strong capital price effect on firms' decision to invest in high tech equipment. However, because financially weak firms are less likely to invest in general, it is reasonable to assume that they will not respond as strongly to changes in capital equipment prices. Thus, their investment decisions were relatively less affected by falling high-tech equipment prices in the last decade.

D.5 MODEL VALIDATION

To validate the results of the regression analysis, EPA used the estimated regression equation to calculate capital expenditures and then compared the resulting estimate of capital expenditures with actual data. EPA used two methods to validate its results:

- EPA used median values for explanatory variable from the Value Line data as input to estimate capital expenditures and then compared the estimated value to the median reported capital expenditures, and
- EPA used MP&M survey data to estimate capital expenditures and then compared the estimated values to depreciation reported in the survey.

First, EPA estimated capital expenditures for a hypothetical firm based on the median values of the four dependent variables from the Value Line data and the relevant values of the three economic indicators. The estimated capital expenditures for this hypothetical firm are $10.9 million. EPA then compared this estimate to the median value of capital expenditures from the Value Line data. The median capital expenditure value in the dataset is $11.3 million, which provides a very close match to the estimated value. This is not surprising since the same dataset was used to estimate the regression model and to calculate the median values used in this analysis.

EPA also used MP&M survey data to confirm that the estimated capital expenditures seem reasonable. Because the MP&M survey does not provide information on capital expenditures, EPA compared the capital expenditure estimates to the depreciation values reported in the survey. Depreciation had been proposed as a possible surrogate for cash outlays for capital replacements and additions. However, depreciation does not capture important variations in capital outlays that result from differences in firms' financial performance.

For this analysis, EPA chose a representative facility from each of the nineteen MP&M sectors for model validation. The selected facility for each sector corresponds as closely as possible to the hypothetical median facility in the sector based on the distribution of facility revenues and facility return on assets. For each of the nineteen facilities, EPA estimated capital expenditures using the estimated regression equation and facility financial data. Table D.5 shows the estimated regression coefficients, financial averages for the nineteen MP&M sectors, estimated facility capital expenditures, reported facility depreciation, and the comparison of capital expenditures and depreciation.

As shown in Table D.5, the estimated model provides reasonable estimates of capital expenditures. A facility's size, as indicated by revenue, is a principal determinant of the general range of value for capital expenditures, all else equal (i.e., greater revenues correspond to greater predicted capital expenditures). However, the size of capital expenditures relative to the depreciation allowance depends substantially on a facility's return on assets. Facilities with lower return on assets tend to invest less than indicated by depreciation while facilities with higher return on assets tend to invest more than depreciation. This finding is consistent with the expectation that businesses with higher financial performance will have relatively more attractive investment opportunities and are more likely to attract the capital to undertake those investments. To highlight this relationship between capital expenditure, depreciation allowance, and a facility's return on assets, EPA presents graphs for the Hardware, Iron & Steel, Job Shops, and Printed Circuit Board sectors that plot MP&M survey facilities in these sectors along with linear trend lines for each sector's depreciation and capital expenditures with respect to return on assets.[4]

[4] For presentation purposes, some outlier facilities were excluded from the graphs.

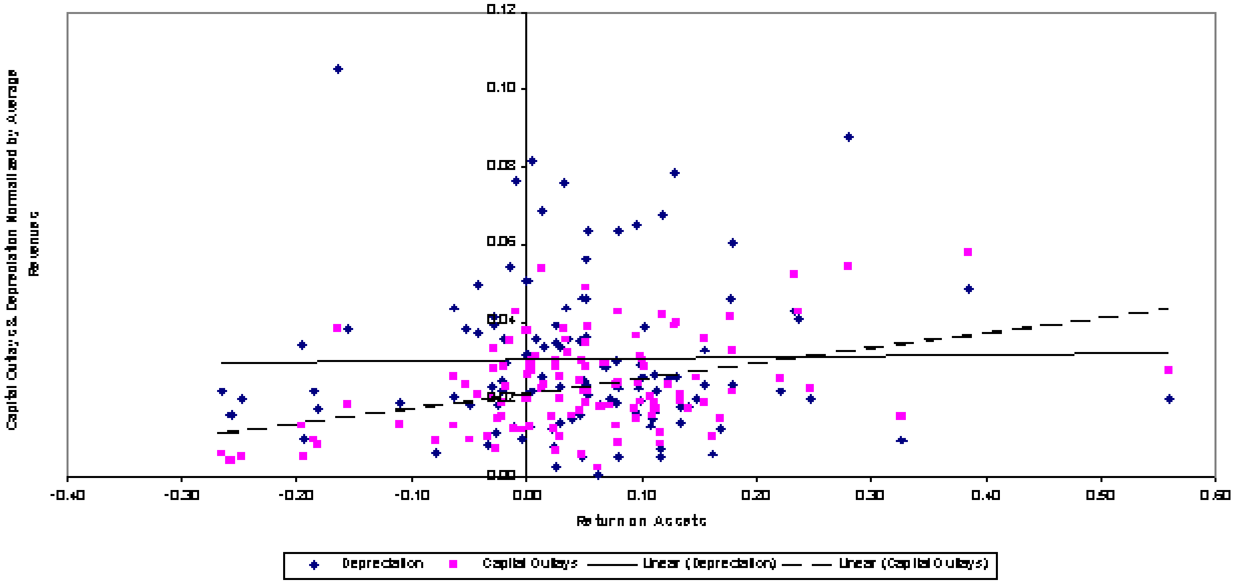
Table D.5: Estimation of Capital Outlays for MP&M Sample Facilities: Median Facilities Selected by Revenue and ROA Percentiles

Sectors	Pre-Tax Return on Assets (ROA)	Revenue	Capital Turnover Rate	Capital Intensity	Cost of Debt	Price of Capital Goods	Capacity Utilization	Estimated Capital Expenditures	Depreciation	Difference between Depreciation and Capital Expenditures
Coefficient Intercept (-2.077)	0.62	1.03	0.60	0.98	(0.21)	(0.48)	0.90			
Aerospace	0.02	90.66	0.02	1.29	7.11	135.4	73.67	2,113,741	1,821,434	-0.14
Aircraft	0.05	18.39	0.06	0.54	9.8	115.87	80.01	440,385	558,478	0.27
Bus & Truck	0.06	58.09	0.03	0.25	7.11	135.4	73.69	471,199	503,124	0.07
Electronic Equipment	0.05	36.85	0.12	0.4	7.11	135.4	86.37	1,100,627	1,730,023	0.57
Hardware	0.03	11.99	0.06	0.61	9.8	115.87	81.93	311,085	403,535	0.3
Household Equipment	0.05	18	0.05	0.8	7.11	135.4	84.24	624,804	745,476	0.19
Instruments	0.15	62.47	0.04	0.47	7.11	135.4	77.21	1,195,144	1,139,873	-0.05
Iron & Steel	0.12	23.17	0.06	0.47	6.4	136.9	90.82	617,740	613,834	-0.01
Job Shop	0.03	2	0.07	0.26	7.11	135.4	81.92	25,146	37,250	0.48
Mobile Industrial Equipment	0.07	37.6	0.03	0.63	9.8	115.87	79.45	670,447	586,609	-0.13
Motor Vehicle	0.1	104.44	0.06	0.46	7.11	135.4	81.24	2,473,215	2,810,386	0.14
Office Machine	0.1	28.95	0.06	0.43	7.11	135.4	85.02	661,715	748,972	0.13
Ordnance	0.05	27.08	0.04	0.65	9.8	115.87	79.77	674,446	770,051	0.14
Other Metal Products	0.08	27.78	0.17	0.44	7.11	135.4	80.01	1,100,691	2,034,831	0.85
Precious Metals & Jewelry	0.04	13.5	0.03	0.62	7.11	135.4	77.21	224,438	226,708	0.01

For facilities that responded to the Phase 1 survey, EPA calculated a 3-year average of the non-facility specific information over the years in which survey data were collected (1987-1989). Likewise, for facilities that responded to the Phase 2 survey, EPA calculated a 3-year average of the non-facility specific information for the years 1994-1996. Since the Iron and Steel sector was surveyed in 1997, EPA calculated a 3-year average of the non-facility specific information for the years 1995-1997.

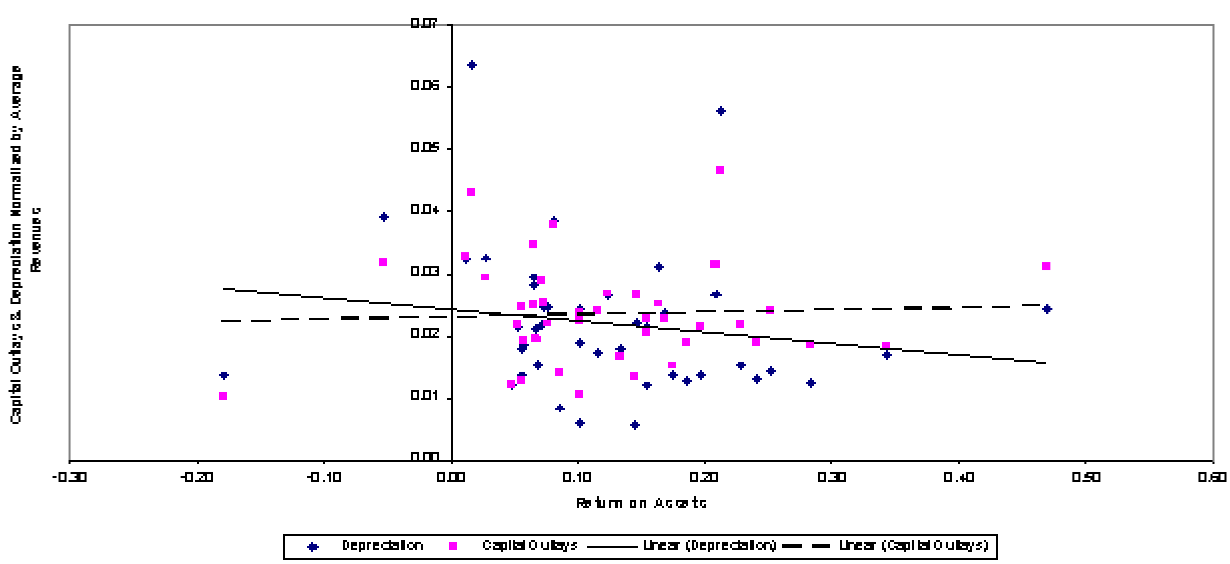
Source: U.S. EPA analysis

Figure D.1: Comparison of Estimated Capital Outlays to Reported Depreciation for MP&M Survey Facilities in the Hardware Sector



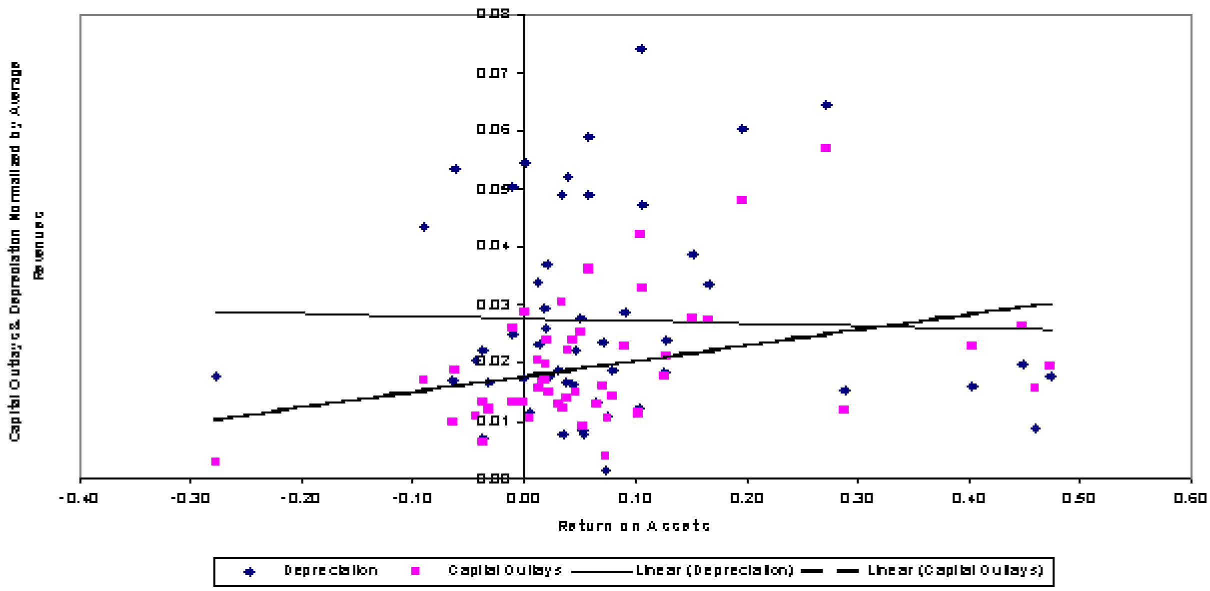
Source: U.S. EPA analysis.

Figure D.2: Comparison of Estimated Capital Outlays to Reported Depreciation for MP&M Survey Facilities in the Iron & Steel Sector



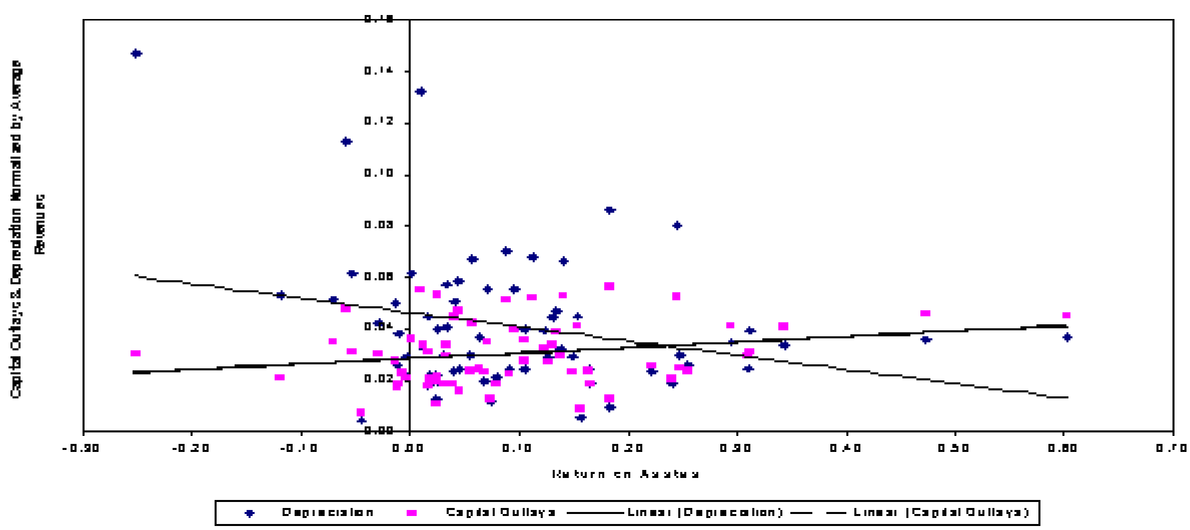
Source: U.S. EPA analysis.

Figure D.3: Comparison of Estimated Capital Outlays to Reported Depreciation for MP&M Survey Facilities in the Job Shop Sector



Source: U.S. EPA analysis.

Figure D.4: Comparison of Estimated Capital Outlays to Reported Depreciation for MP&M Survey Facilities in the Printed Circuit Board Sector



Source: U.S. EPA analysis.

ATTACHMENT D.A: BIBLIOGRAPHY OF LITERATURE REVIEWED FOR THIS ANALYSIS

As noted above, EPA relied on previous studies of investment behavior to select critical determinants of firms' capital expenditures. Empirical results from these studies suggest that investment is most sensitive to quantity variables (output or sales), return-over-cost, and capital utilization (R. Chirinko). Empirical results from more recent studies further found that increasing depreciation rates and capital equipment prices were of first-order importance in the equipment investment behavior in the 1990 (T. Tevlin, K. Whelan). Specifically, declining prices of micro-processor based equipment played a crucial role in the investment boom in the 1990.

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ATTACHMENT D.B: HISTORICAL VARIABLES CONTAINED IN THE VALUE LINE INVESTMENT SURVEY DATASET

All variables are provided for 10 years (except where a firm has been publicly reported for less than 10 years):

- Price of Common Stock
- Revenues
- Operating Income
- Operating Margin
- Net Profit Margin
- Depreciation
- Working Capital
- Cash Flow per share
- Dividends Declared per share
- Capital Spending per share
- Revenues per share
- Average Annual Price-Earnings Ratio
- Relative Price-Earnings Ratio
- Average Annual Dividend
- Return Total Capital
- Return Shareholders Equity
- Retained To Common Equity
- All Dividends To Net Worth
- Employees
- Net Profit
- Income Tax Rate
- Earnings Before Extras
- Earnings per share
- Long Term Debt
- Total Loans
- Total Assets
- Preferred Dividends
- Common Dividends
- Book Value
- Book Value per share
- Shareholder Equity
- Preferred Equity
- Common Shares Outstanding
- Average Shares Outstanding
- Beta
- Alpha
- Standard Deviation

Appendix E: Calculation of Capital Cost Components

INTRODUCTION

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E.1 CALCULATION OF ONE-TIME CAPITAL COST COMPONENTS

EPA used the engineering estimates of total one-time capital costs to calculate the purchase cost paid to manufacturers of compliance equipment, and the costs of shipping, installation, insurance, engineering, and consultants. Two components of capital costs were used to estimate job gains due to compliance requirements: (1) the estimated direct capital equipment cost and (2) the labor cost of installation. Table E.1 shows the cost components that comprise the total capital costs attributed to the regulation.

Table E.1: Components of Total Installed Capital Costs (millions, 2001$, before tax)[a]

Cost Component	Option I: Selected Option	Option II: Proposed/ NODA Option	Option III: 413 to 433 Upgrade Option	Option IV: All to 433 Upgrade Option
(a) Total installed direct capital costs	$4,407,590	$802,051,833	$95,552,532	$148,434,303
(b) Direct capital equipment cost	$3,070,680	$558,773,471	$66,569,538	$103,411,210
(c) Shipping (20% of a)	$881,518	$160,410,367	$19,110,506	$29,686,861
(d) Labor cost of installation (7% of f)	$455,392	$82,867,995	$9,872,488	$15,336,232
(e) Indirect costs: insurance, engineering & consultants (47.6% of a)	$2,098,013	$381,776,672	$45,483,005	$70,654,728
(f) Total installed capital costs	**$6,505,602**	**$1,183,828,505**	**$141,035,538**	**$219,089,032**

[a] Excludes costs for baseline and regulatory closures.

Source: U.S. EPA analysis.

The components of total capital costs for the final rule in Table E.1 are discussed below in reverse order of the table presentation.

- ***Total installed capital costs:*** EPA estimated the total one-time capital cost for each facility expected to comply with the regulation.[1] Compliance costs are discussed in more detail in *Chapter 5: Facility-Level Impact Analysis* of this EEBA. The national estimate of capital costs for the regulation is $6.5 million ($2001).[2]

[1] See the *Technical Development Document* for a description of the methods used to estimate capital costs.

[2] The $6.5 million is the sum of one-time outlays for purchasing and installing the capital equipment needed to comply with the final rule. This expense is not the annual equivalent of that capital investment. The capital outlay is annualized in the economic impact analysis over a 15-year period. The resulting value, which is part of the total annual cost of compliance, is $0.7 million.

- ***Indirect Costs:*** MP&M project engineers estimate that indirect costs such as insurance, engineering, and consulting are 47.6% of installed direct capital cost. EPA calculated the total direct and indirect cost using the total capital cost. The national estimate of indirect costs for the regulation is $2.1 million.

- ***Total Installed Direct Capital Costs:*** The direct capital costs include the cost of compliance equipment, shipping, and the labor cost of installation. The national estimate of direct costs for the regulation is $4.4 million. MP&M project engineers estimate that shipping costs might be as much as 20 percent of the total installed direct capital cost. The estimated one-time shipping cost is $0.9 million for the final regulatory option. Installation labor costs are estimated by the engineers to be seven percent of the total installed capital costs. The estimated one-time cost of installation labor is $0.5 million for the final regulatory option. Therefore, the direct capital equipment cost is $3.1 million, the remainder of the total installed direct capital cost when the cost of shipping and installation are subtracted out.

Appendix F: Administrative Costs

INTRODUCTION

Effluent guidelines and limitations are implemented by Federal, State, and local government entities through the NPDES permit program (for direct dischargers) and the General Pretreatment Regulations (for indirect dischargers). A new effluent guideline rule may require that facilities: (1) be permitted for the first time; (2) be issued a different form of permit, if they already have a permit in the baseline; and (3) be repermitted sooner than would otherwise be required. In these cases, the permitting authority will incur additional costs to implement the effluent guideline rule.

APPENDIX CONTENTS

This appendix provides information on the unit costs of these permitting activities and describes the calculation of government permitting costs for the final MP&M rule and regulatory alternatives. EPA expects no additional costs for permitting direct dischargers under the final rule. Costs for issuing permits for indirect dischargers are based on information reported by publicly-owned treatment works (POTWs) in the Metal Products and Machinery (MP&M) POTW Survey. EPA also used the data provided in the Association of Metropolitan Sewerage Agencies (AMSA) survey to supplement information from the MP&M POTW Survey. EPA evaluated POTW administrative costs for pretreatment options for the final rule. As discussed in Section VI of the preamble to the final rule, EPA is not establishing any pretreatment standards in the final rule.

The remainder of this appendix is organized as follows: Section F.1 provides an overview of permitting requirements under the NPDES Permit Program and the General Pretreatment Regulations. Section F.2 describes the MP&M POTW Survey and the methods used to develop annualized cost estimates for permitting indirect dischargers. Section F.3 presents the estimates of unit costs by permitting activity for indirect dischargers. The final Section F.4 lists the steps involved in applying these unit costs to calculate administrative costs for regulatory options evaluated by EPA for the final rule.

F.1 EFFLUENT GUIDELINES PERMITTING REQUIREMENTS

Any facility that directly discharges wastewater to surface water is required to have a permit issued under the National Pollution Discharge Elimination System (NPDES) permit program. Facilities that discharge indirectly through a POTW are regulated by the General Pretreatment Regulations for Existing and New Sources of Pollution (40 CFR Part 403). The major portion of government administrative costs associated with implementing an effluent guidelines rule are the costs of managing the NPDES and Pretreatment programs.

F.1.1 NPDES Basic Industrial Permit Program

Best Practical Technology (BPT), Best Control Technology (BCT), and New Source Performance Standards (NSPS) for effluent limitations guidelines are implemented through the NPDES industrial permit program. However, EPA does not expect the administrative costs associated with the NPDES industrial permit program to increase as a result of the final rule. The Clean Water Act prohibits discharge of any pollutant to a water of the U.S. except as permitted by a NPDES permit. Therefore, every facility that discharges wastewater directly to surface water must hold a permit specifying the mass of pollutants that can be discharged to waterways. The final rule will affect the terms of the permits but is unlikely to increase the administrative costs associated with permitting.

The final rule may decrease the administrative burden of NPDES permits. The TDD and rulemaking record for the final rule provide valuable information to permitting authorities that may reduce the research required to develop Best Professional Judgment (BPJ) permits.[1] Further, establishing discharge standards may reduce time spent by permitting authorities establishing limits and the frequency of evidentiary hearings. The promulgation of limitations may also enable EPA and the authorized States to cover more facilities under general permits. General permits are single permits covering a common class of dischargers in a specified geographic area.

F.1.2 Pretreatment Program

The General Pretreatment Regulations (40 CFR Part 403) establish procedures, responsibilities, and requirements for EPA, States, local governments, and industry to control pollutant discharges to POTWs. Under the Pretreatment Regulations, POTWs or approved States implement categorical pretreatment standards for existing sources (PSES) and new sources (PSNS).

Discharges from an MP&M facility[2] to a POTW may already be permitted in the baseline.[3] For example, industrial users subject to another Categorical Pretreatment Standard would have a discharge permit. Other significant industrial users (SIU) that are typically permitted by POTWs include industrial users that:

- discharge an average of 25,000 gallons per day or more of process wastewater to a POTW,
- contribute a process waste stream that makes up five percent or more of the average dry weather hydraulic or organic capacity of the POTW treatment plant, or
- have a reasonable potential for adversely affecting the POTW's operation or for violating any pretreatment standard.

As discussed in Section VI of the preamble to the final rule, EPA did not establish or revise any pretreatment standards in the final rule. Consequently, there are no POTW administrative costs associated with the final rule. Under the options evaluated for the final rule, which include options for setting pretreatment standards, EPA expects no increase in permitting costs for indirect dischargers that already hold a permit in the baseline. However, governments will incur additional permitting costs for unpermitted facilities (under the NODA/Proposal option only) and to accelerate repermitting for some indirect dischargers that currently hold permits. The remainder of this appendix estimates these cost increases. As with direct industrial dischargers, promulgation of the MP&M rule may cause some administrative costs to decrease. For example, control authorities will no longer have to repermit facilities that are estimated to close as a result of some of the options EPA evaluated for the final rule. These cost savings are reflected in estimates of total government administrative costs associated with the regulatory options considered for the final rule.

F.2 POTW Administrative Cost Methodology

F.2.1 Data Sources

EPA collected information from POTWs to support development of the MP&M effluent guideline (see Section 3 of the TDD). Of 150 surveys mailed, EPA received responses to 147, for a 98 percent response rate. The POTW Survey asked respondents to provide information on administrative permitting costs for indirect dischargers, sewage sludge use and disposal costs and practices, and general information (including number of permitted users and number of known MP&M dischargers). The administrative cost information included the number of hours required to complete specific permitting and repermitting,

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[1] Permits issued to facilities not covered by effluent guidelines or water quality-based standards are developed based on BPJ (see NPDES' permit writers manual).

[2] MP&M facilities are defined on the basis of three considerations: (1) they produce metal parts, products, or machines for use in one of the 19 industry sectors evaluated for coverage in the MP&M point source category; (2) they use operations in one of the eight regulatory subcategories evaluated for coverage in the MP&M point source category; and (3) they discharge process wastewater, either directly or indirectly, to surface waters. In this document, the term "MP&M facilities" refers to all facilities meeting the above definition, regardless of whether a facility's industrial sector, subcategory, or discharger category is covered by the final regulation.

[3] Under the General Pretreatment Program, a facility's discharges may be controlled through a "permit, order or similar means". For simplicity, this document refers to the control mechanism as a permit.

inspection, monitoring, and enforcement activities. Respondents were also asked to provide an average labor cost for all staff involved in permitting activities. EPA used the survey responses on administrative costs to estimate a range of costs incurred by POTWs to permit a single MP&M facility.

The Association of Metropolitan Sewerage Agencies (AMSA) also provided data on administrative costs to EPA (see Section 3 of the TDD). EPA used the data provided in the AMSA survey to verify and, in some cases, supplement its own analyses of POTW administrative costs for regulatory options evaluated for the final rule. AMSA provided EPA with comments on the proposed MP&M rule and supplemented these comments with a spreadsheet database. The database contains data from an AMSA formulated survey and covers responses from 176 POTWs, representing 66 pretreatment programs. The AMSA survey was conducted to verify data from EPA's survey of POTWs and therefore included similar, although fewer, variables compared to EPA's survey. Elements EPA verified using the AMSA survey include: (1) the estimated number of indirect dischargers; and (2) the unit costs of certain permitting activities, including permit implementation, sampling, and sample analysis. Elements EPA added to its analysis using the AMSA data include: (1) screening costs for POTWs that do not currently operate under a pretreatment program; and (2) oversight costs associated with implementing the MP&M regulation.

F.2.2 Overview of Methodology

EPA estimated the annualized costs of permitting indirect dischargers under the different regulatory options evaluated for the final rule using the following steps:

- **Determine the number and characteristics of indirect dischargers that will be permitted under each regulatory option evaluated for the final rule.** Only the NODA option includes costs for permitting an MP&M facility for the first time. The final rule does not cover indirect dischargers while the other regulatory options only regulate those indirect dischargers that already hold permits in the baseline. For the NODA option, EPA determined how many new permits would be issued. The NODA option requires only concentration-based permits, no mass-based permits.

- **Use the data from the POTW Survey to determine a high, middle, and low hourly burden for permitting a single facility.** EPA defined the low and high estimates of hours such that 90% of the POTW responses fell above the low value and 90% of responses fell below the high value. The median value is used to define the middle hourly burden.

- **Use the data from the POTW Survey to determine the average frequency of performing certain administrative functions.** For administrative functions that are not performed at all facilities, survey data were used to calculate the portion of facilities requiring these functions. For example, the survey data show that on average 38.5% of facilities submit a non-compliance report.

- **Multiply the per-facility burden estimate by the average hourly wage.** EPA determined a high, middle, and low dollar cost of administering the rule for a single facility by multiplying the per-facility hour burden by the average hourly wage. The POTW Survey reported an average hourly labor rate of $39.33 ($2001) for staff involved in permitting. This is a fully-loaded cost, including salaries and fringe benefits.

- **Calculate the annualized cost of administering the rule.** The number of facilities, hourly burden estimate, frequency estimates, and hourly wage estimates are all combined to determine the total cost of administering the rule. The type of administrative activities required varies over time and the total administrative cost is calculated over a 15 year time period. EPA calculated the present value of total costs using a seven percent discount rate, and then annualized the present value using the same seven percent discount rate.

F.3 Unit Costs of Permitting Activities

This section presents unit costs for the following permitting activities:

- ***Permit application and issuance:*** developing and issuing concentration-based permits at previously unpermitted facilities; providing technical guidance; and conducting public and evidentiary hearings;

- ***Inspection:*** inspecting facilities both for the initial permit development and to assess subsequent compliance;

- ***Monitoring:*** sampling and analyzing permittee's effluent; reviewing and recording permittee's compliance self-monitoring reports; receiving, processing, and acting on a permittee's non-compliance reports; and reviewing a permittee's compliance schedule report for permittees in compliance and permittees not in compliance;

- ***Enforcement:*** issuing administrative orders and administrative fines; and

- ***Repermitting.***

EPA believes that theses functions constitute the bulk of the required administrative activities. To these costs, EPA added a provision for managerial oversight of 25 percent.[4] There are other relatively minor or infrequent administrative functions (e.g., providing technical guidance to permittees in years other than the first year of the permit, or repermitting a facility in significant non-compliance), but their costs are likely to be insignificant compared to the estimated costs for the five major categories outlined above. EPA also added a cost for identifying facilities to be permitted for POTWs that do not currently operate under a Pretreatment Program. EPA estimates this cost to be approximately $0.8 million. This cost only applies to the NODA/Proposal Option since facilities subject to the upgrade options already hold permits.

For each major administrative function, this section provides below: (1) a description of the activities involved, (2) the estimated percentage of facilities that require the administrative function; (3) the frequency with which the function is performed, and (4) high, middle, and low estimates of per facility hours and costs. All costs are presented in year 2001 dollars.

F.3.1 Permit Application and Issuance

Before issuing a wastewater discharge permit to a facility, the permit authority typically inspects the facility, monitors the facility's wastewater, and completes pollutant limits calculations and permit paperwork. This section discusses the costs of completing limits calculations and paperwork; subsequent sections address inspection and monitoring costs. This section also discusses the costs of technical assistance that the control authority may provide facilities to facilitate compliance with new limits. Finally, this section includes the costs of public and evidentiary hearings that may be required for some permits.

a. Issue a concentration-based permit at a previously unpermitted facility

To issue a concentration-based permit, permit authorities first review permit applications for completeness. If an application is incomplete, the authorities notify the applicant and request the missing information. Completed applications are assigned to permit writers, who review the applications in more detail as they develop permit conditions. The effort required to complete these activities depends, in part, on the extent to which the permit authority has automated the permitting process.

EPA assumed that one-third of facilities will be permitted in each of the three years following the rule's effective date because compliance is mandated within three years of the date the standard is effective (40 CFR Section 403.6). EPA further assumed that facilities are repermitted in five year cycles. (The administrative costs of repermitting are discussed separately below.) The actual number of facilities that are permitted each year is likely to differ somewhat from EPA's simplifying assumption. These minor differences in permit timing are not expected to significantly change the estimated administrative costs.

[4] The 25 percent oversight cost provision is based on comments and data received from the Association of Metropolitan Sewerage Agencies (AMSA).

Table F.1: Administrative Activity: Develop and issue a concentration-based permit at a previously unpermitted facility				
Percent of facilities for which activity is required	Frequency of activity	Typical costs (2001$)		
		Low	Median	High
100% of unpermitted MP&M facilities (applicable to NODA/Proposal option only)	One time	4.0 hours; $122	10.0 hours; $304	40.0 hours; $1,217

Source: U.S. EPA analysis of POTW Survey responses; U.S. Department of Labor, Bureau of Labor Statistics.

b. Issue a mass-based permit for a previously unpermitted facility[5]

The same administrative activities required to issue a concentration-based permit are also required for a mass-based permit. In addition, for mass-based permits issued under the MP&M rule, the permit writer must determine whether the facility practices pollution prevention and water conservation methods equivalent to those specified as the basis for BPT. If so, the permitting authority must determine the facility's historical flow rate. If not, the authority must derive a mass-based limit based on other factors such as production rates. When a facility matches BPT water conservation practices and provides historic flow data, development of a mass-based permit is a relatively straight-forward process. However, the task will be more challenging at a facility practicing only limited water conservation, particularly if the facility has multiple production units and generates integrated process and sanitary wastewaters.

Table F.2: Administrative Activity: Develop and issue a mass-based permit at a previously unpermitted facility				
Percent of facilities for which activity is required	Frequency of activity	Typical costs (2001$)		
		Low	Median	High
100% of MP&M facilities being issued a new mass-based permit (estimates used for the proposed rule)	One time	4.0 hours; $122	13.0 hours; $396	40.0 hours; $1,217

Source: U.S. EPA analysis of POTW Survey responses; U.S. Department of Labor, Bureau of Labor Statistics.

c. Issue a mass-based permit for a facility with a concentration-based permit[6]

Some of the activities described above for issuing a mass-based permit will be simplified in cases where the facility already holds a concentration-based permit. For example, much of the basic information required in the permitting application will already be in the permitting authorities' records. However, the potentially labor-intensive task of determining the flow basis for the permit remains.

[5] None of the regulatory options considered for the final rule require issuance of mass-based permits for previously unpermitted facilities. However, since these costs were developed for the proposed rule, they are presented in this appendix even though they are not used in the administrative costs estimates.

[6] None of the regulatory options considered for the final rule require conversion of a concentration-based to a mass-based permit. However, since these costs were developed for the proposed rule, they are presented in this appendix even though they are not used in the administrative costs estimates.

Table F.3: Administrative Activity: Develop and issue a mass-based permit at a facility holding a concentration-based permit

Percent of facilities for which activity is required	Frequency of activity	Typical costs (2001$)		
		Low	Median	High
100% of MP&M facilities with permit conversion (estimates used for the proposed rule)	One time	2.0 hours; $61	8.0 hours; $243	20.0 hours; $608

Source: U.S. EPA analysis of POTW Survey responses; U.S. Department of Labor, Bureau of Labor Statistics.

d. Provide technical guidance to a permittee

Technical guidance is frequently provided by permit authorities to permittees concurrent with the issuance of a new permit. There are no legal requirements that a permit authority provide a permittee with technical guidance. However, such guidance is generally in the interest of all parties as it can expedite the permitting process, accelerate the permittee's compliance, and reduce the compliance burden. The extent of technical guidance provided varies dramatically among permit authorities. In some cases, a permit authority may hold a one-day workshop to provide information on a new pretreatment standard to facilities. In other cases, a permit authority may meet extensively with individual permittees to educate them regarding their responsibilities under pretreatment standards. The range of technical guidance appears to depend on whether the permittee already has a wastewater permit, whether the permittee is part of a multi-facility company, the resources of the permit authority, and the extent to which the permit authority has written or standardized guidance available for dissemination.

EPA assumed that permit authorities provide technical guidance to all facilities being issued a new mass-based or concentration-based permit under the MP&M pretreatment standards. Costs for technical guidance were estimated separately for facilities receiving a concentration-based permit and facilities receiving a mass-based permit. EPA assumed that technical guidance is provided in the year the initial permit is issued.

Table F.4: Administrative Activity: Provide technical guidance to permittee on permit compliance

Percent of facilities for which activity is required	Frequency of activity	Typical costs (2001$)		
		Low	Median	High
100% of MP&M facilities being issued a new concentration-based permit (applicable to NODA/Proposal option only)	One time	1.5 hours; $46	4.0 hours; $122	12.0 hours; $365
100% of MP&M facilities being issued a new mass-based permit (estimates used for the proposed rule)	One time	2.0 hours; $61	4.0 hours; $122	12.0 hours; $365

Source: U.S. EPA analysis of POTW Survey responses; U.S. Department of Labor, Bureau of Labor Statistics.

e. Conduct a public or evidentiary hearing on a proposed permit

Federal regulations provide for a period during which the public may submit written comments on a proposed permit for direct dischargers and/or request that a public hearing be held. Permitting authorities for indirect dischargers may have the same requirements. Thus, proposed permits for indirect dischargers may be subject to public comments and hearings. Pretreatment public hearings are typically conducted at a scheduled local government (e.g., City Council) meeting. The meetings may require substantial preparation.

Federal regulations also provide for evidentiary hearings following final permit determination for direct dischargers. Again, permitting authorities for indirect dischargers may have these requirements as well. Thus, final permit determinations for indirect dischargers may be subject to evidentiary hearings.

Data from the POTW Survey indicated that a public or evidentiary hearing would be required for 3.6% of indirect dischargers being issued a new mass-based or concentration-based permit, on average.

Table F.5: Administrative Activity: Conduct a public or evidentiary hearing				
Percent of facilities for which activity is required	**Frequency of activity**	**Typical costs (2001$)**		
		Low	**Median**	**High**
3.2% of MP&M facilities being issued a new mass-based or concentration-based permit (applicable to NODA/Proposal option only)	One time	2.0 hours; $61	8.0 hours; $243	40.0 hours; $1,217

Source: U.S. EPA analysis of POTW Survey responses; U.S. Department of Labor, Bureau of Labor Statistics.

F.3.2 Inspection

Permit authorities may choose to integrate their inspection and monitoring work force or to administer these functions separately. This discussion covers inspections only; monitoring is discussed below. Inspections are performed both to assess conditions for initial permitting and to evaluate compliance with permit requirements. Inspections involve record reviews, visual observations, and evaluations of the treatment facilities, effluents, receiving waters, etc. EPA assumed that the initial inspection would occur in the same year a new permit is issued, and that all permitted facilities would be inspected annually to assess compliance.

Table F.6: Administrative Activity: Inspect facility for permit development				
Percent of facilities for which activity is required	**Frequency of activity**	**Typical costs (2001$)**		
		Low	**Median**	**High**
100% of MP&M facilities being issued a new permit (applicable to NODA/Proposal option only)	One Time	2.2 hours; $66	5.0 hours; $152	12.0 hours; $365

Source: U.S. EPA analysis of POTW Survey responses; U.S. Department of Labor, Bureau of Labor Statistics.

Table F.7: Administrative Activity: Inspect facility for compliance assessment				
Percent of facilities for which activity is required	**Frequency of activity**	**Typical costs (2001$)**		
		Low	**Median**	**High**
100% of MP&M facilities being issued a new permit (applicable to NODA/Proposal option only)	Annual	2.0 hours; $61	3.3 hours; $101	10.0 hours; $304

Source: U.S. EPA analysis of POTW Survey responses; U.S. Department of Labor, Bureau of Labor Statistics.

F.3.3 Monitoring

Permitting authorities monitor facilities both to gather data needed for permit development and to assess compliance with permit conditions. Monitoring includes sampling and analysis of the permittee's effluent, review of the permittee's compliance self-monitoring reports, receipt of non-compliance reports, and review of compliance schedule reports. These activities are discussed below.

a. Sample and analyze permittee's effluent

As noted above, inspection and monitoring staff may be integrated or distinct. The costs of inspection were presented above. Federal regulations require that the permit authority "randomly sample and analyze the effluent from industrial users ... independent of information supplied by industrial users" (40 CFR Part 403.8). The permit authority obtains samples required by the permit and performs chemical analyses. The results are used to verify the accuracy of the permittee's self-monitoring program and reports, determine the quantity and quality of effluents, develop permits, and provide evidence for enforcement proceedings where appropriate.

EPA estimated sampling costs for all facilities issued a new permit under the MP&M rule, and assumed annual monitoring. Although EPA requires only annual effluent sampling, some localities sample more frequently. EPA encourages this practice.

Table F.8: Administrative Activity: Sample and analyze permittee's effluent

Percent of facilities for which activity is required	Frequency of activity	Typical costs (2001$)		
		Low	Median	High
100% of MP&M facilities being issued a new permit (applicable to NODA/Proposal option only)	Annual	1.0 hour; $30	3.0 hours; $91	17.7 hours; $537

Source: U.S. EPA analysis of POTW Survey responses; U.S. Department of Labor, Bureau of Labor Statistics.

b. Review and record permittee's compliance self-monitoring reports

40 CFR Part 403.12 specifies that: "Any Industrial User subject to a categorical pretreatment standard ... shall submit to the Control authority during the months of June and December ... a report indicating the nature and concentration of pollutants in the effluent which are limited by such categorical pretreatment standards." The permit authority briefly reviews these submissions and may enter the information into a computerized system and/or file the data.

EPA estimated the costs of handling annual self-monitoring reports for all facilities being issued a new permit under the MP&M rule.

Table F.9: Administrative Activity: Review and enter data from permittee's compliance self-monitoring reports

Percent of facilities for which activity is required	Frequency of activity	Typical costs (2001$)		
		Low	Median	High
100% of MP&M facilities being issued a new permit (applicable to NODA/Proposal option only)	2 reports per year	0.5 hours; $15	1.0 hour; $30	4.0 hours; $122

Source: U.S. EPA analysis of POTW Survey responses; U.S. Department of Labor, Bureau of Labor Statistics.

c. Receive, process, and act on a permittee's non-compliance report

Generally, when a permittee violates a permit condition, it must submit a non-compliance report to the permit authority. Permittees report both unanticipated bypasses or upsets and violations of maximum daily discharge limits. The permit authority receives and processes both verbal and written non-compliance reports. In some cases, immediate action by the permit authority is required to mitigate the problem.

Data from the POTW Survey indicate that 38.5 percent of all facilities submit at least one non-compliance report annually. Of facilities that submit at least one non-compliance report, the median number of reports filed per year is five reports.

Table F.10: Administrative Activity: Receive, process and act on a permittee's non-compliance reports

Percent of facilities for which activity is required	Frequency of activity	Typical costs (2001$)		
		Low	Median	High
38.5% of all indirect dischargers receiving a new permit (applicable to NODA/Proposal option only)	5 times per year	1.0 hour; $30	2.0 hours; $61	6.0 hours; $183

Source: U.S. EPA analysis of POTW Survey responses; U.S. Department of Labor, Bureau of Labor Statistics.

d. Review a permittee's compliance schedule report

Permittees submit reports to permit authorities that state whether compliance schedule milestones contained in their permits have been met. If the facility is in compliance, the permit authority reviews and files the report.

Data from the POTW Survey indicate that approximately 17% of all facilities are issued compliance milestones. Of these facilities, 94% meet the milestones. Facilities submit an average of two compliance milestone reports per year. The cost of handling the report depends on whether the facility is in compliance with the schedule.

Table F.11: Administrative Activity: Review a compliance schedule report

Percent of facilities for which activity is required	Frequency of activity	Typical costs (2001$)		
		Low	Median	High
Meeting milestones: 16.0% of all facilities issued a new permit – 94% of the 17% who have compliance milestones (applicable to NODA/Proposal option only)	2 reports per year	0.5 hours; $15	1.0 hour; $30	2.7 hours; $81
Not meeting milestones: 1% of all facilities issued a new permit – 6% of the 17% who have compliance milestones (applicable to NODA/Proposal option only	2 reports per year	1.0 hours; $30	2.0 hours; $61	6.0 hours; $183

Source: U.S. EPA analysis of POTW Survey responses; U.S. Department of Labor, Bureau of Labor Statistics.

F.3.4 Enforcement

When a permitting authority identifies a permit violation, the authority determines and implements an appropriate enforcement action. Considerations when determining enforcement response include (1) the severity of the permit violation, (2) the degree of economic benefit obtained by the permittee through the violation, (3) previous enforcement actions taken against the violator, (4) the deterrent effect of the response on similarly situated permittees, and (5) considerations of fairness and equity. EPA estimated administrative costs for two levels of enforcement actions: (1) less severe actions such as issuing an administrative order, and (2) more severe activities such as levying an administrative fine.

EPA estimated that, annually, seven percent of facilities issued a new permit under the MP&M rule will require a minor enforcement action, such as issuing an administrative compliance order. In addition, EPA estimated that seven percent of facilities receiving a new permit will require more severe enforcement actions such as a fine or penalty.

Table F.12: Administrative Activity: Minor enforcement action e.g., issue an administrative order

Percent of facilities for which activity is required	Frequency of activity	Typical costs (2001$)		
		Low	Median	High
7% of MP&M facilities being issued a new permit (applicable to NODA/Proposal option only)	Annual	1.0 hour; $30	3.7 hours; $112	12.0 hours; $365

Source: U.S. EPA analysis of POTW Survey responses; U.S. Department of Labor, Bureau of Labor Statistics.

Table F.13: Administrative Activity: Minor enforcement action, e.g., impose an administrative fine

Percent of facilities for which activity is required	Frequency of activity	Typical costs (2001$)		
		Low	Median	High
7% of MP&M facilities being issued a new permit (applicable to NODA/Proposal option only)	Annual	1.0 hour; $30	5.0 hours; $152	24.0 hours; $730

Source: U.S. EPA analysis of POTW Survey responses; U.S. Department of Labor, Bureau of Labor Statistics.

F.3.5 Repermitting

The duration of permits cannot exceed five years. Renewing a permit for a facility in compliance with an existing permit is expected to be a relatively straightforward task. The data submitted in the permit application generally require few changes, although pollutant limits may need to be recalculated in some cases. The labor required for repermitting depends, in part, on the extent to which the permit authority has automated the paperwork.

Table F.14: Administrative Activity: Repermit

Percent of facilities for which activity is required	Frequency of activity	Typical costs (2001$)		
		Low	Median	High
100% of MP&M facilities being issued a new permit (applicable to NODA/Proposal option only)	every 5 years	1.0 hour; $30	4.0 hours; $122	20.0 hours; $608

Source: U.S. EPA analysis of POTW Survey responses; U.S. Department of Labor, Bureau of Labor Statistics.

In addition to repermitting MP&M facilities being issues a new permit, EPA also considered two other types of cost: (1) the costs associated with repermitting facilities that already hold a permit in the baseline sooner than would otherwise be required; and (2) cost savings associated with no longer having to permit facilities that already hold a permit in the baseline but that are estimated to close as a result of the rule. Both cost components are reflected in the POTW administrative costs presented in the next section.

F.4 POTW Administrative Costs by Option

Exhibits F.1 through F.7 at the end of this appendix present the calculation of POTW permitting costs for the final rule and the three regulatory alternatives considered by EPA.

Exhibit F.1 provides an overview of the permitting activities, the estimated percentage of facilities that require the administrative function, the frequency with the function is performed, and per facility hours and costs for each function.

Exhibit F.2 contains the per facility hour burden and other assumptions described above for each of the three types of permitting (new concentration-based permit, new mass-based permit, and converting a concentration-based to a mass-based permit.)

Exhibits F.3 through F.5 show hours by type of permit for the low, medium, and high estimate of per-facility burden, respectively. These exhibits also summarize costs and dollars by year and permit type.

Exhibit F.6 presents the number of facilities requiring different types of permitting, for each of the regulatory options. The exhibit shows the total number of facilities that will be subject to requirements, the baseline permit status of those facilities, and the number of facilities by expected post-compliance permit status. These estimates are based on facility survey information about baseline permit status and the results of the facility impact analysis described in Chapter 5 of the EEBA. The exhibit also shows the number of currently-permitted facilities that are projected to close as a result of the rule, and which will therefore no longer require re-permitting.

The final Exhibit F.7 shows the resulting calculation of POTW administrative hours and costs by year for each regulatory option. This exhibit also shows the present value of these costs, the annualized cost, and the maximum hours and costs incurred in any one year, for each option. These calculations reflect the incremental number of facilities requiring different types of permitting, inspection, monitoring, enforcement and repermitting in each year multiplied by the unit hours and cost per facility for those activities. All facilities are assumed to receive a permit under the final rule within the three-year compliance period. Some facilities with existing permits are repermitted sooner than they otherwise would be on the normal five-year permitting cycle. The cost analyses calculates incremental costs by subtracting the costs of repermitting these facilities on a five-year schedule from the costs of repermitting all such facilities within three years. EPA assumes that the required initial permitting activities will be equally divided over the three-year period. The analysis also calculates the net change in the number of facilities requiring permitting by subtracting the number of facilities that close due to the rule from the number of facilities that will require new permits under each regulatory option.

More detailed information on these cost calculations is provided in the docket for the final rule.

APPENDIX F EXHIBITS

Exhibit F.1: Government Administrative Activities for Indirect Dischargers: Per Facility Hours and Costs

Administrative Activity	Percent of facilities for which activity is required	Frequency of activity	Typical hours and costs		
			Low	Median	High
Develop and issue a concentration-based permit at a previously unpermitted facility	100% of unpermitted facilities (applicable to NODA/Proposal option only)	One time	4.0 hours; $122	10.0 hours; $304	40.0 hours; $1,217
Develop and issue a mass-based permit at a previously unpermitted facility	100% of MP&M facilities being issued a new mass-based permit (estimates used for the proposed rule)	One time	4.0 hours; $122	13.0 hours; $396	40.0 hours; $1,217
Develop and issue a mass-based permit at a facility holding a concentration-based permit	100% of MP&M facilities with permit conversion (estimates used for the proposed rule)	One time	2.0 hours; $61	8.0 hours; $243	20.0 hours; $608 year
Provide technical guidance to a permittee on permit compliance	100% of MP&M facilities being issued a new concentration-based permit (applicable to NODA/Proposal option only)	One time	1.5 hour; $46	4.0 hours; $122	12.0 hours; $365
	100% of MP&M facilities being issued a new mass-based permit (estimates used for the proposed rule)	One time	2.0 hours; $61	4.0 hours; $122	12.0 hours; $365
Conduct a public or evidentiary hearing	3.2% of MP&M facilities being issued a new mass-based or concentration-based permit (applicable to NODA/Proposal option only)	One time	2.0 hours; $61	8.0 hours; $243	40.0 hours; $1,217
Inspect facility for permit development	100% of MP&M facilities being issued a new permit (applicable to NODA/Proposal option only)	One Time	2.2 hours; $66	5.0 hours; $152	12.0 hours; $365
Inspect facility for compliance assessment	100% of MP&M facilities being issued a new permit (applicable to NODA/Proposal option only)	Annual	2.0 hours; $61	3.3 hours; $101	10.0 hours; $304
Sample and analyze permittee's effluent	100% of MP&M facilities being issued a new permit (applicable to NODA/Proposal option only)	Annual	1.0 hour; $30	3.0 hours; $91	17.7 hours; $537
Review and enter data from permittee's compliance self-monitoring reports	100% of MP&M facilities being issued a new permit (applicable to NODA/Proposal option only)	2 reports per year	0.5 hours; $15	1.0 hour; $30	4.0 hours; $122
Receive, process and act on a permittee's non-compliance reports	38.5% of all indirect dischargers receiving a new permit (applicable to NODA/Proposal option only)	5 times per year	1.0 hour; $30	2.0 hours; $61	6.0 hours; $183
Review a compliance schedule report	Meeting milestones: 16.0% of all facilities issued a new permit – 94% of the 17% who have compliance milestones (applicable to NODA/Proposal option only)	2 reports per year	0.5 hours; $15	1.0 hour; $30	2.7 hours; $81
	Not meeting milestones: 1% of all facilities issued a new permit – 6% of the 17% who have compliance milestones (applicable to NODA/Proposal option only)	2 reports per year	1.0 hours; $30	2.0 hours; $61	6.0 hours; $183
Minor enforcement action e.g., issue an administrative order	7% of MP&M facilities being issued a new permit (applicable to NODA/Proposal option only)	Annual	1.0 hour; $30	3.7 hours; $112	12.0 hours; $365
Minor enforcement action, e.g., impose an administrative fine	7% of MP&M facilities being issued a new permit (applicable to NODA/Proposal option only)	Annual	1.0 hour; $30	5.0 hours; $152	24.0 hours; $730
Repermit	100% of MP&M facilities being issued a new permit (applicable to NODA/Proposal option only)	Every 5 years	1.0 hour; $30	4.0 hours; $122	20.0 hours; $608

Source: Estimates of hours by activity from the 1996 MP&M POTW Survey. Average hourly rate from Bureau of Labor Statistics (Sept. 2002 rate, adjusted to $2001).

Exhibit F.2: Per-Facility Hours and Assumptions

Activity	Low	Medium	High	% Facil	x/yr	Notes
New concentration-based permit						
develop and issue permit	4.0	10.0	40.0	100.0%	1	one-time
provide technical guidance	1.5	4.0	12.0	100.0%	1	one-time
conduct public or evidentiary hearings	2.0	8.0	40.0	3.2%	1	one-time, 3.2% of facilities
inspection for permit development	2.2	5.0	12.0	100.0%	1	one-time
inspection for compliance assessment	2.0	3.3	10.0	100.0%	1	annual
sample and analyze effluent	1.0	3.0	17.7	100.0%	1	annual
review & record self-monitoring reports	0.5	1.0	4.0	100.0%	2	2x/year
process & act on non-compliance reports	1.0	2.0	6.0	38.5%	5	5x/year, 38.5% of facilities
review compliance schedule report - in compliance with schedule	0.5	1.0	2.7	16.0%	2	2x/yr, 17% of facilities with compliance milestones, of which 94% in compliance
review compliance schedule report - not in compliance with schedule	1.0	2.0	6.0	1.0%	2	2x/yr, 17% of facilities with compliance milestones, of which 6% not in compliance
minor enforcement action (e.g., admin order)	1.0	3.7	12.0	7.0%	1	annual, 7% of facilities
minor enforcement action (e.g., admin fine)	1.0	5.0	24.0	7.0%	1	annual, 7% of facilities
repermit	1.0	4.0	20.0	100.0%	1	every three years
New mass-based permit						
develop and issue permit	4.0	13.0	40.0	100.0%	1	one-time
provide technical guidance	2.0	4.0	12.0	100.0%	1	one-time
conduct public or evidentiary hearings	2.0	8.0	40.0	3.2%	1	one-time, 3.2% of facilities
inspection for permit development	2.2	5.0	12.0	100.0%	1	one-time
inspection for compliance assessment	2.0	3.3	10.0	100.0%	1	annual
sample and analyze effluent	1.0	3.0	17.7	100.0%	1	annual
review & record self-monitoring reports	0.5	1.0	4.0	100.0%	2	2x/year
process & act on non-compliance reports	1.0	2.0	6.0	38.5%	5	5x/year, 38.5% of facilities
review compliance schedule report - in compliance with schedule	0.5	1.0	2.7	16.0%	2	2x/yr, 17% of facilities with compliance milestones, of which 94% in compliance
review compliance schedule report - not in compliance with schedule	1.0	2.0	6.0	1.0%	2	2x/yr, 17% of facilities with compliance milestones, of which 6% not in compliance
minor enforcement action (e.g., admin order)	1.0	3.7	12.0	7.0%	1	annual, 7% of facilities
minor enforcement action (e.g., admin fine)	1.0	5.0	24.0	7.0%	1	annual, 7% of facilities
repermit	1.0	4.0	20.0	100.0%	1	every three years
Converting concentration-based to mass-based						
develop and issue permit	2.0	8.0	20.0	100.0%	1	one-time
provide technical guidance	0.0	0.0	0.0	0.0%	0	N/A

Exhibit F.2: Per-Facility Hours and Assumptions

Activity	Low	Medium	High	% Facil	x/yr	Notes
conduct public or evidentiary hearings	0.0	0.0	0.0	0.0%	0	N/A
inspection for permit development	0.0	0.0	0.0	0.0%	0	N/A
inspection for compliance assessment	2.0	3.3	10.0	100.0%	1	annual
sample and analyze effluent	1.0	3.0	17.7	100.0%	1	annual
review & record self-monitoring reports	0.5	1.0	4.0	100.0%	2	2x/year
process & act on non-compliance reports	1.0	2.0	6.0	38.5%	5	5x/year, 38.5% of facilities
review compliance schedule report - in compliance with schedule	0.5	1.0	2.7	16.0%	2	2x/yr, 17% of facilities with compliance milestones, of which 94% in compliance
review compliance schedule report - not in compliance with schedule	1.0	2.0	6.0	1.0%	2	2x/yr, 17% of facilities with compliance milestones, of which 6% not in compliance
minor enforcement action (e.g., admin order)	1.0	3.7	12.0	7.0%	1	annual, 7% of facilities
minor enforcement action (e.g., admin fine)	1.0	5.0	24.0	7.0%	1	annual, 7% of facilities
repermit	1.0	4.0	20.0	100.0%	1	every three years

Discount rate: 7%
Average hourly rate: $30.42 ($2001)

Source: Estimates of hours by activity from the 1996 MP&M POTW Survey. Average hourly rate from Bureau of Labor Statistics (Sept. 2002 rate, adjusted to $2001).

Exhibit F.3: Low Estimate of Hours and Costs per Facility
(average considering frequency of activity and percent of facilities requiring activity)

Activity	Initial Year	Annual (non-permitting year)	Repermit Year
New concentration-based permit			
develop and issue permit	4		
provide technical guidance	2		
conduct public or evidentiary hearings	0		
inspection for permit development	2		
inspection for compliance assessment	2	2	2
sample and analyze effluent	1	1	1
review & record self-monitoring reports	1	1	1
process & act on non-compliance reports	2	2	2
review compliance schedule report - in compliance with schedule	0	0	0
review compliance schedule report - not in compliance with schedule	0	0	0
minor enforcement action (e.g., admin order)	0	0	0
minor enforcement action (e.g., admin fine)	0	0	0
repermit			1
Total Hours by Year	*14*	*6*	*7*
Total Dollars by Year	*$425*	*$190*	*$220*
New mass-based permit			
develop and issue permit	4		
provide technical guidance	2		
conduct public or evidentiary hearings	0		
inspection for permit development	2		
inspection for compliance assessment	2	2	2
sample and analyze effluent	1	1	1
review & record self-monitoring reports	1	1	1
process & act on non-compliance reports	2	2	2
review compliance schedule report - in compliance with schedule	0	0	0
review compliance schedule report - not in compliance with schedule	0	0	0
minor enforcement action (e.g., admin order)	0	0	0
minor enforcement action (e.g., admin fine)	0	0	0
repermit			1
Total Hours by Year	*14*	*6*	*7*
Total Dollars by Year	*$440*	*$190*	*$220*
Upgrading from concentration-based to mass-based			
develop and issue permit	2		
provide technical guidance	0		
conduct public or evidentiary hearings	0		
inspection for permit development	0		
inspection for compliance assessment	2	2	2
sample and analyze effluent	1	1	1

Exhibit F.3: Low Estimate of Hours and Costs per Facility
(average considering frequency of activity and percent of facilities requiring activity)

Activity	Initial Year	Annual (non-permitting year)	Repermit Year
review & record self-monitoring reports	1	1	1
process & act on non-compliance reports	2	2	2
review compliance schedule report - in compliance with schedule	0	0	0
review compliance schedule report - not in compliance with schedule	0	0	0
minor enforcement action (e.g., admin order)	0	0	0
minor enforcement action (e.g., admin fine)	0	0	0
repermit			1
Total Hours by Year	*8*	*6*	*7*
Total Dollars by Year	*$251*	*$190*	*$220*

Source: Estimates of hours by activity from the 1996 MP&M POTW Survey. Average hourly rate from Bureau of Labor Statistics (Sept. 2002 rate, adjusted to $2001).

Exhibit F.4: Medium Estimate of Hours and Costs per Facility (average considering frequency of activity and percent of facilities requiring activity)			
Activity	**Initial Year**	**Annual (non-permitting year)**	**Repermit Year**
New concentration-based permit			
develop and issue permit	10		
provide technical guidance	4		
conduct public or evidentiary hearings	0		
inspection for permit development	5		
inspection for compliance assessment	3	3	3
sample and analyze effluent	3	3	3
review & record self-monitoring reports	2	2	2
process & act on non-compliance reports	4	4	4
review compliance schedule report - in compliance with schedule	0	0	0
review compliance schedule report - not in compliance with schedule	0	0	0
minor enforcement action (e.g., admin order)	0	0	0
minor enforcement action (e.g., admin fine)	0	0	0
repermit			4
Total Hours by Year	*32*	*13*	*17*
Total Dollars by Year	*$986*	*$400*	*$522*
New mass-based permit			
develop and issue permit	13		
provide technical guidance	4		
conduct public or evidentiary hearings	0		
inspection for permit development	5		
inspection for compliance assessment	3	3	3
sample and analyze effluent	3	3	3
review & record self-monitoring reports	2	2	2
process & act on non-compliance reports	4	4	4
review compliance schedule report - in compliance with schedule	0	0	0
review compliance schedule report - not in compliance with schedule	0	0	0
minor enforcement action (e.g., admin order)	0	0	0
minor enforcement action (e.g., admin fine)	0	0	0
repermit			4
Total Hours by Year	*35*	*13*	*17*
Total Dollars by Year	*$1,077*	*$400*	*$522*
Upgrading from concentration-based to mass-based			
develop and issue permit	8		
provide technical guidance	0		
conduct public or evidentiary hearings	0		
inspection for permit development	0		
inspection for compliance assessment	3	3	3

Exhibit F.4: Medium Estimate of Hours and Costs per Facility
(average considering frequency of activity and percent of facilities requiring activity)

Activity	Initial Year	Annual (non-permitting year)	Repermit Year
sample and analyze effluent	3	3	3
review & record self-monitoring reports	2	2	2
process & act on non-compliance reports	4	4	4
review compliance schedule report - in compliance with schedule	0	0	0
review compliance schedule report - not in compliance with schedule	0	0	0
minor enforcement action (e.g., admin order)	0	0	0
minor enforcement action (e.g., admin fine)	0	0	0
repermit			4
Total Hours by Year	*21*	*13*	*17*
Total Dollars by Year	*$643*	*$400*	*$522*

Source: Estimates of hours by activity from the 1996 MP&M POTW Survey. Average hourly rate from Bureau of Labor Statistics (Sept. 2002 rate, adjusted to $2001).

Exhibit F.5: High Estimate of Hours and Costs per Facility (average considering frequency of activity and percent of facilities requiring activity)

Activity	Initial Year	Annual (non-permitting year)	Repermit Year
New concentration-based permit			
develop and issue permit	40		
provide technical guidance	12		
conduct public or evidentiary hearings	1		
inspection for permit development	12		
inspection for compliance assessment	10	10	10
sample and analyze effluent	18	18	18
review & record self-monitoring reports	8	8	8
process & act on non-compliance reports	12	12	12
review compliance schedule report - in compliance with schedule	1	1	1
review compliance schedule report - not in compliance with schedule	0	0	0
minor enforcement action (e.g., admin order)	1	1	1
minor enforcement action (e.g., admin fine)	2	2	2
repermit			20
Total Hours by Year	*116*	*51*	*71*
Total Dollars by Year	*$3,529*	*$1,543*	*$2,151*
New mass-based permit			
develop and issue permit	40		
provide technical guidance	12		
conduct public or evidentiary hearings	1		
inspection for permit development	12		
inspection for compliance assessment	10	10	10
sample and analyze effluent	18	18	18
review & record self-monitoring reports	8	8	8
process & act on non-compliance reports	12	12	12
review compliance schedule report - in compliance with schedule	1	1	1
review compliance schedule report - not in compliance with schedule	0	0	0
minor enforcement action (e.g., admin order)	1	1	1
minor enforcement action (e.g., admin fine)	2	2	2
repermit			20
Total Hours by Year	*116*	*51*	*71*
Total Dollars by Year	*$3,529*	*$1,543*	*$2,151*
Upgrading from concentration-based to mass-based			
develop and issue permit	20		
provide technical guidance	0		
conduct public or evidentiary hearings	0		
inspection for permit development	0		
inspection for compliance assessment	10	10	10

Exhibit F.5: High Estimate of Hours and Costs per Facility (average considering frequency of activity and percent of facilities requiring activity)

Activity	Initial Year	Annual (non-permitting year)	Repermit Year
sample and analyze effluent	18	18	18
review & record self-monitoring reports	8	8	8
process & act on non-compliance reports	12	12	12
review compliance schedule report - in compliance with schedule	1	1	1
review compliance schedule report - not in compliance with schedule	0	0	0
minor enforcement action (e.g., admin order)	1	1	1
minor enforcement action (e.g., admin fine)	2	2	2
repermit			20
Total Hours by Year	*71*	*51*	*71*
Total Dollars by Year	*$2,151*	*$1,543*	*$2,151*

Source: Estimates of hours by activity from the 1996 MP&M POTW Survey. Average hourly rate from Bureau of Labor Statistics (Sept. 2002 rate, adjusted to $2001).

Exhibit F.6: Number of Facilities Requiring Additional Permitting	
Option II: NODA/Proposal Option	
Number of facilities operating post-regulation requiring a permit	**3,687**
Of facilities operating post-regulation:	
existing concentration-based	692
existing mass-based	2,892
no permit in baseline	103
concentration based to be converted to mass-based	0
new concentration-based	103
new mass-based	0
Number of currently permitted facilities closing (no longer requiring a permit)	**722**
Of facilities closing due to the rule:	
existing concentration-based	209
existing mass-based	513
Option III: Directs + 413 to 433 Upgrade	
Number of facilities operating post-regulation requiring a permit	**954**
Of facilities operating post-regulation:	
existing concentration-based	184
existing mass-based	770
no permit in baseline	0
concentration based to be converted to mass-based	0
new concentration-based	0
new mass-based	0
Number of currently permitted facilities closing (no longer requiring a permit)	**120**
Of facilities closing due to the rule:	
existing concentration-based	0
existing mass-based	120
Option IV: Directs + 413+50%LL Upgrade	
Number of facilities operating post-regulation requiring a permit	**1,414**
Of facilities operating post-regulation:	
existing concentration-based	515
existing mass-based	899
no permit in baseline	0
concentration based to be converted to mass-based	0
new concentration-based	0
new mass-based	0
Number of currently permitted facilities closing (no longer requiring a permit)	**120**
Of facilities closing due to the rule:	
existing concentration-based	0
existing mass-based	120

Source: U.S. EPA analysis.

Exhibit F.7: POTW Administrative Costs by Option (@ 7% discount rate)

Option II: NODA/Proposal Option

	Year Relative to Promulgation of Rule														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Total Hours															
High	32,561	-15,017	-28,095	-60,763	-60,763	-30,038	-30,038	-30,038	-60,763	-60,763	-30,038	-30,038	-30,038	-60,763	-60,763
Medium	33,603	-4,289	-7,680	-14,480	-14,480	-8,335	-8,335	-8,335	-14,480	-14,480	-8,335	-8,335	-8,335	-14,480	-14,480
Low	33,638	-2,472	-4,083	-5,908	-5,908	-4,372	-4,372	-4,372	-5,908	-5,908	-4,372	-4,372	-4,372	-5,908	-5,908
Total Costs															
High	$990,604	$-456,868	$-854,738	$-1,848,612	$-1,848,612	$-913,859	$-913,859	$-913,859	$-1,848,612	$-1,848,612	$-913,859	$-913,859	$-913,859	$-1,848,612	$-1,848,612
Medium	$1,022,297	$-130,480	$-233,655	$-440,526	$-440,526	$-253,575	$-253,575	$-253,575	$-440,526	$-440,526	$-253,575	$-253,575	$-253,575	$-440,526	$-440,526
Low	$1,023,378	$-75,221	$-124,220	$-179,746	$-179,746	$-133,008	$-133,008	$-133,008	$-179,746	$-179,746	$-133,008	$-133,008	$-133,008	$-179,746	$-179,746

	High	Medium	Low
NPV	$-9,357,000	$-1,802,000	$-422,000
Annualized Cost	$-1,027,000	$-198,000	$-46,000
Max One Year Hours	32,561	33,603	33,638
Max One Year Costs	$991,000	$1,022,000	$1,023,000

Option III: Directs + 413 to 433 Upgrade

	Year Relative to Promulgation of Rule														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Total Hours															
High	33	-2,513	-5,059	-13,011	-13,011	-5,059	-5,059	-5,059	-13,011	-13,011	-5,059	-5,059	-5,059	-13,011	-13,011
Medium	-144	-805	-1,465	-3,055	-3,055	-1,465	-1,465	-1,465	-3,055	-3,055	-1,465	-1,465	-1,465	-3,055	-3,055
Low	-185	-498	-812	-1,209	-1,209	-812	-812	-812	-1,209	-1,209	-812	-812	-812	-1,209	-1,209
Total Costs															
High	$1,000	$-76,451	$-153,901	$-395,845	$-395,845	$-153,901	$-153,901	$-153,901	$-395,845	$-395,845	$-153,901	$-153,901	$-153,901	$-395,845	$-395,845
Medium	$-4,394	$-24,479	$-44,563	$-92,952	$-92,952	$-44,563	$-44,563	$-44,563	$-92,952	$-92,952	$-44,563	$-44,563	$-44,563	$-92,952	$-92,952
Low	$-5,616	$-15,154	$-24,692	$-36,789	$-36,789	$-24,692	$-24,692	$-24,692	$-36,789	$-36,789	$-24,692	$-24,692	$-24,692	$-36,789	$-36,789

	High	Medium	Low
NPV	$-1,982,000	$-509,000	$-238,000
Annualized Cost	$-218,000	$-56,000	$-26,000
Max One Year Hours	33	-144	-185
Max One Year Costs	$1,000	$-4,000	$-6,000

Exhibit F.7: POTW Administrative Costs by Option (@ 7% discount rate)

Option IV: Directs + 413+50%LL Upgrade

	Year Relative to Promulgation of Rule														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Total Hours															
High	1,566	-980	-3,525	-15,311	-15,311	-3,525	-3,525	-3,525	-15,311	-15,311	-3,525	-3,525	-3,525	-15,311	-15,311
Medium	162	-498	-1,158	-3,515	-3,515	-1,158	-1,158	-1,158	-3,515	-3,515	-1,158	-1,158	-1,158	-3,515	-3,515
Low	-108	-421	-735	-1,324	-1,324	-735	-735	-735	-1,324	-1,324	-735	-735	-735	-1,324	-1,324
Total Costs															
High	$47,645	$-29,805	$-107,256	$-465,813	$-465,813	$-107,256	$-107,256	$-107,256	$-465,813	$-465,813	$-107,256	$-107,256	$-107,256	$-465,813	$-465,813
Medium	$4,935	$-15,150	$-35,234	$-106,945	$-106,945	$-35,234	$-35,234	$-35,234	$-106,945	$-106,945	$-35,234	$-35,234	$-35,234	$-106,945	$-106,945
Low	$-3,283	$-12,822	$-22,360	$-40,288	$-40,288	$-22,360	$-22,360	$-22,360	$-40,288	$-40,288	$-22,360	$-22,360	$-22,360	$-40,288	$-40,288
	High	**Medium**	**Low**												
NPV	$-1,940,000	$-501,000	$-236,000												
Annualized Cost	$-213,000	$-55,000	$-26,000												
Max One Year Hours	1,566	162	-108												
Max One Year Costs	$48,000	$5,000	$-3,000												

Source: Estimates of hours by activity from the 1996 MP&M POTW Survey. Average hourly rate from Bureau of Labor Statistics (Sept. 2002 rate, adjusted to $2001).

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Appendix G: Extrapolation Methods

INTRODUCTION

APPENDIX CONTENTS

EPA estimates both cost and benefits of environmental regulations based on a random stratified sample of MP&M facilities.[1] EPA then estimates national level costs and benefits by extrapolating analytic results from sample facilities to the national level using statistically determined sample facility weights.

Sample facility weights used in the benefit cost analysis of environmental regulations are based on detailed questionnaire stratification. Stratification means dividing the population of facilities into a number of non-overlapping sub-populations (strata). These strata consist of facilities that are homogeneous with respect to facility size (i.e., number of employees or revenue) or engineering characteristics such as wastewater flow because this information was not available at the time the sample frame was developed. The sample weights for facilities in the sample are based on the total population in each category and probabilities of selection in each stratum.

EPA traditionally uses a ***standard linear weighting technique*** (hereafter, traditional extrapolation) to estimate national compliance costs, changes in pollutant removals, and national-level benefits of environmental regulations. However, using sample weights that are based only on facility-specific (e.g., engineering) characteristics and various non-facility factors can lead to a conditional bias in the estimation of national-level benefits. In particular, this approach omits consideration of important non-facility factors that influence the occurrence and size of benefits.

Non-facility factors that are likely to affect the occurrence and size of benefits from reduced sample facility discharges and that are not reflected in the standard stratification and sample-weighting approach include the receiving water body type and size and the size of the population residing in the vicinity of a sample facility. Furthermore, co-occurrences of facilities discharging to the same reach may also affect the occurrence of benefits. Many of the environmental assessment and benefits analyses include comparisons of the estimated baseline and post-compliance pollutant concentrations (e.g., sludge concentrations or in-waterway concentrations) with the relevant threshold values. Because the effect of aggregate discharges from several facilities is likely to be different from the sum of effects from these facilities considered independently, it is also important to account for the likelihood of joint discharges of MP&M facilities to the same reach.

The Agency used two approaches to address omission of these important non-facility factors (i.e., water body type and size, affected population, and co-occurrence of MP&M discharges) in designing the MP&M facilities sample. First, EPA adjusted sampling weights through ***post-stratification*** using two variables receiving water body type and size and the size of the population residing in the vicinity of the sample facility. Section G.1 presents the method of doing this adjustment. Second, EPA used a ***differential sample weighting technique*** in developing national estimates of environmental effects and benefits. This method accounts for the presence of more than one facility with different sample weights discharging directly or indirectly (through a POTW) to reaches affected by multiple MP&M dischargers. Section G.2 of this appendix describes the differential sample weighting technique.

EPA used both the traditional extrapolation-based weights and the sample weights adjusted through post-stratification (hereafter, post-stratification extrapolation) to analyze the final MP&M rule's benefits. The benefit estimates based on the post-stratification extrapolation weights are used to validate general conclusions that EPA draws from its main analysis based on the traditional extrapolation method. In addition to developing national benefit estimates based on both traditional and

[1] A census of all MP&M facilities was not performed due to the large size of the MP&M industry.

post-stratification extrapolation weights, EPA developed a third estimate of national benefits based on the Ohio case study results.[2] Section G.3 of this appendix discusses this method in detail. The Agency recognizes that the extrapolation method used for the Ohio case study results is not rigorous. Therefore, this method is used to supplement the main results.

G.1 Using Raking to Adjust MP&M Facility Sample Weights

Omitting information that affects the occurrence and size of benefits from the original sample frame's design may lead to conditional bias in MP&M rule benefit estimates. To address this problem, EPA used a post-stratification weight-adjustment method called ***raking*** to account for two additional variables that were not accounted for in the original sample design and that may affect benefit occurrence:

- physical characteristics of the receiving water body (including type and size); and
- size of the population residing in the vicinity of the sample facility.

G.1.1 Data Sources

EPA first classified the universe of MP&M facilities into different poststrata. The Agency relied on three data sources to identify discharge reach characteristics and the population size in the vicinity of the discharge reach:

1. EPA's Permit Compliance System database (PCS) indicated water bodies to which MP&M facilities discharge;

2. EPA's Reach File 1 (RF1) provided additional information on the receiving water bodies, including water body type, flow characteristics, and counties abutting these water bodies; and

3. Census data provided information on county populations.

The PCS database provides information on facilities covered by NPDES permits. The database covers only those facilities that discharge directly to surface or ground water. No information is available on the location of MP&M facilities that discharge to surface water indirectly or via POTWs. EPA therefore limited post-stratification to direct discharging facilities. The Agency used the resulting adjusted sample weights to estimate national-level benefits for only the final regulatory option, which covers only direct discharging facilities. Chapters 13 through 19 of this report present benefit estimates in various benefit categories considered in this analysis.

The extent of improvement in estimation accuracy depends on the reliability of the information used for post-stratification. Accordingly, it was necessary to understand and account for PCS database limitations in implementing a post-stratification approach. The PCS database is designed to provide information on a facility's SIC codes, facility flow, and receiving reach characteristics. These characteristics include water body name and type, stream ID, and stream flow. Although these data can be used to classify facilities in the identified poststrata, these fields are not always populated in the database. To fill missing data, EPA combined data from PCS with supplementary analyses and information from RF1, using the following framework:

- PCS provided a stream ID and information on the water body type and flow characteristics. EPA obtained stream characteristics from PCS and used the stream ID to obtain information on counties abutting the reach from RF1;

- PCS provided a stream ID, but not the water body type and flow characteristics. EPA used the stream ID to obtain information on water body type, flow characteristics, and counties abutting the reach from RF1;

- PCS provided water body name and type, but not stream ID and flow characteristics. EPA first used facility lat/long data to assign the PCS facility to the nearest reach that matches the water body name provided in PCS. The Agency then used the identified stream ID from RF1 to obtain information on water body type, flow characteristics, and counties abutting the reach from RF1;

[2] See Chapter 21 for a detailed discussion the Ohio case study.

- PCS provided no receiving stream information on the, but facility lat/long data were available. EPA first used these data to assign the PCS facility to the nearest reach. The Agency then used the identified stream ID to obtain information on water body type, flow characteristics, and counties abutting the reach;

- PCS provided neither information on the receiving stream nor facility lat/long data. EPA assumed the distribution of the receiving water body characteristics, including the size of the population residing in the counties abutting the receiving reaches, to be similar to the distribution of these characteristics across facilities with known characteristics.

PCS identifies 4,290 direct discharging facilities with MP&M SIC codes that had active NPDES permits 1997. Of these, EPA classified 3,242 facilities into the poststrata considered in this analysis. Because the total number of PCS facilities with MP&M SIC codes differs from the sum of sampling weights of direct dischargers considered in the final regulation, the Agency assumed that the sum of the sampling weights provides the correct estimate of the MP&M facility universe. Thus, the count of facilities in the benefits analysis matches the number of MP&M facilities. This analysis yielded an adjustment factor of 2,832/ 3,242= 0.87 Table G.1 lists facility counts from PCS data, adjusted to equal the sample frame total.

Table G.1: Facility Counts from PCS Data (Adjusted to Equal the Sample Frame Total)

First Variable: Water Body Type and Size		Second Variable: Population Size	
Variable Category	**PCS Facilities Count**	**Variable Category**	**PCS Facilities Count**
Bay-Lakes Combined	288	Pop≤100,000	934
Small Streams	543	100,000<Pop≤500,000	1155
Medium Streams	1514	500,000<Pop≤1,000,000	403
Large Streams	487	1,000,000<Pop≤2,000,000	276
		2,000,000<Pop≤4,000,000	47
		Pop<4,000,000	17
Total	2,832		2,832

Source: PCS data.

G.1.2 Raking Adjustment

Raking is a post-stratification method that can be used when multiple variables form the poststrata. If the original sampling weights need to be adjusted using post-stratification with two variables, then the analysis must create a set of poststrata resulting from the cross-classification of the two post-stratification variables. EPA's analysis used the following steps:

1. Combine the variables "water body type" (four categories), with "population size residing in the vicinity of the sampled facility" (six categories) to yield 24 poststrata.

2. Classify each sampled facility into one of the 24 poststrata.

3. Determine how many facilities fall into each poststratum.

4. Multiply the sampling weight of a facility in a poststratum by the ratio of the number of facilities in the population in the poststratum to the sum of the sampling weights of all facilities in that stratum. If the number of facilities in the population are known only by each category of the two variables, then the weights can be adjusted through raking.

This section briefly describes the raking procedure.

Water body type was one of the two post-stratification variables used for raking. EPA originally used six categories of this variable: Bay/Ocean, Great Lakes, Lakes, Lakes, Small Streams, Medium Streams, and Large Streams. However, the number of MP&M sample facilities in Bay/Ocean, Great Lake, and Lake categories was too small for some categories to implement raking. Therefore, EPA combined categories in which the number of facilities in the sample was either zero or too small to create four categories:

- Bay-Lakes Combined (includes, Bays, Oceans, Great Lakes and Lakes);
- Small Streams;
- Medium Streams; and
- Large Streams.

Table G.2 shows the number of sampled facilities in each category of water body type, the sum of the sampling weights of the sampled facilities, and the known number of facilities in the population in that category. Comparing the sum of the MP&M facilities sampling weights and the PCS-based count of facilities for each category of water body type shows that Bay-Lake Combined and Small Streams are under-represented in the MP&M sample frame while Medium and Large Streams are over-represented.

Table G.2: Facility Distribution by Water Body Type

Number of Facilities in the MP&M Sample Frame	MP&M Sample Frame		PCS Facilities	
	Number of Facilities in the Sample	Sum of the Sampling Weights	Number of Facilities in the Population	Ratio of Number PCS to Sample-Weighted Facilities
Bay-Combined	7	38.7	288	7.44
Small Streams	7	231.3	543	2.35
Medium Streams	43	1,439.4	1514	1.05
Large Streams	25	1,122.6	487	0.43
Total	82	2,832.0	2,832.0	1.00

Source: PCS data.

Table G.3 shows the six population categories created in the EPA analysis. Comparing the sum of the MP&M facilities' sampling weights and the PCS-based count of facilities corresponding to each category of water body type shows that facilities from the population size category of less than 100,000, greater than 4,000,000, and greater than 2,000,000 but less than 4,000,000 are over-represented in the sample. Conversely, facilities in the population categories from 100,000 to 500,000 and from 500,000 to 1,000,000 are under-represented.

Table G.3: Distribution of Facilities by Population Size				
Population	MP&M Sample Frame		PCS Facilities	
	Number of Facilities in the Sample	Sum of the Sampling Weights	Number of Facilities in the Population	Ratio of Sample-Weighted to PCS Facilities
Pop≤100,000	18	1,303.0	934	1.40
100,000<Pop≤500,000	35	1,171.8	1,155	1.01
500,000<Pop≤1,000,000	12	136.3	403	0.34
1,000,000<Pop≤2,000,000	12	121.6	276	0.44
2,000,000<Pop≤4,000,000	3	61.8	47	1.31
>4,000,000	2	37.6	17	2.21
Total	82	2,832.0	2,832.0	1.00

Source: PCS data.

Raking is an iterative process in which adjusted sample weights are synthetically generated to match known characteristics of the population along single stratification dimensions and, as a result, should reflect the population characteristics within multi-dimensional stratification cells. The iterative process works as follows. First, EPA multiplied the sampling weight of each facility in each category of water body type by the ratio of the total number of facilities in the population to the sum of the sampling weights in that category. For example, using the numbers in Table G.2, EPA multiplied the sampling weights of all sampled facilities in the Bay-Combined category by the ratio 288/38.7 = 7.44. The sum of the adjusted weights, 38.72x 7.44=288.08, is the known population total. Similarly, EPA multiplied all the sampling weights of facilities in the Large Streams category by the ratio 487/1122.6 = 0.43, to yield 1,122.6x0.43= 482.7 as the sum of the adjusted weights. EPA performed the same calculations for the other categories of water body type.

These calculations match the sum of the sampling weights to the known control totals for the single stratification dimension of water body type. At this first step, however, it is very unlikely that the resulting sums will agree with the known number of facilities within categories of the second stratification dimension, population size category. Table G.4 shows the sum of the adjusted sampling weights and the PCS population totals by population sizes after Iteration 1.

Table G.4: Sum of the Sampling Weight by Population Category after Iteration 1		
Population	Sum of the Adjusted Sampling Weights	Number of Facilities in the Population (PCS Based)
≤100,000	1,542.49	934
100,000<Pop≤500,000	728.62	1,155
500,000<Pop≤1,000,000	133.42	403
1,000,000<Pop≤2,000,000	294.18	276
2,000,000<Pop≤4,000,000	58.31	47
>4,000,000	74.99	17
Total	2,832.01	2,832

Source: U.S. EPA analysis.

To correct for this inconsistency, EPA multiplied each weight by the ratio of the known total to the sum of the adjusted weights for each facility in each population size category. For example, the Agency multiplied each facility in the first population category by the ratio 934/1542.49. Now, the resulting sum of the adjusted weights agrees with the category totals for the population category, but differs from the category totals for water body type.

EPA therefore repeated this process of sequentially adjusting sample weights *one dimension at a time* until the sum of the adjusted sampling weights simultaneously agreed with the total population counts of facilities for *both* water body type and population size categories. After seven iterations, the sum of the sampling weights agreed with PCS-based counts for both variables except for a difference of less than one.

Tables G.5 and G.6 show the sum of the sampling weights before and after this iterative process in each cell. Obtaining the estimated numbers in each cell of Table G.6 by aggregating the final raked sampling weights may yield better estimates of the cell populations than summing the original sampling weights in Table G.5.

Table G.5: Estimated Number of MP&M Facilities in each Poststratum before Raking

Population Size	Water Body Type				
	Bay-Combination	Small Streams	Medium Streams	Large Streams	Total
Pop≤100,000	0	151	1,114	38	1,303
100,000<Pop500,000	11	9	208	944	1,172
500,000<Pop≤1,000,000	1	25	31	79	136
1,000,000<Pop≤2,000,000	27	19	25	51	122
2,000,000<Pop≤4,000,000	0	0	51	11	62
>4,000,000	0	27	10	0	37
Total	39	232	1,439	1,122	2,832

Source: PCS data.

Table G.6: Estimated Number of MP&M Facilities in Each Poststratum after Raking

Population	Water Body Type				Total
	Bay-Combination	Small Streams	Medium Streams	Large Streams	
Pop≤100,0000	0	204	726	4	934
100,000<Pop≤500,000	112	50	575	418	1155
500,000<Pop≤1,000,000	16	210	126	51	403
1,000,000<Pop≤2,000,000	161	64	39	13	277
2,000,000<Pop≤4,000,0000	0	0	45	2	47
>4,000,0000	0	14	3	0	17
Total	289	542	1,514	488	2,833

Source: U.S. EPA analysis

Tables G.5 and G.6 show that sampling weights increase for small stream facilities in the population ≤100,000 category, while sampling weights decrease for medium and large stream facilities in the same population category, due to their over-representation in the sample.

G.2 Methodology for Developing Sample-Weighted Estimates for Sites with More Than One MP&M Facility

The MP&M analysis is based on a random stratified sample of MP&M facilities intended to provide detailed information about specific facility characteristics and to provide national estimates with these characteristics. They are not reach-specific sample weights designed to estimate the national occurrence of reaches associated with a specific characteristic of MP&M discharges. For example, the sum of MP&M sample facility weights discharging to one reach is an accurate estimate of the number of national *facilities* similar to the sample facilities, but is not a valid national estimate of all potential MP&M discharges to that reach or the number of *reaches* similar to that reach. Accordingly, to use the sample weights to estimate the number of similar facilities on similar reaches nationwide requires some adjustments to the standard sample-weight based extrapolation process.

It may not be valid to assume that the co-location of sample facilities is similar to the co-location characteristics of all MP&M facilities. This point is illustrated by the case in which two sample facilities with different weights discharge to the same reach. Assume that one of these two sample facilities has a sample weight of five and the other has a sample weight of 200. The sample weights indicate that there are four additional facilities in the U.S. that are economically and technically similar to the facility with the weight of five. It is also correct to estimate that the other four facilities will discharge the same volume of the same pollutants as the other four facilities. Now let us assume that there are 199 other facilities nationwide similar to the facility with the weight of 200. The more numerous facilities represented by the facility with a weight of 200 could only rarely be co-located with one of the four facilities represented by the sample facility with a weight of five.

EPA developed a method that accounts for joint occurrence on reaches of facilities with different statistical weights to estimate the number of reaches affected by MP&M facilities nationwide. EPA created a series of new discharge variables (a discharge event) for each reach affected by MP&M sample facilities, and assigned weights for the discharge events that provide a national estimate of pollutant discharges across all reaches. The sample discharge events (flows and pollutant loadings) are calculated based on the sum of the flows and pollutant loadings for subsets of the MP&M sample facilities that discharge to that reach. The weights for the discharge events are developed from the facility weights for those subsets of facilities. The calculation includes direct MP&M facility discharges and indirect discharges from POTWs (for options that include them) after considering pollutant removals from POTW treatment.

The number of discharge events on a sample reach equals the number of unique sample weights for the facilities on the reach. EPA calculated a sample weight for each discharge event based on the sample weights of the facilities contributing loadings and flows to the event. Table G.7 illustrates discharge event calculations and corresponding sample weights. Steps for calculating the relevant parameters for discharge events on reaches affected by multiple discharges are as follows:

- Rank pollutant loadings (or discharge flows) in ascending order of facility sample weight for each pollutant of concern discharged by one or more of those facilities.
- Generate the first discharge event loadings (or flows) as the total loadings (or flows) from all sample facilities on the reach. Assign the smallest sample weight to the first discharge event (Wt_1 in Table G.7) among the facilities discharging to the reach. A smaller sample weight relative to the others means that this facility represents no other population facilities that could occur jointly with the other facilities. The weight of the first facility is therefore considered as "used up," and that facility's loadings (or flows) are not included in subsequent discharge events defined for the reach.
- Generate subsequent discharge events by removing the loadings (or flows) of facilities with the smallest sample weight from a running sum of loadings (or flows) of all facilities in the ranking. The weight assigned to each subsequent event is the remaining *unused* weight of the facility with the smallest weight among the facilities remaining in the particular discharge event. Calculate this weight as the difference between the weight of the next facility in the ranking and the weight of the previous facility (Wt_2-Wt_1).

EPA avoids double counting indirect dischargers by including the discharge flow of any given POTW into a reach only once in any given discharge event, even when multiple sample facilities discharge indirectly into one POTW.

This methodology generates a set of discharge events (loadings or flows) for each pollutant discharged to the reach. The following steps illustrate application of the differential weighting technique to estimating the national number of reaches on which ***ambient water quality criteria (AWQC)*** are exceeded:

- assign a weight to each discharge event based on the weights of the facilities discharging to the reach;
- combine the effluent flow with the stream flow of the reach;
- divide the pollutant loading into the stream flow to determine the pollutant concentration caused by the event;
- compare pollutant concentration to AWQC values to determine whether the concentration exceeds those values;
- identify an estimated AWQC "exceedance" if the concentration is greater than a criterion; and

- give the AWQC exceedance event the weight of the discharge event, to establish national estimates of the number of reaches on which an AWQC is exceeded.

Table G.7: Construction of Discharge Events for Any Pollutant Discharged to Any Reach

Event Number	Loadings and Flows Assigned to Event	Weight Assigned to Event
One	$\sum_{i=1}^{N} Load_i \text{ or } Flow_i$	Wt_1
Two	$\sum_{i=2}^{N-1} Load_i \text{ or } Flow_i$	$Wt_2 - Wt_1$
⇓	⇓	⇓
N - 2	$Load_{N-2} + Load_{N-1} + Load_N$ $Flow_{N-2} + Flow_{N-1} + Flow_N$	$Wt_{N-2} - Wt_{N-3}$
N - 1	$Load_{N-1} + Load_N$ $Flow_{N-1} + Flow_N$	$Wt_{N-1} - Wt_{N-2}$
N	$Load_N + Flow_N$	$Wt_N - Wt_{N-1}$

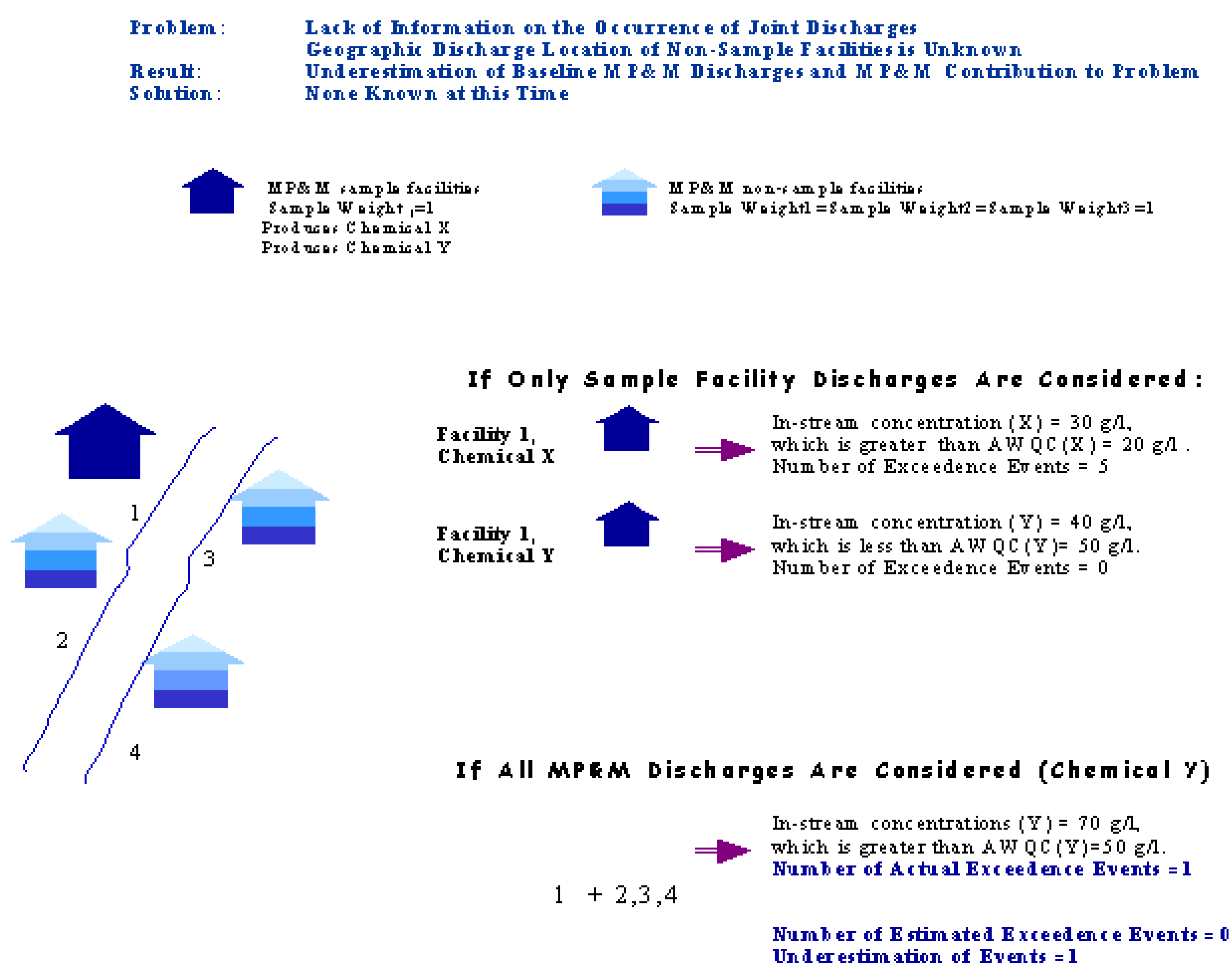
Notes: N sample facilities discharge to the reach and are ranked in ascending order of sample weight and indexed by i (1 = facility with smallest weight, N = facility with largest weight); $Load_i$ = Loading from facility i; $Flow_i$ = Flow from facility i or the POTW associated with facility i; Wt_i = Sample weight of facility i; and a POTW's flow is included only once per event, even if multiple facilities in that event discharged through that POTW, to avoid over-counting the POTW's flow.

Source: U.S. EPA analysis.

This weighting method is a relatively simplistic approach to a complex analytic issue, and does not provide a precise estimate of the national distribution of in-stream MP&M pollutant concentrations that reflects the true co-location characteristics of MP&M facilities. A statistically-valid estimate of that distribution is not possible given the design of the Section 308 surveys. However, the differential weighting technique does correct for the significant overstatement of benefits that would result from using a simple weighting approach to estimate national reach characteristics. The Agency believes that this method is a reasonable approach to addressing this issue, given time and resource constraints. Approaches that are both more sophisticated and more expensive might not yield significantly different aggregate findings.

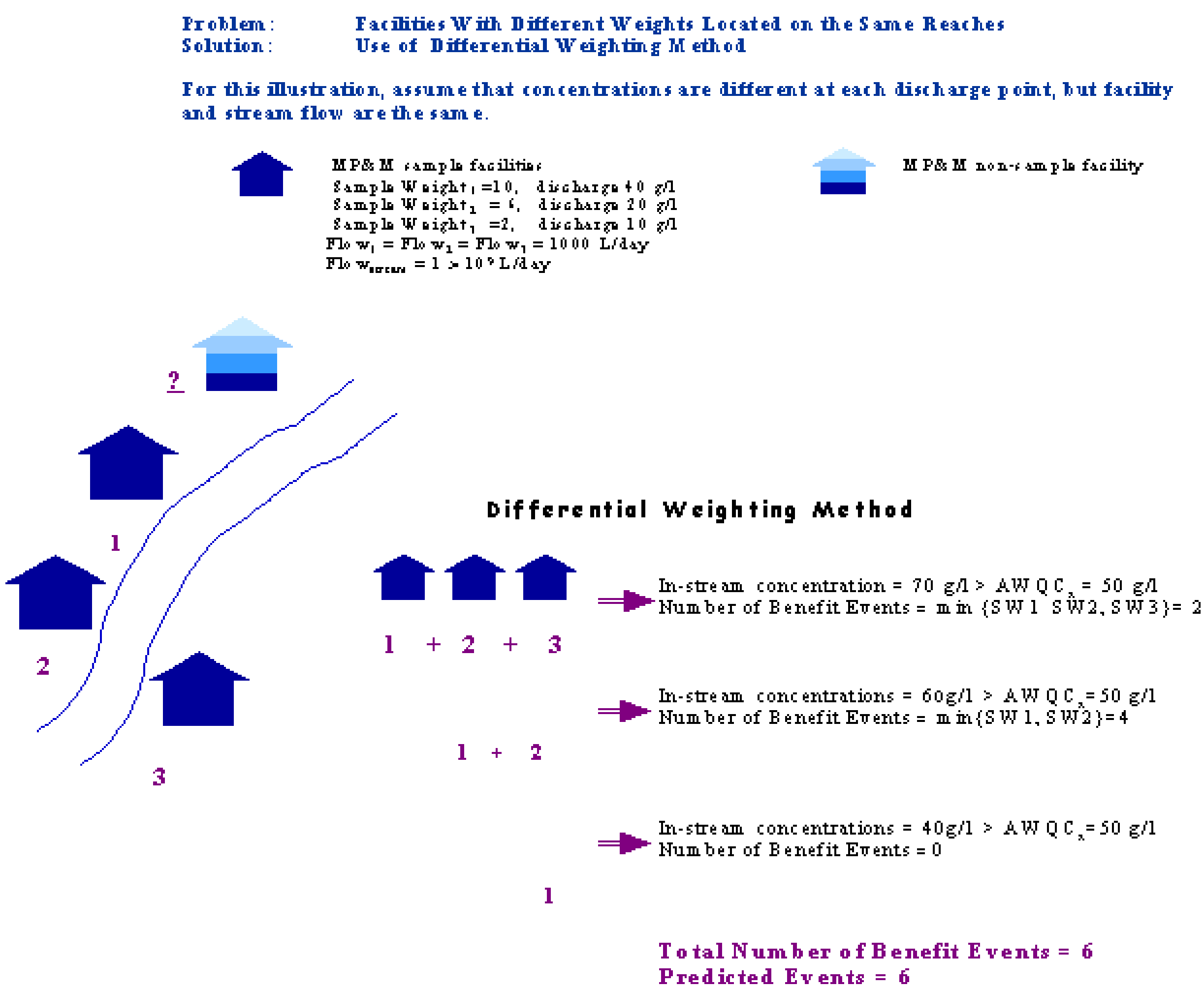
Figure G.1 provides a graphical example of a hypothetical reach to which three known sample facilities discharge. Table G.8 provides a numeric example of this calculation for a hypothetical reach to which three known sample facilities discharge.

Figure G.1a: Estimating MP&M Pollutant Loadings to Receiving Streams When Using a Random Sample of MP&M Facilities



Source: U.S. EPA analysis.

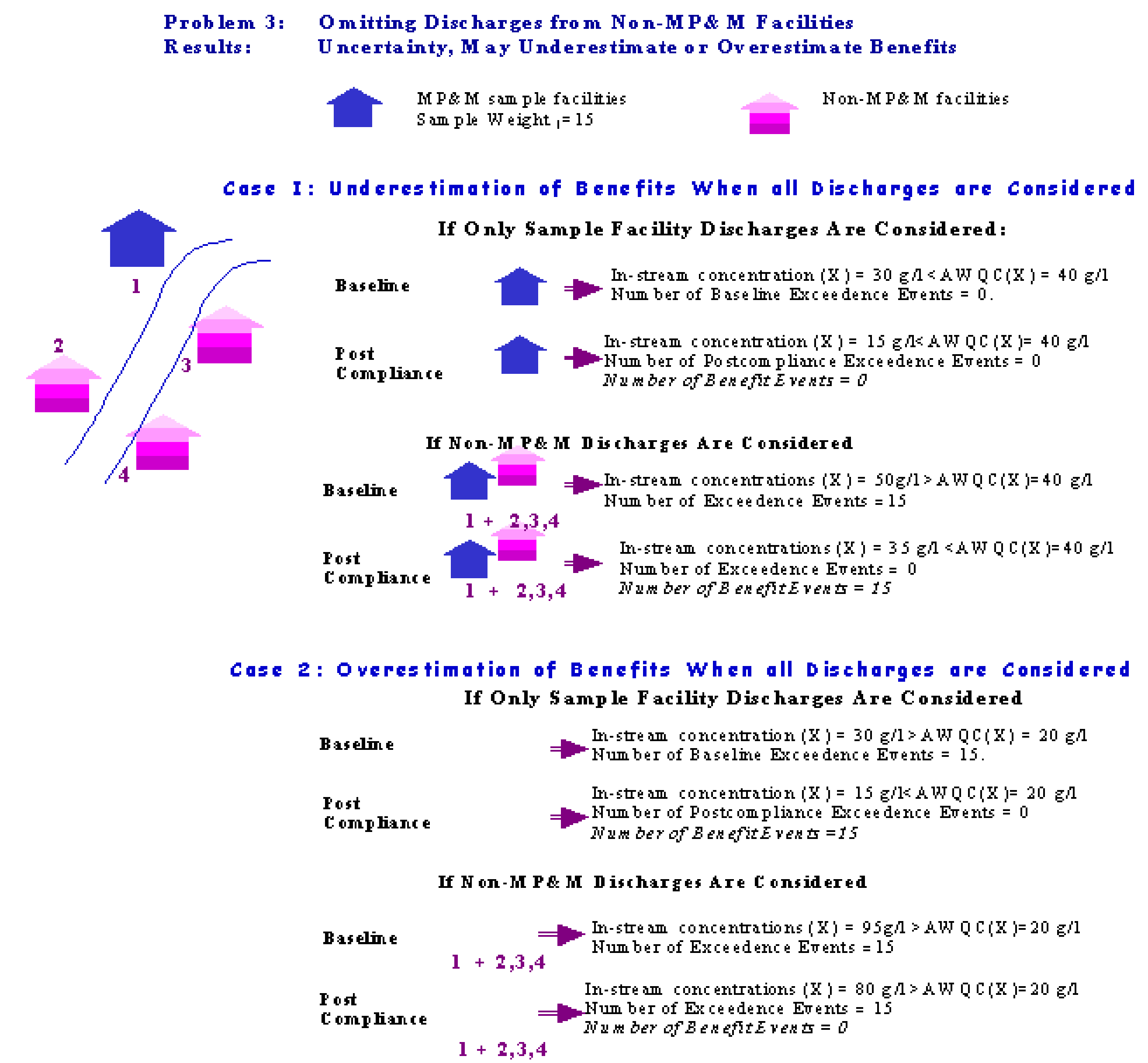
Figure G.1b: Estimating MP&M Pollutant Loadings to Receiving Streams When Using a Random Sample of MP&M Facilities



Note: The situation may be further complicated by actually having a non-sampled MP&M facility on the same reach. The differential weighting method does not address this issue.

Source: U.S. EPA analysis.

Figure G.1c: Estimating MP&M Pollutant Loadings to Receiving Streams When Excluding Background Concentrations



Source: U.S. EPA analysis.

Table G.8: Example of Differential Sample Weighting Technique

Facility	Weight	Pollutant A lbs/yr	Flow gal/year
Raw data:			
1	10	5	2,000,000
2	3	2	4,000,000
3	1	12	10,000,000
Total	14	19	16,000,000
Reach flow (gal/year):			100,000,000
Calculating flow and pollutant loadings for the reach:			
1. Rank facilities in ascending order of weights			
3	1	12	10,000,000
2	3	2	4,000,000
1	10	5	2,000,000
2. Calculate flow and pollutant loadings for discharge event 1 with weight = 1			
Facility	**Pollutant A lbs/yr**	**Flow gal/year**	**Remaining Weight**
3	12	10,000,000	0
2	2	4,000,000	2
1	5	2,000,000	9
Event 1	19	16,000,000	
3. Eliminate the facility with the lowest weight and calculate flow and pollutant loadings for discharge event 2 with weight = 2 (3-1)			
2	2	4,000,000	0
1	5	2,000,000	7
Event 2	7	6,000,000	
4. Eliminate the facility with the next lowest weight and calculate and pollutant loadings for discharge event 3 with weight = 7 (10-3)			
1	5	2,000,000	0
Event 3	5	2,000,000	
5. Estimate national in-stream concentrations based on the flows, loadings, and weights for each discharge event and the reach flow			

Discharge Event	Pollutant A Loading lbs/yr	Facility Flow gal/year	Stream Flow gal/year	Total Flow gal/year	In-stream Concentration ppb	Weight
1	19	16,000,000	100,000,000	116,000,000	0.0955	1
2	7	6,000,000	100,000,000	106,000,000	0.0385	2
		2,000,000	100,000,000	102,000,000	0.0286	7
Total Affected Reaches:						10

Source: U.S. EPA analysis.

G.3 Methodology for Extrapolation of Ohio Case Study Results to the National Level

EPA extrapolated the Ohio case study results to the national level based on three key factors that affect the occurrence and magnitude of benefits:

- the estimated change in MP&M pollutant loadings, which reflects the potential for improvements in surface water quality;

- the level of recreational activities on the reaches affected by MP&M discharges. Recreational level reflects the degree to which potentially affected water resources are likely to be in demand by local residents; and
- the average household income level, which affects the willingness-to-pay (WTP) for water quality improvements.

G.3.1 Change in Pollutant Loads

The first step in applying this alternative extrapolation method was to develop a measure of benefits per pound of pollutant removed for each category of benefits. EPA developed this measure by simply dividing the state-level benefit estimates by the total number of pounds of pollutant removed by the regulation in the state of Ohio ($ per pound of pollutant removed). EPA developed three different measures to better represent the relationship between pollutants and benefit categories:

- ***Cancer health benefits:*** EPA divided cancer benefits from the Ohio case study by total carcinogen pounds removed in Ohio to estimate cancer health benefit per pound of carcinogen load removed;
- ***Lead health benefits:*** EPA divided lead health benefits from the Ohio case study by total lead pounds removed in Ohio to estimate lead health benefit per pound of lead load removed; and
- ***Recreational benefits:*** EPA divided recreational benefits from the Ohio case study by total pounds of pollutants removed (i.e., all pollutants except for total dissolved solids and biological oxygen demand) in Ohio to estimate recreational benefit per pound of pollutant load removed.

All of these values are readily available from the Ohio case study. EPA extrapolated the state-level benefits for each of these benefit categories to the national level. First, the Agency multiplied the three estimated benefit per pound of pollutant values for Ohio by the total number of pounds of pollutant removed in each of the three pollutant categories at the national level. Then, EPA summed across the three benefit categories to obtain an initial estimate for total benefits at the national level.

G.3.2 Level of Recreational Activities on Reaches Affected by MP&M Discharges

The second step was to adjust for differences between Ohio and the nation in the level of recreational activity on reaches affected by MP&M discharges. The level of recreational activity reflects the degree to which water resources likely to be affected by MP&M discharges are in demand by local residents. EPA accounted for differences between Ohio and the nation in recreational intensity because the total user value of water quality improvements is a function of the number of users associated with a particular reach. For this adjustment factor, EPA used the ratio of the number of recreational user days per reach mile at the national level to the number of recreational user days per reach mile in Ohio. Due to data limitations preventing identification of all reaches affected by MP&M discharges, this analysis used total recreational user days and reach miles nationally and in Ohio, rather than only for those reaches affected by MP&M discharges. EPA used the National Demand Study (NDS) to estimate the number of user days for each recreation activity. Appendix N of this report provides the relevant data by state and recreation activity. To estimate the number of recreational user days, EPA summed the activity-specific values over the four activities considered in this analysis (i.e., recreational fishing, boating, swimming, and wildlife viewing). EPA's Reach File 1 provided information on the total number of reach miles in Ohio and in the 48 contiguous states. The Agency then calculated the number of user days per reach mile in the state of Ohio and in the nation by simply dividing the total number of user days by the total number of reach miles in the corresponding region. EPA then calculated the adjustment factor as follows:

$$\begin{aligned} \text{Recreational Activity AF} &= \frac{\text{Average Number of Recreational User Days per Reach Mile in the U.S.}}{\text{Average Number of Recreational User Days per Reach Mile in Ohio}} \\ &= \frac{2{,}306}{4{,}148} = 0.5559 \end{aligned} \qquad (G.1)$$

G.3.3 Differences in Household Income

In the third step, EPA adjusted the extrapolated benefits based on the expectation that the WTP for water quality improvements will vary with household income level for different parts of the country. The adjustment factor used is the ratio of the average household income of the nation to the average household income of Ohio. This adjustment factor assumes that households around the country are willing to pay the same proportion of their incomes for water quality improvements, although the absolute value of this dollar amount will vary due to regional differences in average household income. The average household income of the nation is estimated as a weighted average, with the median household income for each state weighted by the proportion of MP&M facilities located in that state. The U.S. Census Bureau's Current Population Surveys (March 1999, 2000, and 2001) provide the basis for data on the median household income by state for the year 2000.[3] The 1992 Economic Census provides information on total MP&M facilities by state.[4]

$$\begin{aligned} Income\ AF &= \frac{(Weighted)\ Median\ Household\ Income\ in\ the\ U.S.}{Median\ Household\ Income\ in\ Ohio} \\ &= \frac{\$42{,}909}{\$43{,}894} = 0.9776 \end{aligned} \qquad (G.2)$$

G.4 Results

Table G.9 presents national benefits based on the extrapolation of Ohio case study results. Based on this approach, the monetary value of benefits from reduced MP&M discharges is $2.5 million (2001$) for the final option. This estimate is 60% higher compared to the benefit estimate based on the traditional extrapolation methodology (i.e., $1.5 million (2001$)). As noted in the prior discussion, this difference is likely to be due to the more rigorous approach used for the Ohio case study.

The national-level analysis of human health benefits finds negligible health benefits from the final rule. In contrast, the Ohio-based extrapolation of human health benefits yields $10,860 and $295,202 (2001$) in human health benefits at the national level from reduced incidences of cancer cases and adverse health impacts from lead exposure, respectively. As shown in Table G.9, the estimated human health benefits to Ohio residents exceed the national-level benefits based on this extrapolation method. This finding is due to the fact that the estimated pollutant removals for lead and carcinogens in Ohio exceed those at the national level. As discussed in Appendix H, EPA administered 1,600 screener questionnaires to augment information on Ohio's MP&M facilities. The Agency used information from the sampled MP&M facilities to estimate discharge characteristics of non-sampled MP&M characteristics (see Appendix H for detail on estimating sample facility discharges in Ohio). As a result, the MP&M facilities included in the case study analysis represent a significant portion of the MP&M facility universe in Ohio. In contrast, the sample facilities used at the national-level analysis represent only 2 percent of the MP&M facility universe. Thus, analytic findings from the national-level analysis may have a larger than desired degree of uncertainty due to a very small sample size.

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[3] Source: http://www.census.gov/hhes/income/income00/statemhi.html

[4] Appendix J presents information on distribution of MP&M facilities by state.

Table G.9: Extrapolation of Ohio Case Study Results to the National Level (2001$)

Category	Ohio	Nation
Pounds removal of carcinogens	52.45	17.86
Total cancer benefits	$31,895.42	$10,860.86
Total cancer benefits per pound removal of carcinogens	$608.11	
Pounds removal of Lead	217.06	118.54
Total lead benefits	$540,549.14	$295,202.69
Total lead benefits per pound removal of lead	$2,490.32	
Pounds removal of total pollutants	483,258.02	5,412,810.88
Total recreational benefits	$250,932.62	$2,810,612.05
Total recreational benefits per pound removal of total pollutants	$0.52	
Nonuse benefits (½ of total recreational benefits)	$125,466.31	$1,405,306.03
Total benefits prior to application of adjustment factors	$948,843.49	$4,521,981.63
Reach miles	11,927	713,702
Annual recreation days (millions)	49	1,646
Annual recreation days per reach mile	4,148	2,306
Recreational activity adjustment factor		0.5559
Total benefits prior to application of income adjustment factor		$2,513,907.82
Average household income	$43,894	$42,909
Income Adjustment factor		0.9776
Total benefits		$2,457,494.66

Source: U.S. EPA analysis.

Glossary

ambient water quality criteria (AWQC): levels of water quality expected to render a body of water suitable for its designated use. Criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, fish production, or industrial processes. (http://www.epa.gov/OCEPAterms/aterms.html)

differential sample weighting technique: weighting method for all threshold value-based analyses, such as the lead-related benefits analysis.

reach: a specific length of river, lake, or marine shoreline

standard linear weighting technique: weighting method used where the effects being considered (e.g., compliance costs) are linearly additive over facilities.

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Appendix H: Fate and Transport Model for DW and Ohio Analyses

Appendix Contents

Introduction

For the drinking water (DW) and Ohio analyses, EPA used a simplified fate and transport model to quantify the fate and transport of MP&M pollutant releases to surface waters. This model estimates pollutant concentrations at the initial point of discharge and below the initial discharge ***reach***.

The national MP&M analysis considered pollutant concentrations only at the point of discharge (see Appendix I.2.2). The drinking water and Ohio analyses account for the in-stream concentrations of pollutants at the initial point of discharge and in reaches downstream from the initial discharge reach.

This appendix describes the equations characterizing the model, its underlying assumptions, and the data sources used in model estimation. EPA combined the equations defining the model with geographic information (reach flow, velocity, length, etc.) to estimate pollutant concentrations at the initial point of discharge and below the initial discharge reach.

The estimation of pollutant concentrations below the initial discharge reach includes several factors that reduce the in-stream pollutant concentrations with the passage of time. These factors include: ***volatilization***, ***sedimentation***, and chemical decay from ***hydrolysis*** and ***microbial degradation***. EPA adjusted concentrations for changes in stream flow volume in downstream reaches. The discussion below outlines the main assumptions of this analysis. Although more advanced models are available that account for time-variable flow, sediment transport, channel geometry changes within a reach, and detailed simulation of all in-stream processes, these models will not necessarily produce more accurate results without sufficient data to support the input parameters. Estimates of the additional input parameters required by these models are subject to a high degree of uncertainty when applied on a national scale, and gathering such data is beyond the scope of this study.

EPA has previously applied the approach used in this analysis. For example, the first-order contaminant degradation relationship described below in Equation H.1 is currently being used by the Office of Pollution Prevention and Toxics for exposure analysis in the Risk Screening Environmental Indicator ***(RSEI)*** model (U.S. EPA, 1999).

H.1 Model Equations

The total pollutant concentration in the water columns for each reach included in the analysis is calculated by the following equation expressed in generic terms of mass (M), length (L), and time (T):

$$C_T = \frac{W_T}{Q} x e^{\left[-\left(\frac{V_T}{H}\right)\left(\frac{x}{U}\right)\right]} \quad \text{(H.1)}$$

where:
- C_T = total toxicant concentration in the water column (M/L^3),
- W_T = mass input rate of toxicant (M/T),
- Q = river flow (L^3/T),
- V_T = overall net loss rate of chemical (L/T),
- H = flow depth (L),
- x = distance downstream from the point of release (L), and
- U = flow velocity (L/T).

In reaches where more than one facility discharges or where pollutant loadings occur from upstream reaches, the mass input rate (W_T) represents a combined input rate from all relevant industrial facilities affecting the reach. The relevant industrial facilities in the drinking water risk analysis are all MP&M sample facilities (see Chapter 13). The relevant industrial facilities in the Ohio case study analysis include:[1]

- all sample MP&M facilities,
- non-sample MP&M facilities, and
- non-MP&M facilities.

The overall net loss rate of chemical (V_T) is given by:

$$V_T = V_{Td} + V_{Ts} = (k_l + K_d H) \times f_d + v_n f_p \tag{H.2}$$

where:
- V_T = overall net loss rate of chemical (L/T),
- V_{Td} = dissolved chemical loss rate (L/T),
- V_{Ts} = loss of chemical due to sediment interaction (L/T),
- k_l = volatilization transfer coefficient (L/T),
- K_d = dissolved chemical decay rate (hydrolysis and microbial degradation) (1/T),
- H = flow depth (L),
- f_d = dissolved fraction of toxicant (unitless),
- v_n = net loss of solids (L/T), and
- f_p = particulate fraction of toxicant (unitless).

The dissolved and particulate fractions of the pollutant, f_d, and f_p , respectively, are estimated by:

$$f_d = \frac{1}{1 + K_p S} \tag{H.3}$$

and

$$f_p = \frac{K_p S}{1 + K_p S} \tag{H.4}$$

[1] See Chapter 22 for detail.

where:

K_p = partition coefficient [L^3/M], and
S = suspended solids [M/L^3].

The dissolved concentration of ***metals*** and most other pollutants in the water column is generally considered a more accurate expression than the total concentrations of the toxic or bioavailable fraction. For this reason, EPA modified Equation (H.1) to express the pollutant concentrations in terms of dissolved concentration. The dissolved fraction of a pollutant is estimated as:

$$C_d = f_d \times C_T \qquad \text{(H.5)}$$

Substituting Equation (H.1) for C_T yields the dissolved pollutant concentration for downstream distance x from the discharge reach:

$$C_d = \frac{\frac{W_T}{Q} \times e^{\left[-\left(\frac{K_d^H + k_l}{(1 + K_p S)^H} + \frac{v_N K_p S}{(1 + K_p S)^H}\right) \times \left(\frac{x}{U}\right)\right]}}{1 + K_p S} \qquad \text{(H.6)}$$

H.2 Model Assumptions

The following three principal assumptions underlie Equation H.5:

H.2.1 Steady Flow Conditions Exist within the Stream or River Reach

This assumption is necessary due to this study's broad geographical coverage. This assumption significantly reduces the computational effort and input parameter requirements and still produces a good first-order fate and transport model of pollutants in surface waters.

The pollutant concentration is completely mixed, both laterally (across the stream) and vertically (with depth) within each reach. The approach involves a two-dimensional model in which the concentration is uniform over the entire cross-section of the stream reach but varies with the distance of the reach. EPA assumed that the contaminant completely mixes at the point of release. This assumption will likely underestimate the concentration of a contaminant release in areas where mixing is incomplete (e.g., shore-hugging plume) and overestimate concentrations in areas beyond the point showing incomplete mixing (e.g., in areas beyond a shore-hugging plume).

H.2.2 Longitudinal Dispersion of the Pollutant is Negligible

The model does not account for mixing outside the plane of discharge along the river reach, although it predicts variation in pollutant concentrations over distance due to both pollutant fate and decay and the differing hydrology of downstream reaches. In natural streams, longitudinal velocity gradients due to channel irregularities can cause mixing, thereby decreasing the peak concentrations as the contaminant moves downstream from the point of release. Under steady-state situations, however, the longitudinal dispersion of the pollutant is assumed to be negligible.

The solution of the dispersion equation approximates a first-order decay function such as the one shown in Equations H.1 and H.5 under steady flow conditions and complete lateral and vertical mixing.

H.2.3 Flow Geometry, Suspension of Solids, and Reaction Rates Are Constant within a River Reach

EPA assumes the data that describe a river reach and that are calculated for a reach to be constant for the full extent of the reach.

H.3 HYDROLOGIC LINKAGES

EPA modeled pollutant concentrations for a distance of 500 km downstream from the discharge point in the drinking water risk analysis. In the Ohio case study analysis, EPA used the lesser of 500 km or the distance to the Ohio border from the initial discharge point to identify reaches potentially affected by pollutant discharges from the discharge point. The Agency obtained information on the hydrologic linkages between reaches from the RSEI Model (U.S. EPA, 1999). The data file in RSEI provided flow (mean flow, 7Q10) and velocity (mean, low) data for each reach.

EPA used the process equations listed above to estimate both the initial pollutant concentrations at the beginning of each reach and the changes in concentrations as pollutants traveled to the end of the reach. The concentration at the end of each reach served as the value for the beginning of the next reach.

H.4 ASSOCIATING RISK WITH EXPOSED POPULATIONS

The number of individuals served by each drinking water intake is an output of the fate and transport model described in this appendix. If a drinking water intake exists on the initial reach or any downstream reach, then the model calculates the in-stream pollutant concentration at that intake. Data on the population served by the intake is saved with the concentration for further analysis (see Chapter 13 for a discussion of the cancer risk assessment).

H.5 DATA SOURCES

Data sources used for the fate and transport model are discussed briefly in the section below, by categories of information.

H.5.1 Pollutant Loading Data Used in the Drinking Water Risk Analysis

EPA estimated annual pollutant loadings (kg/yr) for the direct and indirect sample MP&M facilities analyzed under the various regulatory options.[2] The Agency first adjusted pollutant loadings for indirect dischargers to reflect POTW treatment, and then divided annual pollutant loadings by the number of days in one year (365) to establish daily pollutant loadings.

H.5.2 Pollutant Loading Data Used in the Ohio Case Study Analysis

EPA estimated pollutant discharges from both MP&M and significant non-MP&M sources at the reaches included in the Ohio case study analysis. Consumer perception and valuation of enhanced water-based recreational opportunities depend on the absolute level of pollutant contamination at recreation sites, and on the change in contamination from the baseline to the post-compliance cases. For this reason, capturing the effect of concurrent discharges from all MP&M and other pollutant sources is particularly important for the recreational benefits analysis.

EPA used the Office of Water's ***BASINS*** software package to identify all possible point source dischargers contributing to ambient pollutant concentrations at a given reach. BASINS is a GIS-based system that serves as a database management system for water quality monitoring, point-source pollutant discharge, and various geo-technical data. Several sources provide information on point source discharges to BASINS, including the ***Permit Compliance System (PCS)*** and ***Toxic Release Inventory (TRI)*** databases. Version 2.0 includes data reported through 1996. Preprogrammed queries in BASINS

[2] EPA is not establishing pretreatment standards for indirect dischargers under the final rule.

generate information on various point source discharge variables at either the state or watershed level. BASINS data on point source dischargers include:

- location information on major industrial dischargers, including PCS facilities and facilities reporting under TRI;
- SIC codes;
- flow volume; and
- discharge characteristics for up to 50 pollutants or parameters for PCS facilities.

The following sections describe steps used to characterize both MP&M and non-MP&M discharges in Ohio.

a. Characterize MP&M facility discharges

EPA used different approaches to assign discharge characteristics to MP&M facilities in Ohio, based on the level of information available for each facility. The Agency divided all MP&M facilities into three groups, based on the level of information provided by different sources:

❖ ***Facilities covered by the detailed Phase 1 and 2 questionnaire (hereafter, sampled MP&M facilities)***

The detailed surveys contain data on:

- discharge status;
- discharge volume;
- industrial processes used;
- pollution prevention activities;
- employment, revenue, and costs.

EPA engineers estimated loadings of 126 MP&M pollutants using information on facilities' processes and pollution prevention activities.[3] All MP&M facilities in this group therefore have extensive data on their location, size, and discharge characteristics.

❖ ***Facilities covered by the detailed Iron and Steel questionnaire (hereafter sampled I&S facilities)***

The detailed I&S survey contained data similar to the detailed MP&M survey. EPA engineers used data on I&S facilities' processes and pollution prevention activities to estimate pollutant loadings from these facilities.

❖ ***Facilities covered by the Phase 2 screener questionnaire or that were covered by the Phase 1 mini-DCP (hereafter, MP&M screener facilities).***

The screener surveys contain significantly fewer data on MP&M facilities. The data collected from the screener survey recipients include:

- facility location, which can be used to assign the facilities to receiving waterways or receiving POTWs;
- SIC codes;
- discharge status (i.e., whether the facility discharges process wastewater and the approximate amount);
- employment and revenue data;
- whether the facility is engaged in manufacturing, maintenance or repairing activities; and

[3] There are 132 pollutants of concern. EPA engineers estimated pollutant loadings for only the pollutants for which EPA is considering calculating pollutant removals at each option. For example, pollutant loadings are not provided for sodium, calcium, and TDS.

- data on MP&M unit operations (including type of MP&M unit operations performed at the site, and whether process wastewater is discharged as a result of each operation).

The project engineers used these data to estimate pollutant loadings for these facilities. Loading estimates for the screener facilities, which are based on less comprehensive information, involve greater uncertainty.

❖ ***Facilities that respond to neither the screener nor detailed questionnaires (hereafter referred to as non-sampled MP&M facilities)***

To address the problem of omitted discharge information on non-sampled MP&M facilities, EPA used information from the 1600 screener MP&M facilities and a random draw approach to assign the relevant characteristics for non-sampled MP&M facilities. Each screener facility represents *n* non-sampled facilities, where *n* is determined by the screener facility sample weight. All non-sampled facilities are smaller indirect dischargers because all direct MP&M facility dischargers and large indirect discharging facilities in Ohio are covered by the long, short, or screener questionnaire.

The exact location of non-sampled facilities is unknown. All non-sampled facilities discharge to one of the Ohio POTWs because they are indirect dischargers. The Agency assigned *n* facilities represented by each screener facility to the receiving POTWs by drawing a random sample of *n* POTWs from the universe of POTWs in Ohio.[4] The Agency assigned screener facility characteristics (i.e., pollutant loadings) to all *n* facilities represented by the screener facility.

EPA used a random draw procedure for all observations from the screener survey that have a sample weight greater than one.

b. Characterize non-MP&M point source discharges

EPA used preprogrammed queries in BASINS to obtain information on all non-MP&M point source discharges in Ohio. BASINS data on non-MP&M point source dischargers include:

- location,
- SIC codes,
- flow volume, and
- discharge characteristics for up to 50 pollutants or parameters for PCS facilities.

The Agency assigned discharge characteristics to all non-MP&M industrial direct discharges based on the information provided in BASINS. POTW effluent may contain pollutants from both MP&M and non-MP&M discharges. The Agency combined information from BASINS with loading estimates provided by the project engineers to estimate total pollutant loadings from a given POTW. This analysis used the following assumptions to estimate total POTW pollutant loadings under the baseline discharge levels:

- If a POTW was not estimated to receive discharges from the MP&M facilities, then the analysis used POTW loadings reported in BASINS.
- If a pollutant or a parameter was not reported in BASINS, then the analysis used aggregate loadings from all MP&M facilities discharging to a given POTW to calculate total POTW loadings of a given pollutant.
- If a POTW was estimated to receives discharges from MP&M facilities and a given pollutant was reported in BASINS, then the analysis used the greater of the aggregate loadings from all MP&M facilities or POTW loadings reported.

EPA estimated post-compliance pollutant loadings from each POTW by subtracting the estimated reduction in the MP&M facility loadings for a given pollutant from its total baseline loadings for a given POTW.

c. Characterize non-point source discharges

The water quality analysis in Ohio used empirical data on ***Total Kjeldahl Nitrogen (TKN)*** concentrations to characterize the baseline water quality conditions. Empirical data on in-stream concentrations captured TKN contribution from both point

[4] The Agency was unable to validate random assignments because POTWs do not know all of their MP&M dischargers.

and non-point sources under baseline conditions. EPA estimated changes in TKN concentrations resulting from the final rule by using the estimated pollutant loading reductions from MP&M sources and the water quality model described above. The Agency assumed that the non-point source contribution of toxic pollutants found in MP&M effluent to ambient concentrations of these pollutants in Ohio's streams and lakes is negligible.

GLOSSARY

BASINS: a software package that serves as a database management system for water quality monitoring, point source pollutant discharge, and various geo-technical data, and also provides an analytic platform for modeling in-stream pollutant concentrations over an entire watershed based on multiple sources of pollutants within the watershed. (http://www.epa.gov.OST/BASINS)

hydrolysis: the decomposition of organic compounds by interaction with water. (http://www.epa.gov/OCEPAterms)

metals: inorganic compounds, generally nonvolatile, and which cannot be broken down by biodegradation processes. They are a particular concern because of their prevalence in MP&M effluents. Metals can accumulate in biological tissues, sequester into sewage sludge in POTWs, and contaminate soils and sediments when released to the environment. Some metals are quite toxic even when present at relatively low levels.

microbial degradation: a process whereby organic molecules are broken down by microbial metabolism.

Permit Compliance System (PCS): a computerized database of information on water discharge permits, designed to support the National Pollutant Discharge Elimination System (NPDES). (http://www.epa.gov/ceisweb1/ceishome/ceisdocs/pcs/pcs-exec.htm)

MP&M reach: a reach to which an MP&M facility discharges.

sedimentation: letting solids settle out of wastewater by gravity. (http://www.epa.gov/OCEPAterms)

Total Kjeldahl Nitrogen (TKN): the total of organic and ammonia nitrogen. TKN is determined in the same manner as organic nitrogen, except that the ammonia is not driven off before the digestion step.

Toxic Release Inventory (TRI): database of toxic releases in the United States compiled from SARA Title III Section 313 reports. (http://www.epa.gov/OCEPAterms)

volatilization: a process whereby chemicals dissolved in water escape into the air. (http://www.epa.gov/OCEPAterms)

ACRONYMS

PCS: Permit Compliance System
RSEI: Risk Screening Environmental Indicator model
TKN: Total Kjeldahl Nitrogen
TRI: Toxic Release Inventory

REFERENCES

U.S. Environmental Protection Agency (U.S. EPA). 1999. Risk-Screening Environmental Indicators Model: Version 1.0, July 6, Washington, DC: Office of Pollution Prevention and Toxics. http://www.epa.gov/opptintr/env_ind/index.html.

Appendix I: Environmental Assessment

Introduction

This Environmental Assessment estimates the environmental impact of MP&M discharges on water bodies and POTWs under both current conditions and those corresponding to four regulatory options: the Final Option, Proposed/NODA Option, Directs + 413 to 433 Upgrade Option, and Directs + All to 433 Upgrade Option.[1] EPA estimates four types of environmental impacts:

- the occurrence of pollutant concentrations in excess of EPA ***ambient water quality criteria (AWQC)*** for protection of human health in waterways (e.g., streams, lakes, bays, and estuaries) receiving discharges from MP&M facilities;
- the occurrence of pollutant concentrations in excess of AWQC for protection of aquatic species in waterways receiving discharges from MP&M facilities;
- the occurrence of POTW inhibition problems resulting from MP&M facilities' discharges; and
- barriers to POTWs' use of preferred sewage sludge management or disposal methods (i.e., beneficial land application or surface disposal), due to metals discharges from MP&M facilities.

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EPA also estimated changes in human health risk from reduced exposure to MP&M pollutants via consumption of contaminated fish and drinking water. Chapters 13 and 14 of this EEBA present both the methodology used to estimate human health impacts from exposure to MP&M pollutants and the results of this analysis.

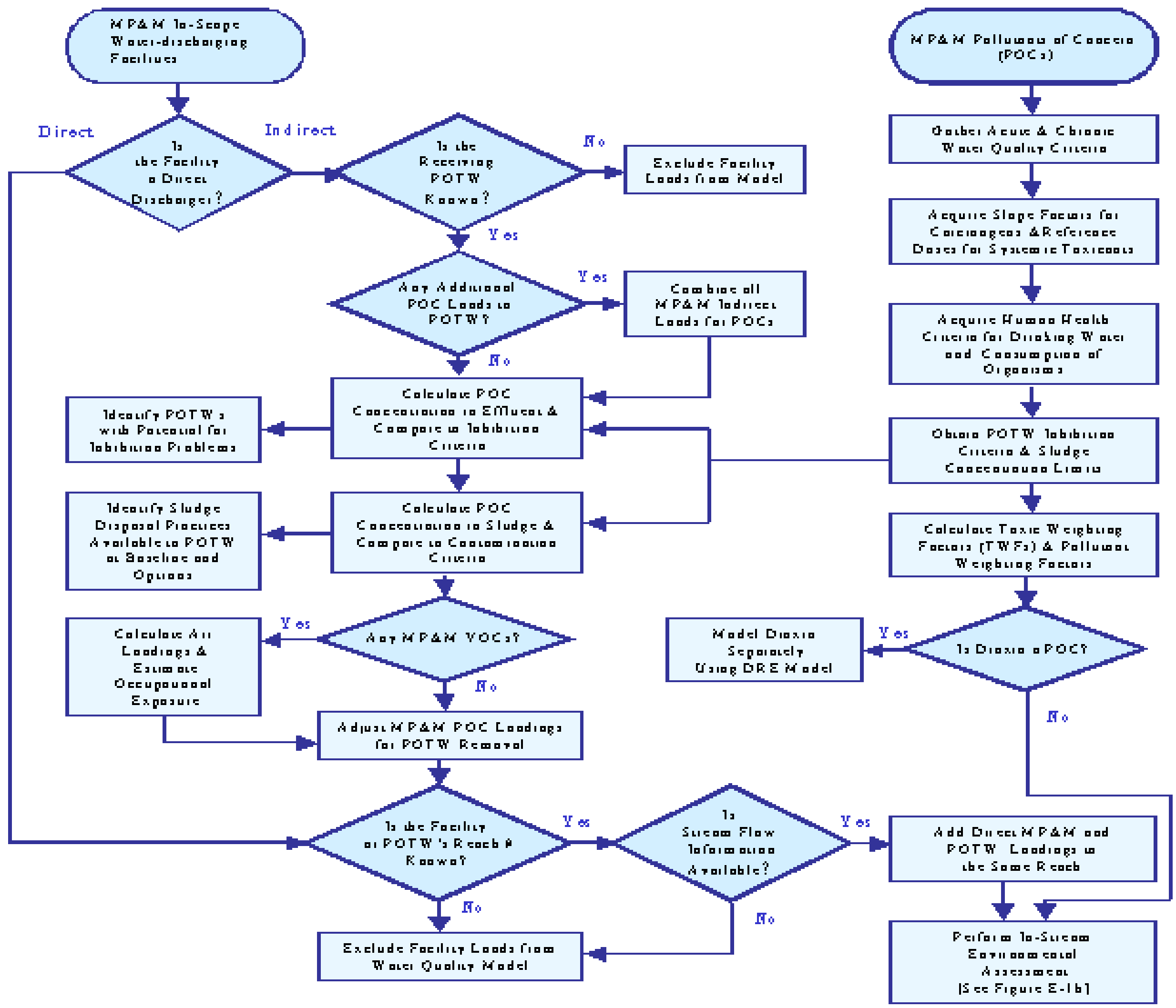
EPA assessed potential environmental impacts of MP&M discharges on the receiving water bodies and POTWs by using pollutant fate and toxicity data in conjunction with various modeling techniques. EPA quantified the releases of 132 pollutants of concern under the final and alternative regulatory options.[2] EPA then evaluated potential site-specific aquatic life and human health impacts resulting from the baseline and post-regulation pollutant releases. EPA compared projected water concentrations for each pollutant to either (a) EPA water quality criteria, or (b) toxic effect levels (i.e., lowest reported

[1] The results of the Proposed/NODA Option are not directly comparable to the final option alternatives. The total number of facilities reported for the Proposed/NODA Option analysis differs from the facility count reported for the final rule and the two upgrade options. After deciding in July 2002 not to consider the NODA option as the basis for the final rule, EPA performed no more analysis on the NODA option, including not updating facility counts and related analyses for the change in subcategory and discharge status classifications.

[2] EPA originally identified 150 MP&M POCs. Of these 150 POCs, the Agency estimated loadings for 132 pollutants for the phase 2 proposal and NODA. The benefits analysis presented in earlier chapters is based on 132 pollutants for which loadings are available. The final regulation covers only the Oily Wastes subcategory and benefit reductions were estimated for 122 pollutants.

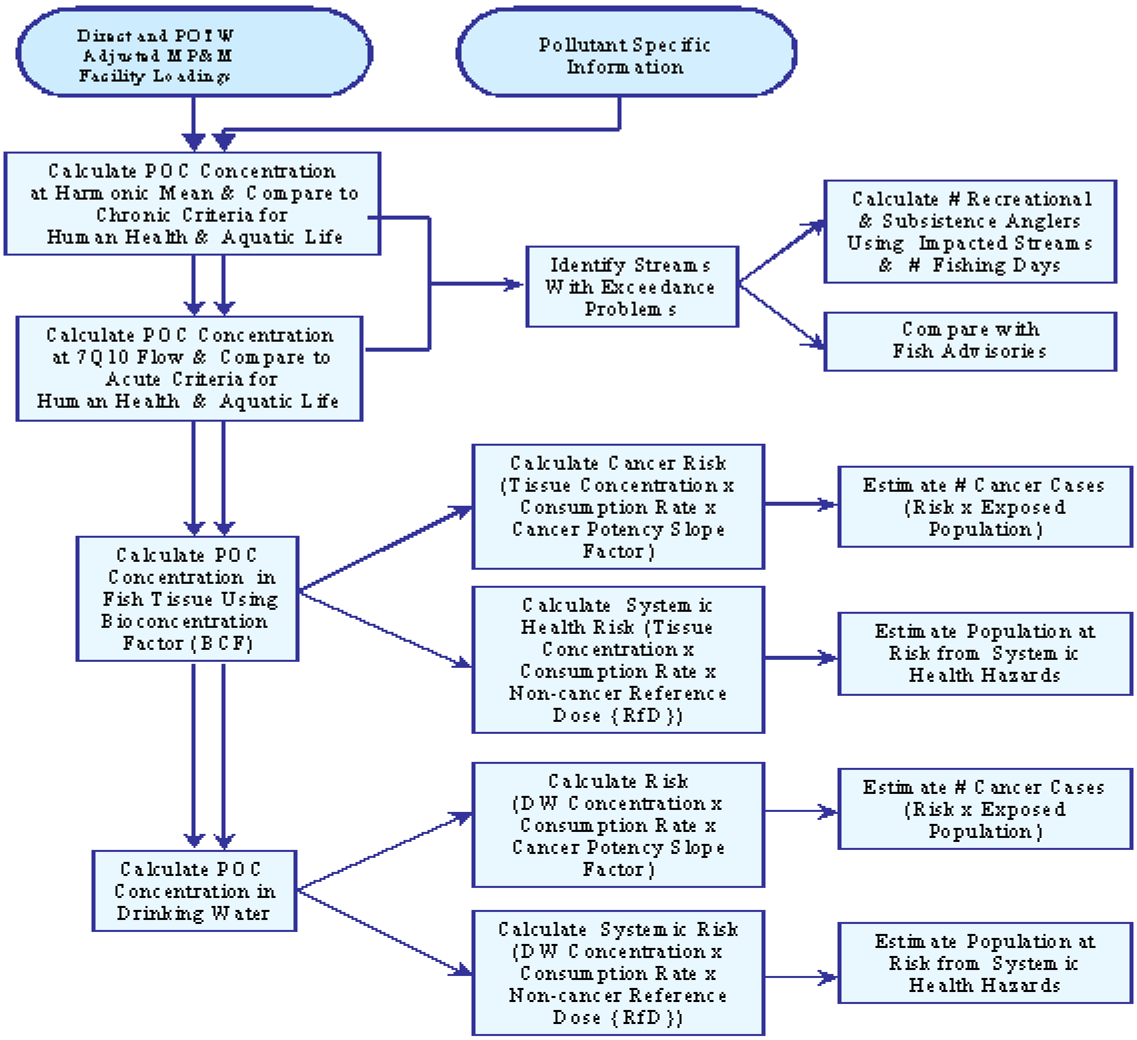
or estimated toxic concentration that causes a problem) in the absence of water quality criteria for a pollutant. Figure I.1 depicts steps used in the environmental assessment. The following sections detail these analytic steps.

Figure I.1a: MP&M Environmental Impact Assessment



Source: U.S. EPA analysis.

Figure I.1b: MP&M Environmental Impact Assessment (Continued)



Source: U.S. EPA analysis.

The remainder of this appendix is organized as follows. Section I.1 provides information on the pollutants found in MP&M discharges. Section I.2 describes the methodology used to estimate environmental impacts, including extrapolation of sample sets to the national level and estimates of water quality impacts. Section I.3 describes data sources for both MP&M facilities and POTWs. Section I.4 presents the environmental assessment results.

I.1 MP&M POLLUTANT CHARACTERIZATION

The extent of human and ecological exposure and risk from environmental releases of toxic chemicals depends on chemical-specific properties, the mechanism and media of release, and site-specific environmental conditions. Chemical-specific properties include toxic effects on living organisms, and the fate of chemicals in the environment. EPA estimated the fate of MP&M pollutants based on their propensity to volatilize, adsorb onto sediments, bioconcentrate, and biodegrade. EPA characterized the fate and toxicity of MP&M pollutants in three steps:

- identifying ***pollutants of concern (POCs)*** in MP&M discharges,
- compiling physical-chemical and toxicity data for those pollutants, and
- grouping pollutants based on their characteristics.

The pollutant-specific fate and toxicity data were used in various portions of the quantitative benefits assessment. In addition, EPA summarized the distribution of MP&M pollutants based on their fate and toxicity properties using the groupings developed in the third step. This summary is presented in Chapter 12.

I.1.1 Identifying MP&M Pollutants

EPA sampled MP&M facilities nationwide to assess the concentrations of pollutants in MP&M effluents. The Agency collected samples of raw wastewater from MP&M facilities and applied standard water analysis protocols to identify and quantify the pollutant levels in each sample. EPA used these analytical data, along with selection criteria, to identify 132 contaminants of potential concern. MP&M POCs include 43 ***priority pollutants (PP)***, 3 conventional pollutants, and 86 nonconventional pollutants.

EPA then evaluated the potential environmental fate of these pollutants and their toxicity to humans and aquatic receptors. EPA was able to assess the potential fate and toxicity of 118 of these pollutants, including 43 priority pollutants (33 priority organics, nine priority metals and one inorganic) and 75 nonconventional pollutants (50 nonconventional organics, 18 nonconventional metals, and seven nonconventional inorganics). Table I.1 presents the potential fate and toxicity, based on known characteristics of each chemical, of 132 pollutants of concern. Potential fate and toxicity data are not available for four conventional, 2 nonconventional, and eight bulk nonconventional pollutants (also listed in Table I.1) associated with adverse water quality impacts, as described in Section 12.1.3 of this report.

Table I.1: Potential Fate and Toxicity of Pollutants of Concern

Type[a]	Pollutant	CAS	Toxicity to Aquatic Life (Freshwater)		Toxicity to Aquatic Life (Saltwater)		Volatility	Adsorption	BCF[b]	Biodeg[c]	RfD[d]	SF[e]	DWC [f/g]	HAP[h]	PP[i]
			Acute	Chronic	Acute	Chronic									
O	Acenaphthene	83329	Moderate	Low	Moderate	Low	Moderate	Moderate	Moderate	Low	✓				✓
O	Acetone	67641	Low	Low	Low	Low	Moderate	Low	Insignificant	Moderate	✓				
O	Acetophenone	98862	Low	Low	Unknown	Unknown	Low	Low	Low	Moderate	✓			✓	
O	Acrolein	107028	High	High	High	High	Moderate	Nonadsorptive	Moderate	Low	✓			✓	✓
O	Aniline	62533	Moderate	High	Low	Low	Low	Low	Low	Moderate		✓		✓	
O	Anthracene	120127	High	High	High	Moderate	Moderate	High	Moderate	Resistant	✓				✓
O	Benzoic acid	65850	Low	Low	Unknown	Unknown	Low	Low	Low	Moderate	✓				
O	Benzyl alcohol	100516	Low	Low	Low	Low	Low	Nonadsorptive	Insignificant	Moderate	✓				
O	Biphenyl	92524	Moderate	Low	Low	Low	Moderate	Moderate	Moderate	Moderate	✓			✓	
O	Bis(2-ethylhexyl) phthalate	117817	Unknown	Unknown	Unknown	Unknown	Nonvolatile	High	Moderate	Moderate	✓	✓	M	✓	✓
O	Bromo-2-chlorobenzene, 1-	694804	Low	Low	Unknown	Unknown	Moderate	Moderate	Moderate	Low					
O	Bromo-3-chlorobenzene, 1-	108372	Low	Low	Unknown	Unknown	Moderate	Moderate	Moderate	Low					
O	Butyl benzyl phthalate	85687	Moderate	Low	Moderate	Low	Low	High	Moderate	Moderate	✓				✓
O	Carbon disulfide	75150	Low	High	Unknown	High	High	Low	Low	Unknown	✓			✓	
O	Chlorobenzene	108907	Low	Low	Low	Low	High	Low	Low	Low	✓		M	✓	✓
O	Chloroethane	75003	Low	Low	Unknown	Unknown	High	Low	Low	Low	✓	✓		✓	✓
O	Cresol, o-	95487	Low	Low	Low	Low	Low	Low	Low	Moderate	✓			✓	
O	Cresol, p-	106445	Low	Low	Unknown	Unknown	Low	Low	Low	High	✓			✓	
O	Cyanide	57125	High	High	High	High	Unknown	Low	Insignificant	Moderate	✓		M		✓
O	Cymene, p-	99876	Low	Low	Low	Low	High	Moderate	High	Low					
O	Decane, n-	124185	Low	Low	Low	Low	Unknown	High	High	Moderate					
O	Dibenzothiophene	132650	Moderate	Low	Unknown	Unknown	Moderate	High	High	Unknown					
O	Dichloroethene, 1,1-	75354	Low	Low	Low	Low	High	Low	Low	Resistant	✓	✓	M	✓	✓
O	Dichloromethane	75092	Low	Low	Low	Low	High	Low	Insignificant	Low	✓	✓	M	✓	✓
O	Dimethyl phthalate	131113	Low	Low	Low	Low	Nonvolatile	Low	Low	Moderate				✓	✓
O	Dimethylformamide, N,N-	68122	Low	Low	Unknown	Unknown	Nonvolatile	Nonadsorptive	Insignificant	Moderate	✓			✓	
O	Dimethylphenanthrene, 3,6-	1576676	Moderate	Moderate	Unknown	Unknown	Low	High	High	Moderate					
O	Dimethylphenol, 2,4-	105679	Low	Low	Unknown	Unknown	Low	Low	Moderate	Moderate	✓				✓
O	Di-n-butyl phthalate	84742	Moderate	Low	Moderate	High	Low	Moderate	Moderate	Moderate	✓			✓	✓
O	Dinitrophenol, 2,4-	51285	Low	Low	Low	Low	Low	Moderate	Insignificant	Resistant	✓			✓	✓
O	Dinitrotoluene, 2,6-	606202	Low	Moderate	Unknown	Unknown	Low	Low	Low	Resistant	✓				✓
O	Di-n-octyl phthalate	117840	Moderate	Moderate	Unknown	Unknown	Low	Moderate	High	Low	✓				✓
O	Dioxane, 1,4-	123911	Low	Low	Unknown	Unknown	Low	Low	Insignificant	Resistant		✓		✓	
O	Diphenylamine	122394	Low	Low	Unknown	Unknown	Low	Moderate	Moderate	Moderate	✓				
O	Diphenyl ether	101848	Moderate	Low	Low	Unknown	Moderate	Moderate	Moderate	Moderate					
O	Docosane, n-	629970	Low	Low	Low	Low	Unknown	High	High	Moderate					
O	Dodecane, n-	112403	Low	Low	Low	Low	Unknown	High	High	Moderate					
O	Eicosane, n-	112958	Low	Low	Low	Low	Unknown	High	High	Moderate					
O	Ethylbenzene	100414	Low	Low	Moderate	Moderate	High	Low	Low	Moderate	✓		M	✓	✓
O	Fluoranthene	206440	High	High	High	Moderate	Moderate	High	High	Resistant	✓				✓
O	Fluorene	86737	Moderate	High	Moderate	Moderate	Moderate	Moderate	Low	Low	✓				✓
O	Hexacosane, n-	630013	Low	Low	Low	Low	Unknown	Unknown	Unknown	Moderate					
O	Hexadecane, n-	544763	Low	Low	Low	Low	Unknown	High	High	Moderate					
O	Hexanoic acid	142621	Low	Low	Unknown	Unknown	Moderate	Low	Low	Moderate					
O	Hexanone, 2-	591786	Low	Low	Unknown	Unknown	Moderate	Low	Low	Moderate	✓				
O	Isobutyl alcohol	78831	Low	Low	Low	Low	Moderate	Low	Insignificant	Moderate	✓				

Table I.1: Potential Fate and Toxicity of Pollutants of Concern

Type[a]	Pollutant	CAS	Toxicity to Aquatic Life (Freshwater)		Toxicity to Aquatic Life (Saltwater)		Volatility	Adsorption	BCF[b]	Biodeg[c]	RfD[d]	SF[e]	DWC [f/g]	HAP[h]	PP[i]
			Acute	Chronic	Acute	Chronic									
O	Isophorone	78591	Low	Low	Low	Low	Low	Low	Insignificant	Low	✓	✓		✓	✓
O	Isopropylnaphthalene, 2-	2027170	Moderate	Moderate	Unknown	Unknown	Moderate	High	High	Unknown					
O	Methyl ethyl ketone	78933	Low	Low	Low	Low	Moderate	Nonadsorptive	Insignificant	Moderate	✓			✓	
O	Methyl isobutyl ketone	108101	Low	Low	Low	Low	Moderate	Low	Insignificant	Moderate	✓			✓	
O	Methyl methacrylate	80626	Low	Low	Unknown	Unknown	Moderate	Low	Low	Low	✓			✓	
O	Methylfluorene, 1-	1730376	Moderate	Low	Unknown	Unknown	Moderate	High	High	Unknown					
O	Methylnaphthalene, 2-	91576	Low	Low	Moderate	Moderate	Moderate	Moderate	High	Moderate	✓				
O	Methylphenanthrene, 1-	832699	Moderate	Moderate	Unknown	Unknown	Low	High	High	Unknown					
O	Naphthalene	91203	Low	Low	Low	Low	Moderate	Low	Low	Moderate	✓			✓	✓
O	Nitrophenol, 2-	88755	Low	Low	Low	Low	Low	Low	Low	Low					✓
O	Nitrophenol, 4-	100027	Low	Low	Low	Low	Nonvolatile	Low	Moderate	Moderate	✓			✓	✓
O	Nitrosodimethylamine, N-	62759	Low	Low	Low	Low	Nonvolatile	Low	Insignificant	Resistant		✓		✓	✓
O	Nitrosodiphenylamine, N-	86306	Low	Low	Low	Low	Low	Moderate	Moderate	Low		✓			✓
O	Nitrosopiperidine, N-	100754	Low	Low	Unknown	Unknown	Nonvolatile	Nonadsorptive	Insignificant	Resistant					
O	Octacosane, n-	630024	Low	Low	Low	Low	Unknown	Unknown	Unknown	Moderate					
O	Octadecane, n-	593453	Low	Low	Low	Low	Unknown	High	High	Moderate					
O	Parachlorometacresol	59507	Low	Low	Unknown	Unknown	Low	Low	Moderate	Low	✓				✓
O	Phenanthrene	85018	Moderate	Moderate	Moderate	Moderate	Moderate	High	Moderate	Resistant					✓
O	Phenol	108952	Low	Low	Low	Low	Low	Low	Insignificant	High	✓			✓	✓
O	Pyrene	129000	Moderate	Moderate	Unknown	Unknown	Moderate	High	High	Resistant	✓				✓
O	Pyridine	110861	Low	Low	Unknown	Unknown	Low	Nonadsorptive	Insignificant	Moderate	✓				
O	Styrene	100425	Low	Low	Low	Low	High	Low	Low	Low	✓		M	✓	
O	Terpineol, alpha-	98555	Low	Low	Unknown	Unknown	Moderate	Low	Low	Moderate					
O	Tetrachloroethene	127184	Low	Low	Low	Low	High	Low	Low	Resistant	✓	✓	M	✓	✓
O	Tetracosane, n-	646311	Low	Low	Low	Low	Unknown	High	High	Moderate					
O	Tetradecane, n-	629594	Low	Low	Low	Low	Unknown	High	High	Moderate					
O	Toluene	108883	Low	Low	Low	Low	High	Low	Low	Moderate	✓		M	✓	✓
O	Triacontane, n-	638686	Low	Low	Low	Low	Unknown	Unknown	Unknown	Moderate					
O	Trichloroethene	79016	Low	Low	Low	Low	High	Low	Low	Resistant	✓	✓	M	✓	✓
O	Trichlorofluoromethane	75694	Low	Low	Unknown	Unknown	High	Low	Low	Resistant	✓				
O	Trichloromethane	67663	Low	Low	Low	Low	High	Low	Insignificant	Resistant	✓	✓	THM	✓	✓
O	Tripropyleneglycolmethylether	20324338	Low	Low	Unknown	Unknown	Nonvolatile	Low	Insignificant	Moderate					
O	Xylene, m-	108383	Low	Low	Low	Low	High	Low	Moderate	Low	✓		M	✓	
O	Xylene, m- & p-*	179601231	Low	Low	Low	Low	High	Low	Moderate	Low	✓		M	✓	
O	Xylene, o-	95476	Low	Low	Low	Low	High	Low	Moderate	Low	✓		M	✓	
O	Xylene, o- & p-*	136777612	Low	Low	Low	Low	High	Low	Moderate	Low	✓		M	✓	
O	Ziram \ Cymate	137304	High	High	Low	Low	Nonvolatile	Nonadsorptive	Insignificant	Resistant	✓				
M	Aluminum	7429905	Moderate	Moderate	Unknown	Unknown	Nonvolatile	High	Moderate	Resistant	✓		SM		
M	Antimony	7440360	Low	Low	Low	Low	Nonvolatile	High	Insignificant	Resistant	✓		M		✓
M	Barium	7440393	Low	Low	Unknown	Unknown	Nonvolatile	High	Unknown	Resistant	✓		M		
M	Beryllium	7440417	Moderate	High	Unknown	Unknown	Nonvolatile	High	Low	Resistant	✓		M		✓
M	Cadmium	7440439	High	High	High	High	Nonvolatile	High	Moderate	Resistant	✓		M		✓
M	Calcium	7440702	Unknown	Low	Unknown	Unknown	Nonvolatile	High	Unknown	Resistant					
M	Chromium	7440473	Moderate	Moderate	Low	Moderate	Nonvolatile	High	Low	Resistant	✓		M		
M	Chromium hexavalent	18540299	High	Moderate	Low	Moderate	Nonvolatile	High	Low	Resistant	✓		M		
M	Cobalt	7440484	Low	Moderate	Unknown	Moderate	Nonvolatile	High	Unknown	Resistant	✓				

Table I.1: Potential Fate and Toxicity of Pollutants of Concern

Type[a]	Pollutant	CAS	Toxicity to Aquatic Life (Freshwater)		Toxicity to Aquatic Life (Saltwater)		Volatility	Adsorption	BCF[b]	Biodeg[c]	RfD[d]	SF[e]	DWC [f/g]	HAP[h]	PP[i]
			Acute	Chronic	Acute	Chronic									
M	Copper	7440508	High	High	High	High	Nonvolatile	High	Moderate	Resistant	✓		TT		✓
M	Gold	7440575	Unknown	Unknown	Unknown	Unknown	Nonvolatile	High	Unknown	Resistant					
M	Iron	7439896	Unknown	Low	Low	Low	Nonvolatile	High	Unknown	Resistant	✓		SM		
M	Lead	7439921	High	High	Moderate	High	Nonvolatile	High	Low	Resistant			TT		✓
M	Magnesium	7439954	Low	Low	Unknown	Unknown	Nonvolatile	High	High	Resistant					
M	Manganese	7439965	Unknown	Low	Unknown	Moderate	Nonvolatile	High	Unknown	Resistant	✓		SM		
M	Mercury	7439976	High	High	High	High	High	High	High	Resistant			M		✓
M	Molybdenum	7439987	Unknown	Moderate	Unknown	Unknown	Nonvolatile	High	Unknown	Resistant	✓				
M	Nickel	7440020	Moderate	Moderate	High	High	Nonvolatile	Low	Low	Resistant	✓		M		✓
M	Selenium	7782492	High	High	Moderate	Moderate	Nonvolatile	High	Insignificant	Resistant	✓		M		
M	Silver	7440224	High	High	High	High	Nonvolatile	High	Insignificant	Resistant	✓		SM		✓
M	Sodium	7440235	Low	Low	Unknown	Unknown	Nonvolatile	High	Unknown	Resistant					
M	Thallium	7440280	Low	Moderate	Low	Low	Nonvolatile	High	Moderate	Resistant	✓		M		✓
M	Tin	7440315	Unknown	Moderate	Unknown	Unknown	Nonvolatile	High	Unknown	Resistant	✓				
M	Titanium	7440326	Unknown	Low	Unknown	Unknown	Nonvolatile	High	Unknown	Resistant	✓				
M	Vanadium	7440622	Low	High	Unknown	Unknown	Nonvolatile	High	Unknown	Resistant	✓				
M	Yttrium	7440655	Unknown	Unknown	Unknown	Unknown	Nonvolatile	High	Unknown	Resistant					
M	Zinc	7440666	Moderate	Low	High	Moderate	Nonvolatile	High	Low	Resistant	✓		SM		
OI	Ammonia as N	7664417	Low	Low	Low	Low	Moderate	Nonadsorptive	Unknown	Moderate					
OI	Arsenic	7440382	Moderate	Low	High	Moderate	Unknown	Unknown	Low	Unknown	✓	✓	M		✓
OI	Boron	7440428	Unknown	Moderate	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	✓				
OI	Chloride	16887006	Low	Low	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown			SM		
OI	Fluoride	16984488	Low	Low	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	✓		M		
OI	Phosphate	14265442	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown					
OI	Sulfate	14808798	Unknown	Low	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown			SM		
OI	Sulfide	18496258	Unknown	High	Unknown	High	Unknown	Unknown	Unknown	Unknown					
OI	Phosphorus (as PO4)		Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown					
CP	BOD 5-day (carbonaceous)	C-003													
CP	Oil and Grease														
CP	Oil and Grease (as Hem)	C-036													
CP	Total Suspended Solids (TSS)	C-009													
BNCP	Amenable Cyanide	C-025													
BNCP	Chemical Oxygen Demand (COD)	C-004													
BNCP	Total Dissolved Solids (TDS)	C-010													
BNCP	Total Kjeldahl Nitrogen	C-021													
BNCP	Total Organic Carbon (TOC)	C-012													

Table I.1: Potential Fate and Toxicity of Pollutants of Concern

Type[a]	Pollutant	CAS	Toxicity to Aquatic Life (Freshwater)		Toxicity to Aquatic Life (Saltwater)		Volatility	Adsorption	BCF[b]	Biodeg[c]	RfD[d]	SF[e]	DWC [f/g]	HAP[h]	PP[i]
			Acute	Chronic	Acute	Chronic									
BNCP	Total Petroleum Hydrocarbons (as Sgt-hem)	C-037													
BNCP	Total Recoverable Phenolics	C-020													
BNCP	Weak-acid Dissociable Cyanide	C-042													

Table Notes:
Unless indicated otherwise, all metals are assumed to be nonvolatile, to have high adsorption, and to be resistant to biodegradation.

[a] Type
- O = Organic
- M = Metal
- OI = Other Inorganic
- CP = Conventional Pollutant
- BNCP = Bulk Nonconventional Pollutant

[b] BCF = Bioconcentration Factor
[c] Biodeg = Biodegradation Potential
[d] RfD = Reference Dose
[e] SF = Slope Factor
[f] DWC = Drinking Water Criteria
[g] Drinking Water Criteria Codes
- M = Maximum Contaminant Level (MCL) established for health-based effect
- SM = Secondary Maximum Contaminant Level (SMCL) established for taste or aesthetic effect
- THM = MCL established for trihalomethanes
- TT = Treatment technology action level established

[h] HAP = Hazardous Air Pollutant
[i] PP = Priority Pollutant

Source: U.S. EPA analysis.

I.1.2 Physical-Chemical Characteristics and Toxicity Data of MP&M Pollutants

Pollutants present in MP&M effluents can have significant effects on human health and aquatic receptors. EPA used various data sources to evaluate both pollutant-specific fate and toxicity and potential human health effects, including:

- ***reference doses (RfDs***),
- ***cancer potency slope factors (SFs)***,
- ***human health-based water quality criteria (WQC***),
- ***maximum contaminant levels (MCLs)*** for drinking water protection and other drinking water related criteria, and
- ***hazardous air pollutant (HAP)*** and priority pollutant (PP) lists.

To evaluate potential fate and effects in aquatic environments, the Agency relied on:

- measures of acute and chronic toxicity to aquatic species,
- bioconcentration factors for aquatic species,
- ***Henry's Law (H)*** constants (to estimate volatility),
- adsorption coefficients (to estimate association with bottom sediments), and
- biodegradation half-lives (to estimate the removal of chemicals via microbial metabolism).

The data sources used in the assessment include:

- EPA ambient WQC documents and updates;
- EPA's ASsessment Tools for the Evaluation of Risk ***(ASTER)***;
- the AQUatic Information REtrieval System ***(AQUIRE)*** and the ***Environmental Research Laboratory-Duluth fathead minnow database***;
- EPA's ***Integrated Risk Information System (IRIS)***;
- EPA's ***Health Effects Assessment Summary Tables (HEAST)***;
- EPA's 1991 and 1993 ***Superfund Chemical Data Matrix (SCDM)***;
- Syracuse Research Corporation's ***CHEMFATE*** and ***BIODEG*** databases; and
- EPA and other government reports, scientific literature, and other primary and secondary data sources.

EPA also obtained information on chemicals for which the sources listed above did not provide physical-chemical properties and/or toxicity data, to ensure that the assessment be as comprehensive as possible. To the extent possible, EPA estimated values for the chemicals using the ***quantitative structure-activity relationship (QSAR)*** model incorporated in ASTER. The Agency also used published linear regression correlation equations to determine some physical-chemical properties.

a. Human health effects

EPA used various data sources to determine pollutant-specific toxicity to human health. EPA obtained RfDs and SFs from IRIS, HEAST, and EPA's Region II Risk-Based Concentration ***(RBC)*** table. EPA developed drinking water criteria and human health-based AWQC values for two exposure routes: (1) ingesting the pollutant via contaminated aquatic organisms only (carcinogens and non-carcinogens), and (2) ingesting the pollutant via both water and contaminated aquatic organisms (non-carcinogens only). Table I.2 summarizes pollutant toxicity data pertaining to human health. In addition to fate and toxicity data, Table I.1 also includes HAP and PP lists. Short descriptions and definitions for each of the measures of human health effects are provided below.

Table I.2: Human Health Data for 132 MP&M Pollutants of Concern

CAS Number	Pollutant Name	Human Health AWQC Values				
		Ingesting Water and Organisms	Ingesting Organisms Only	Slope Factor	Reference Dose	Drinking Water Criteria
		(μg/l)	(μg/l)	(mg/kg/day)	(mg/kg/day)	(μg/l)
51285	Dinitrophenol, 2,4-	70	14000		0.002	
57125	Cyanide	700	220000		0.02	200
59507	Parachlorometacresol	56000	270000		2	
62533	Aniline	5.8	95	0.0057		
62759	Nitrosodimethylamine, N-	0.00069	8.1	51		
65850	Benzoic acid	130000	2900000		4	
67641	Acetone	3500	2800000		0.1	
67663	Trichloromethane	5.7	470	0.0061	0.01	100
68122	Dimethylformamide, N,N-	3500	220000000		0.1	
75003	Chloroethane	12	520	0.0029	0.4	
75092	Dichloromethane	4.7	1600	0.0075	0.06	5
75150	Carbon disulfide	3400	94000		0.1	
75354	Dichloroethene, 1,1-	0.057	3.2	0.6	0.009	7
75694	Trichlorofluoromethane	9100	66000		0.3	
78591	Isophorone	36	2600	0.00095	0.2	
78831	Isobutyl alcohol	10000	1500000		0.3	
78933	Methyl ethyl ketone	21000	6500000		0.6	
79016	Trichloroethene	3.1	92	0.011	0.006	5
80626	Methyl methacrylate	48000	2300000		1.4	
83329	Acenaphthene	1200	2700		0.06	
84742	Di-n-butyl phthalate	2700	12000		0.1	
85018	Phenanthrene					
85687	Butyl benzyl phthalate	3000	5200		0.2	
86306	Nitrosodiphenylamine, N-	5	16	0.0049		
86737	Fluorene	720	1500		0.04	
88755	Nitrophenol, 2-					
91203	Naphthalene	680	21000		0.02	
91576	Methylnaphthalene, 2-	75	84		0.02	
92524	Biphenyl	720	1200		0.05	
95476	Xylene, o-	42000	100000		2	10000
95487	Cresol, o-	1700	30000		0.05	
98555	Terpineol, alpha-					
98862	Acetophenone	3400	98000		0.1	
99876	Cymene, p-					
100027	Nitrophenol, 4-	220	1100		0.008	
100414	Ethylbenzene	3100	29000		0.1	700
100425	Styrene	6700	160000		0.2	100
100516	Benzyl alcohol	10000	810000		0.3	
100754	Nitrosopiperidine, N-					
101848	Diphenyl Ether					
105679	Dimethylphenol, 2,4-	540	2300		0.02	
106445	Cresol, p-	170	3100		0.005	
107028	Acrolein	410	1000		0.02	

Table I.2: Human Health Data for 132 MP&M Pollutants of Concern

CAS Number	Pollutant Name	Human Health AWQC Values				
		Ingesting Water and Organisms (µg/l)	Ingesting Organisms Only (µg/l)	Slope Factor (mg/kg/day)	Reference Dose (mg/kg/day)	Drinking Water Criteria (µg/l)
108101	Methyl isobutyl ketone	2800	360000		0.08	
108372	Bromo-3-chlorobenzene, 1-					
108383	Xylene, m-	42000	100000		2	10000
108883	Toluene	6800	200000		0.2	1000
108907	Chlorobenzene	680	21000		0.02	100
108952	Phenol	21000	4600000		0.6	
110861	Pyridine	35	5400		0.001	
112403	Dodecane, n- (a)					
112958	Eicosane, n- (a)					
117817	Bis(2-ethylhexyl) phthalate	1.8	5.9	0.014	0.02	6
117840	Di-n-octyl phthalate	37	39		0.02	
120127	Anthracene	4100	6800		0.3	
122394	Diphenylamine	470	1000		0.025	
123911	Dioxane, 1,4-	3.2	2400	0.011		
124185	Decane, n-					
127184	Tetrachloroethene	320	3500	0.052	0.01	5
129000	Pyrene	230	290		0.03	
131113	Dimethyl phthalate	310000	2900000			
132650	Dibenzothiophene					
137304	Ziram \ Cymate	700	220000000		0.02	
142621	Hexanoic acid					
206440	Fluoranthene	300	370		0.04	
544763	Hexadecane, n- (a)					
591786	Hexanone, 2-	1400	65000		0.04	
593453	Octadecane, n- (a)					
606202	Dinitrotoluene, 2,6-	34	900		0.001	
629594	Tetradecane, n- (a)					
629970	Docosane, n-					
630013	Hexacosane, n- (b)					
630024	Octacosane, n- (b)					
638686	Triacontane, n- (b)					
646311	Tetracosane, n- (b)					
694804	Bromo-2-chlorobenzene, 1-					
832699	Methylphenanthrene, 1-					
1576676	Dimethylphenanthrene, 3,6-					
1730376	Methylfluorene, 1-					
2027170	Isopropylnaphthalene, 2-					
7429905	Aluminum	20000	47000		1	50
7439896	Iron	300			0.3	300
7439921	Lead					15
7439954	Magnesium					
7439965	Manganese	50	100		0.14	50
7439976	Mercury	0.05	0.051			2
7439987	Molybdenum				0.005	
7440020	Nickel	610	4600		0.02	
7440224	Silver	170	110000		0.005	100
7440235	Sodium					
7440280	Thallium	1.8	6.5		0.00007	2

Table I.2: Human Health Data for 132 MP&M Pollutants of Concern

CAS Number	Pollutant Name	Human Health AWQC Values				
		Ingesting Water and Organisms (μg/l)	Ingesting Organisms Only (μg/l)	Slope Factor (mg/kg/day)	Reference Dose (mg/kg/day)	Drinking Water Criteria (μg/l)
7440315	Tin				0.6	
7440326	Titanium				4	
7440360	Antimony	14	4300		0.0004	6
7440382	Arsenic	0.02	0.16	1.5	0.0003	50
7440393	Barium	1000			0.07	2000
7440417	Beryllium	66	1100		0.002	4
7440428	Boron				0.09	
7440439	Cadmium	14	84		0.0005	5
7440473	Chromium	50000	1000000		1.5	100
7440484	Cobalt				0.06	
7440508	Copper	650	1200		0.04	1300
7440575	Gold					
7440622	Vanadium				0.007	
7440655	Yttrium					
7440666	Zinc	9100	69000		0.3	5000
7440702	Calcium					
7664417	Ammonia as N					
7782492	Selenium	170	11000		0.005	50
14265442	Phosphate					
14808798	Sulfate					250000
16887006	Chloride					250000
16984488	Fluoride				0.06	4000
18496258	Sulfide	100	10000			
18540299	Chromium hexavalent	100	2000		0.003	100
20324338	Tripropyleneglycolmethyl ether					
136777612	Xylene, o- & p- (c)	42000	100000		2	10000
179601231	Xylene, m- & p- (c)	42000	100000		2	10000
C003	BOD 5-day (carbonaceous)					
C004	Chemical Oxygen Demand (COD)					
C009	Total Suspended Solids (TSS)					
C010	Total Dissolved Solids (TDS)					
C012	Total Organic Carbon (TOC)					
C020	Total Recoverable Phenolics					
C021	Total Kjeldahl Nitrogen					
C025	Amenable Cyanide					
C036	Oil And Grease (as Hem)					
C037	Total Petroleum Hydrocarbons (as Sgt-hem)					
C042	Weak-acid Dissociable Cyanide					
	Phosphorus (as PO4)					
	Oil and Grease					

Sources: U.S. EPA (1980), U.S. EPA (1984), U.S. EPA (1997), U.S. EPA (1998), U.S. EPA (1998/99), Worthing (1987).

❖ *Systemic toxicants*

Systemic toxicants are chemicals that EPA believes can cause significant non-carcinogenic health effects when present in the human body above chemical-specific toxicity thresholds. These effects may result from acute or chronic chemical exposures, and include:

- systemic health effects (i.e., loss of one or more neurological, respiratory, reproductive, immunological, or circulatory functions);
- organ-specific toxicity (e.g., liver and kidney effects);
- developmental toxicity (e.g., reduced weight in newborns or loss of IQ); and
- lethality.

EPA typically relies on animal toxicity data to develop RfDs for systemic toxicants that can enter the human body via ingestion. These values represent chemical concentrations expressed in mg of pollutant/kg body weight/day. Certain exposed populations are considered to be protected if these chemical concentrations are not exceeded. These populations include sensitive groups, such as young children or pregnant women. EPA included all available RfD data for the MP&M pollutants of concern (POCs) in the analysis.

❖ *Carcinogens*

Carcinogens are chemicals that EPA believes can cause or have the potential to cause cellular damage, which can lead to tumors or cancers in humans, either directly or indirectly. Unlike systemic toxicants, most carcinogens are not believed to have a toxicity threshold. Any amount of a carcinogen therefore has the potential to result in a cancer event, even though such a probability can be very small at low concentrations. The Agency has developed SFs, using animal or epidemiological data, that express the probability that a chemical will induce tumor or cancer development. EPA included all available SF data for the MP&M POCs in the analysis.

❖ *Drinking water criteria*

EPA developed human health-based drinking water criteria to assess the health hazards associated with the presence of certain toxic chemicals in drinking water. The criteria are usually presented as MCLs. MCLs for non-carcinogens represent chemical-specific concentrations (expressed in **µg/l**) that are not expected to result in adverse health effects in exposed populations if not exceeded in drinking water. MCLs for carcinogens represent chemical-specific concentrations (expressed in µg/l) that are expected to result in less than one additional cancer case per million lifetime exposures if not exceeded in drinking water. The Agency also investigated additional drinking water criteria, including:

- ***Secondary Maximum Contaminant Levels*** **(SMCLs)** established for taste or aesthetic effects,
- MCLs established specifically for trihalomethanes, and
- ***action levels*** developed on the basis of treatment technology.

EPA included all the available primary and secondary drinking water criteria for the MP&M POCs in the analysis.

❖ *Pollutant uptake via water and/or organisms*

EPA has developed WQC for numerous priority toxic pollutants to protect the health of humans who consume water and organisms or only organisms obtained from aquatic habitats contaminated by those PPs. The criteria, expressed in µg/l, represent concentrations in surface waters that will cause adverse health effects in humans when exceeded. EPA obtained all available human health WQC for the MP&M POCs and included them in the analysis.

❖ *Priority pollutants (PPs)*

Priority pollutants are 126 individual chemicals, defined by the Agency as toxic, that EPA routinely analyzes when assessing contaminated surface water, sediment, groundwater, or soil samples. These chemicals are of particular concern to the Agency because of their high toxicity or persistence in the environment. EPA identified all MP&M PPs and included them in the analysis.

❖ ***Hazardous air pollutants (HAPs)***
HAPs are compounds that EPA believes may represent an unacceptable risk to human health if present in the air. HAPs, expressed in $\mu g/m^3$, can be of particular concern to POTW workers if released into the air at high enough concentrations during the wastewater treatment cycle. EPA identified all HAPs among the MP&M POCs analyzed.

b. Aquatic receptor effects

The potential impact of chemicals on aquatic receptors can be assessed qualitatively based on five effect and fate parameters:

- aquatic toxicity (acute and chronic),
- bioconcentration,
- volatilization,
- adsorption, and
- biodegradation.

Site-specific risks require a measure of exposure and cannot be quantified using this approach. Chemicals can be classified and ranked in terms of their impacts on aquatic receptors, however, by using the five parameters discussed below. Table I.3 summarizes the measured or estimated values of these parameters for the MP&M POCs. Each effect and fate parameter is described below.

Biological oxygen demand (BOD), ***oil and grease (O&G)***, ***pH***, and ***total suspended solids (TSS)***: These fate/effect parameters are relevant only for specific chemicals. These parameters are not available for the conventional pollutants or bulk nonconventional pollutants, such as ***total petroleum hydrocarbons (TPH)***, ***alkalinity***, ***total organic carbon (TOC)***, or ***total Kjeldahl nitrogen (TKN)***. Most of these pollutants are responsible for significant environmental impacts, however. Section 12.2.4 outlines these impacts in greater detail.

❖ ***Aquatic toxicity data***
The Agency addressed two general classes of aquatic toxicity:

- ***Acute toxicity (AT)*** assesses the impacts of a pollutant after a relatively short exposure duration, typically 48 and 96 hours for invertebrates and fish, respectively. The endpoint of concern is mortality, reported as the ***LC50***. This value represents the concentration lethal to 50 percent of the test organisms for the duration of the exposure.

- ***Chronic toxicity (CT)*** assesses the impact of a pollutant after a longer exposure duration, typically from one week to several months. The endpoints of concern are one or more sub-lethal responses, such as changes in reproduction or growth in the affected organisms. The results are reported in various ways, including ***EC1*** or ***EC5*** (i.e., the concentration at which one percent or five percent of the test organisms show a significant sub-lethal response), ***NOEC (No Observed Effect Concentration), LOEC (Lowest Observed Effect Concentration)***, or ***MATC (Maximum Allowable Toxicant Concentration)***.

❖ ***Bioconcentration factor (BCF) data***
The ***bioconcentration factor*** (***BCF***, measured in ***l/kg***) is a good indicator of the potential for a chemical dissolved in the water column to be taken up by aquatic biota across external surface membranes, usually fish gills. The BCF is defined as follows:

$$\text{BCF} = \frac{\textit{equilibrium chemical concentration in target organism (mg/kg, wet weight)}}{\textit{mean chemical concentration in surrounding water } (\mu g/L)} \qquad \text{(I.1)}$$

EPA analyzes POCs with elevated BCF values because these pollutants can bioconcentrate in aquatic organisms and transfer up the food chain if they are not metabolized and excreted. This transfer can result in significant exposures to predators (including humans) consuming contaminated fish or shellfish.

Although the bioaccumulation factor (BAF) is a better measure of the potential for a chemical dissolved in the water column to be taken up by aquatic biota, field measured BAFs are not yet available. EPA recognizes that using bioconcentration factors will underestimate the risk to aquatic organisms.

❖ *Volatilization data*

Volatilization is a process whereby chemicals dissolved in water escape into the air. Chemicals with higher volatilization potential are typically of less concern to aquatic receptors because they tend to be removed quickly from the water column. These volatile pollutants are a concern to human health when inhaled. For aquatic receptors, however, POCs with higher volatilization potential present lower hazards.

EPA used the air/water partitioning coefficient H to estimate a chemical's volatilization potential. H represents the ratio of a chemical's aqueous phase concentration to its equilibrium partial pressure in the gas phase (at 25°C); units are typically expressed as **$atm.m^3/mole$**. Metals do not have measurable partial pressures (with some notable exceptions, including several organic mercury compounds), and are therefore considered to be nonvolatile unless otherwise indicated.

❖ *Adsorption data*

Adsorption is a process whereby chemicals associate preferentially with the **organic carbon (OC)** found in soils and sediments. Highly adsorptive compounds tend to accumulate in sludge or sediments. Such chemicals are also more likely to be taken up by **benthic** invertebrates and to affect local food chains. Both accumulation in sediment and the effect on local food chains make these chemicals more likely to impact higher predators, including humans.

EPA used the **adsorption coefficient (K_{oc})** to assess the potential of organic MP&M POCs to associate with organic carbon. K_{oc} represents the ratio of the target chemical adsorbed per unit weight of organic carbon in the soil or sediment to the concentration of that same chemical in solution at equilibrium. Metals in the aquatic environment typically end up in the sediment phase but do not bind to the organic carbon (except for nickel). The Agency assumed that all metals show a high affinity for sludge and sediments independent of their negligible K_{oc} values.

❖ *Biodegradation data*

Biodegradation is a process whereby organic molecules are broken down by microbial metabolism. Biodegradation represents an important removal process: compounds that are readily biodegraded generally represent lower intrinsic hazards because they can be eliminated rapidly. These compounds are therefore less likely to create long-term toxicity problems or to accumulate in sludge or sediments and organisms. Chemicals that biodegrade slowly or not at all can accumulate and linger for longer periods of time in sludge or sediments, and represent a higher hazard to aquatic receptors.

EPA used **biodegradation half-life** to estimate the potential for an organic chemical to biodegrade in the aquatic environment. Biodegradation half-life represents the number of days a compound takes to be degraded to half of its starting concentration under prescribed laboratory conditions. Metals do not biodegrade.

Table I.3 summarizes pollutant toxicity data pertaining to aquatic life.

Table I.3: Aquatic Life Toxicity Data for 132 MP&M Pollutants of Concern

CAS Number	Pollutant Name	Freshwater Aquatic Life		Saltwater Aquatic Life		Bio concentration Factor	Henry's Law Constant	Adsorption Coefficient (K_{oc})	Bio degradation Half-Life
		Acute Value (µg/l)	Chronic Value (µg/l)	Acute Value (µg/l)	Chronic Value (µg/l)	Value (l/kg)	Value (atm/ m^3-mole)	Value	Value (days)
51285	Dinitrophenol, 2,4-	1160	790	1500	940	1.51	0.000000443	2386	263
57125	Cyanide	22	5.2	1	1	1		45	16
59507	Parachlorometacresol	4050	1300			79	0.0000025	604	100
62533	Aniline	250	4	29400	2940	19.9	0.0000019	54	26
62759	Nitrosodimethylamine, N-	280000	4000	4300000	430000	0.026	0.000000263	12	180
65850	Benzoic acid	180000	17178			15	0.00000154	182	16
67641	Acetone	6210000	1866000	5640000	10000	0.39	0.00004	18	7
67663	Trichloromethane	13300	6300	19610	1961	3.75	0.00367	40	180
68122	Dimethylformamide, N,N-	7100000	710000			0.005	0.000000018	6.1	16
75003	Chloroethane	65614	21069			7.2	0.00882	37.6	28
75092	Dichloromethane	330000	82500	256000	2560	0.91	0.00219	28	28
75150	Carbon disulfide	2100	2		2	11.5	0.0303	89	
75354	Dichloroethene, 1,1-	11600	5114	224000	22400	5.6	0.0261	343	180
75694	Trichlorofluoromethane	17387	6412			49	0.097	93	360
78591	Isophorone	120000	11000	12900	1290	4.38	0.00000576	25	28
78831	Isobutyl alcohol	949000	4000	600000	60000	2.2	0.0000118	61.7	7.2
78933	Methyl ethyl ketone	3220000	233550	1287000	128700	1	0.00006	5.2	7
79016	Trichloroethene	40700	14850	14000	2000	10.6	0.0103	104	360
80626	Methyl methacrylate	191000	19100			6.6	0.00034	22	28
83329	Acenaphthene	580	208	970	710	242	0.00009	3890	102
84742	Di-n-butyl phthalate	850	500	450	3.4	89	0.00000181	6310	23
85018	Phenanthrene	180	19	110	11	486	0.00002	18800	200
85687	Butyl benzyl phthalate	820	260	510	400	414	0.00000126	17000	7
86306	Nitrosodiphenylamine, N-	5800	1000	3300000	33000	136	0.000005	1200	34
86737	Fluorene	212	8	1000	100	30	0.00006	2830	60
88755	Nitrophenol, 2-	160000	3451	32000	16000	13.5	0.00000947	114	28
91203	Naphthalene	1600	370	1200	120	10.5	0.00048	871	20
91576	Methylnaphthalene, 2-	1133	417	600	60	2566	0.00052	8500	20
92524	Biphenyl	360	230	4600	460	436	0.0003	1400	7
95476	Xylene, o-	3820	1332	6000	600	208	0.00519	129	28
95487	Cresol, o-	14000	2251	10200	1020	18	0.0000012	103	7
98555	Terpineol, alpha-	12742	4879			48	0.0000544	589	15

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		Acute Value (µg/l)	Chronic Value (µg/l)	Acute Value (µg/l)	Chronic Value (µg/l)	Value (l/kg)	Value (atm/ m^3-mole)	Value	Value (days)
98862	Acetophenone	162000	31094			11	0.00001	45	16
99876	Cymene, p-	6500	237	4400	440	770	0.011	4000	100
100027	Nitrophenol, 4-	7680	1300	7170	1900	79	0.000000000415	236	7
100414	Ethylbenzene	9090	4600	430	43	37.5	0.00788	250	10
100425	Styrene	4020	402	9100	910	13.5	0.00283	920	28
100516	Benzyl alcohol	10000	1000	15000	1500	4	0.000000743	6.1	16
100754	Nitrosopiperidine, N-	1019538	282592				0.000000275	9	180
101848	Diphenyl Ether	4000			240	930	0.000448	7800	15
105679	Dimethylphenol, 2,4-	2120	1970			94	0.000000951	18	7
106445	Cresol, p-	7500	2570			17.6	0.000001	49	0.667
107028	Acrolein	14	5.8	55	5.5	215	0.00012	5	28
108101	Methyl isobutyl ketone	505000	50445	812000	81200	2.4	0.00014	19	7
108372	Bromo-3-chlorobenzene, 1-	1784	682			190	0.00078	1500	100
108383	Xylene, m-	16000	3900	12000	1200	208	0.00718	190	28
108883	Toluene	5500	1000	6300	5000	10.7	0.00664	95	22
108907	Chlorobenzene	2370	2100	10500	1050	10.3	0.00377	275	150
108952	Phenol	4200	200	5800	2410	1.4	0.000000333	30.2	3.5
110861	Pyridine	93800	25000			2	0.00000888	5	7
112403	Dodecane, n- (a)	18000	1300	500000	50000	14500		95000	17
112958	Eicosane, n- (a)	18000	1300	500000	50000	100000		30000000	17
117817	Bis(2-ethylhexyl) phthalate					130	0.0000001	87420	23
117840	Di-n-octyl phthalate	690	69			5460	0.000000445	2390	28
120127	Anthracene	2.78	2.2	40	16	478	0.00007	16000	460
122394	Diphenylamine	3790	734			269	0.000000496	1910	20
123911	Dioxane, 1,4-	9850000	1457300			0.4	0.0000048	17	180
124185	Decane, n- [a]	18000	1300	500000	50000	8800		58200	17
127184	Tetrachloroethene	4990	510	10200	450	30.6	0.0184	363	360
129000	Pyrene	591	61			1110	0.000011	62700	1900
131113	Dimethyl phthalate	33000	1700	58000	5800	36	0.000000105	40	7
132650	Dibenzothiophene	420	122			1100	0.00002	11000	
137304	Ziram \ Cymate	8	1.8	5200	520	0.001		0.4	
142621	Hexanoic acid	320000	15170			16	0.0000225	38	12

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CAS Number	Pollutant Name	Freshwater Aquatic Life		Saltwater Aquatic Life		Bio concentration Factor	Henry's Law Constant	Adsorption Coefficient (K_{oc})	Bio degradation Half-Life
		Acute Value (µg/l)	Chronic Value (µg/l)	Acute Value (µg/l)	Chronic Value (µg/l)	Value (l/kg)	Value (atm/ m^3-mole)	Value	Value (days)
206440	Fluoranthene	45	7.1	40	16	1150	0.0000161	41700	440
544763	Hexadecane, n- (a)	18000	1300	500000	50000	32300		207000	17
591786	Hexanone, 2-	428000	38868			6.6	0.000113	12	16
593453	Octadecane, n- (a)	18000	1300	500000	50000	10100		66900	17
606202	Dinitrotoluene, 2,6-	18500	60			12	0.000000747	100	180
629594	Tetradecane, n- (a)	18000	1300	500000	50000	19500		126000	17
629970	Docosane, n- [b]	530000	68000	500000	50000	100000		110000000	17
630013	Hexacosane, n- (b)	530000	68000	500000	50000				17
630024	Octacosane, n- (b)	530000	68000	500000	50000				17
638686	Triacontane, n- (b)	530000	68000	500000	50000				17
646311	Tetracosane, n- (b)	530000	68000	500000	50000	100000		420000000	17
694804	Bromo-2-chlorobenzene, 1-	2942	1196			240	0.0006	1500	100
832699	Methylphenanthrene, 1-	555	54			4790	0.0000078	36000	
1576676	Dimethylphenanthrene, 3,6-	543	21			33000	0.0000053	330000	20
1730376	Methylfluorene, 1-	627	115			3300	0.00008	33000	
2027170	Isopropylnaphthalene, 2-	540	78			3200	0.00063	33000	
7429905	Aluminum	750	87			231			
7439896	Iron		1000	33000	3300				
7439921	Lead	65	2.5	210	8.1	49			
7439954	Magnesium	64700	6470			85215			
7439965	Manganese		388		10				
7439976	Mercury	1.4	0.77	1.8	0.94	5500	0.018	30000	
7439987	Molybdenum		27.8						
7440020	Nickel	470	52	74	8.2	47		300	
7440224	Silver	3.4	0.34	1.9	0.19	0.5			
7440235	Sodium	1640000	1020000						
7440280	Thallium	1400	40	2130	213	116			
7440315	Tin		18.6						
7440326	Titanium		191						
7440360	Antimony	3500	1600	4800	2900	1			
7440382	Arsenic	340	150	69	36	44			
7440393	Barium	410000	2813						

Table I.3: Aquatic Life Toxicity Data for 132 MP&M Pollutants of Concern

CAS Number	Pollutant Name	Freshwater Aquatic Life		Saltwater Aquatic Life		Bio concentration Factor	Henry's Law Constant	Adsorption Coefficient (K_{oc})	Bio degradation Half-Life
		Acute Value (µg/l)	Chronic Value (µg/l)	Acute Value (µg/l)	Chronic Value (µg/l)	Value (l/kg)	Value (atm/ m^3-mole)	Value	Value (days)
7440417	Beryllium	130	5.3			19			
7440428	Boron		31.6						
7440439	Cadmium	4.3	2.2	42	9.3	64			
7440473	Chromium	570	74	1100	50	16			
7440484	Cobalt	1620	49		10				
7440508	Copper	13	9	4.8	3.1	360			
7440575	Gold								
7440622	Vanadium	11200	9						
7440655	Yttrium								
7440666	Zinc	120	120	90	81	47			
7440702	Calcium		200000						
7664417	Ammonia as N	13300	3060	3800	570		0.0000161	3.1	16
7782492	Selenium	12.83	5	290	71	4.8			
14265442	Phosphate								
14808798	Sulfate		1000000						
16887006	Chloride	860000	230000						
16984488	Fluoride	1600	160						
18496258	Sulfide		2		2				
18540299	Chromium hexavalent	16	11	1100	50	16			
20324338	Tripropyleneglycolmethylether	2484600	683870			0.2	0.0000000001	46	16
136777612	Xylene, o- & p- [c]	2600	1205	6000	600	208	0.0076	260	28
179601231	Xylene, m- & p- [c]	2600	1205	6000	600	208	0.0076	260	28
C003	BOD 5-day (carbonaceous)								
C004	Chemical Oxygen Demand (COD)								
C009	Total Suspended Solids (TSS)								
C010	Total Dissolved Solids (TDS)								
C012	Total Organic Carbon (TOC)								
C020	Total Recoverable Phenolics								
C021	Total Kjeldahl Nitrogen								
C025	Amenable Cyanide								
C036	Oil and Grease (as Hem)								

Table I.3: Aquatic Life Toxicity Data for 132 MP&M Pollutants of Concern

CAS Number	Pollutant Name	Freshwater Aquatic Life		Saltwater Aquatic Life		Bio concentration Factor	Henry's Law Constant	Adsorption Coefficient (K_{oc})	Bio degradation Half-Life
		Acute Value (µg/l)	Chronic Value (µg/l)	Acute Value (µg/l)	Chronic Value (µg/l)	Value (l/kg)	Value (atm/ m^3-mole)	Value	Value (days)
C037	Total Petroleum Hydrocarbons (as Sgt-hem)								
C042	Weak-acid Dissociable Cyanide								
	Phosphorus (as PO4)								
	Oil and Grease								

[a] Aquatic toxicity data for n-decane are reported based on structural similarity
[b] Aquatic toxicity data for n-docosane are reported based on structural similarity
[c] Values for the most stringent isomer (p-Xylene) are assumed

Sources: Arthur D. Little (1983), Arthur D. Little (1986), Birge et al. (1979), Clay (1986), Holdway and Spraque (1979), ICF, Inc. (1985), Leblanc (1980), Lyman et al. (1981), U.S. Atomic Energy Commission (1973), U.S. EPA (1972), U.S. EPA (1976), U.S. EPA (1980), U.S. EPA (1993), U.S. EPA (1998/99a), U.S. EPA (1998/99b), Zhang and Zhang (1982).

I.1.3 Grouping MP&M Pollutants Based on Risk to Aquatic Receptors

The impact assessment for aquatic receptors looks at the six individual fate and effects parameters for each MP&M POC, including acute and chronic aquatic toxicities, bioconcentration factors, Henry's Law constants, adsorption coefficients, and biodegradation half-lives. EPA grouped POCs with similar attributes, and assigned qualitative descriptors of potential environmental behavior and impact to each group. This grouping was used to describe the range of MP&M pollutant characteristics in Chapter 12. The grouping described below focuses specifically on aquatic environments and their biological receptors; it does not cover the human health toxicity data discussed in the previous section.

Table I.4 provides a summary of the categorization scheme for the six fate and effects parameters.

Table I.4: Summary of Categorization Scheme For Six Fate and Effects Parameters

Parameter	High Hazard	Moderate Hazard	Low Hazard	Insignificant Hazard
Acute Toxicity (AT)	AT < 100µg/l	100 ≤ AT≤ 1,000µg/l	AT > 1,000µg/l	
Chronic Toxicity (CT)	CT < 10µg/l	10 ≤ CT ≤ 100µg/l	CT > 100µg/l	
Bioconcentration Factor (BCF)	BCF > 500	50 ≤ BCF ≤ 500	5 ≤ BCF < 50	BCF < 5
Henry's Law Constant (H)	$H > 10^{-3}$	$10^{-5} \leq H \leq 10^{-3}$	$3.0x10^{-7} \leq H < 10^{-5}$	$H < 3.0x10^{-7}$
Adsorption Coefficient (K_{OC})	K_{oc} > 10,000	1,000 ≤ K_{oc} ≤ 10,000	10 ≤ K_{oc} < 1,000	K_{oc} < 10
Biodegradation Half-Life ($t_{1/2}$)	$t_{1/2}$ < 7 d	7 d ≤ $t_{1/2}$ < 28 d	28 d ≤$t_{1/2}$ < 180 d	$t_{1/2}$ ≥180 d

Source: U.S. EPA analysis.

a. Acute and chronic aquatic toxicity

EPA used the available AT data to group chemicals according to their relative short-term effects on aquatic organisms, using the following categories:

- AT < 100µg/l — High acute toxicity
- 100µg/l ≤ AT ≤ 1,000µg/l — Moderate acute toxicity
- AT > 1,000 µg/l — Low acute toxicity

These categories reflect the fact that acute toxicity decreases when higher concentrations of a pollutant are required to induce short-term mortality in the test organisms. EPA's Office of Pollution Prevention and Toxics (OPPT) uses this categorization as guidance to assess data submitted in ***Premanufacture Notices (PMN)*** (EPA, 1996).

EPA used the available CT data to group chemicals according to their relative long-term effects on aquatic organisms, based on the following categories:

- CT < 10µg/l — High chronic toxicity
- 10µg/l ≤ CT ≤ 100µg/l — Moderate chronic toxicity
- CT > 100 µg/l — Low chronic toxicity

These categories assume that CT occurs at a concentration averaging one tenth of that responsible for acute toxicity. They also reflect the fact that chronic toxicity decreases when higher concentrations of a pollutant are required to induce longer-term lethal or sub-lethal responses in the test organisms.

b. Bioconcentration factor (BCF)

EPA used the available BCF data to group chemicals according to their potential to bioconcentrate in aquatic organisms, based on the following categories:

- $BCF > 500$ High potential to bioconcentrate
- $50 \leq BCF \leq 500$ Moderate potential to bioconcentrate
- $5 \leq BCF < 50$ Low potential to bioconcentrate
- $BCF < 5$ No significant potential to bioconcentrate

These categories reflect the fact that decreased BCF reduces the intrinsic hazard of a chemical to aquatic receptors, because the chemical is less likely to accumulate in biological tissues.

c. Volatilization potential

EPA used available H data to group organic chemicals according to their potential to volatilize from water into air, based on the following categories:

- $H > 10^{-3}$ High potential to volatilize
- $10^{-5} \leq H \leq 10^{-3}$ Moderate potential to volatilize
- $3.0\times10^{-7} \leq H < 10^{-5}$ Low potential to volatilize
- $H < 3.0\times10^{-7}$ No potential to volatilize

Increased volatility decreases a chemical's hazard to aquatic receptors because the chemical is more likely to quickly move from the receiving water into the atmosphere. (The opposite is true for human health; hazard to human health *increases* with increased volatility because a volatile chemical is more available for intake by inhalation.)

d. Adsorption potential

EPA used the available K_{oc} to group the organic POCs according to their potential to adsorb to sediments, based on the following categories:

- $K_{oc} > 10{,}000$ High potential for adsorption
- $1{,}000 \leq K_{oc} \leq 10{,}000$ Moderate potential for adsorption
- $10 \leq K_{oc} < 1{,}000$ Low potential for adsorption
- $K_{oc} < 10$ No significant adsorption

A lower adsorption potential indicates a lower potential for a chemical to be a hazard to aquatic receptors. The lower the adsorption potential the less likely a chemical is to accumulate in sediments or to affect benthic invertebrates and to be taken up into local food chains.

e. Biodegradation potential

EPA used biodegradation half-lives to group organic POCs according to their potential to biodegrade, based on the following categories:

- $t_{1/2} < 7$ d Rapid rate of biodegradation
- 7 d $\leq t_{1/2} < 28$ d Moderate rate of biodegradation
- 28 d $\leq t_{1/2} < 180$ d Slow rate of biodegradation
- $t_{1/2} \geq 180$ d Resistant to biodegradation

A faster rate of biodegradation by microbial metabolism decreases an organic chemical's hazard to aquatic receptors. The more rapid the rate of biodegradation, the more quickly a chemical will be removed from the aquatic environment. Most metals occur as inorganic compounds (notable exceptions include organic forms of certain metals, such as mercury, lead, or selenium), and are not removed by biodegradation. EPA assumes that all metals are resistant to biodegradation for the purposes of this assessment.

I.1.4 Assumptions and Limitations

The following are the major assumptions and limitations associated with the data compilation and categorization used in the MP&M analysis:

- Some data are estimated, and subject to uncertainty;
- Data are unavailable for some chemicals and parameters;
- The POCs considered in this study do not include all the constituents that may be present in MP&M pollutants;
- Data derived from laboratory tests may not accurately reflect conditions in the field; and
- Available aquatic toxicity and bioconcentration test data may not represent the most sensitive species.

I.2 METHODOLOGY

I.2.1 Sample Set Data Analysis and National Extrapolation

This analysis uses discharge information from 862 sample MP&M facilities (excluding two sample facilities in Puerto Rico) that discharge directly or indirectly to 607 receiving waterways (521 rivers/streams, 62 bays/estuaries, and 24 lakes). The in-stream water quality analysis excluded eight of the 62 marine reaches due to data limitations. EPA performed environmental assessment on a basis of the sample facility data. The Agency then extrapolated findings from the sample facility analyses to the national level using two alternative extrapolation methods: (1) traditional extrapolation and (2) post-stratification extrapolation. EPA also used the differential extrapolation technique in addition to both traditional and post-stratification approaches when a sample reach was estimated to receive discharges from multiple facilities. Appendix G provides detailed information on the extrapolation approaches used in this analysis. Based on the extrapolation methods used in this analysis, EPA estimates that approximately 43,901 MP&M facilities discharge to between 29,500 and 40,000 water bodies nationwide.[3]

EPA evaluated the national-level environmental impacts of reducing pollutant discharges from MP&M facilities to the nation's water bodies for the final rule. EPA considered only pollutant loadings from MP&M facilities to particular water bodies in the national analysis. With one exception, EPA did not take background loadings from other sources into account. For the analysis of sewage sludge quantity, EPA was able to use information from the Phase 2 Section 308 survey of POTWs to estimate total metal loadings from all sources to a POTW of a given size (i.e., small, medium, and large). The Agency based this estimate on survey estimates of the average number of small, medium, and large MP&M facilities discharging to a POTW in each size category and the percent contribution of total metal loadings discharged from MP&M facilities.

I.2.2 Water Quality Modeling

EPA used four different equations to model the impacts of MP&M discharges on receiving waterways. EPA used a simple stream dilution model for MP&M facilities that discharge into streams or rivers. This model does not account for fate processes other than complete immediate mixing.[4] EPA derived the facility-specific data (i.e., pollutant loading and facility flow) used in this equation from sources described in Sections 3.1 and 5.2 of this report.

The Agency used one of three receiving stream flow conditions (the lowest one-day average flow with a recurrence interval of 10 years (1Q10), the lowest consecutive seven-day average flow with a recurrence interval of 10 years (7Q10), and the harmonic mean flow), depending on the criterion or toxic effect level being considered.

[3] These estimates include facilities that were assessed to be baseline closures by the MP&M economic analysis.

[4] EPA used an exponential decay model to estimate pollutant concentrations for the analysis of cancer risk from drinking water consumption for streams. This model is discussed in detail in Appendix G.

The 1Q10 and 7Q10 flows are used in comparisons of in-stream concentrations with acute and chronic aquatic life criteria or toxic effect levels, respectively, as recommended in the *Technical Support Document for Water Quality-based Toxics Control* (U.S. EPA, 1991).

The harmonic mean flow, defined as the inverse mean of reciprocal daily arithmetic mean flow values, is used in comparisons of in-stream concentrations with human health criteria or toxic effect levels based on lifetime exposure. EPA recommends the long-term harmonic mean flow as the design flow for assessing potential long-term human health impacts. Harmonic mean flow is preferable to arithmetic mean flow because in-stream pollutant concentration is a function of, and inversely proportional to, the stream flow downstream of the discharge.

The event frequency represents the number of times an exposure event occurs during a specified time period. EPA set the event frequency equal to the facility operating days to assess impacts on aquatic life. The calculated in-stream concentration is thus the average concentration on days the facility is discharging wastewater. EPA set the event frequency at 365 days to assess long-term human health impacts. The calculated in-stream concentration is thus the average concentration on all days of the year. This frequency leads to a lower calculated concentration because of the additional dilution from days when the facility is not operating, but it is consistent with the conservative assumption that the target population is present to consume drinking water every day and contaminated fish throughout an entire lifetime. The following equation calculates in-stream concentration for streams and rivers:

$$C_{is} = \frac{L}{(OD \cdot FF) + (EF \cdot SF)} \qquad (I.2)$$

where:

- C_{is} = in-stream pollutant concentration (µg/L);
- L = facility pollutant loading (µg/yr); for indirect dischargers, $L = L_{indirect\ facility} * (1\text{-}TMT)$, where TMT is POTW treatment removal efficiency (unitless);
- OD = facility or POTW operating days (days/yr);
- FF = MP&M facility flow (L/day); for indirect dischargers, FF = POTW flow (L/day);
- EF = event frequency (days/yr); and
- SF = receiving stream flow (L/day).

EPA used the following simple steady-state model for facilities that discharge into lakes other than the Great lakes. This model takes into account pollutant degradation and the hydraulic residence time of the lake:

$$C_{lake} = \frac{C_i}{(1 + T_w \cdot k)} \qquad (I.3)$$

where:

- C_{lake} = steady-state lake concentration of pollutant (µg/L),
- C_i = steady-state inflow concentration of pollutant (µg/L),
- T_w = mean hydraulic residence time (yr),
- k = first-order pollutant decay rate (yr-1), and

$$T_w = \frac{V}{Q} \qquad (I.4)$$

where:

- V = lake volume (m^3), and
- Q = mean total inflow rate (m^3/yr).

EPA used alternative means to predict pollutant concentrations suitable for comparison with ambient criteria or toxic effect levels for facilities discharging to hydrologically complex waters, such as bays and estuaries. Where possible, EPA employed site-specific ***critical dilution factors (CDFs)*** to predict the concentration at the edge of a mixing zone. Where CDFs were not available, EPA used available estuarine ***dissolved concentration potentials (DCPs)***.

EPA obtained site-specific CDFs from a survey of states and regions conducted by EPA's Office of Pollution Prevention and Toxics (*Mixing Zone Dilution Factors for New Chemical Exposure Assessments*, U.S. EPA, 1992a). The dilution model for estimating estuary concentrations by using a CDF is presented below:

$$C_{es} = \frac{L}{EF \cdot FF \cdot CDF} \qquad (I.5)$$

where:

C_{es}	=	estuary pollutant concentration (µg/L);
L	=	facility pollutant loading (µg/yr); for indirect dischargers, $L = L_{indirect\ facility} * (1\text{-}TMT)$, where TMT is POTW treatment removal efficiency (unitless);
EF	=	event frequency (days/yr);
FF	=	facility flow (L/day); for indirect dischargers, FF = POTW flow (L/day); and
CDF	=	critical dilution factor (unitless).

EPA used acute CDFs to evaluate acute aquatic life effects and chronic CDFs to evaluate chronic aquatic life or adverse human health effects. EPA assumed that the drinking water intake and fishing location are at the edge of the chronic mixing zone. EPA set the event frequency equal to the facility operating days for comparison with aquatic life criteria or toxic effect levels, and equal to 365 days for comparison with human health criteria or toxic effect levels.

The ***National Oceanic and Atmospheric Administration (NOAA)*** has developed DCPs to predict pollutant concentrations in various salinity zones for each estuary in NOAA's ***National Estuarine Inventory (NEI)***. A DCP represents the concentration of a nonreactive dissolved substance under well-mixed, steady-state conditions given an annual load of 10,000 tons. DCPs account for the effects of flushing by considering the freshwater inflow rate, and dilution by considering the total estuarine volume. DCPs reflect the predicted estuary-wide response, and may therefore not be indicative of concentrations at the edge of much smaller mixing zones. The dilution model used for estimating pollutant concentrations using DCPs is presented below:

$$C_{es} = \frac{L \cdot DCP}{BL \cdot CF} \qquad (I.6)$$

where:

C_{es}	=	estuary pollutant concentration (µg/L);
L	=	facility pollutant loading (kg/yr); for indirect dischargers, $L = L_{indirect\ facility} *(1\text{-}TMT)$, where TMT is POTW treatment removal efficiency (unitless);
DCP	=	dissolved concentration potential (µg/L);
BL	=	benchmark load (10,000 tons/yr); and
CF	=	conversion factor (907.2 kg/ton).

EPA determined potential water quality impacts by comparing projected waterway pollutant concentrations to EPA water quality criteria or toxic effect levels for the protection of aquatic life and human health. EPA determined water quality exceedances by dividing the projected waterway pollutant concentration by the EPA water quality criteria or toxic effect levels for the protection of aquatic life and human health. A value greater than one indicates an exceedance.

I.2.3 Impact of Indirect Discharging Facilities on POTW Operations

a. Analysis of biological inhibition

Inhibition of POTW operations occurs when high levels of toxics, such as metals or cyanide, kill the bacteria required for the wastewater treatment process. EPA analyzed inhibition of POTW operations by comparing calculated POTW influent concentrations with available inhibition levels. Exceedances are indicated by a value greater than one. POTW influent concentrations are estimated as:

$$C_{pi} = \frac{L}{OD \cdot PF} \tag{I.7}$$

where:

- C_{pi} = POTW influent concentration (µg/L),
- L = facility pollutant loading (µg/yr),
- OD = facility operating days (days/yr), and
- PF = POTW flow (L/day).

b. Analysis of sludge disposal practices

EPA also analyzed the effects of MP&M discharges on POTW operations by comparing the estimated concentrations of metals in sewage sludge with the published metals concentration limits for preferable sewage sludge disposal or use practices. In particular, EPA examined:

- whether MP&M baseline discharges would prevent POTWs from being able to meet the metals concentration limits required for more favorable and lower-cost sewage sludge use/disposal practices (i.e., beneficial land application and surface disposal); and
- whether limitations on the selection of management practices would be removed under the final rule.

EPA estimated the sewage sludge concentrations of eight metals for sample facilities under baseline and post-regulatory option discharge levels. EPA compared these concentrations with the relevant metals concentration limits for three sewage sludge management options: Land Application-High (Concentration Limits), Land Application-Low (Ceiling Limits), and Surface Disposal. Metal concentrations in sewage sludge are estimated as:

$$C_{sp} = \frac{L \cdot TMT \cdot PART \cdot SGF}{OD \cdot PF} \tag{I.8}$$

where:

- C_{sp} = sewage sludge pollutant concentration (mg/kg),
- L = facility pollutant loading (µg/yr),
- TMT = POTW treatment removal efficiency (unitless),
- PART = pollutant-specific sludge partition factor (unitless),
- SGF = sludge generation factor (mg/kg per µg/L),
- OD = POTW operating days (days/yr), and
- PF = POTW flow (L/day).

EPA derived the facility-specific data to evaluate POTW operations from the sources described in Sections 3.1 and 5.2. EPA examined multiple MP&M facilities discharging to the same POTW by summing the individual loadings before calculating the POTW influent and sewage sludge concentrations.

The ***partition factor*** is a chemical-specific value representing the fraction of the load expected to partition to sewage sludge during wastewater treatment. For this analysis, EPA used a sludge generation factor of 5.96 mg/kg per µg/L. This factor indicated that the resulting concentration in sewage sludge is 5.96 mg/kg dry weight for every 1 µg/L of pollutant removed from wastewater and partitioned to sewage sludge.

I.2.4 Assumptions and Limitations

The following discussion focuses on major assumptions and limitations associated with these in-stream water quality analyses.

a. Other source contributions

EPA did not account for "other source contributions" of MP&M pollutants to estimate in-stream concentrations of these pollutants. Accounting for the discharges from other sources is important because assessing benefits from reduced exceedance of AWQC limits depends on comparing concentrations of pollutants from all sources with applicable thresholds. Analyses must also identify situations in which threshold criteria are exceeded in the baseline case but met under a regulatory option. Failing to account for other source contributions has an uncertain effect on estimated benefits. For example, if non-sample MP&M facilities are major contributors to aggregate pollutant discharges to a receiving stream, then the analysis will likely understate the extent of aquatic habitat improvements that may be accomplished by reduced MP&M pollutant discharges. Conversely, if the total MP&M contribution to the aggregate pollutant discharges to a receiving stream is not significant, then reducing MP&M discharges may reduce but not eliminate AWQC exceedances, and the benefits of the MP&M regulation can be overstated. The net effect of the following are unknown:

- excluding other sources understates the number and extent of baseline exceedances;
- excluding non-sample MP&M facilities understates the reduction in MP&M pollutant discharges due to the rule; and
- the number of cases in which estimated baseline exceedances are eliminated may be either over- or understated, depending on the contribution of pollutants from non-MP&M sources.

b. Water body modeling

EPA made four major assumptions concerning all water body modeling, and two major assumptions specific to stream modeling. These assumptions are summarized below:

- Complete mixing of POTW discharge flow occurs immediately. This mixing results in the calculation of an "average" concentration, even though the actual concentration may vary across the width and depth of the water body.
- Pollutant loads to the receiving water body are continuous and representative of long-term facility operations. This assumption may overestimate long-term risks to human health and aquatic life, but may underestimate potential short-term effects.
- In the absence of data from EPA's ***Permit Compliance System (PCS)*** on specific individual POTW flow, POTW daily flow rates were set equal to the simple arithmetic mean flow among minor POTWs reporting flows in PCS. The arithmetic mean for minor POTWs was used because all POTWs receiving discharges from the sample MP&M facilities for which flow data are not available in the PCS database are classified as minor dischargers in the PCS database.
- EPA used 1Q10 and 7Q10 receiving stream flow rates to estimate aquatic life impacts, and harmonic mean flow rates to estimate human health impacts, when modeling stream reaches. EPA estimated 1Q10 low flows by using the results of a regression analysis conducted for OPPT of 1Q10 and 7Q10 flows from representative U.S. rivers and streams (Versar, 1992). EPA estimated harmonic mean flows from the mean and 7Q10 flows as recommended in the *Technical Support Document for Water Quality-based Toxics Control* (U.S. EPA, 1991). These flows may not be the same as those used by specific states to assess impacts.
- Where data on stream flow parameters were not available, EPA set mean and 7Q10 flow values equal to the corresponding mean values associated with reaches located upstream and downstream of the sample reach.

c. Exposure analyses

MP&M exposure assessment in freshwater locations uses two sets of human health-based AWQC:

- AWQC for the protection of human health from the consumption of organisms and drinking water, and
- AWQC for the protection of human health from consumption of organisms only.

MP&M exposure assessments in marine locations use AWQC for the protection of human health from the consumption of organisms only, because saltwater is not used for drinking water supply.

d. Extrapolation from sample set to national level

Although the sample set should represent a national group of facilities discharging to waterways and POTWs, effluent from an individual sample facility may have a different potential environmental impact than effluent from the facilities it is assumed to represent. For example, a facility that discharges to a stream with a very low flow may be similar to the facilities it represents in all aspects except available dilution in the receiving stream. The sample frame used in the MP&M analysis was not designed to take receiving water body characteristics into account. Using sample weights to extrapolate environmental impacts may either under- or overstate estimated impacts.

I.3 DATA SOURCES

The following three sections describe the various data sources used to evaluate water quality and POTW impacts.

I.3.1 Facility-Specific Data

Section I.2.1 provides detailed information on sample size and distribution, and on receiving waterways. The names, locations, and the flow data for the POTWs to which the MP&M facilities discharge were obtained from the MP&M facility surveys and EPA's PCS database. EPA took alternative measures to obtain a complete set of receiving POTWs if these sources did not yield information for a given facility. EPA used latitude/longitude coordinates (if available) to locate those POTWs that have not been assigned a reach number in PCS. EPA identified the nearest POTW in the case of facilities for which the POTW receiving the plant discharge could not be positively identified. EPA based its identification of the closest linear distance on the latitude/longitude coordinates of the MP&M facility or the city in which it was located. EPA then identified the corresponding reach in PCS, and obtained POTW flow from the Needs Survey or PCS.

EPA identified reaches to which direct MP&M facilities discharge by identifying the receiving reach in PCS or by identifying the nearest reach. EPA based its identification of the closest linear distance on the MP&M facility's latitude/longitude coordinates.

I.3.2 Water body-Specific Data

a. Streams and rivers

EPA used 1Q10, 7Q10, and mean flow data for the 521 streams and rivers. EPA obtained 7Q10 and mean flow data from the W.E. Gates study data or from measured stream flow data, both of which are contained in EPA's ***GAGE*** file. The W.E. Gates study contains calculated average and low flow statistics based on the best available flow data and on drainage areas for reaches throughout the United States. The GAGE file also includes average and low flow statistics based on measured data from ***United States Geological Survey (USGS)*** gaging stations. In the absence of data on stream flow parameters, EPA set 7Q10 and mean flow values equal to the corresponding median values associated with the sample reaches. EPA used the results of a regression analysis conducted for OPPT of 1Q10 and 7Q10 flows from representative U.S. rivers and streams (Versar, 1992) to estimate 1Q10 flows. EPA estimated harmonic mean flows from the mean and 7Q10 flows as recommended in the *Technical Support Document for Water Quality-based Toxics Control* (U.S. EPA, 1991).

b. Lakes

EPA used data on hydraulic residence time (i.e., the amount of time water remains in a lake) to analyze small lakes, and CDFs (which describe dilution in a portion of a lake) to analyze the Great lakes.[5]

The sample MP&M facilities discharged directly to one lake reach and indirectly to 23 lake reaches: 15 to small lakes, 3 to sections of Lake Erie, 5 to sections of Lake Michigan, and 1 to a section of Lake Ontario. EPA calculated the average hydraulic residence time for small lakes based on lake surface and drainage areas. EPA obtained data on lake surface and drainage area from the U.S. Army Corps of Engineers, Major Dams: Map Layer Description File (USCE, 1999). CDFs were readily available for Lake Michigan, but not for the three sample reaches on Lake Erie. EPA arithmetically averaged the seven chronic CDFs available for reaches discharging to Lake Erie (1, 1, 4, 4, 10, 10, 4) (U.S. EPA, 1992a, p. A-4) for the three reaches being modeled.

c. Estuaries and bays

Sixty-two bays and estuaries receive discharges from sample MP&M facilities. Data necessary to support water quality modeling were not available for eight of the 62 bays/estuaries. A dilution model predicted pollutant concentrations in the chronic and acute mixing zones, based on site-specific CDFs (U.S. EPA, 1992a and Versar, 1994), to estimate the pollutant concentrations in 28 of these complex water bodies.

Both acute and chronic CDFs were available for 20 of the 62 bays/estuaries. EPA estimated acute and chronic CDFs for New York bays/estuaries by arithmetically averaging available values for nearby New Jersey sites discharging to the Arthur Kill (acute: 1.5, 4.0, 5.0; chronic: 5; 20; 10) and Upper New York Bay (acute: 8.0; chronic: 22.9). Acute and chronic CDFs for Buzzards Bay in Massachusetts were estimated by arithmetically averaging values for nearby Massachusetts and Rhode Island sites discharging to the Atlantic Ocean.

EPA could not identify or approximate chronic CDFs for the remaining 13 sample reaches. Acute CDFs are available for 46 of the 62 bays/estuaries. EPA extrapolated acute CDFs for two bays/estuaries in Florida by using CDFs for another Florida bay. Likewise, EPA extrapolated acute CDFs for four bays/estuaries in California by using CDFs for another California bay.

EPA obtained DCP values for five of the 13 sample bays/estuaries for which CDFs were not available from the Development of Mixing Zone Dilution Factors report (Versar, 1994). EPA then used a dilution model that predicts pollutant concentrations in the estuarine environment using a site-specific DCP value.

I.3.3 Information Used to Evaluate POTW Operations

Since many MP&M facilities considered in the alternative options are indirect dischargers, the Agency consulted with POTWs as they would have had to implement the rule. EPA consulted with POTWs individually and through the Association of Municipal Sewerage Agencies (AMSA). In addition, EPA consulted with pretreatment coordinators and State and local regulators.

EPA used removal efficiency rates, inhibition values, and sewage sludge regulatory levels to evaluate POTW operations. EPA obtained POTW removal efficiency rates from several sources. The Agency developed rates from POTW removal data and pilot-plant studies or used removals for a similar pollutant when data were not available. Use of the selected removal rates assumes that the evaluated POTWs are well-operated and have at least secondary treatment in place (U.S. EPA, 2000).

EPA obtained inhibition values from the *Guidance Manual for Preventing Interference at POTWs* (U.S. EPA, 1987a) and from *CERCLA Site Discharges to POTWs: Guidance Manual* (U.S. EPA, 1990). EPA used the most conservative values for activated sludge (i.e., the lowest influent concentrations that would cause inhibition). The Agency used a value based on compound type (e.g., aromatics) for pollutants with no specific inhibition value.

EPA obtained sewage sludge regulatory levels from the Federal Register 40 CFR Part 257 et al., *Standards for the Use or Disposal of Sewage Sludge; Final Rules* (February 19, 1993) and from the Federal Register 59(38):9095-9099 (February 25, 1994) and 60(206):54,764-54,770 (October 25, 1995) for eight metals regulated in sewage sludge. EPA used pollutant limits established for the final use or disposal of sewage sludge when the sewage sludge is applied to agricultural and non-agricultural land or is applied to a dedicated surface disposal site.

[5] Small lakes are defined as any non-Great lakes, including reservoirs.

Finally, EPA obtained sludge partition factors from the *Report to Congress on the Discharge of Hazardous Wastes to Publicly-Owned Treatment Works* (Domestic Sewage Study) (U.S. EPA, 1986).

Table I.5 lists POTW treatment removal efficiency rates, inhibition values, sewage sludge partition factors, and sewage sludge regulatory levels used in the evaluation of POTW operations.

Table I.5: POTW-Related Data for 132 MP&M Pollutants

CAS Number	Pollutant Name	POTW Inhibition Level Value (µg/l)	POTW Sludge Partition Factor	Sludge Criteria Value (mg/kg)	POTW Removal Efficiency Rate (Percentage)
51285	Dinitrophenol, 2,4-	1000	0.10000000149		77.51
57125	Cyanide	5000	1		70.44
59507	Parachlorometacresol	5000	0.07900000364		63
62533	Aniline	1000	0.1		93.41
62759	Nitrosodimethylamine, N-		0.1		77.51
65850	Benzoic acid	10000	0.1		80.5
67641	Acetone	120000	0.1		83.75
67663	Trichloromethane	500000	0.015		
68122	Dimethylformamide, N,N-	1000	0.1		87
75003	Chloroethane		0.0075		77.51
75092	Dichloromethane	150000	0.1395		54.28
75150	Carbon disulfide	50000	0.0075		84
75354	Dichloroethene, 1,1-	150000			77.51
75694	Trichlorofluoromethane	700			77.32
78591	Isophorone	120000	0.079		77.51
78831	Isobutyl alcohol	1000000	0.1		28
78933	Methyl ethyl ketone	120000	0.1		96.6
79016	Trichloroethene	20000	0.0578		77.51
80626	Methyl methacrylate	120000			99.96
83329	Acenaphthene	500000	0.366		98.29
84742	Di-n-butyl phthalate	10000	0.216		84.66
85018	Phenanthrene	500000	0.366		94.89
85687	Butyl benzyl phthalate	10000	0.452		81.65
86306	Nitrosodiphenylamine, N-				90.11
86737	Fluorene	500000	0.366		69.85
88755	Nitrophenol, 2-	50000			26.83
91203	Naphthalene	500000	0.275		94.69
91576	Methylnaphthalene, 2-	5000	0.079		28
92524	Biphenyl	5000	0.366		96.28
95476	Xylene, o-	5000	0.149		77.32
95487	Cresol, o-	90000	0.079		52.5
98555	Terpineol, alpha-	1000000	0.1		94.4
98862	Acetophenone	120000	0.1		95.34
99876	Cymene, p-	5000	0.0075		99.79
100027	Nitrophenol, 4-	50000	0.1		77.51
100414	Ethylbenzene	200000	0.06		93.79
100425	Styrene	500000	0.149		93.65
100516	Benzyl alcohol	1000000	0.1		78
100754	Nitrosopiperidine, N-	1000			77.32
101848	Diphenyl Ether	1000			77.32
105679	Dimethylphenol, 2,4-	40000	0.079		77.51

Table I.5: POTW-Related Data for 132 MP&M Pollutants					
CAS Number	Pollutant Name	POTW Inhibition Level Value (μg/l)	POTW Sludge Partition Factor	Sludge Criteria Value (mg/kg)	POTW Removal Efficiency Rate (Percentage)
106445	Cresol, p-	90000	0.079		71.67
107028	Acrolein	50	0.10000000149		77.51
108101	Methyl isobutyl ketone	120000	0.1		87.87
108372	Bromo-3-chlorobenzene, 1-	100			77.32
108383	Xylene, m-	5000	0.149		95.07
108883	Toluene	200000	0.278		96.18
108907	Chlorobenzene	140000	0.154		96.37
108952	Phenol	90000	0.146		95.25
110861	Pyridine	1000	0.1		95.4
112403	Dodecane, n- (a)				
112958	Eicosane, n- (a)				
117817	Bis(2-ethylhexyl) phthalate	10000	0.728		59.78
117840	Di-n-octyl phthalate	10000	0.075		68.43
120127	Anthracene	500000	0.55		77.51
122394	Diphenylamine	1000	0.08		77.32
123911	Dioxane, 1,4-	120000	0.1		45.8
124185	Decane, n-				9
127184	Tetrachloroethene	20000	0.034		84.61
129000	Pyrene	500000	0.366		83.9
131113	Dimethyl phthalate		0.1		77.51
132650	Dibenzothiophene	5000	0.366		84.68
137304	Ziram \ Cymate	50			
142621	Hexanoic acid	10000			84
206440	Fluoranthene	5000	0.366		42.46
544763	Hexadecane, n- (a)				
591786	Hexanone, 2-	120000			77.32
593453	Octadecane, n- (a)				
606202	Dinitrotoluene, 2,6-	5000	0.1		77.51
629594	Tetradecane, n- (a)				
629970	Docosane, n-				88
630013	Hexacosane, n- (b)				
630024	Octacosane, n- (b)				
638686	Triacontane, n- (b)				
646311	Tetracosane, n- (b)				
694804	Bromo-2-chlorobenzene, 1-	100			77.32
832699	Methylphenanthrene, 1-	5000	0.366		84.55
1576676	Dimethylphenanthrene, 3,6-	500000	0.366		84.55
1730376	Methylfluorene, 1-	500000	0.366		84.55
2027170	Isopropylnaphthalene, 2-	500000	0.1		77.32
7429905	Aluminum		1		91.36
7439896	Iron	5000	1		81.99
7439921	Lead	100	1	300	77.45
7439954	Magnesium	1000000	1		14.14
7439965	Manganese	10000	1		35.51
7439976	Mercury	100	1	17	71.66
7439987	Molybdenum		1		18.93
7440020	Nickel	5000	1	420	51.44

Table I.5: POTW-Related Data for 132 MP&M Pollutants

CAS Number	Pollutant Name	POTW Inhibition Level Value (µg/l)	POTW Sludge Partition Factor	Sludge Criteria Value (mg/kg)	POTW Removal Efficiency Rate (Percentage)
7440224	Silver	30	1		88.28
7440235	Sodium	3500000	1		2.69
7440280	Thallium		1		71.66
7440315	Tin	9000	1		42
7440326	Titanium		1		91.82
7440360	Antimony		1		66.78
7440382	Arsenic	40	1	41	65.77
7440393	Barium		1		15.98
7440417	Beryllium		1		71.66
7440428	Boron	1000	1		30.42
7440439	Cadmium	500	1	39	90.05
7440473	Chromium	1000	1		80.33
7440484	Cobalt		1		6.11
7440508	Copper	1000	1	1500	84.2
7440575	Gold		1		32.52
7440622	Vanadium	20000	1		9.51
7440655	Yttrium		1		32.52
7440666	Zinc	5000	1	2800	79.14
7440702	Calcium	2500000	1		8.54
7664417	Ammonia as N	480000			38.94
7782492	Selenium		1	100	34.33
14265442	Phosphate				57.41
14808798	Sulfate				84.61
16887006	Chloride				57.41
16984488	Fluoride				61.35
18496258	Sulfide	25000			57.41
18540299	Chromium hexavalent	1000	1		57.41
20324338	Tripropyleneglycolmethylether	120000			52.4
136777612	Xylene, o- & p- (c)	5000	0.149		36832
179601231	Xylene, m- & p- (c)				
C003	BOD 5-day (carbonaceous)				89.12
C004	Chemical Oxygen Demand (COD)				81.3
C009	Total Suspended Solids (TSS)				
C010	Total Dissolved Solids (TDS)				
C012	Total Organic Carbon (TOC)				70.28
C020	Total Recoverable Phenolics				57.41
C021	Total Kjeldahl Nitrogen				57.41
C025	Amenable Cyanide				57.41
C036	Oil and Grease (as Hem)				86.08
C037	Total Petroleum Hydrocarbons (as Sgt-hem)				
C042	Weak-acid Dissociable Cyanide				
	Phosphorus (as PO4)				
	Oil and Grease				

Sources: U.S. EPA (1985), U.S. EPA (1987), U.S. EPA (1990).

In the absence of data on POTW flow rates, EPA set the POTW flow rate equal to the arithmetic mean flow among minor POTWs in the PCS database, using the following steps:

1. Calculate arithmetic mean flow among minor POTWs in the PCS database. The estimated arithmetic mean flow for minor POTWs in the PCS database is one million gallons per day (MGD).

2. Set POTW flow rate equal to the relevant arithmetic mean flow. For all POTWS with missing flow data, EPA set their flow rates equal to the arithmetic mean flow rate for minor POTWs in the PCS database, one MGD.

I.4 RESULTS

EPA assessed the environmental impacts of MP&M dischargers on water bodies and POTWs under the baseline conditions and those corresponding to four regulatory options: the Final Option, Proposed/NODA Option, and two 433 Upgrade Options on the basis of sample facility data. The Agency extrapolated the findings from the sample facility analyses to the national level using facility sample weights, as described in Appendix G.

MP&M facilities nationwide currently discharge an estimated 53 million pounds of pollutants per year to publicly-owned treatment works (POTWs) and approximately 6.2 million pounds of pollutants directly to surface waters. MP&M facility effluents contain 42 priority or toxic pollutants, 81 nonconventional pollutants, and three conventional pollutants (BOD, TSS, and O&G).

EPA estimates that the final rule will lead to a modest reduction in pollutant discharges to the waters of the U.S. As shown by Table I.6, the regulation will reduce discharges of pollutants with acute and chronic effects on aquatic life by 8,959 and 12,270 pounds per year, respectively. The final rule does not regulate indirect dischargers and thus will not reduce pollutant loads received by POTWs.

EPA estimates that the Proposed/NODA Option, Directs + 413 to 433 Upgrade Option, and Directs + All to 433 Upgrade Option would remove 3,299, 91, and 110 thousand pounds per year of eight sewage sludge contaminants, respectively. In addition, the Proposed/NODA Option, Directs + 413 to 433 Upgrade Option, and Directs + All to 433 Upgrade Option would result in 30,226, 133, and 551 thousand pounds per year reduction in 86 pollutants causing inhibition of POTW operations.

The Proposed/NODA Option would reduce discharges of pollutants with acute and chronic effects on aquatic life by 97 and 117 million pounds per year, respectively. The Directs + 413 to 433 Upgrade Option and the Directs + All to 433 Upgrade Option would reduce discharges of 132 and 353 thousand pounds of pollutants with acute effects on aquatic life, and 136 and 576 thousand pounds of pollutants with chronic effects on aquatic life, respectively.

Table I.6: MP&M Facility Discharges (National Basis)[a]					
Category	POTW Impacts			Receiving Stream Impacts: Aquatic Life Toxicity	
	Activated Sludge Inhibition	Biosolids Contaminants	HAP	Acute	Chronic
Selected Option					
# of Pollutants	N/A	N/A	N/A	106	113
Baseline (1,000 lbs/yr)	N/A	N/A	N/A	868	1,154
Post-Compliance (1,000 lbs/yr)	N/A	N/A	N/A	859	1,142
Proposed/NODA Option					
# of Pollutants	85	8	35	105	112
Baseline (1,000 lbs/yr)	39,594	3,589	408	141,522	187,742
Post-Compliance (1,000 lbs/yr)	9,369	290	189	44,827	70,428
Directs + 413 to 433 Upgrade					
# of Pollutants	86	8	35	106	113
Baseline (1,000 lbs/yr)	1,085	253	3	868	1,154
Post-Compliance (1,000 lbs/yr)	952	161	3	935	1,018
Directs + All to 433 Upgrade					
# of Pollutants	86	8	35	106	113
Baseline (1,000 lbs/yr)	1,085	253	3	868	1,154
Post-Compliance (1,000 lbs/yr)	534	143	3	514	578

[a] Excludes loadings from facilities projected to close in the baseline. See Chapter 5.

Source: U.S. EPA analysis.

I.4.1 Human Health Impacts

Under this human health benefit category EPA assessed the reduced occurrence of pollutant concentrations that are estimated to exceed human health-based AWQC. This analysis provides an alternative measure of the expected reduction in risk to human health. Table I.7 presents information on baseline and post-compliance exceedances of human health AWQC criteria for all the regulatory options.

EPA estimates that in-stream concentrations of four pollutants (i.e., arsenic, iron, manganese, and n-nitrosodimethylamine) will exceed human health criteria for consumption of water and organisms in 78 receiving reaches nationwide as the result of baseline MP&M pollutant discharges. EPA estimates that there are human health AWQC exceedances caused by n-nitrosodimethylamine (NDMA). EPA did not consider NDMA pollutant reductions in its benefits analyses because of the low number of detected values for that pollutant. EPA estimates that the final rule will not eliminate the occurrence of concentrations in excess of human health criteria for consumption of water and organisms and for consumption of organisms on any of the reaches on which baseline discharges are estimated to cause concentrations in excess of AWQC values.

The Proposed/NODA Option would eliminate instances of in-stream pollutant concentrations exceeding AWQC limits for consumption of water and organisms and consumption of organisms only in 63 and 68 reaches, respectively, nationwide. The Directs + 413 to 433 Upgrade Option would not eliminate any instances of in-stream pollutant concentrations exceeding AWQC limits for consumption of water and organisms and consumption of organisms only. The Directs + All to 433 Upgrade Option would not eliminate any occurrences of pollutant concentrations in excess of AWQC values for consumption of water and organisms, but would eliminate instances of pollutant concentrations in excess of AWQC values for consumption of organisms only in 21 reaches nationwide. As noted above the Agency did not estimate reductions in NDMA loadings under the post-compliance scenario due to data limitations.

Category	Human Health Water and Organisms			Human Health Organisms Only		
	Streams (No.)	Pollutants (No.)	Total Exceedances	Streams (No.)	Pollutants (No.)	Total Exceedances
Selected Option: Traditional Extrapolation						
Baseline	78	4	121	21	1	21
Post-Compliance	78	4	121	21	1	21
Selected Option: Post-Stratification Extrapolation						
Baseline	112	4	154	21	1	21
Post-Compliance	112	4	154	21	1	21
Proposed/NODA Option						
Baseline	5,852	26	7,085	197	12	335
Post-Compliance	5,789	21	6,667	128	9	212
Directs + 413 to 433 Upgrade						
Baseline	78	4	121	21	1	21
Post-Compliance	78	4	121	21	1	21
Directs + All to 433 Upgrade						
Baseline	78	4	121	21	1	21
Post-Compliance	78	2	78	0	0	0

Table I.7: Summary of Estimated AWQC Exceedances for Protection of Human Health (National Basis)

Source: U.S. EPA analysis.

Table I.8 summarizes pollutants estimated to exceed human health-based AWQC criteria for consumption of water and organisms under the baseline and post-compliance conditions.

Table I.8: Summary of Pollutants Estimated to Exceed Human Health-Based AWQC Criteria for Consumption of Water and Organisms (National Basis)

Pollutant	Selected Option: Traditional Extrapolation		Selected Option: Post-Stratification Extrapolation		Proposed/NODA Option		Directs + 413 to 433 Upgrade		Directs + All to 433 Upgrade	
	Base[a]	PC[b]	Base	PC	Base	PC	Base	PC	Base	PC
Aniline	0	0	0	0	20	17	0	0	0	0
Antimony	0	0	0	0	0	0	0	0	0	0
Arsenic	45	45	45	45	772	557	45	45	45	45
Bis(2-ethylhexyl) phthalate	0	0	0	0	85	43	0	0	0	0
Cadmium	0	0	0	0	0	0	0	0	0	0
Chloroethane	0	0	0	0	17	14	0	0	0	0
Copper	0	0	0	0	16	0	0	0	0	0
Cresol, p-	0	0	0	0	9	9	0	0	0	0
Dibenzofuran	0	0	0	0	12	9	0	0	0	0
Dichloroethene, 1,1-	0	0	0	0	97	81	0	0	0	0
Dichloromethane	0	0	0	0	17	17	0	0	0	0
Dinitrophenol, 2,4-	0	0	0	0	9	9	0	0	0	0
Dinitrotoluene, 2,6-	0	0	0	0	9	9	0	0	0	0
Dioxane, 1,4-	0	0	0	0	17	17	0	0	0	0
Fluoranthene	0	0	0	0	9	9	0	0	0	0
Iron	21	21	21	21	28	0	21	21	21	0
Isophorone	0	0	0	0	9	9	0	0	0	0
Manganese	21	21	21	21	54	0	21	21	21	0
Mercury	0	0	0	0	0	0	0	0	0	0
Naphthalene	0	0	0	0	9	9	0	0	0	0
Nickel	0	0	0	0	16	0	0	0	0	0
Nitrophenol, 4-	0	0	0	0	9	9	0	0	0	0
Nitrosodimethylamine, N-	32	32	67	67	5,789	5,789	32	32	32	32
Nitrosodiphenylamine, N-	0	0	0	0	17	17	0	0	0	0
Pyrene	0	0	0	0	9	9	0	0	0	0
Pyridine	0	0	0	0	12	9	0	0	0	0
Thallium	0	0	0	0	16	0	0	0	0	0
Trichloroethene	0	0	0	0	21	17	0	0	0	0
Trichloromethane	0	0	0	0	12	12	0	0	0	0
Total Exceedances	121	121	154	154	7,085	6,667	121	121	121	77

[a] Base = Baseline discharge level
[b] PC = Post-Compliance discharge level
Source: U.S. EPA analysis.

Table I.9 summarizes pollutants estimated to exceed human health-based AWQC criteria for consumption of organisms only under the baseline and post-compliance conditions.

Table I.9: Summary of Pollutants Estimated to Exceed Human Health-Based AWQC Criteria for Consumption of Organisms Only (National Basis)

Pollutant	Selected Option: Traditional Extrapolation		Selected Option: Post-Stratification Extrapolation		Proposed/NODA Option		Directs + 413 to 433 Upgrade		Directs + All to 433 Upgrade	
	Base[a]	PC[b]	Base	PC	Base	PC	Base	PC	Base	PC
Aniline	0	0	0	0	12	9	0	0	0	0
Antimony	0	0	0	0	0	0	0	0	0	0
Arsenic	0	0	0	0	154	111		0	0	0
Bis(2-ethylhexyl) phthalate	0	0	0	0	24	12	0	0	0	0
Cadmium	0	0	0	0	0	0	0	0	0	0
Chloroethane	0	0	0	0	0	0	0	0	0	0
Copper	0	0	0	0	16	0	0	0	0	0
Cresol, p-	0	0	0	0	0	0	0	0	0	0
Dibenzofuran	0	0	0	0	12	9	0	0	0	0
Dichloroethene, 1,1-	0	0	0	0	17	17	0	0	0	0
Dichloromethane	0	0	0	0	0	0	0	0	0	0
Dinitrophenol, 2,4-	0	0	0	0	0	0	0	0	0	0
Dinitrotoluene, 2,6-	0	0	0	0	0	0	0	0	0	0
Dioxane, 1,4-	0	0	0	0	0	0	0	0	0	0
Fluoranthene	0	0	0	0	9	9	0	0	0	0
Iron	0	0	0	0	0	0	0	0	0	0
Isophorone	0	0	0	0	0	0	0	0	0	0
Manganese	21	21	21	21	32	0	21	21	21	0
Mercury	0	0	0	0	0	0	0	0	0	0
Naphthalene	0	0	0	0	0	0	0	0	0	0
Nickel	0	0	0	0	16	0	0	0	0	0
Nitrophenol, 4-	0	0	0	0	0	0	0	0	0	0
Nitrosodimethylamine, N-	0	0	0	0	27	27	0	0	0	0
Nitrosodiphenylamine, N-	0	0	0	0	9	9	0	0	0	0
Pyrene	0	0	0	0	9	9	0	0	0	0
Pyridine	0	0	0	0	0	0	0	0	0	0
Thallium	0	0	0	0	0	0	0	0	0	0
Trichloroethene	0	0	0	0	0	0	0	0	0	0
Trichloromethane	0	0	0	0	0	0	0	0	0	0
Total Exceedances	21	21	21	21	335	212	21	21	21	0

[a] Base = Baseline discharge level
[b] PC = Post-Compliance discharge level
Source: U.S. EPA analysis.

I.4.2 Aquatic Life Effects

EPA evaluated the effects of MP&M facility discharges on aquatic habitats and ecosystem functioning under the baseline conditions and the post-compliance scenarios corresponding to the four regulatory alternatives considered for the MP&M regulation. This analysis compared the estimated baseline and post-compliance in-stream concentrations of MP&M pollutants with AWQC for aquatic species. As noted in the preceding sections, aquatic life AWQCs addressed in this analysis set the upper limit on pollutant concentrations assumed to be protective of aquatic life.

Table I.10 presents the number of MP&M discharge reaches on which pollutant concentrations are estimated to exceed chronic and acute exposure criteria for protection of aquatic life. EPA estimated that, as the result of baseline MP&M pollutant discharges, in-stream concentrations exceed acute exposure criteria for aquatic species in 18 and 15 receiving reaches nationwide based on the traditional extrapolation and post-stratification extrapolation, respectively. In addition, baseline in-stream concentrations in 353 and 350 receiving reaches exceed chronic AWQC for protection of aquatic life based on the traditional extrapolation and post-stratification extrapolation, respectively.

Table I.10: Summary of Estimated AWQC Exceedances for Protection of Aquatic Life (National Basis)

Category	Acute Aquatic Life			Chronic Aquatic Life		
	Streams (No.)	Pollutants (No.)	Total Exceedances	Streams (No.)	Pollutants (No.)	Total Exceedances
Selected Option: Traditional Extrapolation						
Baseline	18	4	35	353	9	423
Post-Compliance	9	1	9	344	5	362
Selected Option: Post-Stratification Extrapolation						
Baseline	15	4	26	350	9	402
Post-Compliance	9	1	9	344	5	362
Proposed/NODA Option						
Baseline	330	17	631	928	47	2,582
Post-Compliance	86	12	254	539	39	1,369
Directs + 413 to 433 Upgrade						
Baseline	18	4	35	353	9	423
Post-Compliance	0	0	0	53	3	53
Directs + All to 433 Upgrade						
Baseline	18	4	35	353	9	423
Post-Compliance	0	0	0	32	2	32

Source: U.S. EPA analysis.

Based on the traditional extrapolation**,** EPA estimates that the final option will eliminate concentrations in excess of acute and chronic criteria in nine reaches. Likewise, EPA estimates that the final option will eliminate concentrations in excess of acute and chronic criteria in six reaches based on the post-stratification extrapolation.

The Proposed/NODA Option, Directs + 413 to 433 Upgrade Option, and Directs + All to 433 Upgrade Option would eliminate exceedances of chronic AWQC values on 389, 300, and 321 reaches, respectively. These options would also eliminate in-stream pollutant concentrations in excess of acute AWQC value on 244, 18, and 18 reaches under the Proposed/NODA Option, Directs + 413 to 433 Upgrade Option, and Directs + All to 433 Upgrade Option, respectively.

Table I.11 presents the number MP&M reaches on which pollutant concentrations are estimated to exceed chronic AWQC for protection of aquatic life by pollutant.

Table I.11: Summary of Pollutants Estimated to Exceed Chronic AWQC for Protection of Aquatic Life (National Basis)

Pollutant	Selected Option: Traditional Extrapolation		Selected Option: Post-Stratification Extrapolation		Proposed/NODA Option		Directs + 413 to 433 Upgrade		Directs + All to 433 Upgrade	
	Base[a]	PC[b]	Base	PC	Base	PC	Base	PC	Base	PC
Acenaphthene	0	0	0	0	9	9	0	0	0	0
Acrolein	0	0	0	0	44	33	0	0	0	0
Aluminum	0	0	0	0	32	12	0	0	0	0
Ammonia as N	0	0	0	0	51	0	0	0	0	0
Aniline	0	0	0	0	45	42	0	0	0	0
Anthracene	0	0	0	0	64	29	0	0	0	0
Biphenyl	0	0	0	0	9	9	0	0	0	0
Butyl benzyl phthalate	0	0	0	0	9	0	0	0	0	0
Cadmium	9	0	6	0	70	21	9	0	9	0
Carbon disulfide	0	0	0	0	38	34	0	0	0	0
Chromium	0	0	0	0	46	12	0	0	0	0
Cobalt	0	0	0	0	12	12	0	0	0	0
Copper	9	9	9	9	344	69	9	0	9	0
Cyanide	0	0	0	0	3	0	0	0	0	0
Di-n-butyl phthalate	0	0	0	0	9	9	0	0	0	0
Di-n-octyl phthalate	0	0	0	0	12	12	0	0	0	0
Dibenzofuran	0	0	0	0	21	12	0	0	0	0
Dibenzothiophene	0	0	0	0	15	12	0	0	0	0
Dimethylphenanthrene, 3,6-	0	0	0	0	24	21	0	0	0	0
Dinitrophenol, 2,4-	0	0	0	0	9	9	0	0	0	0
Dinitrotoluene, 2,6-	0	0	0	0	21	21	0	0	0	0
Diphenyl Ether	0	0	0	0	21	21	0	0	0	0
Fluoranthene	0	0	0	0	30	24	0	0	0	0
Fluorene	0	0	0	0	27	21	0	0	0	0
Fluoride	0	0	0	0	54	13	0	0	0	0
Iron	0	0	0	0	12	0	0	0	0	0
Isopropylnaphthalene, 2-	0	0	0	0	15	12	0	0	0	0
Lead	0	0	0	0	244	83	0	0	0	0
Magnesium	0	0	0	0	12	12	0	0	0	0
Manganese	0	0	0	0	32	0	0	0	0	0
Methylfluorene, 1-	0	0	0	0	15	12	0	0	0	0
Methylnaphthalene, 2-	0	0	0	0	12	12	0	0	0	0
Methylphenanthrene, 1-	0	0	0	0	15	12	0	0	0	0
Molybdenum	0	0	0	0	103	39	0	0	0	0
Naphthalene	0	0	0	0	9	9	0	0	0	0
Nickel	0	0	0	0	163	16	0	0	0	0
Phenanthrene	0	0	0	0	24	21	0	0	0	0
Phenol	0	0	0	0	9	0	0	0	0	0
Pyrene	0	0	0	0	21	21	0	0	0	0
Selenium	0	0	0	0	78	50	0	0	0	0
Silver	9	0	6	0	166	131	9	0	9	0
Styrene	0	0	0	0	9	0	0	0	0	0
Sulfide	0	0	0	0	293	283	0	0	0	0

Table I.11: Summary of Pollutants Estimated to Exceed Chronic AWQC for Protection of Aquatic Life (National Basis)

Pollutant	Selected Option: Traditional Extrapolation		Selected Option: Post-Stratification Extrapolation		Proposed/NODA Option		Directs + 413 to 433 Upgrade		Directs + All to 433 Upgrade	
	Base[a]	PC[b]	Base	PC	Base	PC	Base	PC	Base	PC
Tin	0	0	0	0	83	21	0	0	0	0
Titanium	0	0	0	0	6	0	0	0	0	0
Vanadium	0	0	0	0	157	142	0	0	0	0
Zinc	9	0	6	0	85	33	9	0	9	0
Total Exceedances	35	9	26	9	2,582	1,369	35	0	35	0

[a] Base = Baseline discharge level
[b] PC = Post-Compliance discharge level
Source: U.S. EPA analysis.

Table I.12 presents the number MP&M reaches on which pollutant concentrations are estimated to exceed acute AWQC for protection of aquatic life by pollutant.

Table I.12: Summary of Pollutants Estimated to Exceed Aquatic Life Based Acute AWQC (National Basis)

Pollutant	Selected Option: Traditional Extrapolation		Selected Option: Post-Stratification Extrapolation		Proposed/NODA Option		Directs + 413 to 433 Upgrade		Directs + All to 433 Upgrade	
	Base[a]	PC[b]	Base	PC	Base	PC	Base	PC	Base	PC
Acenaphthene	0	0	0	0	0	0	0	0	0	0
Acrolein	0	0	0	0	33	26	0	0	0	0
Aluminum	9	0	6	0	10	0	9	0	9	0
Ammonia as N	0	0	0	0	0	0	0	0	0	0
Aniline	0	0	0	0	9	0	0	0	0	0
Anthracene	0	0	0	0	64	29	0	0	0	0
Biphenyl	0	0	0	0	9	0	0	0	0	0
Butyl benzyl phthalate	0	0	0	0	0	0	0	0	0	0
Cadmium	9	0	6	0	9	6	9	0	9	0
Carbon disulfide	0	0	0	0	0	0	0	0	0	0
Chromium	0	0	0	0	7	0	0	0	0	0
Cobalt	0	0	0	0	0	0	0	0	0	0
Copper	276	267	273	267	241	69	276	9	276	9
Cyanide	0	0	0	0	0	0	0	0	0	0
Di-n-butyl phthalate	0	0	0	0	0	0	0	0	0	0
Di-n-octyl phthalate	0	0	0	0	0	0	0	0	0	0
Dibenzofuran	0	0	0	0	0	0	0	0	0	0
Dibenzothiophene	0	0	0	0	0	0	0	0	0	0
Dimethylphenanthrene, 3,6-	0	0	0	0	0	0	0	0	0	0
Dinitrophenol, 2,4-	0	0	0	0	9	9	0	0	0	0
Dinitrotoluene, 2,6-	0	0	0	0	0	0	0	0	0	0
Diphenyl Ether	0	0	0	0	0	0	0	0	0	0
Fluoranthene	0	0	0	0	21	21	0	0	0	0
Fluorene	0	0	0	0	21	21	0	0	0	0
Fluoride	0	0	0	0	0	0	0	0	0	0
Iron	0	0	0	0	0	0	0	0	0	0
Isopropylnaphthalene, 2-	0	0	0	0	0	0	0	0	0	0

Pollutant	Selected Option: Traditional Extrapolation		Selected Option: Post-Stratification Extrapolation		Proposed/NODA Option		Directs + 413 to 433 Upgrade		Directs + All to 433 Upgrade	
	Base[a]	PC[b]	Base	PC	Base	PC	Base	PC	Base	PC
Lead	18	9	15	9	9	6	18	0	18	0
Magnesium	21	21	21	21	0	0	21	21	21	0
Manganese	9	0	6	0	0	0	9	0	9	0
Methylfluorene, 1-	0	0	0	0	0	0	0	0	0	0
Methylnaphthalene, 2-	0	0	0	0	0	0	0	0	0	0
Methylphenanthrene, 1-	0	0	0	0	0	0	0	0	0	0
Molybdenum	0	0	0	0	0	0	0	0	0	0
Naphthalene	0	0	0	0	0	0	0	0	0	0
Nickel	9	9	9	9	23	0	9	0	9	0
Phenanthrene	0	0	0	0	9	9	0	0	0	0
Phenol	0	0	0	0	0	0	0	0	0	0
Pyrene	0	0	0	0	0	0	0	0	0	0
Selenium	0	0	0	0	12	12	0	0	0	0
Silver	64	56	61	56	60	12	64	23	64	23
Styrene	0	0	0	0	0	0	0	0	0	0
Sulfide	0	0	0	0	0	0	0	0	0	0
Tin	0	0	0	0	0	0	0	0	0	0
Titanium	0	0	0	0	0	0	0	0	0	0
Vanadium	0	0	0	0	0	0	0	0	0	0
Zinc	9	0	6	0	85	33	9	0	9	0
Total Exceedances	423	362	402	362	631	254	423	53	423	32

Table I.12: Summary of Pollutants Estimated to Exceed Aquatic Life Based Acute AWQC (National Basis)

[a] Base = Baseline discharge level
[b] PC = Post-Compliance discharge level.
Source: U.S. EPA analysis.

I.4.3 POTW Effects

EPA evaluated the effects of indirect MP&M dischargers on POTW operations for the final and alternative options. 788 sample MP&M facilities discharge 132 pollutants to 572 POTWs. Of these, EPA evaluated 89 pollutants for potential inhibition of POTW operations and eight pollutants for potential sludge contamination. The 788 indirect sample MP&M facilities discharge 52.8 million pounds per year of priority and nonconventional pollutants to the receiving POTWs. The final MP&M rule does not regulate indirect dischargers and thus will not reduce the baseline MP&M loadings to receiving POTWs.

a. Biological inhibition

EPA estimated inhibition of POTW operations by comparing predicted POTW influent concentrations to available inhibition levels for 89 pollutants. EPA's analysis shows that 51 POTWs had influent concentrations that exceed the biological inhibition values for one of the four following pollutants silver, cadmium, chromium and copper under the baseline conditions corresponding to the Final Option and the 433 Upgrade Options (see Table I.13). Both of the 433 Upgrade Options would eliminate influent concentrations in excess of POTW inhibition criteria at 21 POTWs. Under the baseline conditions corresponding to the Proposed/NODA Option, 293 POTWs had influent concentrations in excess of the biological inhibition criteria. The Proposed/NODA Option would eliminate influent concentrations in excess of the biological inhibition criteria at 156 POTWs.

Table I.13: National Summary of Projected Inhibition and Sludge Contamination Problems

Category	Biological Inhibition (# of POTWs)			Sludge Contamination (# of POTWs)		
	POTWs (No.)	Pollutants (No.)	Total Exceedances	POTWs (No.)	Pollutants (No.)	Total Exceedances
Selected Option: Traditional Extrapolation						
Baseline	51	4	139	1,020	7	2,702
Post-Compliance	51	4	139	1,020	7	2,702
Selected Option: Post-Stratification Extrapolation						
Baseline	51	4	139	1,020	7	2,702
Post-Compliance	51	4	139	1,020	7	2,702
Proposed/NODA Option						
Baseline	293	12	885	5,328	8	14,493
Post-Compliance	137	8	410	5,259	8	14,321
Directs + 413 to 433 Upgrade						
Baseline	51	4	139	1,020	7	2,702
Post-Compliance	30	4	115	1,005	7	2,626
Directs + All to 433 Upgrade						
Baseline	5	4	139	1,020	7	2,702
Post-Compliance	30	4	115	1,005	7	2,562

Source: U.S. EPA analysis.

Table I.14 presents MP&M pollutants that are estimated to upset POTW operations and contaminate sewage sludge.

Table I.14: Summary of Pollutants Estimated to Impact POTW Operations (National basis)

Pollutant	Selected Option: Traditional Extrapolation		Selected Option: Post-Stratification Extrapolation		Proposed/NODA Option		Directs + 413 to 433 Upgrade		Directs + All to 433 Upgrade	
	Base[a]	PC[b]	Base	PC	Base	PC	Base	PC	Base	PC
Biological Inhibition (# of POTWs)										
Acrolein	0	0	0	0	77	65	0	0	0	0
Arsenic	0	0	0	0	75	65	0	0	0	0
Benzoic acid	0	0	0	0	68	0	0	0	0	0
Bromo-2-chlorobenzene, 1-	0	0	0	0	48	48	0	0	0	0
Bromo-3-chlorobenzene, 1-	0	0	0	0	48	48	0	0	0	0
Chromium	30	30	30	30	81	7	30	27	30	27
Copper	27	27	27	27	142	0	27	27	27	27
Iron	0	0	0	0	65	32	0	0	0	0
Lead	39	39	39	39	150	81	39	30	39	30
Nickel	0	0	0	0	50	0	0	0	0	0
Silver	42	42	42	42	65	65	42	30	42	30
Zinc	0	0	0	0	16	0	0	0	0	0
Total Exceedances	139	139	139	139	885	410	139	115	139	115
Sludge Contamination (# of POTWs)										
Lead	234	234	234	234	2,829	2,790	234	234	234	234
Mercury	0	0	0	0	118	118	0	0	0	0
Nickel	763	763	763	763	2,371	2,325	763	751	763	687
Arsenic	84	84	84	84	1,686	1,683	84	84	84	84
Cadmium	754	754	754	754	1,877	1,871	754	739	754	739
Copper	534	534	534	534	1,874	1,835	534	500	534	500
Zinc	224	224	224	224	2,132	2,132	224	209	224	209
Selenium	109	109	109	109	1,567	1,567	109	109	109	109

[a] Base = Baseline discharge level
[b] PC = Post-Compliance discharge level.
Source: U.S. EPA analysis.

b. Sewage sludge

EPA estimated that baseline concentrations of seven metals at the national level fail to meet Land Application-High limits for sludge disposal at 1,020 POTWs under the final regulatory alternatives. These concentrations were compared with the relevant metals concentration limits for the following sewage sludge management options: Land Application-High (Concentration Limits), Land Application-Low (Ceiling Limits), and Surface Disposal.

The Agency estimates that the final regulation will not eliminate metal concentrations in excess of sludge contamination criteria at any of these 1,020 POTWs, since indirect dischargers are exempted from the final rule. EPA estimated that 15 POTWs would be able to upgrade their sewage sludge disposal practices by meeting Land Application-High sludge concentration limits under the 433 Upgrade Options. Under the Proposed/NODA Option, 69 POTWs would be able to upgrade their sewage sludge disposal practices to Land Application-High.

GLOSSARY

action levels: the existence of a contaminant concentration in the environment high enough to warrant implementation of drinking water treatment technology.

acute toxicity (AT): the ability of a substance to cause severe biological harm or death soon after a single exposure or dose. Also, any poisonous effect resulting from a single short-term exposure to a toxic substance (See also: chronic toxicity). (http://www.epa.gov/OCEPAterms/aterms.html)

adsorption: removal of a pollutant from air or water by collecting the pollutant on the surface of a solid material; an advanced method of treating waste in which activated carbon removes organic matter from wastewater. (http://www.epa.gov/OCEPAterms/aterms.html)

adsorption coefficient (K_{oc}): represents the ratio of the target chemical adsorbed per unit weight of organic carbon in the soil or sediment to the concentration of that same chemical in solution at equilibrium.

alkalinity: the capacity of bases to neutralize acids (e.g., adding lime to lakes to decrease acidity). (http://www.epa.gov/OCEPAterms/aterms.html)

ambient water quality criteria (AWQC): levels of water quality expected to render a body of water suitable for its designated use. Criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, fish production, or industrial processes. (http://www.epa.gov/OCEPAterms/aterms.html)

atm/m^3-mole: atmosphere per cubic meter mole (see also: mole).

benthic: relating to the bottom of a body of water; living on, or near, the bottom of a water body. (http://www.ucmp.berkeley.edu/glossary/gloss5ecol.html)

bioconcentration factor (BCF): indicator of the potential for a chemical dissolved in the water column to be taken up by aquatic biota across external surface membranes, usually gills.

BIODEG: a web-based biodegradation database developed by Syracuse Research Corporation. (http://esc.syrres.com/efdb/biodgsum.htm)

biodegradation: a process whereby organic molecules are broken down by microbial metabolism.

biodegradation half-life: represents the number of days a compound takes to be degraded to half of its starting concentration under prescribed laboratory conditions.

biological oxygen demand (BOD): the amount of dissolved oxygen consumed by microorganisms as they decompose organic material in an aquatic environment.

cancer potency slope factors (SFs): a plausible upper-bound estimate of the probability of a response per unit intake of a chemical over a lifetime. The slope factor is used to estimate an upper-bound probability of an individual developing cancer as a result of a lifetime of exposure to a particular level of a potential carcinogen.

carcinogens: chemicals that EPA believes can cause or have the potential to cause tumors or cancers in humans, either directly or indirectly.

CHEMFATE: a web-based chemical fate database developed by Syracuse Research Corporation. (http://esc.syrres.com/efdb/Chemfate.htm)

chronic toxicity (CT): the capacity of a substance to cause long-term toxic or poisonous health effects in humans, animals, fish, and other organisms (see also: acute toxicity). (http://www.epa.gov/OCEPAterms/cterms.html)

critical dilution factors (CDFs): express the relationship between a point source loading and the resulting concentration at the edge of the mixing zone. Typically, this is expressed as a ratio of parts receiving water to one part effluent.

dissolved concentration potentials (DCPs): represents the concentration of a nonreactive dissolved substance under well-mixed, steady-state conditions given an annual load of 10,000 tons.

dry metric tons (DMT): dry measure is a system of units for measuring dry commodities. 1 DMT=1,000 kilogram.

EC1: the concentration at which one percent of the test organisms show a significant sub-lethal response.

EC5: the concentration at which five percent of the test organisms show a significant sub-lethal response.

Environmental Research Laboratory-Duluth fathead minnow database: a database developed by EPA's Mid-Continent Ecology Division (MED) which provides data on the acute toxicity of hundreds of industrial organic compounds to the fathead minnow. (http://www.eoa.gov/med/databases/fathead_minnow.html)

GAGE: a U.S. Geological Survey stream flow database. The database contains stream flow data and drainage area measurement from all U.S. Geological Survey flow gages.

hazardous air pollutant (HAP): air pollutants that are not covered by ambient air quality standards but which, as defined in the Clean Air Act, may present a threat of adverse human health effects or adverse environmental effects (e.g., beryllium, mercury, ethylbenzene, chloroethane, and doxane). (http://www.epa.gov/OCEPAterms/hterms.html)

Health Effects Assessment Summary Tables (HEAST): a comprehensive listing of provisional human health risk assessment data relative to oral and inhalation routes for chemicals of interest to EPA. Unlike data in IRIS, HEAST entries have received insufficient review to be recognized as high quality, Agency-wide consensus information (U.S. EPA. 1997. Health Effects Assessment Table; FY 1997 Update. EPA-540-R-97-036).

Henry's Law (H): chemical law stating that the amount of a gas that dissolves in a liquid is proportional to the partial pressure of the gas over the liquid, provided no chemical reaction takes place between the liquid and the gas. The law is named after William Henry (1774 1836), the English chemist who first reported the relationship. (www.infoplease.com)

human health-based water quality criteria (WQC): levels of water quality expected to render a body of water suitable for its designated use. Criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, fish production, or industrial processes. (http://www.epa.gov/OCEPAterms/wterms.html)

Integrated Risk Information System (IRIS): IRIS is an electronic database with information on human health effects of various chemicals. IRIS provides consistent information on chemical substances for use in risk assessments, decision-making, and regulatory activities.

LC50 (Lethal Concentration): a standard measure of toxicity that tells how much of a substance is needed to kill half of a group of experimental organisms in a given time (see also: LD 50). (http://www.epa.gov/OCEPAterms/lterms.html)

LD50 (Lethal Dose): the dose of a toxicant or microbe that will kill 50 percent of the test organisms within a designated period. The lower the LD 50, the more toxic the compound.

l/kg: liter per kilogram

Lowest Observed Effect Concentration (LOEC): the lowest level of pollutant concentration that causes statistically and biologically significant differences in test samples as compared to other samples subjected to no stressor. (http://www.epa.gov/OCEPAterms)

Maximum Allowable Toxicant Concentration (MATC): for a given ecological effects test, the range (or geometric mean) between the No Observable Adverse Effect Level and the Lowest Observable Adverse Effects Level. (http://www.epa.gov/OCEPAterms/mterms.html)

maximum contaminant levels (MCLs): the maximum permissible level of a contaminant in water delivered to any user of a public system. MCLs are enforceable standards. (http://www.epa.gov/OCEPAterms/mterms.html)

mg/kg: milligram per kilogram

µg/l: microgram per liter

mole: the amount of substance that contains Avogardo's number of atoms, molecules or other elementary units.

National Estuarine Inventory (NEI): The National Estuarine Inventory is a series of inter-related activities that define, characterize, and assess the nation's estuarine systems. NEI data are compiled in a systematic and consistent manner that enables the nation's estuaries to be compared and assessed according to their environmental quality, economic values, and resource uses. A principal feature of the NEI is the determination of the physical dimensions and hydrologic features of estuarine systems of the United States which are primary determinants of estuarine processes and ultimately affect the ecology of a system.

National Oceanic and Atmospheric Administration (NOAA): organization within the Bureau of Commerce that conducts research and gathers data about the global oceans, atmosphere, space, and sun.

No Observed Effect Concentration (NOEC): exposure level at which there are no statistically or biologically significant differences in the frequency or severity of any effect in the exposed or control populations. (http://www.epa.gov/OCEPAterms/nterms.html)

oil and grease (O&G): organic substances that may include hydrocarbons, fats, oils, waxes, and high-molecular fatty acids. Oil and grease may produce sludge solids that are difficult to process. (http://www.epa.gov/owmitnet/reg.htm)

organic carbon (OC): carbon in compounds derived from living organisms.

partition factor: a chemical-specific value representing the fraction of the load expected to partition to sewage sludge during wastewater treatment.

Permit Compliance System (PCS): a computerized database of information on water discharge permits, designed to support the National Pollutant Discharge Elimination System (NPDES). (http://www.epa.gov/ceisweb1/ceishome/ceisdocs/pcs/pcs-exec.htm)

pH: an expression of the intensity of the basic or acid condition of a liquid; natural waters usually have a pH between 6.5 and 8.5. (http://www.epa.gov/OCEPAterms/pterms.html)

pollutants of concern (POCs): the 150 contaminants identified by EPA as being of potential concern for this rule and which are currently being discharged by MP&M facilities.

Premanufacture Notices (PMN): a notice, required by Section 5 of TSCA, that must be submitted to EPA by anyone who plans to manufacture or import a new chemical substance for a non-exempt commercial distribution. The notice must be submitted at least 90 days prior to the manufacture or import of the chemical. (http://www.epa.gov/oppt/newchems/index.htm)

priority pollutant (PP): 126 individual chemicals that EPA routinely analyzes when assessing contaminated surface water, sediment, groundwater, or soil samples. These chemicals are also known as toxic pollutants.

quantitative structure-activity relationship (QSAR): an expert system that uses a large database of measured physicochemical properties, such as melting point, vapor pressure, and water solubility, to estimate the fate and effect of a specific chemical based on its molecular structure. (http://www.epa.gov/med/databases/aster.html)

reference doses (RfDs): RfDs represent chemical concentrations - expressed in mg of pollutant/kg body weight/day - which, if not exceeded, are expected to protect an exposed population, including sensitive groups such as young children or pregnant women.

Secondary Maximum Contaminant Levels (SMCLs): non-enforceable water treatment levels applying to public water systems and specifying the maximum contamination levels that, in the judgment of EPA, are required to protect the public welfare. These treatment levels apply to any contaminants that may adversely affect the odor or appearance of such water and consequently may cause people served by the system to discontinue its use.

suspended solids: small particles of solid pollutants that float on the surface of, or are suspended in, sewage or other liquids. They resist removal by conventional means.

Superfund Chemical Data Matrix (SCDM): a source for factor values and benchmark values applied when evaluating potential National Priorities List (NPL) sites using the Hazard Ranking System (HRS). (http://www.epa.gov/superfund/resources/scdm/index.htm)

systemic toxicants: chemicals that EPA believes can cause significant non-carcinogenic health effects when present in the human body above chemical-specific toxicity thresholds.

total Kjeldahl nitrogen (TKN): TKN is defined as the total of organic and ammonia nitrate. It is determined in the same manner as organic nitrogen, except that the ammonia is not driven off before the digestion step.

total organic carbon (TOC): a measure of the suspended solids in wastewater, effluent, or water bodies, determined by tests for "total suspended non-filterable solids" (see also: suspended solids).

total petroleum hydrocarbons (TPH): a general measure of the amount of crude oil or petroleum product present in an environmental media (e.g. soil, water, or sediments). While it provides a measure of the overall concentration of petroleum hydrocarbons present, TPH does not distinguish between different types of petroleum hydrocarbons.

total suspended particles (TSP): method of monitoring airborne particulate matter by total weight. (http://www.epa.gov/OCEPAterms/tterms.html)

total suspended solids (TSS): a measure of the suspended solids in wastewater, effluent, or water bodies, determined by tests for "total suspended non-filterable solids" (see also: suspended solids).

United States Geological Survey (USGS): a governmental organization that provides reliable scientific information to: describe and understand the Earth; minimize loss of life and property from natural disasters; manage water, biological, energy, and mineral resources; and enhance and protect our quality of life. (www.noaa.gov)

volatilization: a process whereby chemicals dissolved in water escape into the air.

ACRONYMS

AQUIRE: AQUatic Information REtrieval System
ASTER: ASsessment Tools for the Evaluation of Risk
AT: acute toxicity
AWQC: ambient water quality criteria
BCF: bioconcentration factor
BOD: biological oxygen demand
CDF: critical dilution factor
CT: chronic toxicity
DCP: dissolved concentration potential
DMT: dry metric tons
H: Henry's Law
HAP: hazardous air pollutant
HEAST: Health Effects Assessment Summary Tables
IRIS: Integrated Risk Information System
K_{oc}: adsorption coefficient
LOEC: Lowest Observed Effect Concentration
MATC: Maximum Allowable Toxicant Concentration
MCL: maximum contaminant level
NEI: National Estuarine Inventory
NOAA: National Oceanic and Atmospheric Administration
NOEC: No Observed Effect Concentration
O&G: oil and grease
OC: organic carbon
PCS: Permit Compliance System
PMN: Premanufacture Notices
POC: pollutant of concern
PP: priority pollutant
QSAR: quantitative structure-activity relationship
RBC: EPA's Region III Risk-Based Concentration Table
RfD: reference dose
SCDM: Superfund Chemical Data Matrix
SF: cancer potency slope factor
SMCL: Secondary Maximum Contaminant Level
TKN: total Kjeldahl nitrogen
TOC: total organic carbon
TPH: total petroleum hydrocarbons
TSP: total suspended particulates
TSS: total suspended solids
USGS: United States Geological Survey
WQC: water quality criteria

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Appendix J: Spacial Distribution of MP&M Facilities and Recreational User Populations

Introduction

This appendix compares the national distribution of all MP&M facilities by state and the national distribution of recreational participants by state (see Table J.1 and Figure J.1).

Appendix Contents

EPA based the distribution of MP&M facilities by state on Census data on total numbers of facilities in the SICs that make up the MP&M industries, not just water dischargers. This comparison assumes that the state distribution of water-discharging MP&M facilities is the same as the overall distribution of MP&M facilities.

EPA based the distribution of recreational participants by state and by type of recreation activity on information provided by the National Demand Study data. This comparison suggests that the reaches that benefit from the final rule are also those where a very large percentage of all recreational participants reside and recreate.

Table J.1: Distribution of MP&M Facilities and Participants of Water-based Recreation by State

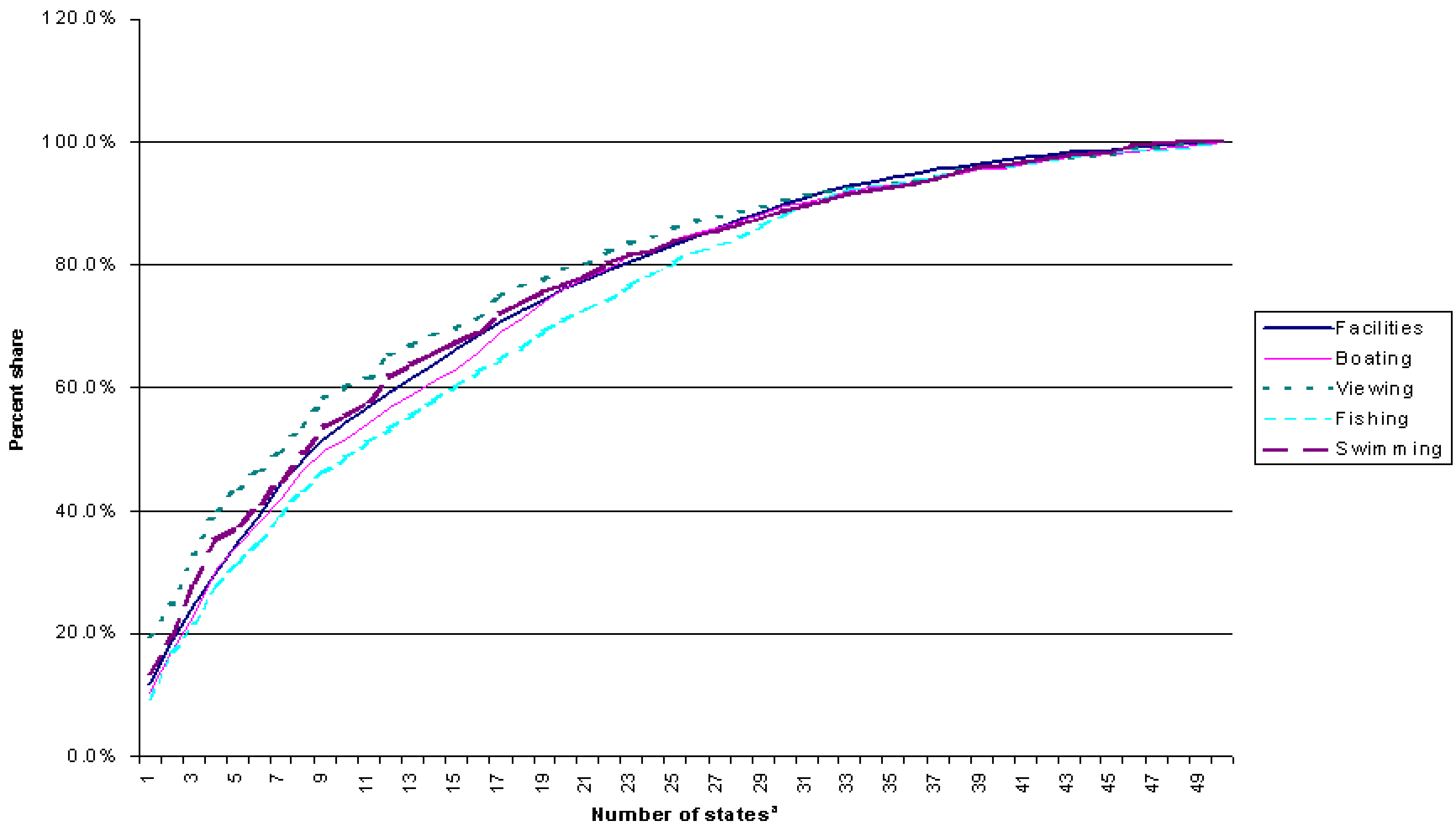
State	Percent of State Population Participating by Activity				Average # of Per-Person Trips per Season by Activity				Total State Pop. (1990) (Millions)	Potential (Extrapolated) # Participants Based on State Population				Nat.'l # of MP&M Facilities	State % of National Facilities	Cum. ST % of Facilities	Cumulative Percent Distribution of Participants by State			
	Boat	View	Fish	Swim	Boat	View	Fish	Swim		Boat	View	Fish	Swim				Boat	View	Fish	Swim
CA	11.7%	36.9%	13.6%	20.1%	5.4	14	7.1	11.7	29.8	3,490,513	10,992,849	4,057,154	5,983,736	68,359	11.9%	11.9%	10.3%	19.5%	9.4%	13.8%
TX	12.8%	16.4%	18.9%	14.5%	7.2	5	10.6	6.5	17.0	2,171,791	2,792,303	3,205,978	2,456,192	38,176	6.6%	18.5%	16.7%	24.5%	16.8%	19.4%
NY	12.4%	25.6%	11.2%	20.5%	7.9	5.7	9.2	8.7	18.0	2,231,374	4,602,209	2,022,183	3,695,714	36,329	6.3%	24.8%	23.3%	32.6%	21.5%	27.9%
FL	18.7%	32.6%	20.5%	24.2%	10.1	17.9	17.1	15.4	12.9	2,423,418	4,221,438	2,657,943	3,126,991	30,198	5.2%	30.0%	30.5%	40.1%	27.7%	35.1%
IL	11.8%	17.2%	14.6%	9.4%	9.6	9	13.7	5.7	11.4	1,349,105	1,962,335	1,667,985	1,079,284	28,343	4.9%	34.9%	34.5%	43.6%	31.5%	37.6%
OH	11.5%	15.8%	14.2%	14.0%	8	8.2	13.1	8.8	10.8	1,251,590	1,718,851	1,535,284	1,518,596	26,460	4.6%	39.5%	38.2%	46.6%	35.1%	41.1%
PA	10.5%	14.4%	15.2%	13.7%	9.4	7.4	10.9	8	11.9	1,249,014	1,713,391	1,809,469	1,633,326	26,237	4.6%	44.1%	41.9%	49.7%	39.3%	44.8%
MI	16.0%	24.8%	18.4%	20.8%	8.6	9.4	12	8.5	9.3	1,484,665	2,307,687	1,710,593	1,936,520	23,662	4.1%	48.2%	46.3%	53.8%	43.2%	49.3%
NJ	15.9%	32.3%	15.9%	23.9%	10.9	6.4	6.3	7.3	7.7	1,225,246	2,495,046	1,225,246	1,849,008	19,805	3.4%	51.6%	49.9%	58.2%	46.1%	53.5%
NC	8.8%	17.9%	16.5%	13.5%	7.7	5.2	13.6	7.4	6.6	586,317	1,188,920	1,091,201	895,762	15,158	2.6%	54.3%	51.6%	60.3%	48.6%	55.6%
IN	14.3%	15.0%	20.3%	16.3%	7.7	9	11.8	5.5	5.5	794,663	831,624	1,127,312	905,546	14,656	2.5%	56.8%	54.0%	61.8%	51.2%	57.7%
MA	15.7%	30.9%	15.7%	28.9%	8.7	11.6	14.3	9.5	6.0	942,332	1,860,501	942,332	1,739,689	13,915	2.4%	59.2%	56.8%	65.1%	53.4%	61.7%
WI	15.7%	22.1%	18.1%	19.7%	10	6.1	11.5	6.2	4.9	768,940	1,079,788	883,463	965,266	13,845	2.4%	61.6%	59.0%	67.0%	55.4%	63.9%
GA	11.5%	13.9%	16.6%	11.5%	11.4	4.1	10.3	7.4	6.5	746,819	903,129	1,076,808	746,819	13,747	2.4%	64.0%	61.2%	68.6%	57.9%	65.6%
MO	13.0%	12.6%	18.8%	15.2%	5.2	4	5	8	5.1	665,035	646,562	960,606	775,874	13,395	2.3%	66.3%	63.2%	69.8%	60.1%	67.4%
VA	13.4%	17.0%	16.2%	13.4%	9	4.2	8.4	6.1	6.2	827,102	1,049,783	1,002,066	827,102	12,829	2.2%	68.6%	65.7%	71.6%	62.5%	69.3%
WA	25.0%	39.2%	18.8%	25.9%	5.8	11.7	18.2	5.8	4.9	1,216,673	1,907,623	916,260	1,261,735	11,991	2.1%	70.6%	69.3%	75.0%	64.6%	72.2%
MN	17.6%	19.6%	19.6%	17.6%	5.4	16.5	11.5	6.8	4.4	767,875	857,162	857,162	767,875	11,272	2.0%	72.6%	71.5%	76.5%	66.6%	73.9%
TN	17.9%	13.5%	22.6%	14.5%	7.5	3.7	15.1	6.7	4.9	873,280	659,079	1,103,957	708,510	10,808	1.9%	74.5%	74.1%	77.7%	69.1%	75.6%
MD	14.8%	18.7%	17.1%	12.1%	8.8	12.1	13.2	8.4	4.8	706,988	893,037	818,617	576,753	8,993	1.6%	76.0%	76.2%	79.3%	71.0%	76.9%
AL	14.7%	11.9%	20.6%	13.8%	7.5	9.2	18.6	10.6	4.0	593,114	481,905	834,066	556,044	8,825	1.5%	77.6%	77.9%	80.1%	72.9%	78.2%
CT	16.4%	37.1%	14.5%	27.0%	7.7	6.8	7.7	12.3	3.3	537,516	1,219,747	475,495	888,969	8,593	1.5%	79.1%	79.5%	82.3%	74.0%	80.2%
LA	16.4%	15.3%	27.0%	13.8%	4	3.4	13.4	4.4	4.2	692,165	647,509	1,138,723	580,525	8,500	1.5%	80.5%	81.6%	83.4%	76.7%	81.5%
CO	6.6%	13.2%	25.9%	11.3%	17.2	14.8	13.1	5.2	3.3	217,554	435,109	854,678	372,950	8,231	1.4%	82.0%	82.2%	84.2%	78.7%	82.4%
OR	20.3%	37.8%	24.9%	23.0%	8.8	7.2	13.2	7.4	2.8	576,323	1,074,057	707,306	654,913	7,978	1.4%	83.3%	83.9%	86.1%	80.3%	83.9%
KY	11.9%	12.3%	22.4%	10.0%	6.5	3	9.4	17.5	3.7	437,524	454,352	824,564	370,212	7,822	1.4%	84.7%	85.2%	86.9%	82.2%	84.8%
AZ	7.3%	11.2%	11.8%	10.7%	7.2	8	8.3	5.7	3.7	267,685	411,823	432,415	391,232	7,799	1.4%	86.1%	86.0%	87.7%	83.2%	85.7%
IA	13.5%	16.4%	18.7%	13.5%	5	4.4	13.8	2.7	2.8	373,482	454,673	519,627	373,482	7,661	1.3%	87.4%	87.1%	88.5%	84.4%	86.5%
OK	11.2%	12.6%	25.2%	14.0%	4.9	3.4	14.6	4.2	3.1	351,954	395,948	791,896	439,942	6,972	1.2%	88.6%	88.2%	89.2%	86.2%	87.5%

Table J.1: Distribution of MP&M Facilities and Participants of Water-based Recreation by State

State	Percent of State Population Participating by Activity				Average # of Per-Person Trips per Season by Activity				Total State Pop. (1990) (Millions)	Potential (Extrapolated) # Participants Based on State Population				Nat.'l # of MP&M Facilities	State % of National Facilities	Cum. ST % of Facilities	Cumulative Percent Distribution of Participants by State			
	Boat	View	Fish	Swim	Boat	View	Fish	Swim		Boat	View	Fish	Swim				Boat	View	Fish	Swim
SC	13.8%	19.9%	26.0%	15.5%	9.8	8.5	16.2	7.5	3.5	481,589	693,488	905,387	539,380	6,907	1.2%	89.8%	89.6%	90.4%	88.3%	88.8%
KS	6.7%	17.0%	18.5%	13.3%	17.6	9	12.9	6.2	2.5	165,172	422,105	458,810	330,343	6,370	1.1%	90.9%	90.1%	91.1%	89.4%	89.5%
AR	14.1%	12.5%	28.1%	18.0%	4.6	10.2	13.3	7.3	2.4	330,571	293,841	661,141	422,396	5,825	1.0%	91.9%	91.1%	91.7%	90.9%	90.5%
MS	13.6%	12.1%	23.6%	15.7%	6.3	24.2	17.4	12.9	2.6	349,222	312,462	606,544	404,363	5,165	0.9%	92.8%	92.1%	92.2%	92.3%	91.4%
NE	10.7%	15.5%	10.7%	15.5%	3.9	2.1	13.9	3.9	1.6	169,113	244,274	169,113	244,274	4,424	0.8%	93.6%	92.6%	92.7%	92.7%	92.0%
UT	8.1%	17.1%	13.5%	12.6%	6.6	3.5	3.6	6.8	1.7	139,691	294,902	232,818	217,296	3,633	0.6%	94.2%	93.0%	93.2%	93.3%	92.5%
WV	9.5%	10.3%	18.3%	15.9%	6.6	4.6	17.2	6.7	1.8	170,807	185,041	327,381	284,679	3,442	0.6%	94.8%	93.5%	93.5%	94.0%	93.1%
RI	15.8%	40.4%	19.3%	36.8%	6.9	4.6	8.3	7	1.0	158,442	404,907	193,651	369,697	3,106	0.5%	95.3%	94.0%	94.2%	94.5%	94.0%
ME	22.2%	44.4%	27.8%	37.5%	7.6	5.7	10.5	10.3	1.2	272,873	545,746	341,091	460,473	2,980	0.5%	95.9%	94.8%	95.2%	95.3%	95.1%
NH	18.8%	31.2%	14.1%	34.4%	3.3	14.9	13.2	15.7	1.1	207,985	346,641	155,989	381,305	2,960	0.5%	96.4%	95.4%	95.8%	95.6%	95.9%
NM	6.7%	8.6%	12.4%	9.5%	3.7	5.6	9.8	3.8	1.5	101,005	129,863	187,580	144,292	2,927	0.5%	96.9%	95.7%	96.0%	96.1%	96.3%
ID	24.1%	25.3%	20.5%	20.5%	5.8	4.3	13.4	9.5	1.0	242,590	254,720	206,202	206,202	2,572	0.4%	97.3%	96.4%	96.5%	96.5%	96.7%
NV	17.3%	21.3%	13.3%	12.0%	4.8	7.3	15.4	6.3	1.2	208,318	256,391	160,244	144,220	2,406	0.4%	97.7%	97.0%	96.9%	96.9%	97.1%
MT	14.5%	20.0%	34.5%	29.1%	7.8	15.6	20.7	8.3	0.8	116,228	159,813	276,041	232,455	2,204	0.4%	98.1%	97.4%	97.2%	97.5%	97.6%
SD	16.7%	21.4%	16.7%	21.4%	2.3	1.8	6	7	0.7	116,001	149,144	116,001	149,144	2,049	0.4%	98.5%	97.7%	97.5%	97.8%	97.9%
ND	15.0%	15.0%	25.0%	15.0%	3.7	3	4.5	11.5	0.6	95,820	95,820	159,700	95,820	1,749	0.3%	98.8%	98.0%	97.7%	98.2%	98.2%
HI	16.4%	58.2%	18.2%	47.3%	6.7	33.9	6.6	15.5	1.1	181,347	644,788	201,496	523,890	1,677	0.3%	99.1%	98.5%	98.8%	98.7%	99.4%
VT	20.6%	17.6%	8.8%	20.6%	7.1	5.5	8.7	10.4	0.6	115,862	99,310	49,655	115,862	1,488	0.3%	99.3%	98.9%	99.0%	98.8%	99.6%
DE	15.7%	41.2%	15.7%	13.7%	6.4	11	11.5	6.9	0.7	104,497	274,305	104,497	91,435	1,379	0.2%	99.6%	99.2%	99.5%	99.0%	99.8%
WY	19.4%	16.1%	48.4%	6.5%	6.3	4.6	8.1	8	0.5	87,791	73,159	219,478	29,264	1,309	0.2%	99.8%	99.4%	99.6%	99.5%	99.9%
AK	34.5%	41.4%	37.9%	6.9%	5.4	7.1	17.4	2	0.6	189,670	227,604	208,637	37,934	1,156	0.2%	100.0%	100.0%	100.0%	100.0%	100.0%

Source: Information on total MP&M facilities by state is from Census data; information on where recreating people live is from NDS data.

Figure J.1: Cumulative Distribution of Facilities and Participants



[a] The numbers refer to states in the order they appear in the above table. Therefore, 1 is California, 2 is Texas, 3 is New York, etc.

Sources: Information on total MP&M facilities by state is from Census data; information on where recreating people live is from NDS data.

Appendix K: Selecting WTP Values for Benefits Transfer

INTRODUCTION

EPA identified eight surface water evaluation studies that quantified the effects of water quality improvements on various water-based recreational activities. As noted in Chapter 15 of this report, the Agency selected these studies based on technical criteria for evaluating study transferability (Desvousges et al., 1987; Desvousges et al., 1992; and Boyle and Bergstrom, 1992), including the following:

- The environmental change valued at the study site must be the same as the environmental quality change caused by the rule (e.g., changes in toxic contamination vs. changes in nutrient concentrations);
- The populations affected at the study site and at the policy site must be the same (e.g., recreational users vs nonusers);
- The assignment of property rights at both the study and policy sites must lead to the same theoretically-appropriate welfare measure (e.g., ***willingness-to-pay*** ***(WTP)*** vs. willingness-to-accept compensation); and
- The candidate studies should be based on defensible research methods. Six of the eight studies are published in peer reviewed journals. One study, Tudor et al. (2002), was presented at the annual American Agricultural Economic Association and the Northeastern Resource and Environmental Economic meetings.[1] The eighth study, Lyke (1993), is an unpublished Ph.D. dissertation.

APPENDIX CONTENTS

In addition to the above criteria, the Agency considered authors' recommendations regarding the robustness and theoretical soundness of various estimates in selecting point estimates for benefits transfer.

The rest of this appendix presents welfare estimates from seven studies used in estimating recreational benefits from the final regulation and provides EPA's reasons for selecting specific values from each study. The study by Tudor et al. (2002) is discussed in detail in Chapter 21. All welfare estimates from that study are eligible for use in benefits transfer, because the study is based on the policy scenarios specific to the MP&M regulation.

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[1] Preliminary results of this study were presented at the annual American Agricultural Economic Association meeting (L. Tudor et al., 1999a) and at the annual Northeastern Agricultural and Resource Economic Association meeting (L. Tudor et al., 1999b). EPA subjected this study to a formal peer review by experts in the natural resource valuation field. The peer review concluded that EPA had done a competent job, especially given the available data. This study can be found in Chapter 21. The peer review report is in the docket for the rule.

K.1 Desvousges et al., 1987. Option Price Estimates for Water Quality Improvements: A Contingent Valuation Study for the Monongahela River

This study used findings from a ***contingent valuation (CV)*** survey to estimate WTP for improved recreational fishing from enhanced water quality in the Pennsylvania portion of the Monongahela River. In a hypothetical market, each survey respondent was asked to provide an option price for different water quality changes, such as "raising the water quality from suitable for boating (hereafter, 'boatable' water) to a level where gamefish would survive (hereafter, 'fishable' water)." Table K.1 lists water quality changes evaluated in the study and the corresponding WTP estimates. The following discussion provides justification for selecting the point estimates EPA used in the benefits transfer analysis in Chapter 15.

Table K.1: Changes in the Resource Value from a Specified Water Quality Improvement from Desvousges et al. (1987)

Water Quality Change Valued	Adjusted to 2001$ [b]			Original Estimates (1981$)		
	User	Nonuser	Combined	User	Nonuser	Combined
Iterative Bidding: $25 starting point						
Unsuitable to Boatable	$53.4	$57.8	$56.4	$27.4	$29.7	$29.0
Boatable to Fishable[a]	**$36.8**	$28.3	$30.9	**$18.9**	$14.5	$15.9
Fishable to Swimmable	$23.0	$14.0	$16.9	$11.8	$7.2	$8.7
Boatable to Swimmable	$62.5	$42.2	$48.9	$32.1	$21.7	$25.1
Unsuitable to Swimmable	$115.9	$100.0	$105.3	$59.5	$51.4	$54.1
Iterative Bidding: $125 starting point						
Unsuitable to Boatable	$184.4	$75.6	$111.7	$94.7	$38.8	$57.4
Boatable to Fishable	$113.1	$51.2	$71.9	$58.1	$26.3	$36.9
Fishable to Swimmable	$64.4	$22.5	$36.6	$33.1	$11.6	$18.8
Boatable to Swimmable	$194.1	$78.9	$117.3	$99.7	$40.5	$60.2
Unsuitable to Swimmable	$378.5	$154.2	$229.0	$194.4	$79.2	$117.6
Direct Question: no payment card						
Boatable to Unsuitable	$88.2	$27.6	$47.7	$45.3	$14.2	$24.5
Boatable to Fishable	$60.9	$21.0	$34.2	$31.3	$10.8	$17.6
Fishable to Swimmable	$39.3	$16.6	$24.1	$20.2	$8.5	$12.4
Boatable to Swimmable	$103.0	$39.5	$60.7	$52.9	$20.3	$31.2
Unsuitable to Swimmable	$191.2	$67.2	$108.4	$98.2	$34.5	$55.7
Direct Question: payment card						
Boatable to Unsuitable	$91.1	$103.2	$99.3	$46.8	$53.0	$51.0
Boatable to Fishable	$88.2	$42.6	$57.1	$45.3	$21.9	$29.3
Fishable to Swimmable	$44.5	$15.0	$24.3	$22.9	$7.7	$12.5
Boatable to Swimmable	$138.6	$58.3	$83.6	$71.2	$29.9	$42.9
Unsuitable to Swimmable	$229.6	$161.3	$182.8	$117.9	$82.8	$93.9

Location: Pennsylvania portion of the Monongahela River
Estimating Approach: CV
Survey Population : Recreational Users and Nonusers
[a] The value selected for benefits transfer is given in bold.
[b] WTP values from the original study are adjusted to 2001$ based on the Consumer Price Index (CPI).

Source: Desvousges et al., 1987.

EPA judged that only one value from this study met the requirements for the quality of research methods and was compatible with the environmental changes and population characteristics considered in the analysis of recreational benefits from the MP&M rule. EPA selected this value for the following reasons:

- **Environmental quality change.** The Desvousges et al. (1987) study derived WTP values for five different changes in water quality, as shown in Table K.1 above. EPA judged that only one of these improvements, from "boatable" to "fishable," is compatible with the changes in water quality expected under the MP&M rule. Streams unsuitable for recreational activities such as boating are likely to be affected by multiple environmental stressors from many sources, including many that are not related to MP&M discharges (e.g., severe oxygen depletion.) In these cases, it is reasonable to assume that changes in concentrations of MP&M pollutants would reduce or eliminate one of the stressors on the reach, but would be unlikely to change the designation of the reach.

  The analysis in Chapter 15 assumes that reaches with ***ambient water quality criteria (AWQC)*** exceedances under the baseline conditions are boatable and likely to support rough fishing, but may not be clean enough to support gamefishing. AWQC are set at a level below which pollutant concentrations are not expected to cause significant harm to human health or aquatic life. Exposure to pollutant concentrations above the AWQC levels are expected to have a harmful effect. Therefore, by definition, water with pollutant levels that exceed criteria set to protect human health or aquatic life are not suitable waters for sensitive aquatic species or ideal as a sources of fish for consumption.

  Removing AWQC exceedances is therefore comparable to shifting water quality from "boatable"to "fishable." The Agency did not use the boatable to swimmable designation because a more limited number of reaches are suitable for swimming nationally due to reasons not related to MP&M discharges (e.g., amenities, pathogens). Determining national level locations affected by MP&M pollutants that are suitable for swimming required more resources than were available for the national analysis.

- **Research methods.** The authors used four different payment vehicles in their CV study. For the recreational benefits analysis, EPA decided to use the WTP estimates derived from the "***iterative bidding***" ***(IB)*** payment vehicle, because it is universally preferred to the "***direct question/open-ended***" format for eliciting option price bids.

  Survey respondents in the direct question format are asked to state the most that they would be willing to pay for the program or policy. This format confronts respondents with an unfamiliar choice. Studies that use this approach usually have high non-response rates.

  Respondents in the IB format are asked whether they would be willing to pay a given amount. If the answer is yes, then this amount is raised in pre-set increments until the respondent says that he or she will not pay the last amount given. If the answer is no, then the amount is decreased until the respondent indicates WTP the stated amount. Some studies found that the respondent's final WTP amount depends on the initial amount offered. This problem is referred to in economic literature as starting point bias. The Agency selected the WTP estimates derived using the $25 starting point IB process to avoid upward starting point bias. Table K.1 shows that the selected estimates are the most conservative among all the payment vehicles used.

- **Population characteristics.** The user population considered in this study matches the user population characteristics considered in EPA's analysis (i.e., recreational anglers, boaters, and wildlife viewers).

K.2 Farber and Griner, 2000. Valuing Watershed Quality Improvements Using Conjoint Analysis

Farber and Griner (2000) used a CV study to estimate changes in water resource values to users from various improvements in Pennsylvania's water quality. The study defines water quality as "polluted," "moderately polluted," and "unpolluted" based on a water quality scale developed by EPA Region III. "Polluted" streams are unable to support aquatic life, "moderately polluted" streams are somewhat unable to support aquatic life, and "unpolluted" streams adequately support aquatic life. Farber and Griner developed WTP estimates for water quality improvements for the following three water quality changes:

- from "moderately polluted" to "unpolluted,"
- from "severely polluted" to "moderately polluted," and

- from "severely polluted" to "unpolluted."

The authors used six different model variations to estimate the WTP for the three improvements scenarios for various population groups (e.g., users, nonusers, and a mix of users and nonusers). Table K.2 presents the estimated WTP values. The following discussion provides EPA's reasons for selecting point estimates for the use in benefits transfer.

Table K.2: Estimate WTP for Specified Water Quality Improvements from Farber and Griner (2001$)

Water Quality Change Valued	Binary Choice Model			Intensity of Preference Model		
	User	Nonuser	Combine	User	Nonuser	Combine
Basic						
Moderately Polluted to Unpolluted	$49.7	$6.3	$40.4	$56.2	$14.0	$54.2
Severely Polluted to Moderately Polluted	$66.9	$5.8	$55.6	$73.8	$51.4	$70.9
Severely Polluted to Unpolluted	$117.3	$44.9	$95.7	$129.6	$57.7	$116.8
Interactive						
Moderately Polluted to Unpolluted	$48.2	$3.2	$38.0	$56.9	$13.3	$54.6
Severely Polluted to Moderately Polluted	$65.2	$1.5	$52.7	$75.1	$50.6	$71.9
Severely Polluted to Unpolluted	$115.5	$41.3	$92.9	$133.1	$57.6	$119.5
Fixed Effects						
Moderately Polluted to Unpolluted [a]	**$24.5**	$16.4	$28.3	**$41.8**	$5.5	$41.0
Severely Polluted to Moderately Polluted	$42.4	$10.6	$38.2	$63.4	$30.3	$59.0
Severely Polluted to Unpolluted	$86.6	$48.4	$80.4	$110.5	$31.0	$98.6

Location: Lower Allegheny Watershed in Western Pennsylvania
Estimating Approach: Conjoint Analysis
Survey Population: Recreational users and nonusers
[a] Values selected for the use in benefits transfer are given in bold.
[b] WTP values from the original study are adjusted to 2001$ based on CPI.

Source: Farber and Griner, 2000.

The Agency selected only two values from this study based on their compatibility with the environmental changes and population characteristics considered in both the original study and the analysis of recreational benefits from the MP&M rule. The following discussion summarizes EPA's reasons used in the selection process:

- **Environmental quality change.** EPA judged that only one water quality improvement scenario change from "moderately polluted" to "unpolluted" is compatible with the environmental quality change expected from the final regulation

  AWQC are set at a level below which pollutant concentrations have not been demonstrated to cause significant harm to human health or aquatic life. Exposure to pollutant concentrations above the AWQC levels are expected to have a harmful effect. Therefore, by definition, water with pollutant levels that exceed criteria set to protect human health or aquatic life are polluted waters.

  EPA chose the case where the policy variable changed from moderately polluted to unpolluted because this is likely to be the most frequently occurring scenario for reaches with MP&M discharges. Streams unable to support any aquatic life (i.e., "severely polluted") are likely to be affected by numerous environmental stressors, in addition to MP&M discharges. Eliminating MP&M-related AWQC exceedences would eliminate or reduce one of the stressors, but is unlikely to change the quality of the water from severely polluted to unpolluted. It is more realistic to assume that most streams affected by MP&M facility discharges are moderately polluted, i.e., these streams support some aquatic life; but sensitive species are adversely affected by MP&M pollutants exceeding AWQC values protective of aquatic life. Removing all AWQC exceedances would make such streams unpolluted.

- **Research methods.** EPA considered only two of the six versions of the benefits transfer model based on the authors' recommendations. The authors appear to prefer the "fixed effects" versions of both the ***binary choice***

(BC) and ***intensity of preference (IP)*** models. Specifically, they note that "A likelihood ratio test, with degrees of freedom being the number of individuals in the estimating sample, can be used to test the superiority of the fixed effects model. Such a test shows the fixed effects model to be a statistical improvement over either the basic or interactive models" (see Table K.2). In addition, they state that, "the purpose of estimating a fixed effects model was to account for the possibility that some respondents may approve of all changes, regardless of price and quality. If this behavior existed in the sample, not controlling for it would result in overestimates of marginal valuations for each type of quality change. This expectation is supported by the fact that the fixed effects valuation estimates are lower than the others."

- **Population characteristics.** The user population considered in this study matches the user population characteristics considered in EPA's analysis (i.e., recreational anglers, boaters, and wildlife viewers).

K.3 Jakus et al., 1997. Do Sportfish Consumption Advisories Affect Reservoir Anglers' Site Choice?

Jakus et al. (1997) used a repeated discrete choice ***travel cost (TC)*** model to examine the impacts of ***fish consumption advisories (FCA)*** in eastern and middle Tennessee. The estimated consumer surplus from recreational fishing in middle and east Tennessee is $26.02 and $52.57 per angler per day, respectively, under the baseline water quality conditions. The estimated welfare gain from removing FCAs is $2.04 and $3.16 per angler per day , respectively. Table K.3 summarizes the study's estimates.

Table K.3:Consumer Surplus from Recreational Fishing from Jakus et al. (1997)[a]

Water Quality Change Valued	Consumer Surplus Adjusted to 2001$	Consumer Surplus ($1997)
Site Choice Model -- multinomial logit		
Average surplus per trip in middle TN (baseline water quality	$26.02	$23.60
Benefit per trip from removing all advisories in middle TN	**$2.04**	**$1.85**
Average surplus per trip in East TN (baseline water quality conditions)	$52.57	$47.67
Benefit per trip from removing all advisories in east TN	**$3.16**	**$2.86**
Benefit per trip from removing Watts Bar advisory	$1.75	$1.59
Repeated Discrete Choice Model -- repeated nested logit model		
Seasonal benefit from removing all advisories in middle TN	$24.22	$21.96
Seasonal benefit from removing all advisories in east TN	$52.27	$47.40
Seasonal benefit from removing Watts Bar advisory	$30.43	$27.60

Location: Tennessee
Estimating Approach: TC
Survey Population: Tennessee residents; anglers and non-anglers
[a] Values selected for the use in benefits transfer are given in bold.
[b] WTP values from the original study are adjusted to 2001$ based on CPI.

Source: Jakus et al, 1997.

EPA selected two values from this study for use in benefits transfer, based on their compatibility with the environmental quality change and population characteristics at both the original study and policy sites, for the following reason:

- **Environmental quality change.** FCAs are usually triggered by the presence of toxic pollutants in fish tissue. EPA expects the final regulation to reduce discharges of toxic pollutants, including those linked to FCAs (e.g., mercury and lead). The Agency therefore assumed that the removal of FCAs is compatible with water quality improvements expected from the final regulation.

The recreational benefits analysis uses consumer surplus estimates for both regions studied by the authors, because MP&M facilities are located in these regions as well as throughout heavily populated regions of the U.S. EPA did not include the value corresponding to the Watts Bar lake in the benefits transfer analysis because this lake is included in the set of fishing areas for east Tennessee.

K.4 Lant and Roberts, 1990. Greenbelts in the Cornbelt: Riparian Wetlands, Intrinsic Values, and Market Failure

Lant and Roberts (1990) used a CV study to estimate the recreational and nonuse benefits of improved water quality in selected Iowa and Illinois river basins. River quality was defined by means of an interval scale of "poor," "fair," "good," and "excellent." The authors defined the four water quality intervals as follows:

- "poor" water quality is inadequate to support any recreation activity,
- "fair" water quality is adequate for boating and rough fishing,
- "good" water quality is adequate for gamefishing, and
- "excellent" is adequate to support swimming and exceptional fishing.

Table K.4 summarizes WTP values for specified water quality improvements from this study.

Table K.4: WTP Values for a Specified Water Quality Improvement from Lant and Roberts (1990)

Water Quality Change Valued	Adjusted to 2001$		Original Study Values 1987$	
	Use Value	Nonuse Value	Use Value	Nonuse Value
Poor to fair	$47.5	$58.6	$30.50	$37.61
Fair to good[a]	**$57.8**	$73.5	**$37.10**	$47.16
Good to excellent	$64.7	$67.3	$41.51	$43.22

Location: Selected Iowa and Illinois river basins
Estimating Approach: CV
Survey Population: Recreational users and nonusers

[a] The values given in bold were selected for the use in benefits transfer.
[b] WTP values from the original study are adjusted to 2001$ based on CPI.

Source: Lant and Roberts, 1990.

The Agency judged that only one value from this study is compatible with the environmental changes and population characteristics considered in the analysis of recreational benefits from the MP&M rule, for the following reasons:

- **Environmental quality change.** The Agency judged that only one of the three possible water quality changes considered in this study "fair" to "good" was compatible with the water quality change expected under the MP&M rule. EPA assumed in its analysis of recreational benefits expected from the MP&M rule that reaches with AWQC exceedances under the baseline conditions may support rough fishing, but may not be clean enough to support more sensitive species such as those desired for game fishing. Removing AWQC exceedances will shift water quality from "fair" to "good."
- **Population characteristics.** The user population considered in this study matches the population characteristics considered in EPA's analysis (i.e., recreational anglers, boaters, and wildlife viewers).

K.5 Audrey Lyke, 1993. Discrete Choice Models to Value Changes in Environmental Quality: A Great Lakes Case Study

Lyke's (1993) study of the Wisconsin Great Lakes open water sport fishery showed that anglers may place a significantly higher value on a contaminant-free fishery than on one with some level of contamination. Lyke estimated the value of the fishery to Great Lakes trout and salmon anglers if it was improved enough to be "completely free of contaminants that may threaten human health." The author also estimated various policy scenarios that affect the value of recreational fishing in the Wisconsin Great Lakes, including reducing the daily bag limit for lake trout and restoring naturally reproducing populations of lake trout. Table K.5 presents welfare estimates from this study.

Table K.5: WTP Estimates for Specified Water Quality Improvements from Lyke (1993)[a]

Water Quality Change Valued	Adjusted to 2001$ [b]		Original Study Value	
	Value of WI Fishing	Change in Value	Value of WI Fishing	Change in Value
CV -- linear logit model				
1990 fishing conditions remain the same as 1989	**$95,062,744**		**$66,600,000**	
WI daily bag limit for lake trout reduced to one a day	$43,962,951	($51,099,793	$30,800,000	($35,800,000
Great Lakes fish are free of pollutants affecting human health	$105,625,27	**$10,562,527**	$74,000,000	**$7,400,000**
Restoring naturally reproducing populations of lake trout	$17,271,159	$17,271,159	$12,100,000	$12,100,000
WI inland fishing conditions remain the same as 1989	$964,330,17		$675,600,00	
Restoring naturally reproducing populations of lake trout in WI waters of Great Lakes (inland anglers only)	$0	$0	$0	$0
CV -- constant elasticity of substitution model (mean)				
1990 fishing conditions remain the same as 1989	**$118,899,79**		**$83,300,000**	
Great Lakes fish are free of pollutants affecting human health	$156,011,38	**$37,111,581**	$109,300,00	**$26,000,000**
CV -- constant elasticity of substitution model (median)				
1990 fishing conditions remain the same as 1989	$26,834,528		$18,800,000	
Great Lakes fish are free of pollutants that affect human health	$40,537,266	$13,702,738	$28,400,000	$9,600,000

Location: Wisconsin
Estimating Approach: TC and CV
Survey Population: Wisconsin Great Lakes and inland anglers

[a] The values selected for the use in benefits transfer are given in bold.
[b] WTP values from the original study are adjusted to 2001$ based on CPI.

Source: Lyke, 1993.

EPA selected two WTP values from this study for use in benefits transfer for the following reasons:

- **Environmental quality change.** EPA judged that only one policy scenario Great Lakes fish that are free from contaminants harmful to human health is compatible with water quality improvements associated with removal of all AWQC exceedances. Other scenarios, such as reducing daily bag limit for lake trout to one per day and restoring naturally reproducing populations of lake trout, are irrelevant to the MP&M regulation. The Agency used estimates from the "1990 fishing conditions remain the same as 1989 conditions" scenario as an estimate of the baseline value of recreational fishing in Wisconsin.

- **Research methods.** The Agency did not consider estimates from the TC model because the author noted that "the nested logit travel cost model results seem too high."

K.6 Montgomery and Needelman, 1997. The Welfare Effects of Toxic Contamination in Freshwater Fish

Montgomery and Needelman (1997) estimated benefits from removing "toxic" contamination from lakes and ponds in New York State. They used a binary variable as their primary water quality measure, which indicates whether the New York Department of Environmental Conservation considers water quality in a given lake to be impaired by toxic pollutants. Their model controls for major causes of impairments other than "toxic" pollutants, to separate the effects of various pollution problems that affect the fishing experience. Table K.6 lists environmental quality changes considered in the study and the WTP values corresponding to a specified water quality change.

Table K.6: Welfare Estimates from Montgomery and Needelman (1997)

Water Quality Change Valued	Compensating Variation per Capita per Season (2001$)[b]	Compensating Variation per Capita per Season (1989$)
Eliminate toxic contamination in all lakes[a]	**$90.28**	**$63.25**
All toxic lakes are closed to fishing	$124.31	$87.09
Raise pH in acidic lakes (none are threatened or impaired)	$19.73	$13.82
Close all acidic lakes to fishing	$21.20	$14.85
Eliminate toxic contamination and raise pH in acidic lakes	$113.39	$79.44

Location: New York State
Estimating Approach: TC -- Repeated discrete choice model
Survey Population: New York State residents; anglers and non-anglers
[a] The values selected for the use in benefits transfer are given in bold.
[b] WTP values from the original study are adjusted to 2001$ based on CPI.

Source: Montgomery and Needelman, 1997.

The Agency selected only one value from this study for use in the benefits transfer based on its compatibility with environmental quality changes at both the original study and the MP&M sites, for the following reason:

- **Environmental quality change.** Only one of the five policy scenarios considered eliminate toxic contamination in all lakes is directly compatible with the potential changes brought about by the MP&M rule. The MP&M rule is unlikely to significantly affect the acidity in lakes and streams affected by MP&M discharges. The last three policy scenarios in Table K.6 involve changes in pH levels, and are therefore not included in the benefits transfer. The Agency also did not consider the estimate from the second scenario in Table K.6 closing all toxic lakes to fishing in benefits transfer, because it does not consider water quality improvement per se.

K.7 Phaneuf et al., 1998. Valuing Water Quality Improvements Using Revealed Preference Methods When Corner Solutions are Present

Phaneuf et al. (1998) studied angling in Wisconsin Great Lakes. They estimated changes in recreational fishing values resulting from a 20 percent reduction of toxin levels in lake trout flesh. The study uses a TC model to value water quality improvements when ***corner solutions*** are present in the data. Corner solutions arise when consumers visit only a subset of the available recreation sites, setting their demand to zero for the remaining sites. Phaneuf et al. found that improved industrial and municipal waste management results in general water quality improvement. Table K.7 presents findings from this study based on two policy scenarios and four different model specifications.

Table K.7: Welfare Estimates from Phaneuf et al. (1998)								
Water Quality Change Valued	Adjusted to 2001$[a]				Study Values (1989$)			
	RNL	RPRN	KT	System	RNL	RPRN	KT	System
20% reduction in toxins	$41.62	$12.53	**$166.21**	$15.69	$29.16	$8.78	**$116.45**	$10.99
Loss of South Lake Michigan	$232.19	$140.37	$12,119	$441.36	$162.67	$98.34	$849.09	$309.21

Location: Wisconsin Great Lakes
Estimating Approach: TC models, including:
RNL: Repeated Nested Logit model;
RPRNL: Random Parameters Repeated Nested Logit model;
KT: Kuhn-Tucker model; and
System: Systems of Demands model
Survey Population: Wisconsin anglers; Great Lakes and inland anglers
[a] WTP values from the original study are adjusted to 2001$ based on CPI.

Source: Phaneuf et al, 1998.

The Agency selected only one value for use in benefits transfer for the following reasons:

- **Environmental quality change.** Only one policy scenario evaluated in this study a 20 percent reduction in the toxin levels in fish tissue is compatible with the water quality changes expected from the MP&M regulation (i.e., removal of aquatic life-based AWQC exceedances. The second scenario loss of South Lake Michigan fishing sites is irrelevant to the final regulation.

- **Research methods.** Phaneuf et al. estimated four different models and provided WTP estimates based on each of them. The authors indicated, however, that "the KT model comes closest to matching the ideal theoretical model" (see authors conclusions, page 1030). Other models either rely on more restrictive assumptions or require additional research. The Agency chose the value from the KT model based on the authors' recommendation, which is one of the selection criteria for values used in benefits transfer.

GLOSSARY

ambient water quality criteria (AWQC): Levels of water quality expected to render a body of water suitable for its designated use. Criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, fish production, or industrial processes. (http://www.epa.gov/OCEPAterms/aterms.html)

binary choice (BC): offers respondents to a contingent valuation survey specific dollars and cents choices, for example, "Would you be willing to pay between $10 and $20 per year to improve visibility at the Grand Canyon?"

conjoint analysis: "any decompositional method that estimates the structure of consumer's preferences given his or her overall evaluations of a set of alternatives that are prespecified in terms of levels of different attributes. Price typically is included as an attribute." (Green and Srinivasan, 1990).

contingent valuation (CV): a method used to determine a value for a particular event, where people are asked what they are willing to pay for a benefit and/or are willing to receive in compensation for tolerating a cost. Personal valuations for increases or decreases in the quantity of some good are obtained contingent upon a hypothetical market. The aim is to elicit valuations or bids that are close to what would be revealed if an actual market existed. (http://www.damagevaluation.com/glossary.htm)

corner solutions: a corner solution arises when a consumer who has a choice of two goods, x_1 and x_2, chooses to consume no x_1 at the utility maximum.

direct question/open-ended (OE): in the OE approach, respondents are asked the most they would be willing to pay for the program or policy. This approach has a virtue of not providing any hints about what might be a reasonable value. This approach, however, confronts respondents with an unfamiliar choice (i.e., placing a price on environmental commodities). Studies that use the OE approach have high item non-response rates.

fish consumption advisory (FCA): an official notification to the public about specific areas where fish tissue samples have been found to be contaminated by toxic chemicals which exceed FDA action limits or other accepted guidelines. Advisories may be species specific or community wide.

intensity of preference (IP): an experimental design that allows individuals to state an intensity of preferences for or against the alternative to the status quo. For example, the individual designates they would "probably yes" or "definitely yes" prefer the alternative to the status quo.

iterative bidding (IB): with IB, respondents are asked whether they would be WTP a given amount. If the answer is yes, this amount is raised in pre-set increments until the respondent says that he or she will not pay the last amount given. If the answer is no, then the amount is decreased until the respondent indicates a willingness-to-pay the stated amount.

starting point bias: when survey interviewers suggest a first bid this can influence the respondent's answer and cause the respondent to agree too readily with bids in the vicinity of the initial bid. (http://www.damagevaluation.com/glossary.htm)

travel cost (TC): method to determine the value of an event by evaluating expenditures of participants. Travel costs are used as a proxy for price in deriving demand curves for a recreation site. (http://www.damagevaluation.com/glossary.htm)

willingness-to-pay (WTP): maximum amount of money one would be willing to pay or give up to buy some good. (http://www.damagevaluation.com/glossary.htm)

ACRONYMS

AWQC: ambient water quality criteria
BC: binary choice
CV: contingent valuation
FCA: fish consumption advisory
IB: iterative bidding"
IP: intensity of preference
TC: travel cost
WTP: willingness-to-pay

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Appendix L: Parameters Used in the IEUBK Model

INTRODUCTION

This appendix contains a comprehensive list of model parameters that are used in the IEUBK model for lead in children.

APPENDIX CONTENTS

The remainder of this appendix is a reproduction of *Appendix B: Description of Parameters In the IEUBK Lead Model,* taken from the *Technical Support Document for the Integrated Exposure Uptake Biokinetic Model for Lead in Children (v0.99d) (December 1994)*.

APPENDIX B: DESCRIPTION OF PARAMETERS IN THE IEUBK LEAD MODEL

TABLE B-1. DESCRIPTION OF PARAMETERS IN THE IEUBK LEAD MODEL

PARAMETER NAME	DESCRIPTION	DEFAULT VALUE OR EQN. NO.	AGE RANGE (mo)	I or E	BASIS FOR VALUES/EQUATIONS	UNITS	EQUATION WHERE USED
ABSD	Total absorption for dust at low saturation	0.3	0-84	E	Based on US EPA (1989a).	unitless	U-1c, U-2
ABSF	Total absorption for food at low saturation	0.5	0-84	E	Based on US EPA (1989a).	unitless	U-1a,U-2
ABSO	Total absorption for other ingested lead at low saturation	0.0	0-84	E	Based on the default condition that there is no other source of lead ingestion in the household.	unitless	U-1d,U-2
ABSS	Total absorption for soil at low saturation	0.3	0-84	E	Based on US EPA (1989a).	unitless	U-1e,U-2
ABSW	Total absorption for water at low saturation	0.5	0-84	E	Based on US EPA (1989a).	unitless	U-1b,U-2
air_absorb(t)	Net percentage absorption of air lead	32 32 32 32 32 32 32	0-11 12-23 24-35 36-47 48-59 60-71 72-84	E	Deposition efficiencies of airborne lead particles were estimated by U S EPA (1989a). A respiratory deposition/absorption rate of 25% to 45% is reported for young children living in non-point source areas while a rate of 42% is calculated for those living near point sources. An intermediate value of 32% was chosen.	%	U-4
air_concentration(t)	Outdoor air lead concentration	0.1 0.1 0.1 0.1 0.1 0.1 0.1	0-11 12-23 24-35 36-47 48-59 60-71 72-84	E	Based on the lower end of the range 0.1 - 0.3 µg Pb/m^3 that is reported for outdoor air lead concentration in U.S. cities without lead point sources (US EPA 1989)	µg/m^3	E-1,2,11

NOTE: I = interior parameter, E = Exterior, user selectable parameter

PARAMETER NAME	DESCRIPTION	DEFAULT VALUE OR EQN. NO.	AGE RANGE (mo)	I or E	BASIS FOR VALUES/EQUATIONS	UNITS	EQUATION WHERE USED
AVF, AVW, AVD, AVO, AVS	Bioavailability	1	0-84	I	Parameter added for later flexibility in describing the absorption process; has no effect in current algorithm.	unitless	U-1a-U-1e
AVINTAKE	Available intake	U-2	0-84	I	The amount of Pb that is available for intake	µg	U-1a,b,c,d,e
can_fruit(t)	Lead intake from canned fruit when fruit is consumed only in canned form	1.811 1.063 1.058 0.999 0.940 0.969 1.027	0-11 12-23 24-35 36-47 48-59 60-71 72-84	I	Pb concentration from data provided to EPA by FDA (US EPA (1986). Quantity consumed from Pennington (1983).	µg/day	E-5d
can_veg(t)	Lead intake from canned vegetables when vegetable is consumed only in canned form	0.074 0.252 0.284 0.295 0.307 0.291 0.261	0-11 12-23 24-35 36-47 48-59 60-71 72-84	I	Pb concentration from data provided to EPA by FDA (US EPA (1986). Quantity consumed from Pennington (1983).	µg/day	E-5b
contrib_percent	Ratio of indoor dust lead concentration to soil lead concentration	0.70	0-84	E	Analysis of soil and dust data from 1983 East Helena study (US EPA, 1989)	g/g per g/g	E-11
CONRBC	Maximum lead concentration capacity of red blood cells	1200	0-84	I	Based on Marcus (1983) reanalysis of infant baboon data from Mallon (1983). See Marcus (1985a) for assessment of form of relationship and estimates from data on human adults [data from deSilva (1981a,b), Manton and Malloy (1983), and Manton and Cook (1984)] and infant and juvenile baboons (Mallon, 1983).	µg/dL	B-2.5
constant_soil_conc(t)	Soil lead concentration	200 200 200 200 200 200 200	0-11 12-23 24-35 36-47 48-59 60-71 72-84	E	Air Quality Criteria Document for Lead. (US EPA, 1986)	µg/g	E-8

NOTE: I = interior parameter, E = Exterior, user selectable parameter

PARAMETER NAME	DESCRIPTION	DEFAULT VALUE OR EQN. NO.	AGE RANGE (mo)	I or E	BASIS FOR VALUES/EQUATIONS	UNITS	EQUATION WHERE USED
constant_water_conc	Water lead concentration	4.0	0-84	E	Based on analysis of data from the American Water Works Service Co. (Marcus, 1989)	µg/L	E-6a
CRBONEBL(t)	Ratio of lead concentration (µg/kg) in bone to blood lead concentration (µg/L)	B-4c	0-84	I	Data in Barry (1981) were used. Bone lead concentration was calculated as an arithmetic average of the concentrations in the rib, tibia, and calvaria. The blood lead concentrations were taken directly from the study. Concentrations in each of the following eight age groups were considered: stillbirths, 0-12 days, 1-11 mos, 1-5 yrs, 6-9 yrs, 11-16 yrs, adult (men), and adult (women). Ages 0 and 40 yrs were assumed for stillbirths and adults, respectively.	L/kg	B-1h
CRKIDBL(t)	Ratio of lead concentration (µg/kg) in kidney to blood lead concentration (µgL)	B-4a	0-84	I	Data in Barry (1981) were used. Lead concentrations in kidney (combined values for cortex and medulla) and blood were taken directly from the study. Concentrations in each of the following eight age groups were considered: stillbirths, 0-12 days, 1-11 mos, 1-5 yrs, 6-9 yrs, 11-16 yrs, adult (men), and adult (women). Ages 0 and 40 yrs were assumed for stillbirths and adults, respectively.	L/kg	B-2h
CRLIVBL(t)	Ratio of lead concentration (µg/kg) in liver to blood lead concentration (µg/l)	B-4b	0-84	I	Data in Barry (1981) were used. Lead concentrations in liver and blood were taken directly from the study. Concentrations in each of the following eight age groups were considered: stillbirths, 0-12 days, 1-11 mos, 1-5 yrs, 6-9 yrs, 11-16 yrs, adult (men), and adult (women). Ages 0 and 40 yrs were assumed for stillbirths and adults, respectively.	L/kg	B-2e,2f

NOTE: I = interior parameter, E = Exterior, user selectable parameter

PARAMETER NAME	DESCRIPTION	DEFAULT VALUE OR EQN. NO.	AGE RANGE (mo)	I or E	BASIS FOR VALUES/EQUATIONS	UNITS	EQUATION WHERE USED
CROTHBL(t)	Ratio of lead concentration (µg/kg) in other soft tissue to blood lead concentration (µg/L)	B-4d	0-84	I	Data in Barry (1981) were used. Lead concentration ratio for soft tissues was calculated as a weighted arithmetic average of concentration ratios for muscle (53.8%), fat (24.0%), skin (9.4%), dense connective tissue (4.4%), brain (2.7%), GI tract (2.3%), lung (1.9%), heart (0.7%), spleen (0.3%), pancreas (0.2%), and aorta (0.2%), where the weights applied are given in parentheses. The weight associated with each soft tissue component was equal to the weight of the component (kg) divided by weight of all soft tissues (kg). These weights were estimated from Schroeder and Tipton (1968) and are assumed to apply in the range 0-84 months of age. Concentrations in each of the following eight age groups were considered: stillbirths, 0-12 days, 1-11 mos, 1-5 yrs, 6-9 yrs, 11-16 yrs, adult (men), and adult (women). Ages 0 and 40 yrs were assumed for stillbirths and adults, respectively.	L/kg	B-2n,2o
DAYCARE(t)	Dust lead intake at daycare	E-12c	0-84	I	Simple combination of the total amount of dust ingested daily, fraction of total dust ingested as daycare dust, and dust lead concentration at daycare.	µg/day	E-9d
DaycareConc	Dust lead concentration at daycare	200	0-84	E	Based on the assumption that default daycare dust concentrations are the same as default residence dust concentrations.	µg/g	E-12c
DaycareFraction	Fraction of total dust ingested daily as daycare dust	0	0-84	E	Based on the default assumption that the child does not attend daycare.	unitless	E-9.5,12c
diet_intake(t)	User-specified diet lead intake	5.53 5.78 6.49 6.24 6.01 6.34 7.00	0-11 12-23 24-35 36-47 48-59 60-71 72-84	E	Pb concentration from data provided to EPA by FDA (US EPA (1986). Quantity consumed from Pennington (1983).	µg/day	E-4a
DietTotal(t)	Total Dietary Intake	E-4b	0.84	I	Summation of all dietary sources; same as INDIET(t)	µg/day	E-4b
DustTotal(t)	Daily amount of dust ingested	E-10	0-84	I	Simple combination of total amount soil and dust ingested daily and fraction of this combined ingestion that is dust alone.	g/day	E-9c,12a-12e

NOTE: I = interior parameter, E = Exterior, user selectable parameter

PARAMETER NAME	DESCRIPTION	DEFAULT VALUE OR EQN. NO.	AGE RANGE (mo)	I or E	BASIS FOR VALUES/EQUATIONS	UNITS	EQUATION WHERE USED
EXAIR(t)	Air lead intake	E-3	0-84	I	Simple combination of average air lead concentration and ventilation rate.	µg/day	U-4
f_fruit(t)	Lead intake from fresh fruit if no home-grown fruit is consumed	0.039 0.196 0.175 0.175 0.179 0.203 0.251	0-11 12-23 24-35 36-47 48-59 60-71 72-84	I	Pb concentration from data provided to EPA by FDA (US EPA (1986). Quantity consumed from Pennington (1983).	µg/day	E-5e
f_veg(t)	Lead intake from fresh vegetables if no home-grown vegetables are consumed	0.148 0.269 0.475 0.466 0.456 0.492 0.563	0-11 12-23 24-35 36-47 48-59 60-71 72-84	I	Pb concentration from data provided to EPA by FDA (US EPA (1986). Quantity consumed from Pennington (1983).	µg/day	E-5c
FirstDrawConc	First Draw water lead concentration	4.0	0-84	E	Based on analysis of data from the American Water Works Service Co. (Marcus, 1989)	µg/L	E-6b
FirstDrawFraction	Fraction of total water consumed daily as first draw	0.5	0-84	E	In the absence of appropriate data, a conservative value corresponding to consumption largely after four fours stagnation time was used, e.g. early morning or late afternoon.	unitless	E-6b,7
FountainConc	Fountain water lead concentration	10	0-84	E	Default assumption is that the drinking fountain has a lead-lined reservoir, but that consumption is not always first draw. Therefore, a value was selected from the range of 5-25 g/L.	µg/L	E-6b
FountainFraction	Fraction of total water consumed daily from fountains	0.15	0-84	E	A default value was based on 4-6 trips to the water fountain at 40-50 ml per trip.	none	E-6b,7
fruit_all(t)	Daily amount of all fruits consumed	38.481 169.000 63.166 61.672 61.848 67.907 80.024	0-11 12-23 24-35 36-47 48-59 60-71 72-84	I	Pb concentration from data provided to EPA by FDA (US EPA (1986). Quantity consumed from Pennington (1983).	g/day	E-5f

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PARAMETER NAME	DESCRIPTION	DEFAULT VALUE OR EQN. NO.	AGE RANGE (mo)	I or E	BASIS FOR VALUES/EQUATIONS	UNITS	EQUATION WHERE USED
HomeFlushedConc	Home flushed water lead concentration	1.0	0-84	E	Based on analysis of data from the American Water Works Service Co. (Marcus, 1989)	µg/L	E-6b
HCT0	Hematocrit at birth	0.45	0	I	Data from Silve et al. (1987); also Spector (1956) and Altman and Ditmer (1973)	decimal percent	B-7b,d
InCanFruit(t)	Lead intake from canned fruit	E-5d	0-84	I	Simple combination of the fraction of non-home grown fruits consumed daily, and lead intake from canned fruits when fruits are consumed only in canned form.	µg/day	E-4b
InCanVeg(t)	Lead intake from canned vegetables	E-5b	0-84	I	Simple combination of the fraction of vegetables consumed daily as non-home grown, and lead intake from canned vegetables when vegetables are consumed only in canned form.	µg/day	E-4b
INDIET(t)	Diet lead intake	E-4a *or* E-4b	0-84	I	Two options are provided. Default option - Considers composite diet lead intake. Alternate option - Combines lead intake from several individual components of diet.	µg/day	U-1a, U-2
IndoorConc(t)	Indoor air lead concentration	E-1	0-84	I	Algebraic expression of relationship	µg/m^3	E-2
indoorpercent	Ratio of indoor dust lead concentration to corresponding outdoor concentration	30	0-84	E	Based on homes near lead point sources. The default value is reported in OAQPS (USEPA 1989, pp A-1) and is estimated by Cohen and Cohen (1980).	%	E-1
INDUST(t)	Household dust lead intake	E-9a *or* E-9c	0-84	I	Two options are provided. Default option - Assumes that all dust lead exposure is from the household. Alternate option - Considers dust lead exposure from several alternative sources as well.	µg/day	U-1-c, U-2

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PARAMETER NAME	DESCRIPTION	DEFAULT VALUE OR EQN. NO.	AGE RANGE (mo)	I or E	BASIS FOR VALUES/EQUATIONS	UNITS	EQUATION WHERE USED
INDUSTA(t)	Lead intake from alternate dust sources	E-9b *or* E-9d	0-84	I	Two options are provided. Default option - Assumes that lead intake from alternate sources is zero. Alternate option - Combines lead intake from several alternate sources.	µg/day	U-1.5c, U-2
InFish(t)	Lead intake from fish	E-5h	0-84	I	Simple combination of total meat consumed daily, fraction of meat consumed as fish, and lead concentration in fish.	µg/day	E-4b
InFrFruit(t)	Lead intake from non-home grown fresh fruits	E-5e	0-84	I	Simple combination of the fraction of fruits consumed daily as non-home grown and lead intake from fresh fruits.	µg/day	E-4b
InFrVeg(t)	Lead intake from non-home grown fresh vegetables	E-5c	0-84	I	Simple combination of the fraction of vegetables consumed daily as non-home grown and lead intake from fresh vegetables.	µg/day	E-4b
InGame(t)	Lead intake from game animal meat	E-5i	0-84	I	Simple combination of total meat consumed daily, fraction of meat consumed as game animal meat, and lead concentration in game animal meat.	µg/day	E-4b
InHomeFruit(t)	Lead intake from home grown fruits	E-5f	0-84	I	Simple combination of total amount of fruit consumed daily, fraction of fruit consumed as home grown, and lead concentration in home grown fruit.	µg/day	E-4b
InHomeVeg(t)	Lead intake from home grown vegetables	E-5g	0-84	I	Simple combination of total amount of vegetable consumed daily, fraction of vegetables consumed as home grown, and lead concentration in home grown vegetables.	µg/day	E-4b
InMeat(t)	Lead intake from non-game and non-fish meat	E-5a	0-84	I	Simple combination of total amount of meat consumed daily, fraction of meat consumed as non-game and non-fish meat, and lead concentration in non-game and non-fish meat.	µg/day	E-4b
InOtherDiet(t)	Combined lead intake from dairy food, juice, nuts, beverage, pasta, bread, sauce, candy, infant and formula food	3.578 3.506 3.990 3.765 3.545 3.784 4.215	0-11 12-23 24-35 36-47 48-59 60-71 72-84	I	Sum of the amounts of lead ingested in food items not substituted by the calculation of exposure to lead in home grown fruits and vegetables, wild game or fish. Pb concentration from data provided to EPA by FDA (US EPA (1986). Quantity consumed from Pennington (1983).	µg/day	E-4b, E-4c

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PARAMETER NAME	DESCRIPTION	DEFAUL T VALUE OR EQN. NO.	AGE RANGE (mo)	I or E	BASIS FOR VALUES/EQUATIONS	UNITS	EQUATION WHERE USED
INOTHER(t)	Combined other sources of ingested lead, such as paint chips, ethnic medicines, etc.	0	0-84	E	Assumes no other sources of ingested lead	g/day	U-1d, U-2
INSOIL(t)	Soil lead intake	E-8	0-84	I	Simple combination of total amount of soil and dust ingested daily, fraction of this combined ingestion that is soil alone, and lead concentration in soil.	µg/day	U-1e,U-2
INWATER(t)	Water lead intake	E-6a *or* E-6b	0-84	I	Two options are provided. Default option - Simple combination of water consumed daily and a constant water lead concentration. Alternate option - Water lead concentration depends on contribution from several individual sources of water.	µg/day	U-1b, U-2
MCORT(t)	Mass of lead in cortical bone	B-7e *and* B-9f	0 *and* 0-84	I	0 months - Simple combination of an assumed bone to blood lead concentration ratio, blood lead concentration, and weight of cortical bone. Basis for value of bone to blood lead concentration ratio was human autopsy data (Barry, 1981). 0-84 months - Application of the Backward Euler solution algorithm to the system of differential equations (B-6a-B-6i in Table A-3). Both cases above assume that the cortical bone to blood lead concentration ratio is equal to the bone (composite) to blood lead concentration ratio.	µg	B-6b,6i,6.5b, 6.5i,8a,9f
meat_all(t)	Daily amount of meat (including fish and game) consumed	29.551 87.477 95.700 101.570 107.441 111.948 120.961	0-11 12-23 24-35 36-47 48-59 60-71 72-84	I	Pb concentration from data provided to EPA by FDA (US EPA (1986). Quantity consumed from Pennington (1983).	g/day	E-5h

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PARAMETER NAME	DESCRIPTION	DEFAULT VALUE OR EQN. NO.	AGE RANGE (mo)	I or E	BASIS FOR VALUES/EQUATIONS	UNITS	EQUATION WHERE USED
meat(t)	Lead intake from meat if no game meat or fish is consumed	0.226 0.630 0.811 0.871 0.931 1.008 1.161	0-11 12-23 24-35 36-47 48-59 60-71 72-84	I	Pb concentration from data provided to EPA by FDA (US EPA (1986). Quantity consumed from Pennington (1983).	µg /day	E-5a
MKIDNEY(t)	Mass of lead in kidney	B-7f *and* B-9c	0 *and* 0-84	I	0 months - Simple combination of an assumed kidney to blood lead concentration ratio, blood lead concentration, and weight of kidney. Basis for the value of the kidney to blood lead concentration ratio was human autopsy data (Barry, 1981). 0-84 months - Application of the Backward Euler solution algorithm to the system of differential equations (B-6a-B-6i in Table A-3).	µg	B-6b,6f,6.5b,6.5f,8d,9c
MLIVER(t)	Mass of lead in liver	B-7g *and* B-9b	0 *and* 0-84	I	0 months - Simple combination of an assumed liver to blood lead concentration ratio, blood lead concentration, and weight of the liver. Basis for the value of the liver to blood lead concentration ratio was human autopsy data (Barry, 1981). 0-84 months - Application of the Backward Euler solution algorithm to the system of differential equations (B-6a-B-6i in Table A-3).	µg	B-6b,6e,6.5b,6.5e,8d,9b
MOTHER(t)	Mass of lead in soft tissues	B-7h *and* B-9d	0 *and* 0-84	I	0 months - Simple combination of an assumed soft tissue to blood lead concentration ratio, blood lead concentration, and weight of the soft tissues at birth. Basis for the value of soft tissue to blood lead concentration ratio was human autopsy data (Barry et al., 1981), using total lead and total weight of other tissue. 0-84 months - Application of the Backward Euler solution algorithm to the system of differential equations (B-6a-B-6i in Table A-3).	µg	B-6b,6g,6.5b,6.5g,8d,9d
MPLASM(t)	Mass of lead in plasma pool	B-7d *and* B-9g	0 *and* 0-84	I	0 months - Simple combination of the mass of lead in blood and red blood cells. 0-84 months - Based on the assumption that the lead concentration in plasma-ECF is equal to the lead concentration in the plasma.	µg	B-10a

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PARAMETER NAME	DESCRIPTION	DEFAULT VALUE OR EQN. NO.	AGE RANGE (mo)	I or E	BASIS FOR VALUES/EQUATIONS	UNITS	EQUATION WHERE USED
MPLECF(t)	Mass of lead in plasma-extra-cellular fluid (plasma-ECF)	B-7b *and* B-8a	0 *and* 0-84	I	0 months - Based on two assumptions. (1) masses of lead in plasma-ECF and red blood cells are in kinetic quasi-equilibrium, and (2) lead concentration in the plasma-ECF is equal to lead concentration in the plasma. 0-84 months - Application of the Backward Euler solution algorithm to the system of differential equations (B-6a-B-6i in Table A-3).	µg	B-6a,6c-6i,6.5a, 6.5c-6.5i,8a,9a-9g
MRBC(t)	Mass of lead in red blood cells	B-7c *and* B-9a	0 *and* 0-84	I	0 months - Based on the assumption that the masses of lead in plasma-ECF and red blood cells are in kinetic quasi-equilibrium. 0-84 months - Application of the Backward Euler solution algorithm to the system of differential equations (B-6a-B-6i in Table A-3).	µg	B-6a,6d,6.5a,6.5d,8d,9a,10a
MTRAB(t)	Mass of lead in trabecular bone	B-7i *and* B-9e	0 *and* 0-84	I	0 months - Simple combination of an assumed bone to blood lead concentration ratio, blood lead concentration, and weight of trabecular bone. Basis for the value of bone to blood lead concentration ratio was human autopsy data (Barry, 1981). 0-84 months - Application of the Backward Euler solution algorithm to the system of differential equations (B-6a-B-6i in Table A-3). Both cases above assume that trabecular bone to blood lead concentration ratio is equal to bone (composite) to blood lead concentration ratio.	µg	B-6b,6h,6.5b,6.5h,8d,9e
multiply_factor	Ratio of indoor dust lead concentration to air lead concentration	100	0-84	E	Analyses of the 1983 East Helena study in (USEPA 1989, Appendix B-8) suggest about 267 µg/g increment of lead in dust for each µg /m³. lead in air. A much smaller factor of 100 µg/g PbD per µg/m³ is assumed for non-smelter community exposure.	µg /g per µg/m³	E-11
OCCUP(t)	Dust lead intake from secondary occupation	E-12a	0-84	I	Simple combination of amount of dust ingested, fraction of the total dust ingested as secondary occupational dust, and lead concentration in secondary occupational dust	µg/day	E-9d
OccupConc	Secondary occupational dust lead concentration	1200	0-84	E	Air Quality Criteria Document for Lead. (US EPA, 1986)	µg/g	E-12a

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PARAMETER NAME	DESCRIPTION	DEFAULT VALUE OR EQN. NO.	AGE RANGE (mo)	I or E	BASIS FOR VALUES/EQUATIONS	UNITS	EQUATION WHERE USED
OccupFraction	Fraction of total dust ingested as secondary occupation dust	0	0-84	E	The default condition is that there is no adult in the residence who works at a lead-related job.	unitless	E-9.5,12a
PAINT(t)	Dust lead intake from lead based home paint	E-12e	0-84	I	Simple combination of amount of dust ingested daily, fraction of the total dust ingested as lead-based home paint, and lead concentration in lead-based home paint.	µg/day	E-9d
PaintConc	Leadconcentration in housedust containing lead based paint	1200	0-84	E	Air Quality Criteria Document for Lead. (US EPA, 1986)	µg/g	E-12e
PAF	Fraction of total absorption as passive absorption at low dose	0.20	0-84	E	Based on in vitro everted rat intestine data (Aungst and Fung, 1981), reanalyses (Marcus, 1994) of infant baboon data (Mallon, 1983) and infant duplicate diet study (Sherlock and Quinn, 1986)	unitless	U-1a thru U-1f
PaintFraction	Fraction of total dust ingested that results from lead based home paint	0	0-84	E	The default is that there is no lead-based paint in the home.	unitless	E-12e
PBBLDMAT	Maternal blood lead concentration	2.5	adult	E	Based in part on Midvale 1989 study. The default value of 2.5 g/dL has little influence of the early post natal exposure of the child.	µg/dL	B-7a
PBBLD0	Lead concen tration in blood	B-7a	0	I	Based on 85% of maternal blood lead concentration (US EPA 1989)	µg/dL	B-7b, 7c, 7e-7i
PBBLOODEND(t)	Lead concen tration in blood	B-10a	0-84	I	Simple combination of the blood lead concentrations determined in each iteration in the solution algorithm between the previous month and that month.	µg/dL	B-10c
RATBLPL	Ratio of lead mass in blood to lead mass in plasma-ECF	100	0-84	I	Based on the lower end of the 50-500 range for the red cell/plasma lead concentration ratio recommended in Diamond and O'Flaherty (1992a).	unitless	B-2b-2d,2g,2i,2k,2m

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PARAMETER NAME	DESCRIPTION	DEFAULT VALUE OR EQN. NO.	AGE RANGE (mo)	I or E	BASIS FOR VALUES/EQUATIONS	UNITS	EQUATION WHERE USED
RATFECUR	Ratio of endogenous fecal lead elimination rate to urinary lead elimination rate	0.75	0-84	I	Assume child ratio is larger than the adult ratio; values derived from a reanalysis of data from Ziegler et al. (1978) and Rabinowitz and Wetherill (1973).	unitless	B-1f
RATOUTFEC	Ratio of elimination rate via soft tissues to endogenous fecal lead elimination rate	0.75	0-84	I	Within the range of values derived from a reanalysis of data from Ziegler et al. (1978) and Rabinowitz and Wetherill (1973).	unitless	B-1g
SATINTAKE(t)	Half saturation absorbable lead intake	U-3	0-84	I	Assumed proportional to the weight of body . The coefficient of proportionality is assumed to depend on the estimate of the parameter for a 24 month old and the corresponding body weight.	µg/day	U-1a thru U-1e
SATINTAKE24	Half saturation absorbable lead intake for a 24 month old	100	0-84	E	Extrapolated from reanalysis of human infant data (Sherlock and Quinn, 1986) and infant baboon data (Mallon, 1983)	µg/day	U-3
SCHOOL(t)	Dust lead intake from school	E-12b	0-84	I	Simple combination of amount of dust ingested daily, the fraction of total dust ingested daily as school dust, and lead concentration in dust at school	µg/day	E-9d
SchoolConc	Dust lead concentration at school	200	0-84	E	By default, this dust lead concentration is set to the same as the residential dust lead concentration.	µg/g	E-12b
SchoolFraction	Fraction of total dust ingested daily as school dust	0	0-84	E	Based on the default assumption that children are not in school.	unitless	E-9c,E-9.5,12b
SECHOME(t)	Dust lead intake at secondary home	E-12d	0-84	I	Simple combination of amount of dust ingested daily, fraction of dust ingested daily as secondary home dust, and lead concentration in dust at the secondary home.	µg/day	E-9d
SecHomeConc	Secondary home dust lead concentration	200	0-84	E	Based on the assumption that dust lead concentration in a secondary home is the same as the default dust lead concentration in the primary home.	µg/g	E-12d

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PARAMETER NAME	DESCRIPTION	DEFAULT VALUE OR EQN. NO.	AGE RANGE (mo)	I or E	BASIS FOR VALUES/EQUATIONS	UNITS	EQUATION WHERE USED
SecHomeFraction	Fraction of total dust ingested daily as secondary home dust	0	0-84	E	Based on the default assumption that the child does not spend a significant amount of time in a secondary home.	unitless	E-9b,12d
soil_indoor(t)	Indoor household dust lead concentration	E-11	0-11 12-23 24-35 36-47 48-59 60-71 72-84	I	Under alternate dust sources model, based on assumption that both soil and outdoor air contribute to indoor dust lead.	µg/g	E-9c
soil_ingested(t)	Soil and dust (combined) consumption	0.085 0.135 0.135 0.135 0.100 0.090 0.085	0-11 12-23 24-35 36-47 48-59 60-71 72-84	E	Based on values reported in OAQPS report (USEPA 1989, pp. A-16). The values reported were estimated for children, ages 12-48 mos, by several authors such as Binder et al. (1986) and Clausing et al. (1987). Sedman (1987) extrapolated these estimates to those for children, ages 0-84 mos.	g/day	E-8-9a,10
TBLBONE(t)	Lead transfer time from blood to bone	1 *and* B-1e	24 *and* 0-84	I	24 months - Initialization is keyed to the two year old child, based in part on information from Heard and Chamberlain, (1982) for adults, and O'Flaherty (1992). Once the concentration ratios are fixed, the exact value of this parameter, within a wide range of possible values, has little effect on the blood lead value. 0-84 months - Assumed proportional body surface area. The coefficient of proportionality is assumed to depend on an estimate of the parameter for a 24 month old and the corresponding body surface area. Also, it is assumed that body surface area varies as 1/3 power of the weight of body based on Mordenti (1986).	days	B-1h,2i,2k
TBLFEC(t)	Lead transfer time from blood to feces	B-1f	0-84	I	Simple combination of an assumed ratio of urinary lead elimination rate to endogenous fecal lead elimination rate, and lead transfer time from blood to urine (See RATFECUR). The ratio of of elimination rates was estimated for adults using Chamberlain et al. (1978), and Chamberlain (1985) and is assumed to apply to ages 0-84 months.	days	B-1g,2e,2f

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PARAMETER NAME	DESCRIPTION	DEFAULT VALUE OR EQN. NO.	AGE RANGE (mo)	I or E	BASIS FOR VALUES/EQUATIONS	UNITS	EQUATION WHERE USED
TBLKID(t)	Lead transfer time from blood to kidney	10 *and* B-1d	24 *and* 0-84	I	24 months - Initialization is keyed to the two year old child, based in part on information from Heard and Chamberlain, (1982) for adults, and O'Flaherty (1992). Once the concentration ratios are fixed, the exact value of this parameter, within a wide range of possible values, has little effect on the blood lead value. 0-84 months - Assumed proportional body surface area. The coefficient of proportionality is assumed to depend on an estimate of the parameter for a 24 month old and the corresponding body surface area. Also, it is assumed that body surface area varies as 1/3 power of the weight of body based on (Mordenti, 1986).	days	B-2g,2h
TBLLIV(t)	Lead transfer time from blood to liver	10 *and* B-1b	24 *and* 0-84	I	24 months - Initialization is keyed to the two year old child, based in part on information from Heard and Chamberlain, (1982) for adults, and O'Flaherty (1992). Once the concentration ratios are fixed, the exact value of this parameter, within a wide range of possible values, has little effect on the blood lead value. 0-84 months - Assumed proportional body surface area. The coefficient of proportionality is assumed to depend on an estimate of the parameter for a 24 month old and the corresponding body surface area. Also, it is assumed that body surface area varies as 1/3 power of the weight of body based on (Mordenti, 1986).	days	B-2d,2e
TBLOTH(t)	Lead transfer time from blood to other soft tissue	10 *and* B-1c	24 *and* 0-84	I	24 months - Initialization is keyed to the two year old child, based in part on information from Heard and Chamberlain, (1982) for adults, and O'Flaherty (1992). Once the concentration ratios are fixed, the exact value of this parameter, within a wide range of possible values, has little effect on the blood lead value. 0-84 months - Assumed proportional body surface area. The coefficient of proportionality is assumed to depend on an estimate of the parameter for a 24 month old and the corresponding body surface area. Also, it is assumed that body surface area varies as 1/3 power of the weight of body based on (Mordenti, 1986).	days	B-2m,2n
TBLOUT(t)	Lead transfer time from blood to elimination pool via soft tissue	B-1g	0-84	I	Simple combination of an assumed ratio of elimintion rate via soft tissues to endogenous fecal lead elimination rate, times the lead transfer time from blood to feces (See RATOUTFEC).	days	B-2n,2o

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PARAMETER NAME	DESCRIPTION	DEFAULT VALUE OR EQN. NO.	AGE RANGE (mo)	I or E	BASIS FOR VALUES/EQUATIONS	UNITS	EQUATION WHERE USED
TBLUR(t)	Lead transfer time from blood to urine	20 *and* B-1a	24 *and* 0-84	I	24 months - Assumed proportional to body surface area. The coefficient of proportionality is assumed to depend on an adult estimate for the parameter and the corresponding body surface area. The adult estimate of 39 days was obtained using Araki et al (1986a, 1986b, 1987), Assenato et al (1986), Campbell et al (1981), Carton et al (1987), Chamberlain et al. (1978), Folashade et al (1991), Heard and Chamberlain (1981), He et al (1988), Kawaii et al (1983), Kehoe (1961), Koster et al (1989), Manton and Malloy (1983), Rabinowitz and Wetherill (1973), Rabinowitz et al (1976), and Yokoyama et al (1985). 0-84 months - Assumed proportional body surface area. The coefficient of proportionality is assumed to depend on an estimate of the parameter for a 24 month old and the corresponding body surface area. Both cases above assume that (a) body surface area varies as 1/3 power of weight of body based on (Mordenti, 1986) and (b) respectively, 70 kg and 12.3 kg are standard adult and 2 year old body weights based on Spector (1956). Since glomerular filtration rate (GFR) is proportional to body surface area for ages 24 months based on (Weil, 1955), surface area scaling is equivalent to scaling by GFR for ages 24 months.	days	B-1f,2c
TBONEBL(t)	Lead transfer time from bone to blood	B-1h	0-84	I	Based on the assumption that masses of lead in bone and blood are in kinetic quasi-equilibrium.	days	B-2j,2l
TCORTPL(t)	Lead transfer time from cortical bone to plasma-ECF	B-2l	0-84	I	Based on the assumption that the cortical and trabecular bone pools have similar lead kineticsfor children younger than 84 months.	days	B-6b,6i,6.5b, 6.5i,8d,9f
time_out(t)	Time spent outdoors	1 2 3 4 4 4 4	0-11 12-23 24-35 36-47 48-59 60-71 72-84	E	Values are reported in the OAQPS staff report (USEPA 1989, pp. A-2) and the TSD (USEPA 1990a). The values have been derived from a literature review (Pope, 1985).	hrs/day	E-2

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PARAMETER NAME	DESCRIPTION	DEFAULT VALUE OR EQN. NO.	AGE RANGE (mo)	I or E	BASIS FOR VALUES/EQUATIONS	UNITS	EQUATION WHERE USED
TimeStep	Length of time-step in solution algorithm	1/6	0-84	E	This user-selectable parameter is available mainly for adjusting the model run time to the speed of the computer. Newer, faster computers can run the model at the shortest TimeStep (15 min) in less than one minute. The default value, 4 hours, is based on a tradeoff between numerical accuracy of results and computer run-time. Except in the case of extreme exposure scenarios, there is no difference in the numerical accuracy at any user selectable value for TimeStep.	day	B-6.5a,6.5d-6.5i,7b,7c, 8a,d,9a-9f,10a-10b
TKIDPL(t)	Lead transfer time from kidney to plasma-ECF	B-2h	0-84	I	Based on the assumption that the lead transfer time from kidney to blood is equal to the lead transfer time from kidney to plasma-ECF.	days	B-6b,6f,6.5b,6.5f,8d,9c
TLIVFEC(t)	Lead transfer time from liver to feces	B-2f	0-84	I	Based on the assumption that the masses of lead in liver and blood are in kinetic quasi-equilibrium.	days	B-6e,6.5e, 8c,d,9b
TLIVPL(t)	Lead transfer time from liver to plasma-ECF	B-2e	0-84	I	Based on the assumption that the lead transfer time from liver to blood is equal to the lead transfer time from liver to plasma-ECF.	days	B-6b,6e,6.5b,6.5e,8c,d, 9b
TOTHOUT(t)	Lead transfer time from soft tissues to elimination pool	B-2o	0-84	I	Based on the assumption that the masses of lead in soft tissues and blood are in kinetic quasi-equilibrium.	days	B-6g,6.5g, 8c,d,9h
TOTHPL(t)	Lead transfer time from soft tissues to plasma-ECF	B-2n	0-84	I	Based on the assumption that the lead transfer time from soft tissues to blood is equal to the lead transfer time from soft tissues to plasma-ECF.	days	B-6c,6g,6.5c,6.5g,8c,d, 9h
TPLCORT(t)	Lead transfer time from plasma-ECF to cortical bone	B-2k	0-84	I	Based on the following assumptions: The rate at which lead leaves the plasma-ECF to reach the bone is proportional to the rate which lead leaves the blood to reach the same pool. The cortical and trabecular bone pools have similar lead kinetics for children younger than 84 months. The cortical bone is 80% of the weight of bone based on Leggett et al. (1982).	days	B-6c,6i,6.5c, 6.5i,8b,c,9f

NOTE: I = interior parameter, E = Exterior, user selectable parameter

PARAMETER NAME	DESCRIPTION	DEFAULT VALUE OR EQN. NO.	AGE RANGE (mo)	I or E	BASIS FOR VALUES/EQUATIONS	UNITS	EQUATION WHERE USED
TPLKID(t)	Lead transfer time from plasma-ECF to kidney	B-2g	0-84	I	Based on the assumption that the rate at which lead leaves the plasma-ECF to reach the kidney is proportional to the rate at which lead leaves the blood to reach the same pool.	days	B-6c,6f,6.5c,6.5f,8b,c,9c
TPLLIV(t)	Lead transfer time from plasma-ECF to liver	B-2d	0-84	I	Based on the assumption that the rate at which lead leaves the plasma-ECF to reach the liver is proportional to the rate at which lead leaves the blood to reach the same pool.	days	B-6c,6e,6.5c,6.5e,8b,c, 9b
TPLOTH(t)	Lead transfer time from plasma-ECF to soft tissues	B-2m	0-84	I	Based on the assumption that the rate at which lead leaves the plasma-ECF to reach the soft tissues is proportional to the rate which lead leaves the blood to reach the same pool.	days	B-6c,6g,6.5c,6.5g,8b,c, 9d
TPLRBC	Lead transfer time from plasma-ECF to red blood cells	0.1	0-84	I	Initialization value of 0.1 was assigned as plausible nominal value reflecting best professional judgement on appropriate time scale for composite process of transfer of lead through the red blood cell membrane to lead binding components.	days	B-2b,2.5,7b, 7c
TPLRBC2(t)	Lead transfer time from plasma-ECF to red blood cells constrained by the maximum capacity of red blood cell lead concentration	B-2.5	0-84	I	Simple combination of the lead transfer time from plasma-ECF to red blood cells, and the ratio of red blood cell lead concentration to the corresponding maximum concentration. Based on Marcus (1985a) and reanalysis of infant baboon data.	days	B-6a,6d,6.5a,6.5d,8b,9a
TPLTRAB(t)	Lead transfer time from plasma-ECF to trabecular bone	B-2i	0-84	I	Based on the following assumptions: The rate at which lead leaves the plasma-ECF to reach the bone is proportional to the rate which lead leaves the blood to reach the same pool. The cortical and trabecular bone pools have similar lead kinetics. The trabecular bone is 20% of the weight of bone based on Leggett et al. (1982).	days	B-6c,6h,6.5c,6.5h,8b,c, 9e
TPLUR(t)	Lead transfer time from plasma-ECF to urine	B-2c	0-84	I	Based on the assumption that the rate at which lead leaves the plasma-extra-cellular fluid to reach the urine pool is proportional to the rate at which lead leaves the blood to reach the same pool.	days	B-6c,6.5c,8a

NOTE: I = interior parameter, E = Exterior, user selectable parameter

PARAMETER NAME	DESCRIPTION	DEFAULT VALUE OR EQN. NO.	AGE RANGE (mo)	I or E	BASIS FOR VALUES/EQUATIONS	UNITS	EQUATION WHERE USED
TRBCPL	Lead transfer time from red blood cells to plasma-ECF	B-2b	0-84	I	Based on the assumption that the transfer time out of RBC is similar at all ages, since mean red cell value is similar.	days	B-6b,6d,6.5b,6.5d,7b,7c, 8c,d,9a
TTRABPL(t)	Lead transfer time from trabecular bone to plasma-extra-cellular fluid	B-2j	0-84	I	Based on the assumption that the cortical and trabecular bone pools have similar lead kinetics for children younger than 84 months.	days	B-6b,6h,6.5b,6.5h,8c,d, 9e
TWA(t)	Time weighted average air lead concentration	E-2	0-84	I	Simple combination of outdoor and indoor air lead concentrations and the number of hours spent outdoors.	µg/m^3	E-3
UPAIR(t)	Air lead uptake	U-4	0-84	I	Simple combination of media-specific lead intake and the corresponding net absorption coefficient.	µg/day	U-5
UPDIET(t)	Diet lead uptake	U-1a	0-84	I	Simple combination of media-specific lead intake and the corresponding net absorption coefficient.	µg/day	U-1f
UPDUST(t)	Dust lead uptake	U-1c	0-84	I	Simple combination of media-specific lead intake and the corresponding net absorption coefficient.	µg/day	U-1f
UPDUSTA(t)	Dust lead uptake rate from alternate sources	U-1.5c	0-84	I	Simple combination of media-specific lead intake and the corresponding net absorption coefficient.	µg/day	U-1f
UPGUT(t)	Total gut uptake	U-1f	0-84	I	Sum of all gastrointestinal uptake.	µg/day	U-5
UPOTHER(t)	Uptake of other ingested lead	U-1d	0-84	I	Assumes no other gut lead intake	µg/day	U-1f
UPSOIL(t)	Soil lead uptake	U-1e	0-84	I	Simple combination of media-specific lead intake and the corresponding net absorption coefficient.	µg/day	U-1f
UPTAKE(t)	Total lead uptake	U-5	0-84	I	Simple combination of the media-specific daily lead uptake rates, translated to a monthly rate.	µg/mo	B-6a,6.5a,8a
UPWATER(t)	Water lead uptake	U-1b	0-84	I	Simple combination of media-specific lead intake and the corresponding net absorption coefficient.	µg/day	U-1f

NOTE: I = interior parameter, E = Exterior, user selectable parameter

PARAMETER NAME	DESCRIPTION	DEFAULT VALUE OR EQN. NO.	AGE RANGE (mo)	I or E	BASIS FOR VALUES/EQUATIONS	UNITS	EQUATION WHERE USED
UserFishConc	Lead concentration in fish	0	0-84	E	Based on the assumption that only commercially available fish are consumed.	µg/g	E-5h
userFishFraction	Fraction of total meat consumed as fish	0	0-84	E	Based on the assumption that only commercially available fish are consumed.	unitless	E-5a,5h
UserFruitConc	Lead concentration in home grown fruits	0	0-84	E	Based on the assumption that only commercially available fruits are consumed.	µg/g	E-5f
userFruitFraction	Fraction of total fruits consumed as home grown fruits	0	0-84	E	Based on the assumption that only commercially available fruits are consumed.	unitless	E-5d,5e,5f
UserGameConc	Lead concentration in game animal meat	0	0-84	E	Based on the assumption that only commercially available meat is consumed.	µg/g	E-5i
userGameFraction	Fraction of total meat consumed as game animal meat excluding fish	0	0-84	E	Based on the assumption that only commercially available meat is consumed.	unitless	E-5a,5i
UserVegConc	Lead concentration in home grown vegetables	0	0-84	E	Based on the assumption that only commercially available vegetables are consumed.	µg/g	E-5g
userVegFraction	Fraction of total vegetables consumed as home grown vegetables	0	0-84	E	Based on the assumption that only commercially available vegetables are consumed.	unitless	E-5b,5c,5g

NOTE: I = interior parameter, E = Exterior, user selectable parameter

PARAMETER NAME	DESCRIPTION	DEFAULT VALUE OR EQN. NO.	AGE RANGE (mo)	I or E	BASIS FOR VALUES/EQUATIONS	UNITS	EQUATION WHERE USED
veg_all(t)	Daily amount of all vegetables consumed	56.84 106.50 155.75 157.34 158.93 172.50 199.65	0-11 12-23 24-35 36-47 48-59 60-71 72-84	I	Pb concentration from data provided to EPA by FDA (US EPA (1986). Quantity consumed from Pennington (1983).	g/day	E-5g
vent_rate(t)	Ventilation rate	2 3 5 5 5 7 7	0-11 12-23 24-35 36-47 48-59 60-71 72-84	E	Values are reported in the OAQPS report (USEPA 1989, pp. A-3) and the TSD (USEPA 1990a). These estimates are based on body size in combination with smoothed data from Phalen et al., (1985).	m^3/day	E-3
VOLBLOOD(t)	Volume of blood	B-5a	0-84	I	Statistical fitting of data from Silve et al (1987); also Spector (1956) and Altman and Ditmer (1973)	µg/dL	B-1h,2e,2f,2h,2n,2o,5d, 5e,5m,10a
VOLECF(t)	Volume of extra-cellular fluid (ECF)	B-5d	0-84	I	The volume of extracellular fluid that exchanges rapidly with plasma is estimated 73% of the blood volume based on Rabinowitz (1976). This additional volume of distribution is assumed to be the volume the extra-cellular fluid pool, which is the difference between the volume of the distribution and the blood volume.	dL	B-9g
VOLPLASM(t)	Volume of plasma	B-5c	0-84	I	Statistical fit to VOLBLOOD(t) - VOLRBC(t)	dL	B-7b,7c,9g
VOLRBC(t)	Volume of red blood cells	B-5b	0-84	I	Statistical fit to hematocrit × blood volume	dL	B-2.5
water_consumption(t)	Daily amount of water consumed	0.20 0.50 0.52 0.53 0.55 0.58 0.59	0-11 12-23 24-35 36-47 48-59 60-71 72-84	E	Exposure Factors Handbook (US EPA, 1989b)	L/day	E-6a,6b

NOTE: I = interior parameter, E = Exterior, user selectable parameter

PARAMETER NAME	DESCRIPTION	DEFAULT VALUE OR EQN. NO.	AGE RANGE (mo)	I or E	BASIS FOR VALUES/EQUATIONS	UNITS	EQUATION WHERE USED
weight_soil	Percentage of total soil and dust ingestion that is soil	45	0-84	E	Guidance Manual, Section 2.3 (US EPA, 1994)	%	E-8,10
WTBLOOD(t)	Weight of blood	B-5m	0-84	I	Based on an blood density of 1.056 kg/l (Spector 1956).	kg	B-5l
WTBODY(t)	Weight of body	B-5f	0-84	I	Statistical fitting of data from Silve et al. (1987); also Spector (1956) and Altman and Ditmer (1973). Also, body weight of 24 month old is assumed to be 12.3 kg (Spector 1956).	kg	B-1a-1e,5f,5g,5l
WTBONE(t)	Weight of bone	B-5g	0-84	I	12-84 months - Based on child skeletal ash data in Harley and Kneip (1984) and the following assumptions. $WTBONE = (WTBONE_{ADULT} / WTSKEL\_ASH_{ADULT}) * WTSKEL\_ASH$ where $WTBONE_{ADULT}$ = 10 kg $WTSKEL\_ASH_{ADULT}$ = 2.91 kg 0-12 months - Assumed to be 11% of the weight of the body. The ratio of weight of bone to weight of body (11%) is based on the 12-month estimate for WTBONE from the above equation, and an estimate for WTBODY at the same age.	kg	B-5h,5i
WTCORT(t)	Weight of cortical bone	B-5i	0-84	I	Assumed to be 80% of the weight of the bone based on Leggett et al. (1982).	kg	B-1h,5l,7e
WTECF(t)	Weight of extra-cellular fluid (ECF)	B-5e	0-84	I	Based on an assumed ECF density approximately the same as water, of 1.0 kg/L.	kg	B-5l
WTKIDNEY(t)	Weight of kidney	B-5j	0-84	I	Statistical fitting of data from Silve et al. (1987); also Spector (1956) and Altman and Ditmer (1973). Also, body weight of 24 month old is assumed to be 12.3 kg (Spector 1956).	kg	B-5j,5l,7f
WTLIVER(t)	Weight of liver	B-5k	0-84	I	Statistical fitting of data from Silve et al. (1987); also Spector (1956) and Altman and Ditmer (1973). Also, body weight of 24 month old is assumed to be 12.3 kg (Spector 1956).	kg	B-2e,2f,5l,7g
WTOTHER(t)	Weight of soft tissues	B-5l	0-84	I	Simple combination of the weight of body and the weights of kidney, liver, bone, blood and extra-cellular fluid.	kg	B-2n,2o,7h

NOTE: I = interior parameter, E = Exterior, user selectable parameter

PARAMETER NAME	DESCRIPTION	DEFAULT VALUE OR EQN. NO.	AGE RANGE (mo)	I or E	BASIS FOR VALUES/EQUATIONS	UNITS	EQUATION WHERE USED
WTTRAB(t)	Weight of trabecular bone	B-5h	0-84	I	Assumed to be 20% of the weight of the bone based on Leggett et al. (1982).	kg	B-1h, 5l,7i

NOTE: I = interior parameter, E = Exterior, user selectable parameter

Appendix M: Sensitivity Analysis of Lead-Related Benefits

INTRODUCTION

APPENDIX CONTENTS

The methodology for estimating lead-related benefits for the MP&M regulation is discussed in Chapter 14. In its main analysis, EPA uses a three percent discount rate to value benefits associated with reductions in exposure to lead. OMB, however, frequently recommends the use of a seven percent discount rate in benefit-cost analyses for government regulations. This appendix therefore presents a sensitivity analysis of the results for lead-related benefits estimated using a seven percent discount rate and compares them with estimated lead-related benefits in the main (three percent) analysis. Because EPA found that the final rule will not yield any lead-related health benefits to either children or adults, the analysis in this appendix is limited only to the two Upgrade Options considered as alternatives to the final rule, and the Proposed/NODA Option.

M.1 VALUES FOR QUANTIFIED LEAD-RELATED HEALTH EFFECTS

Table M.1 below compares per-case values for lead-related health effects estimated using a three percent discount rate and a seven percent discount rate. Values for some health effect categories do not change for the following two reasons:

- Discounting is not used in estimating a specific value. For example, the cost of treating hypertension used in this analysis is the estimate of *annual* medical costs and lost work time associated with this condition.

- The original study did not provide sufficient information for estimating the cost of illness value based on a seven percent discount rate. Taylor et al. (1996) used a five percent discount rate to estimate the expected lifetime cost of a stroke. The authors do not provide sufficient information to recalculate the value based on a different discount rate. Therefore, EPA did not revise this value in the main analysis to reflect discounting at a three percent rate.

Table M.1: Comparison of Per-Case Values for Lead-Related Health Effects (2001 $)

Health Category	Value/Cost @ 3% Discount Rate	Value/Cost @ 7% Discount Rate
Lead-Related Health Effects for Children		
Value of an IQ point [A-(B+C)]	$9,419	$1,817
(A) Wage loss per IQ point	$10,675	$2,427
(B) Cost of additional education per IQ point	$511	$247
(C) Opportunity cost of lost income while in school	$746	$363
Additional education cost for children with IQ < 70	$58,012	$36,831
Additional education cost for children with PbB > 20 µg/dL	$16,485	$12,169
Value of preventing neonatal mortality[a]	$6,500,000	$6,500,000
Lead-Related Health Effects for Adults		
Hypertension (male & female)[b]	$1,141	$1,141
CHD (male & female)	$76,347	$74,115
Stroke (male)[c]	$335,135	$335,135
Stroke (female)[c]	$251,351	$251,351
Mortality (male & female)[a]	$6,500,000	$6,500,000

[a] Value of a Statistical Life (VSL) is taken from U.S. EPA's Guidelines for Preparing Economic Analyses. The recommended value was not adjusted in the main analysis.
[b] Annual cost of treatment. No discounting is required.
[C] Values based on Taylor et al. (1996) which uses a five percent discount rate to estimate the expected lifetime cost of a stroke. EPA used this value in the main analysis presented in Chapter 14 of this report.

Source: U.S. EPA analysis.

M.2 Lead-Related Benefit Results

This section presents lead-related benefits of the alternative regulatory options – the 433 Upgrade Options and the Proposed/NODA Option – based on a seven percent discount rate.

M.2.1 Preschool Age Children Lead-Related Benefits

Table M.2 summarizes lead-related benefits for children estimated for the 433 Upgrade Options based on a three percent and a seven percent discount rate. As shown in Table M.2, using a seven percent discount rate results in a 19 percent reduction in the total monetary value of lead-related benefits for preschool children compared to the value of benefits estimated based on a three percent discount rate. Changes in the monetary values associated with individual benefit categories range from zero percent (neonatal mortality) to 81 percent (avoided IQ loss).

Table M.2: Comparison of the Monetary Value of Lead-Related Benefits to Children (2001$) Based on Alterantive Discount Rates – 433 Upgrade Options

Category	Directs + 413 to 433 Upgrade				Directs + All to 433 Upgrade			
	Reduced Cases or IQ Points	Mean Benefit Value (2001$)			Reduced Cases or IQ Points	Mean Benefit Value (2001$)		
		3% DR	7% DR	% Change		3% DR	7% DR	% Change
Neonatal mortality	0.15	$995,630	$995,630	0%	0.17	$1,109,294	$1,109,294	0%
Avoided IQ Loss	31.99	$301,323	$58,128	81%	36.19	$340,845	$65,752	81%
Reduced IQ < 70	0.11	$6,637	$4,213	37%	0.13	$7,501	$4,762	37%
Reduced PbB > 20 µg/L	0.00	$0	$0	0%	0.00	$0	$0	0%
Total Benefits		$1,305,590	$1,057,970	19%		$1,457,640	$1,179,808	19%

Source: U.S. EPA analysis.

Table M.3 summarizes lead-related benefits for children estimated for the Proposed/NODA Option based on a three percent and a seven percent discount rate. As shown in Table M.3, using a seven percent discount rate results in a 40 percent reduction in the total monetary value of lead-related benefits for preschool children compared to the value of benefits estimated based on a three percent discount rate. Changes in the monetary values associated with individual benefit categories range from zero percent (neonatal mortality) to 81 percent (avoided IQ loss).

Table M.3: Comparison of the Monetary Value of Lead-Related Benefits to Children (2001$) Based on Alterantive Discount Rates – Proposed/NODA Option

Category Category	Reduced Cases or IQ Points	Benefit Value (2001$)		
		3% DR	7% DR	% Change
Neonatal Mortality	1.60	$10,417,781	$10,417,781	0%
Avoided IQ Loss	1,078.38	$10,157,286	$1,959,421	81%
Reduced IQ < 70	3.72	$216,007	$137,140	37%
Reduced PbB > 20 µg/L	0.00	$0	$0	0%
Total Benefits		$20,791,073	$12,514,342	40%

Source: U.S. EPA analysis.

M.2.2 Adult Lead-Related Benefits

Table M.4 presents lead-related benefits for adults for the 433 Upgrade Options based on a three percent and a seven percent discount rate. Under both 433 Upgrade Options the difference between the total monetary value of benefits to adults estimated based on a three percent and a seven percent discount rate is negligible (less than 0.1 percent). The reduction in total benefits is marginal between the two discount rate scenarios because the monetary value of only one lead-related benefit category for adults (i.e., CHD) is affected by the discount rate.

Table M.4: Comparison of the Monetary Value of Lead-Related Benefits to Adults (2001$) Based on Alterantive Discount Rates – 433 Upgrade Options

Category		Directs + 413 to 433 Upgrade			Directs + All to 433 Upgrade		
			Mean Value of Benefits			Mean Value of Benefits	
		Reduced Cases	3% DR	7% DR	Reduced Cases	3% DR	7% DR
Men	Hypertension	53.47	$61,004	$61,004	59.58	$67,982	$67,982
	CHD	0.05	$4,155	$4,033	0.06	$4,631	$4,495
	CBA	0.02	$5,698	$5,698	0.02	$6,350	$6,350
	BI	0.01	$3,226	$3,226	0.01	$3,596	$3,596
	Mortality	0.07	$474,735	$474,735	0.08	$529,125	$529,125
Women	CHD	0.02	$1,662	$1,614	0.02	$1,853	$1,799
	CBA	0.01	$2,417	$2,417	0.01	$2,694	$2,694
	BI	0.01	$1,487	$1,487	0.01	$1,658	$1,658
	Mortality	0.02	$150,190	$150,190	0.03	$167,417	$167,417
Total Benefits			$704,574	$704,404		$785,304	$785,115

Source: U.S. EPA analysis.

Table M.5 summarizes lead-related benefits for adults for the Proposed/NODA Option based on a three percent and a seven percent discount rate. For this option, the estimated total monetary values of benefits drop from $7,048,025 under the three percent discount rate to $7,046,328 under the seven percent discount rate (i.e., a decrease of less than 0.1 percent). This marginal difference in the total value of benefits based the three percent and the seven percent discount rate is due to the fact that only one benefit category (i.e., CHD) is affected by the discount rate.

Table M.5: Comparison of the Monetary Value of Lead-Related Benefits to Adults (2001$) Based on Alterantive Discount Rates – Proposed/NODA Option

Category		Reduced Cases	Mean Value of Benefits	
			3% DR	7% DR
Men	Hypertension	545.25	$622,126	$622,126
	CHD	0.54	$41,564	$40,349
	CBA	0.17	$56,907	$56,907
	BI	0.10	$32,197	$32,197
	Mortality	0.73	$4,750,132	$4,750,132
Women	CHD	0.22	$16,472	$15,991
	CBA	0.10	$23,928	$23,928
	BI	0.06	$14,714	$14,714
	Mortality	0.23	$1,489,984	$1,489,984
Total Benefits			$7,048,025	$7,046,328

Source: U.S. EPA analysis.

Appendix N: Analysis of the National Demand for Water-Based Recreation Survey

Introduction

This appendix presents EPA's analysis of the National Demand for Water-based Recreation Survey (NDS). The objective of this analysis is to determine the number of people who participate in water-based recreation and their total number of recreation trips, characterize participation and number of trips taken by water body type, and provide more detailed information on specific recreation activities (e.g., fish species targeted on fishing trips) and expenditures associated with various activities.

Appendix Contents

N.1 Background Information

U.S. EPA cooperated with the National Forest Service and several other federal agencies and interested groups to collect data on the outdoor recreation activities of Americans. The 1993 NDS collected data on demographic characteristics and water-based recreation behavior using a nationwide stratified random sample of 13,059 individuals aged 16 and over. Respondents reported on water-based recreation trips taken within the past 12 months, including the primary purpose of their trips (i.e., fishing, boating, swimming, and viewing), and number of trips, trip length, distance to the recreation site(s), number of participants, their trip expenditures, and detailed trip allocation information on the last trip taken for each recreation type. For example, respondents reported:

- where fishing was the primary purpose of a trip, the number of fish caught and the species targeted (i.e., coldwater, warmwater, anadromous, or marine);
- the type of water body (e.g., lake, river, ocean, wetland); and
- where boating was the primary purpose of trip, the type of boating (i.e., motorboating, sailing, canoeing, rowing, rafting, and other floating).

EPA used NDS data to characterize water-based recreation activities nationwide, including:

- percent of state population participating in water-based recreation by recreation activity and trip length (i.e., single-day vs. multiple-day trips);
- average number of water-based recreation trips per person by recreation activity and trip length;
- allocation of single- or multiple-day trips among different water body types by recreation type;
- mean one-way distance traveled to the site visited on last trip;
- total expenditures per person for last single-day or multiple-day trip;
- distribution of total expenditures among various expenditure categories for single- and multiple-day trips (e.g., lodging, boat rental, and entrance fee);
- allocation of fishing trips by target species; and
- allocation of boating trips by boating type.

N.2 Data Analysis

The NDS used a random digit dialed population-based sample (aged 16 and over) of the nation. For simple random sampling, estimates of the sample mean and total are consistent estimates of the population mean and total. EPA therefore treats sample-based estimates as being representative of the population-based estimates. For example, the percent of survey respondents participating in a given water-based recreation activity is theoretically consistent with the percent of the state population (aged 16 and over) that participates in that activity. The estimated percentages can be applied to the state population (aged 16 and over) to derive the number of participants in various water-based recreation activities in each state.

The survey database cannot be used to characterize subsistence fishing because subsistence fishermen's behavior differs significantly from recreational fishermen's behavior. In addition, this population subgroup is likely to be under-represented in the survey database due to various factors. First, subsistence fishermen constitute a relatively small portion of the total fisherman population. They also tend to have a lower education level. Some of them may lack long-distance telephone services and/or have language barriers. These factors are likely to result in inadequate representation of this subgroup in the survey data.

N.3 Participation in Water-Based Recreation by Activity Type

This analysis estimates the percent and the number of state residents who participated in water-based recreation by activity type and trip length (i.e., single-day vs. multiple-day). Participants in each activity in a given state include state residents who took at least one single-day and/or multiple-day trip for each respective activity during the previous 12 months. Because some participants took both single-day and multiple-day trips, the percent and the number of state residents participating in all trips does not equal the sum of the single-day plus multiple-day percentages or number of participants. The analysis also estimates the average number of recreation trips per person per year, by recreational activity, trip length (single-day vs. multiple-day trips), and state of residence. Tables N.1, N.2, N.3, and N.4 characterize participation in boating, fishing, swimming, and viewing, respectively.

1. ***Estimating the percent of state population participating in each of the four water-based recreation activities.*** The total percent of state residents participating in each activity equals the total number of respondents who took at least one single-day and/or multiple-day trip divided by the state's sample size. Similarly, the percent participating in single-day or multiple-day trips for each respective activity equals the respective number of sample respondents who took either single-day or multiple-day trips, respectively, divided by the state's sample size.

2. ***Estimating the number of state residents participating in each of the four water-based recreation activities.*** EPA calculated the total number of participants in each state by multiplying the percent of sample respondents who took at least one single-day and/or multiple-day trip by each state's actual population 16 years of age and older. Similarly, the total number of participants in single-day or multiple-day trips for each respective activity equals the respective percent of sample respondents who took either single-day or multiple-day trips, respectively, times the state's population 16 years of age and older.

3. ***Estimating the average number of trips per person per year.*** EPA estimated the average number of recreation trips per person per year by dividing the total number of trips taken for each activity by state residents by the total number of participants in this activity. Similarly, dividing the number of single-day trips or multiple-day trips by the respective number of participants provided the average number of single-day and multiple-day trips per person, respectively. Tables N.1-N.4 also show the mean trip length for the last multiple-day trip.

For comparison purposes, Tables N.2 and N.4 also present estimates of the total percent and the number of state residents participating in recreational fishing and wildlife viewing based on the U.S. Fish and Wildlife Service's (USFWS) 1996 National Survey of Fishing Hunting and Wildlife Associated Recreation. The table shows that the two surveys yield similar results. NDS estimates, however, are slightly higher than USFWS estimates for some states. NDS fishing and viewing participation estimates are higher for 47 and 30 states, respectively. This discrepancy may be due to the difference in the year when the respective surveys were conducted.

Table N.1: Participation in Boating

State	State Pop. 16 and Up	NDS Sample Size	Sample Weight	Total Participation in Boating				Participation in Single-Day Trips			Participation in Multiple-Day Trips			
				Percent Population	# People	Avg # Trips per Person per Year	Days per Year	Percent Population	Number of People	Avg # of Trips per Person per Year	Percent Population	Number of People	Avg # of Trips per Person per Year	Mean Trip Length (days)
AK	457,728	29	15,784	48%	219,709	5.1	5.7	45%	205,978	5.1	14%	64,082	1.2	2.5
AL	3,451,586	218	15,833	18%	621,285	7.9	10.6	16%	552,254	7.1	6%	207,095	5.5	2.3
AR	2,072,622	128	16,192	20%	414,524	6.4	24.1	16%	331,620	5.0	7%	145,084	6.9	8.3
AZ	3,907,526	178	21,952	12%	468,903	7.3	10.8	9%	351,677	7.3	6%	234,452	3.3	3.2
CA	25,599,275	1,313	19,497	20%	5,119,855	5.3	11.3	14%	3,583,898	5.1	11%	2,815,920	3.3	4.2
CO	3,322,455	212	15,672	13%	431,919	10.6	14.0	8%	265,796	14.6	7%	232,572	2.6	3.5
CT	2,651,452	159	16,676	20%	530,290	8.7	18.3	18%	477,261	7.9	7%	185,602	5.2	6.2
DC	468,575	35	13,388	11%	51,543	2.0	2.7	9%	42,172	2.3	3%	14,057	1.0	3.0
DE	610,269	51	11,966	20%	122,054	10.6	13.3	18%	109,848	10.8	8%	48,822	2.2	4.0
FL	12,741,821	662	19,247	23%	2,930,619	10.3	16.6	20%	2,548,364	9.8	5%	637,091	7.0	5.3
GA	6,250,708	373	16,758	18%	1,125,127	10.9	19.0	15%	937,606	10.4	9%	562,564	5.2	4.0
HI	949,184	55	17,258	20%	189,837	7.6	9.5	18%	170,853	6.6	2%	18,984	18.0	2.0
IA	2,281,002	171	13,339	19%	433,390	6.6	13.3	17%	387,770	4.7	5%	114,050	8.3	4.1
ID	969,166	83	11,677	30%	290,750	5.8	8.1	25%	242,292	5.6	8%	77,533	4.0	3.2
IL	9,530,327	466	20,451	18%	1,715,459	8.3	15.9	13%	1,238,943	9.0	8%	762,426	4.9	4.3
IN	4,682,392	300	15,608	21%	983,302	9.3	18.3	15%	702,359	7.5	8%	374,591	9.3	3.6
KS	2,058,489	135	15,248	13%	267,604	13.9	27.1	9%	185,264	14.2	9%	185,264	6.6	3.8
KY	3,161,283	219	14,435	16%	505,805	6.2	9.0	13%	410,967	6.4	5%	158,064	2.6	4.7
LA	3,394,854	189	17,962	20%	678,971	4.2	6.2	18%	611,074	4.1	5%	169,743	2.0	5.0
MA	5,008,007	249	20,112	23%	1,151,842	11.8	11.7	18%	901,441	8.1	8%	400,641	4.2	3.7
MD	4,085,342	257	15,896	19%	776,215	9.1	18.2	17%	694,508	8.9	6%	245,121	4.1	7.9
ME	1,010,273	72	14,032	33%	333,390	7.1	18.2	26%	262,671	6.7	13%	131,335	4.7	7.0
MI	7,628,170	576	13,243	24%	1,830,761	9.3	17.4	19%	1,449,352	9.0	11%	839,099	5.0	4.5
MN	3,782,817	245	15,440	24%	907,876	5.9	8.8	20%	756,563	5.9	7%	264,797	4.1	3.3
MO	4,331,937	277	15,639	22%	953,026	6.0	11.4	16%	693,110	5.3	12%	519,832	3.5	3.9
MS	2,160,165	140	15,430	18%	388,830	10.0	14.9	16%	345,626	7.1	6%	129,610	10.3	2.5
MT	701,423	55	12,753	22%	154,313	5.8	7.9	15%	105,213	7.8	7%	49,100	1.8	4.7
NC	6,291,182	407	15,457	14%	880,765	7.5	12.1	12%	754,942	7.2	6%	377,471	4.0	3.5
ND	502,176	40	12,554	28%	140,609	4.2	13.8	18%	90,392	3.9	13%	65,283	3.8	6.4
NE	1,314,974	84	15,654	20%	262,995	5.2	13.3	13%	170,947	3.8	10%	131,497	5.8	3.8
NH	960,593	64	15,009	23%	220,936	3.7	8.4	22%	211,330	3.2	5%	48,030	3.3	7.3
NJ	6,545,471	347	18,863	18%	1,178,185	10.1	12.2	17%	1,112,730	10.5	3%	196,364	2.7	5.1

Table N.1: Participation in Boating

State	State Pop. 16 and Up	NDS Sample Size	Sample Weight	Total Participation in Boating				Participation in Single-Day Trips			Participation in Multiple-Day Trips			
				Percent Population	# People	Avg # Trips per Person per Year	Days per Year	Percent Population	Number of People	Avg # of Trips per Person per Year	Percent Population	Number of People	Avg # of Trips per Person per Year	Mean Trip Length (days)
NM	1,370,134	105	13,049	19%	260,325	3.8	8.9	10%	137,013	3.5	11%	150,715	3.4	3.6
NV	1,537,896	75	20,505	23%	353,716	10.1	18.4	21%	322,958	6.8	9%	138,411	8.9	3.5
NY	14,797,284	774	19,118	18%	2,663,511	6.5	9.2	13%	1,923,647	7.5	5%	739,864	3.0	4.5
OH	8,789,530	650	13,522	17%	1,494,220	7.0	10.6	13%	1,142,639	7.5	7%	615,267	3.3	3.6
OK	2,665,966	143	18,643	20%	533,193	4.5	8.3	13%	346,576	4.9	8%	213,277	3.2	3.9
OR	2,673,283	217	12,319	26%	695,054	8.4	12.2	22%	588,122	8.9	9%	240,595	2.7	4.9
PA	9,693,987	742	13,065	15%	1,454,098	9.2	16.1	12%	1,163,278	9.1	5%	484,699	5.6	4.7
RI	827,474	57	14,517	16%	132,396	8.0	N/A	16%	132,396	6.9	2%	16,549	10.0	N/A
SC	3,115,130	181	17,211	19%	591,875	9.0	16.5	15%	467,270	8.9	7%	218,059	4.5	5.8
SD	577,391	42	13,747	26%	150,122	6.5	24.1	21%	121,252	4.8	10%	57,739	7.0	7.5
TN	4,445,987	296	15,020	23%	1,022,577	7.9	10.3	20%	889,197	7.7	6%	266,759	4.5	3.1
TX	15,618,097	657	23,772	18%	2,811,257	8.2	14.7	15%	2,342,715	7.4	7%	1,093,267	5.7	3.9
UT	1,598,531	111	14,401	20%	319,706	4.5	9.6	11%	175,838	5.6	13%	207,809	2.3	4.4
VA	5,529,436	389	14,214	19%	1,050,593	9.9	17.4	15%	829,415	8.6	6%	331,766	8.1	4.2
VT	479,265	34	14,096	24%	115,024	7.1	12.4	21%	100,646	7.1	9%	43,134	2.3	7.0
WA	4,552,631	324	14,051	35%	1,593,421	6.0	10.4	29%	1,320,263	5.7	14%	637,368	3.4	4.2
WI	4,156,609	299	13,902	22%	914,454	10.3	14.7	19%	789,756	10.0	7%	290,963	4.5	4.2
WV	1,455,370	126	11,551	13%	189,198	5.1	8.3	10%	145,537	6.6	2%	29,107	2.3	9.0
WY	381,882	31	12,319	26%	99,289	5.5	6.2	23%	87,833	5.7	6%	22,913	2.0	2.5

N/A - Not Available

Source: NDS.

Table N.2: Participation in Recreational Fishing

				Total Participation in Fishing					Single-Day Trips			Multiple-Day Trips			
State	Pop. 16 and Up	NDS Sample Size	Sample Weight	Percent Pop. (NDS-based)	Percent Pop. (USFWS-based)	Number of People	Avg # of Trips per Person per Year	Days per Year	% Pop.	# People	Avg # of Trips per Person per Year	% Pop.	# People	Avg # of Trips per Person per Year	Mean trip length (days)
AK	457,728	29	15,784	59%	41%	270,060	13.8	18.3	55%	251,750	12.8	24%	109,855	4.3	3.7
AL	3,451,586	218	15,833	25%	21%	862,896	16.8	19.5	21%	724,833	18.5	6%	207,095	5.0	3.2
AR	2,072,622	128	16,192	37%	26%	766,870	11.9	16.2	31%	642,513	12.5	12%	248,715	4.1	4.3
AZ	3,907,526	178	21,952	20%	14%	781,505	8.1	16.5	15%	586,129	7.0	11%	429,828	5.4	3.8
CA	25,599,275	1,313	19,497	22%	12%	5,631,840	6.5	13.1	16%	4,095,884	6.6	10%	2,559,928	3.8	4.8
CO	3,322,455	212	15,672	38%	23%	1,262,533	12.0	19.5	30%	996,736	12.2	17%	564,817	5.1	4.3
CT	2,651,452	159	16,676	18%	14%	477,261	6.9	8.0	16%	424,232	7.1	4%	106,058	2.1	3.6
DC	468,575	35	13,388	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
DE	610,269	51	11,966	20%	19%	122,054	10.3	16.0	18%	109,848	10.8	4%	24,411	3.0	10.5
FL	12,741,821	662	19,247	25%	18%	3,185,455	15.3	17.4	21%	2,675,782	16.6	5%	637,091	4.7	3.7
GA	6,250,708	373	16,758	23%	18%	1,437,663	8.8	12.6	19%	1,187,635	9.8	8%	500,057	2.9	4.6
HI	949,184	55	17,258	20%	14%	189,837	6.1	6.2	18%	170,853	6.6	2%	18,984	1.0	3.0
IA	2,281,002	171	13,339	24%	23%	547,440	11.9	16.7	19%	433,390	13.4	7%	159,670	3.8	5.4
ID	969,166	83	11,677	40%	32%	387,666	12.3	19.4	33%	319,825	10.8	20%	193,833	6.0	3.5
IL	9,530,327	466	20,451	20%	18%	1,906,065	13.7	27.4	16%	1,524,852	14.2	7%	667,123	7.8	5.9
IN	4,682,392	300	15,608	26%	19%	1,217,422	11.0	14.6	23%	1,076,950	11.1	8%	374,591	3.8	4.0
KS	2,058,489	135	15,248	28%	19%	576,377	11.3	18.8	21%	432,283	12.2	13%	267,604	4.8	4.3
KY	3,161,283	219	14,435	30%	23%	948,385	9.0	13.9	25%	790,321	9.2	12%	379,354	3.9	4.0
LA	3,394,854	189	17,962	34%	26%	1,154,250	15.0	18.9	29%	984,508	15.3	8%	271,588	7.8	3.2
MA	5,008,007	249	20,112	22%	12%	1,101,762	15.3	24.0	18%	901,441	13.3	6%	300,480	14.1	3.4
MD	4,085,342	257	15,896	21%	15%	857,922	12.2	15.7	18%	735,362	12.9	6%	245,121	2.9	5.7
ME	1,010,273	72	14,032	31%	21%	313,185	9.9	11.2	28%	282,876	10.5	6%	60,616	2.0	4.5
MI	7,628,170	576	13,243	27%	20%	2,059,606	10.5	16.4	20%	1,525,634	11.3	10%	762,817	5.0	4.3
MN	3,782,817	245	15,440	34%	31%	1,286,158	10.3	18.7	24%	907,876	10.9	19%	718,735	4.5	4.4
MO	4,331,937	277	15,639	26%	23%	1,126,304	5.8	10.5	20%	866,387	5.5	9%	389,874	4.3	4.2
MS	2,160,165	140	15,430	27%	21%	583,245	17.0	19.3	25%	540,041	16.8	7%	151,212	5.8	2.5
MT	701,423	55	12,753	42%	24%	294,598	19.5	26.2	36%	252,512	19.7	20%	140,285	4.9	4.0
NC	6,291,182	407	15,457	25%	20%	1,572,796	11.2	15.1	20%	1,258,236	12.5	12%	754,942	3.2	3.4

Table N.2: Participation in Recreational Fishing

State	Pop. 16 and Up	NDS Sample Size	Sample Weight	Total Participation in Fishing					Single-Day Trips			Multiple-Day Trips			
				Percent Pop. (NDS-based)	Percent Pop. (USFWS-based)	Number of People	Avg # of Trips per Person per Year	Days per Year	% Pop.	# People	Avg # of Trips per Person per Year	% Pop.	# People	Avg # of Trips per Person per Year	Mean trip length (days)
ND	502,176	40	12,554	33%	24%	165,718	4.5	6.3	30%	150,653	3.9	10%	50,218	3.0	3.0
NE	1,314,974	84	15,654	20%	19%	262,995	11.9	24.8	14%	184,096	13.2	12%	157,797	4.3	6.0
NH	960,593	64	15,009	16%	18%	153,695	14.9	23.6	14%	134,483	13.2	8%	76,847	6.0	4.0
NJ	6,545,471	347	18,863	19%	13%	1,243,639	5.9	7.0	16%	1,047,275	6.1	4%	261,819	3.1	2.8
NM	1,370,134	105	13,049	22%	19%	301,429	8.7	12.3	16%	219,221	8.5	12%	164,416	4.2	2.7
NV	1,537,896	75	20,505	21%	17%	322,958	11.9	15.2	17%	261,442	13.5	5%	76,895	3.8	4.8
NY	14,797,284	774	19,118	15%	11%	2,219,593	8.8	16.2	12%	1,775,674	9.1	5%	739,864	4.4	6.0
OH	8,789,530	650	13,522	19%	13%	1,670,011	14.6	23.2	16%	1,406,325	14.0	7%	615,267	7.6	4.1
OK	2,665,966	143	18,643	32%	31%	853,109	13.0	12.9	28%	746,470	13.4	1%	26,660	4.1	9.0
OR	2,673,283	217	12,319	36%	21%	962,382	11.4	15.2	29%	775,252	11.8	13%	347,527	4.6	3.5
PA	9,693,987	742	13,065	21%	15%	2,035,737	10.8	16.1	17%	1,647,978	11.1	8%	775,519	5.0	3.7
RI	827,474	57	14,517	21%	14%	173,770	7.8	7.5	19%	157,220	8.3	2%	16,549	2.0	N/A
SC	3,115,130	181	17,211	29%	24%	903,388	16.1	20.4	27%	841,085	15.6	7%	218,059	6.8	3.6
SD	577,391	42	13,747	26%	31%	150,122	8.2	13.7	24%	138,574	7.7	12%	69,287	2.6	5.5
TN	4,445,987	296	15,020	26%	17%	1,155,957	15.1	19.0	24%	1,067,037	14.8	6%	266,759	5.2	4.4
TX	15,618,097	657	23,772	29%	18%	4,529,248	10.2	16.6	23%	3,592,162	10.1	13%	2,030,353	5.3	3.6
UT	1,598,531	111	14,401	23%	21%	367,662	5.6	17.9	15%	239,780	4.1	11%	175,838	5.9	5.4
VA	5,529,436	389	14,214	26%	18%	1,437,653	8.2	13.0	19%	1,050,593	8.7	10%	552,944	4.3	4.0
VT	479,265	34	14,096	9%	19%	43,134	12.0	8.7	9%	43,134	8.7	3%	14,378	10.0	N/A
WA	4,552,631	324	14,051	27%	22%	1,229,210	14.9	21.3	22%	1,001,579	16.1	12%	546,316	4.6	4.0
WI	4,156,609	299	13,902	29%	25%	1,205,417	10.4	18.4	22%	914,454	11.1	14%	581,925	4.5	4.6
WV	1,455,370	126	11,551	25%	18%	363,842	17.0	22.4	22%	320,181	16.3	8%	116,430	6.9	3.7
WY	381,882	31	12,319	58%	31%	221,492	12.9	46.0	52%	198,579	8.2	32%	122,202	10.0	7.0

N/A - Not Available

Source: U.S. Fish and Wildlife Service's (USFWS) 1996 National Survey of Fishing Hunting and Wildlife Associated Recreation.

Table N.3: Participation in Recreational Swimming														
				Total Participation in Swimming				Participation in Single-Day Trips			Participation in Multiple-Day Trips			
State	State Pop. 16 and Up	NDS Sample Size	Sample Weight	Percent Pop.	Number of People	Avg # Trips per Person per Year	Days per Year	Percent Pop.	Number of People	Avg # of Trips per Person per Year	Percent Pop.	Number of People	Avg # of Trips per Person per Year	Mean Trip length (days)
AK	457,728	29	15,784	7%	32,041	2.0	N/A	7%	32,041	2.0	3%	13,732	1.0	N/A
AL	3,451,586	218	15,833	23%	793,865	7.7	11.5	17%	586,770	9.3	7%	241,611	3.3	4.6
AR	2,072,622	128	16,192	23%	476,703	8.5	20.1	21%	435,251	6.8	9%	186,536	5.9	6.0
AZ	3,907,526	178	21,952	19%	742,430	4.5	7.6	13%	507,978	5.3	7%	273,527	1.9	5.6
CA	25,599,275	1,313	19,497	29%	7,423,790	9.5	13.0	22%	5,631,840	11.0	9%	2,303,935	3.1	4.9
CO	3,322,455	212	15,672	17%	564,817	4.0	6.4	12%	398,695	5.0	6%	199,347	1.7	4.8
CT	2,651,452	159	16,676	41%	1,087,095	11.0	19.8	33%	874,979	11.3	18%	477,261	4.4	5.5
DC	468,575	35	13,388	17%	79,658	2.5	6.4	9%	42,172	2.0	9%	42,172	3.3	3.0
DE	610,269	51	11,966	22%	134,259	5.3	8.5	14%	85,438	6.9	6%	36,616	2.7	5.8
FL	12,741,821	662	19,247	33%	4,204,801	13.3	17.9	26%	3,312,873	14.9	8%	1,019,346	5.2	4.9
GA	6,250,708	373	16,758	29%	1,812,705	5.3	11.0	15%	937,606	6.6	13%	812,592	3.6	4.8
HI	949,184	55	17,258	58%	550,527	19.2	27.6	56%	531,543	16.5	24%	227,804	8.3	3.4
IA	2,281,002	171	13,339	18%	410,580	2.4	4.0	13%	296,530	2.7	4%	91,240	1.3	6.8
ID	969,166	83	11,677	25%	242,292	8.9	11.1	23%	222,908	8.8	8%	77,533	3.1	3.0
IL	9,530,327	466	20,451	21%	2,001,369	4.0	8.0	12%	1,143,639	5.4	8%	762,426	2.2	5.9
IN	4,682,392	300	15,608	22%	1,030,126	5.0	8.9	17%	796,007	5.4	8%	374,591	2.3	5.5
KS	2,058,489	135	15,248	19%	391,113	5.5	9.3	14%	288,188	6.0	7%	144,094	3.0	4.4
KY	3,161,283	219	14,435	17%	537,418	11.0	13.2	11%	347,741	15.7	5%	158,064	1.8	5.5
LA	3,394,854	189	17,962	24%	814,765	4.3	9.3	16%	543,177	4.7	11%	373,434	2.8	4.9
MA	5,008,007	249	20,112	41%	2,053,283	9.4	17.8	34%	1,702,722	8.9	14%	701,121	6.1	5.0
MD	4,085,342	257	15,896	27%	1,103,042	5.6	11.4	14%	571,948	7.8	12%	490,241	3.2	5.1
ME	1,010,273	72	14,032	46%	464,726	14.5	29.7	40%	404,109	12.8	15%	151,541	9.9	5.8
MI	7,628,170	576	13,243	30%	2,288,451	8.5	16.3	24%	1,830,761	8.6	10%	762,817	4.7	6.0
MN	3,782,817	245	15,440	24%	907,876	5.4	6.5	18%	680,907	6.6	5%	189,141	2.2	3.4
MO	4,331,937	277	15,639	22%	953,026	6.4	10.9	16%	693,110	7.7	9%	389,874	2.5	5.1
MS	2,160,165	140	15,430	21%	453,635	10.5	12.8	17%	367,228	11.9	6%	129,610	2.5	4.4
MT	701,423	55	12,753	40%	280,569	6.9	10.1	33%	231,470	7.6	16%	112,228	2.0	4.8
NC	6,291,182	407	15,457	23%	1,446,972	5.7	10.8	15%	943,677	7.0	10%	629,118	2.4	6.0
ND	502,176	40	12,554	25%	125,544	8.0	N/A	15%	75,326	11.5	13%	65,283	2.4	N/A
NE	1,314,974	84	15,654	19%	249,845	3.5	10.7	15%	197,246	3.9	6%	78,898	1.6	15.0

Table N.3: Participation in Recreational Swimming														
				Total Participation in Swimming				Participation in Single-Day Trips			Participation in Multiple-Day Trips			
State	State Pop. 16 and Up	NDS Sample Size	Sample Weight	Percent Pop.	Number of People	Avg # Trips per Person per Year	Days per Year	Percent Pop.	Number of People	Avg # of Trips per Person per Year	Percent Pop.	Number of People	Avg # of Trips per Person per Year	Mean Trip length (days)
NH	960,593	64	15,009	42%	403,449	15.8	56.5	38%	365,025	14.5	16%	153,695	7.2	15.8
NJ	6,545,471	347	18,863	39%	2,552,734	6.2	12.7	28%	1,832,732	6.9	16%	1,047,275	3.1	6.1
NM	1,370,134	105	13,049	15%	205,520	2.7	4.2	10%	137,013	3.8	5%	68,507	1.4	3.7
NV	1,537,896	75	20,505	19%	292,200	6.3	13.2	12%	184,548	6.3	9%	138,411	4.6	4.2
NY	14,797,284	774	19,118	33%	4,883,104	7.6	15.0	25%	3,699,321	8.1	11%	1,627,701	4.5	6.0
OH	8,789,530	650	13,522	23%	2,021,592	7.3	15.6	15%	1,318,430	8.7	6%	527,372	4.7	8.1
OK	2,665,966	143	18,643	28%	746,470	3.4	5.7	16%	426,555	4.1	8%	213,277	2.9	4.1
OR	2,673,283	217	12,319	34%	908,916	6.7	12.7	27%	721,786	7.1	12%	320,794	3.2	6.4
PA	9,693,987	742	13,065	28%	2,714,316	5.7	10.4	17%	1,647,978	7.5	12%	1,163,278	2.7	5.1
RI	827,474	57	14,517	40%	330,990	6.9	N/A	37%	306,165	7.0	11%	91,022	2.5	N/A
SC	3,115,130	181	17,211	22%	685,329	6.0	9.4	17%	529,572	6.9	5%	155,756	3.0	6.0
SD	577,391	42	13,747	24%	138,574	7.3	9.2	24%	138,574	7.2	7%	40,417	1.0	7.0
TN	4,445,987	296	15,020	23%	1,022,577	5.8	9.7	17%	755,818	6.7	8%	355,679	2.5	5.4
TX	15,618,097	657	23,772	24%	3,748,343	5.1	7.7	16%	2,498,896	6.0	9%	1,405,629	2.3	4.3
UT	1,598,531	111	14,401	20%	319,706	5.9	10.4	15%	239,780	6.2	10%	159,853	2.5	4.5
VA	5,529,436	389	14,214	28%	1,548,242	4.9	11.1	17%	940,004	5.5	13%	718,827	3.2	5.2
VT	479,265	34	14,096	26%	124,609	12.3	19.6	24%	115,024	11.6	6%	28,756	8.5	4.5
WA	4,552,631	324	14,051	35%	1,593,421	5.4	10.7	28%	1,274,737	5.7	14%	637,368	2.4	6.3
WI	4,156,609	299	13,902	27%	1,122,284	5.5	8.9	22%	914,454	6.1	7%	290,963	2.1	7.0
WV	1,455,370	126	11,551	25%	363,842	6.5	12.7	18%	261,967	6.4	9%	130,983	5.1	4.4
WY	381,882	31	12,319	6%	22,913	8.0	N/A	6%	22,913	8.0	3%	11,456	1.0	N/A

N/A - Not Available

Source: NDS.

Table N.4: Participation in Wildlife Viewing (Near-Water Recreation)

State	Pop. 16 and Up	NDS Sample Size	Sample Weight	Total Participation in Near-Water Recreation					Single-Day Trips			Multiple-Day Trips			
				Percent Pop. (NDS-based)	Percent Pop. (USFWS-based)	Number of People	Avg # of Trips per Person per Year	Days per Year	Percent Pop.	Number of People	Avg # of Trips per Person per Year	Percent Pop.	Number of People	Avg # of Trips per Person per Year	Mean trip length
AK	457,728	29	15,784	48%	50%	219,709	7.2	8.4	41%	187,668	7.1	7%	32,041	8.0	2.0
AL	3,451,586	218	15,833	36%	30%	1,242,571	4.4	8.2	12%	414,190	9.2	24%	828,381	1.9	4.0
AR	2,072,622	128	16,192	28%	34%	580,334	6.4	15.0	13%	269,441	10.2	16%	331,620	3.3	5.5
AZ	3,907,526	178	21,952	25%	31%	976,882	4.7	8.7	11%	429,828	8.0	13%	507,978	2.1	4.7
CA	25,599,275	1,313	19,497	51%	25%	13,055,630	11.2	14.3	37%	9,471,732	14.0	16%	4,095,884	3.2	4.2
CO	3,322,455	212	15,672	25%	42%	830,614	8.6	11.7	13%	431,919	14.8	10%	332,246	1.9	5.4
CT	2,651,452	159	16,676	60%	31%	1,590,871	5.3	8.8	38%	1,007,552	6.7	20%	530,290	3.1	4.4
DC	468,575	35	13,388	51%	N/A	238,973	3.9	30.7	23%	107,772	2.4	31%	145,258	4.6	10.5
DE	610,269	51	11,966	57%	34%	347,853	9.9	16.6	41%	250,210	11.0	24%	146,465	4.7	4.5
FL	12,741,821	662	19,247	44%	25%	5,606,401	14.2	18.2	32%	4,077,383	17.9	13%	1,656,437	3.7	4.7
GA	6,250,708	373	16,758	36%	29%	2,250,255	3.1	9.4	14%	875,099	4.1	21%	1,312,649	2.6	5.2
HI	949,184	55	17,258	64%	14%	607,478	30.3	30.7	56%	531,543	33.9	9%	85,427	1.8	4.0
IA	2,281,002	171	13,339	32%	38%	729,921	2.9	7.1	16%	364,960	4.4	15%	342,150	1.2	9.0
ID	969,166	83	11,677	43%	40%	416,741	3.2	7.0	24%	232,600	4.2	23%	222,908	1.5	5.6
IL	9,530,327	466	20,451	31%	35%	2,954,401	5.9	10.6	17%	1,620,156	9.0	13%	1,238,943	2.2	6.1
IN	4,682,392	300	15,608	31%	35%	1,451,542	5.4	11.2	15%	702,359	9.0	14%	655,535	2.4	6.3
KS	2,058,489	135	15,248	33%	32%	679,301	5.8	12.8	17%	349,943	9.0	14%	288,188	2.5	7.7
KY	3,161,283	219	14,435	28%	32%	885,159	2.4	9.1	12%	379,354	3.0	15%	474,192	2.0	7.3
LA	3,394,854	189	17,962	34%	27%	1,154,250	3.2	8.5	15%	509,228	3.4	19%	645,022	3.1	4.0
MA	5,008,007	249	20,112	50%	35%	2,504,004	9.8	21.0	31%	1,552,482	11.5	22%	1,101,762	5.9	5.3
MD	4,085,342	257	15,896	46%	34%	1,879,257	6.3	12.7	18%	735,362	12.1	29%	1,184,749	2.4	5.2
ME	1,010,273	72	14,032	54%	46%	545,547	5.4	6.6	44%	444,520	5.7	11%	111,130	3.5	2.8
MI	7,628,170	576	13,243	44%	36%	3,356,395	6.3	10.3	24%	1,830,761	9.4	16%	1,220,507	2.7	5.2
MN	3,782,817	245	15,440	33%	38%	1,248,330	10.5	15.2	19%	718,735	16.5	14%	529,594	2.4	5.5
MO	4,331,937	277	15,639	32%	40%	1,386,220	2.7	8.1	13%	563,152	4.0	17%	736,429	2.1	5.8
MS	2,160,165	140	15,430	29%	23%	626,448	11.3	15.2	12%	259,220	24.2	14%	302,423	1.8	5.7
MT	701,423	55	12,753	33%	47%	231,470	10.1	12.9	20%	140,285	15.6	15%	105,213	1.2	6.0
NC	6,291,182	407	15,457	45%	35%	2,831,032	4.1	11.5	18%	1,132,413	5.2	29%	1,824,443	3.2	4.5
ND	502,176	40	12,554	25%	23%	125,544	2.6	3.4	15%	75,326	3.0	5%	25,109	4.0	2.0
NE	1,314,974	84	15,654	25%	35%	328,744	1.8	5.9	14%	184,096	2.1	8%	105,198	1.7	8.6
NH	960,593	64	15,009	42%	44%	403,449	12.2	21.5	31%	297,784	14.9	9%	86,453	5.2	9.5

Table N.4: Participation in Wildlife Viewing (Near-Water Recreation)

State	Pop. 16 and Up	NDS Sample Size	Sample Weight	Total Participation in Near-Water Recreation					Single-Day Trips			Multiple-Day Trips			
				Percent Pop. (NDS-based)	Percent Pop. (USFWS-based)	Number of People	Avg # of Trips per Person per Year	Days per Year	Percent Pop.	Number of People	Avg # of Trips per Person per Year	Percent Pop.	Number of People	Avg # of Trips per Person per Year	Mean trip length
NJ	6,545,471	347	18,863	54%	26%	3,534,554	5.5	11.8	32%	2,094,551	6.3	23%	1,505,458	3.7	5.0
NM	1,370,134	105	13,049	29%	29%	397,339	2.6	7.8	9%	123,312	5.6	18%	246,624	1.4	6.9
NV	1,537,896	75	20,505	35%	21%	538,264	6.2	11.0	21%	322,958	7.2	23%	353,716	2.6	3.8
NY	14,797,284	774	19,118	45%	23%	6,658,778	4.3	9.9	25%	3,699,321	5.7	18%	2,663,511	2.2	7.5
OH	8,789,530	650	13,522	36%	33%	3,164,231	4.7	11.1	16%	1,406,325	8.2	19%	1,670,011	1.9	7.3
OK	2,665,966	143	18,643	34%	35%	906,428	1.9	5.3	12%	319,916	3.4	17%	453,214	1.5	5.4
OR	2,673,283	217	12,319	59%	42%	1,577,237	6.4	12.4	38%	1,015,848	7.2	33%	882,183	3.3	4.3
PA	9,693,987	742	13,065	39%	37%	3,780,655	3.9	9.4	14%	1,357,158	7.4	24%	2,326,557	1.9	5.7
RI	827,474	57	14,517	56%	32%	463,385	4.0	9.2	40%	330,990	4.6	9%	74,473	4.6	8.0
SC	3,115,130	181	17,211	45%	29%	1,401,808	5.3	10.9	20%	623,026	8.3	25%	778,782	2.8	4.7
SD	577,391	42	13,747	29%	30%	167,443	2.1	7.9	21%	121,252	1.8	5%	28,870	4.5	8.5
TN	4,445,987	296	15,020	41%	37%	1,822,855	2.1	6.1	13%	577,978	3.7	25%	1,111,497	1.4	5.7
TX	15,618,097	657	23,772	33%	25%	5,153,972	3.6	7.6	16%	2,498,896	5.0	16%	2,498,896	2.2	4.8
UT	1,598,531	111	14,401	31%	30%	495,545	2.4	4.6	17%	271,750	3.5	11%	175,838	1.2	5.9
VA	5,529,436	389	14,214	41%	37%	2,267,069	3.4	11.4	17%	940,004	4.2	25%	1,382,359	2.7	5.7
VT	479,265	34	14,096	47%	48%	225,255	5.6	9.6	18%	86,268	5.5	32%	153,365	2.5	4.3
WA	4,552,631	324	14,051	58%	39%	2,640,526	9.2	13.4	40%	1,821,052	11.6	29%	1,320,263	2.6	4.1
WI	4,156,609	299	13,902	38%	42%	1,579,511	4.6	8.8	22%	914,454	6.1	16%	665,057	2.3	5.4
WV	1,455,370	126	11,551	27%	31%	392,950	4.3	16.1	10%	145,537	4.6	17%	247,413	3.9	5.8
WY	381,882	31	12,319	29%	39%	110,746	3.1	4.5	16%	61,101	4.6	13%	49,645	1.2	3.5

N/A - Not Available

Source: U.S. Fish and Wildlife Service's (USFWS) 1996 National Survey of Fishing Hunting and Wildlife Associated Recreation.

N.4 ALLOCATION OF TRIPS BY WATER BODY TYPE

This analysis assesses the allocation of trips by water body type, recreation activity, and state of residence. EPA determined the number of trips taken to each water body type based on the water body type visited on the last single- or multiple-day trip for each recreation activity. Dividing the total number of trips taken in a state to a given water body type for a given activity by the total number of trips taken for that activity in the state provided estimates of the percent taken to the various water body types. The NDS distinguishes four general water body types:

- Lakes:
  — lakes,
  — ponds, and
  — reservoirs;
- Streams:
  — rivers,
  — streams, and
  — canals;
- Oceans:
  — oceans,
  — bays, and
  — sounds; and
- Other:
  — wetlands, and
  — unknown water body types.

Note that respondents in several states apparently provided inaccurate information. For example, Montana residents are unlikely to take single-day trips to the ocean. The data indicate, however, that five, six, and eleven percent of participants reported that they took single-day fishing, swimming, and viewing trips to the ocean, respectively. This inconsistency may arise due to the following two factors:

- respondents traveled to other states for multi-purpose multiple-day trips and participated in the given activity on only one day per trip; and
- response errors (e.g., some respondents identified water body types incorrectly).

Tables N.5 and N.6 show allocation of single- and multiple-day trips by water body type for boating, fishing, swimming, and viewing.

Table N.5: Allocation of Single-Day Trips by Water Body Type

State	Boating (%)				Fishing (%)				Swimming (%)				Viewing (%)			
	Lake	Stream	Ocean[a]	Other[b]	Lake	Stream	Ocean	Other	Lake	Stream	Ocean	Other	Lake	Stream	Ocean	Other
AK	30%	20%	50%	0%	9%	45%	45%	0%	100%	0%	0%	0%	18%	18%	64%	0%
AL	50%	44%	6%	0%	56%	29%	16%	0%	57%	13%	30%	0%	25%	15%	55%	5%
AR	78%	22%	0%	0%	78%	22%	0%	0%	78%	17%	0%	4%	38%	38%	23%	0%
AZ	100%	0%	0%	0%	76%	19%	5%	0%	63%	32%	5%	0%	50%	11%	33%	6%
CA	38%	8%	51%	2%	43%	16%	40%	1%	28%	9%	61%	2%	11%	2%	86%	1%
CO	79%	21%	0%	0%	65%	33%	2%	0%	83%	4%	8%	4%	65%	15%	19%	0%
CT	38%	27%	35%	0%	35%	22%	43%	0%	33%	5%	60%	2%	20%	9%	69%	2%
DC	0%	33%	67%	0%	N/A	N/A	N/A	N/A	67%	0%	33%	0%	0%	50%	50%	0%
DE	25%	0%	75%	0%	25%	38%	38%	0%	0%	0%	100%	0%	18%	6%	76%	0%
FL	15%	27%	56%	1%	24%	24%	52%	1%	13%	9%	79%	0%	4%	5%	90%	1%
GA	79%	12%	9%	0%	60%	21%	18%	2%	67%	7%	23%	2%	53%	2%	44%	0%
HI	22%	0%	78%	0%	10%	0%	90%	0%	0%	0%	100%	0%	0%	0%	93%	7%
IA	43%	52%	0%	4%	59%	38%	0%	3%	70%	17%	9%	4%	60%	28%	8%	4%
ID	65%	35%	0%	0%	47%	53%	0%	0%	59%	35%	6%	0%	44%	44%	6%	6%
IL	55%	40%	5%	0%	74%	22%	4%	0%	93%	7%	0%	0%	76%	11%	9%	4%
IN	88%	12%	0%	0%	82%	13%	5%	0%	92%	4%	2%	2%	78%	15%	5%	2%
KS	100%	0%	0%	0%	96%	4%	0%	0%	94%	6%	0%	0%	71%	10%	14%	5%
KY	77%	23%	0%	0%	73%	24%	2%	0%	64%	18%	18%	0%	58%	25%	13%	4%
LA	45%	45%	10%	0%	39%	43%	14%	4%	38%	27%	27%	8%	32%	16%	48%	4%
MA	21%	36%	44%	0%	49%	21%	31%	0%	33%	4%	63%	0%	15%	8%	76%	2%
MD	13%	34%	53%	0%	30%	32%	39%	0%	23%	19%	58%	0%	10%	18%	70%	3%
ME	63%	19%	19%	0%	65%	15%	20%	0%	67%	4%	30%	0%	19%	6%	74%	0%
MI	80%	14%	5%	0%	73%	20%	8%	0%	92%	3%	5%	0%	81%	8%	8%	3%
MN	77%	23%	0%	0%	90%	10%	0%	0%	84%	7%	7%	2%	95%	5%	0%	0%
MO	53%	42%	3%	3%	73%	21%	4%	2%	52%	36%	7%	5%	60%	30%	7%	3%
MS	47%	42%	11%	0%	76%	15%	9%	0%	50%	36%	14%	0%	38%	13%	50%	0%
MT	75%	25%	0%	0%	42%	53%	5%	0%	63%	31%	6%	0%	78%	11%	11%	0%
NC	61%	19%	19%	0%	52%	24%	24%	0%	36%	15%	42%	7%	22%	14%	63%	2%
ND	100%	0%	0%	0%	80%	20%	0%	0%	83%	17%	0%	0%	100%	0%	0%	0%
NE	89%	11%	0%	0%	100%	0%	0%	0%	77%	23%	0%	0%	64%	27%	9%	0%

Table N.5: Allocation of Single-Day Trips by Water Body Type

State	Boating (%)				Fishing (%)				Swimming (%)				Viewing (%)			
	Lake	Stream	Ocean[a]	Other[b]	Lake	Stream	Ocean	Other	Lake	Stream	Ocean	Other	Lake	Stream	Ocean	Other
NH	58%	25%	17%	0%	44%	44%	11%	0%	55%	0%	41%	5%	25%	0%	75%	0%
NJ	24%	11%	65%	0%	31%	13%	55%	2%	20%	2%	77%	0%	9%	4%	86%	1%
NM	43%	43%	14%	0%	38%	62%	0%	0%	50%	30%	20%	0%	25%	38%	38%	0%
NV	92%	0%	8%	0%	60%	40%	0%	0%	100%	0%	0%	0%	85%	0%	8%	8%
NY	47%	18%	35%	0%	53%	21%	26%	0%	43%	7%	49%	1%	40%	9%	50%	1%
OH	83%	11%	5%	1%	84%	13%	2%	1%	86%	4%	7%	3%	71%	9%	18%	2%
OK	88%	13%	0%	0%	94%	3%	3%	0%	80%	15%	0%	5%	87%	7%	7%	0%
OR	41%	36%	23%	0%	31%	56%	13%	0%	50%	26%	22%	2%	11%	13%	77%	0%
PA	46%	32%	19%	3%	54%	27%	18%	2%	53%	19%	26%	2%	37%	10%	51%	2%
RI	11%	22%	67%	0%	36%	18%	45%	0%	29%	5%	67%	0%	4%	0%	96%	0%
SC	64%	20%	12%	4%	66%	13%	19%	2%	68%	4%	29%	0%	31%	7%	62%	0%
SD	100%	0%	0%	0%	57%	43%	0%	0%	89%	11%	0%	0%	75%	13%	13%	0%
TN	75%	17%	8%	0%	63%	34%	3%	0%	72%	23%	5%	0%	48%	18%	33%	0%
TX	74%	8%	18%	0%	64%	13%	23%	0%	62%	16%	20%	2%	41%	10%	48%	1%
UT	78%	0%	22%	0%	87%	13%	0%	0%	64%	36%	0%	0%	89%	6%	6%	0%
VA	31%	35%	35%	0%	27%	38%	35%	0%	23%	17%	58%	2%	16%	13%	70%	2%
VT	100%	0%	0%	0%	67%	33%	0%	0%	71%	14%	14%	0%	80%	0%	20%	0%
WA	38%	27%	33%	1%	36%	30%	34%	0%	63%	25%	12%	0%	21%	11%	67%	1%
WI	66%	30%	4%	0%	78%	20%	2%	0%	80%	10%	5%	5%	73%	13%	7%	7%
WV	83%	8%	8%	0%	43%	57%	0%	0%	55%	35%	10%	0%	55%	18%	27%	0%
WY	83%	0%	17%	0%	73%	27%	0%	0%	100%	0%	0%	0%	100%	0%	0%	0%

[a] Note that respondents in several states apparently provided inaccurate information because some states at great distances from the ocean report individuals taking single-day trips to the ocean.

[b] Other includes wetlands and unknown water body types.

N/A - Not Available

Source: NDS.

Table N.6: Allocation of Multiple-Day Trips by Water Body Type

State	Boating (%)				Fishing (%)				Swimming (%)				Viewing (%)			
	Lake	Stream	Ocean	Other[a]	Lake	Stream	Ocean	Other	Lake	Stream	Ocean	Other	Lake	Stream	Ocean	Other
AK	75%	0%	25%	0%	33%	0%	67%	0%	0%	0%	0%	0%	33%	0%	33%	33%
AL	43%	0%	43%	14%	40%	0%	40%	20%	19%	0%	62%	19%	7%	0%	72%	21%
AR	71%	14%	0%	14%	45%	36%	0%	18%	0%	17%	67%	17%	30%	0%	43%	26%
AZ	63%	13%	25%	0%	73%	13%	7%	7%	7%	7%	50%	36%	7%	11%	52%	30%
CA	49%	23%	25%	3%	58%	17%	11%	13%	19%	12%	41%	29%	13%	6%	52%	29%
CO	85%	8%	0%	8%	48%	36%	12%	4%	33%	0%	25%	42%	30%	4%	41%	26%
CT	33%	33%	33%	0%	60%	0%	40%	0%	14%	5%	73%	9%	10%	0%	60%	30%
DC	0%	0%	100%	0%	N/A	N/A	N/A	N/A	0%	0%	67%	33%	8%	0%	75%	17%
DE	100%	0%	0%	0%	50%	0%	50%	0%	0%	0%	100%	0%	0%	8%	83%	8%
FL	11%	25%	43%	21%	21%	11%	36%	32%	9%	2%	52%	38%	7%	3%	53%	36%
GA	46%	19%	27%	8%	24%	12%	40%	24%	15%	5%	62%	18%	8%	2%	70%	20%
HI	0%	0%	50%	50%	0%	0%	100%	0%	0%	0%	83%	17%	0%	0%	40%	60%
IA	78%	0%	11%	11%	78%	22%	0%	0%	14%	0%	57%	29%	21%	7%	52%	21%
ID	80%	20%	0%	0%	56%	38%	0%	6%	75%	25%	0%	0%	50%	11%	28%	11%
IL	58%	23%	10%	10%	70%	7%	11%	11%	33%	8%	25%	35%	23%	7%	36%	34%
IN	68%	16%	5%	11%	69%	6%	13%	13%	35%	0%	24%	41%	17%	4%	57%	23%
KS	100%	0%	0%	0%	100%	0%	0%	0%	63%	0%	25%	13%	30%	9%	39%	22%
KY	78%	22%	0%	0%	71%	18%	0%	12%	25%	19%	38%	19%	5%	0%	78%	16%
LA	57%	0%	14%	29%	31%	15%	31%	23%	11%	0%	79%	11%	8%	5%	67%	21%
MA	42%	11%	32%	16%	53%	0%	20%	27%	7%	0%	63%	30%	16%	3%	52%	29%
MD	18%	9%	55%	18%	44%	33%	11%	11%	15%	5%	69%	10%	9%	5%	71%	15%
ME	63%	13%	13%	13%	50%	50%	0%	0%	50%	0%	17%	33%	25%	0%	25%	50%
MI	76%	10%	10%	4%	65%	8%	6%	20%	50%	6%	22%	22%	40%	2%	22%	36%
MN	63%	6%	6%	25%	83%	9%	0%	9%	50%	0%	6%	44%	44%	2%	30%	23%
MO	75%	17%	4%	4%	52%	29%	5%	14%	30%	10%	25%	35%	20%	5%	42%	32%
MS	50%	33%	17%	0%	60%	0%	20%	20%	14%	0%	57%	29%	8%	4%	67%	21%
MT	25%	25%	25%	25%	50%	50%	0%	0%	50%	0%	17%	33%	33%	11%	33%	22%
NC	52%	19%	19%	10%	11%	8%	72%	8%	3%	3%	79%	16%	2%	2%	82%	13%

Table N.6: Allocation of Multiple-Day Trips by Water Body Type

State	Boating (%)				Fishing (%)				Swimming (%)				Viewing (%)			
	Lake	Stream	Ocean	Other[a]	Lake	Stream	Ocean	Other	Lake	Stream	Ocean	Other	Lake	Stream	Ocean	Other
ND	100%	0%	0%	0%	100%	0%	0%	0%	25%	0%	0%	75%	25%	0%	0%	75%
NE	75%	25%	0%	0%	75%	13%	13%	0%	33%	0%	33%	33%	40%	10%	30%	20%
NH	0%	33%	67%	0%	0%	0%	100%	0%	40%	0%	60%	0%	14%	0%	71%	14%
NJ	0%	0%	67%	33%	18%	18%	18%	45%	4%	0%	83%	13%	9%	3%	58%	30%
NM	85%	8%	0%	8%	70%	20%	10%	0%	33%	17%	0%	50%	27%	0%	50%	23%
NV	75%	0%	25%	0%	33%	17%	17%	33%	20%	20%	40%	20%	31%	0%	62%	8%
NY	41%	17%	22%	20%	50%	17%	20%	13%	22%	0%	62%	16%	12%	5%	55%	28%
OH	68%	18%	9%	6%	70%	13%	7%	10%	14%	5%	59%	21%	20%	2%	59%	19%
OK	62%	8%	8%	23%	50%	10%	10%	30%	30%	10%	25%	35%	21%	6%	38%	35%
OR	38%	31%	15%	15%	42%	33%	8%	17%	9%	17%	30%	43%	8%	5%	72%	16%
PA	42%	9%	36%	12%	53%	16%	22%	9%	17%	3%	64%	16%	12%	4%	65%	20%
RI	0%	0%	0%	0%	0%	0%	0%	100%	0%	0%	0%	100%	11%	11%	33%	44%
SC	56%	0%	33%	11%	17%	17%	50%	17%	0%	8%	67%	25%	2%	2%	81%	15%
SD	75%	0%	0%	25%	25%	75%	0%	0%	100%	0%	0%	0%	25%	0%	25%	50%
TN	50%	14%	21%	14%	33%	33%	11%	22%	15%	4%	65%	15%	11%	1%	71%	16%
TX	53%	6%	26%	15%	53%	10%	25%	12%	16%	16%	42%	26%	17%	2%	57%	24%
UT	85%	0%	0%	15%	70%	10%	0%	20%	50%	25%	0%	25%	25%	0%	38%	38%
VA	35%	15%	45%	5%	24%	19%	43%	14%	12%	2%	71%	16%	4%	3%	78%	15%
VT	100%	0%	0%	0%	0%	0%	0%	0%	50%	0%	50%	0%	55%	0%	45%	0%
WA	27%	27%	36%	9%	29%	32%	25%	14%	29%	19%	39%	13%	12%	9%	68%	11%
WI	78%	11%	11%	0%	73%	15%	3%	9%	43%	9%	30%	17%	34%	4%	38%	25%
WV	20%	20%	0%	60%	25%	50%	0%	25%	9%	9%	55%	27%	9%	9%	70%	13%
WY	100%	0%	0%	0%	100%	0%	0%	0%	0%	0%	0%	0%	50%	0%	0%	50%

[a] Other includes wetlands and unknown water body types.
N/A - Not Available

Source: NDS.

N.5 One-Way Travel Distance

This analysis estimates the average one-way distance to sites by trip duration (i.e., single day versus multi-day trips), trip length, recreation activity, and state of residence. EPA estimated the mean one-way distance traveled based on the distance reported for the last single- or multiple-day trip for each activity. As shown in Table N.7, some respondents indicated traveling to the ocean across long distances on single-day trips. These values are likely to be due to the following two factors:

- respondents traveled long distances for multi-purpose multiple-day trips and participated in the given activity on only one day on the trip; and
- response errors.

EPA estimated the average travel distance traveled after dropping outliers because these outliers may provide undue influence on sample means.

Table N.7: Average One-Way Distance

State	Miles to Single-Day Site				Miles to Multiple-Day Site			
	Boating	Fishing	Swimming	Viewing	Boating	Fishing	Swimming	Viewing
AK	41	47	32	39	76	193	N/A	43
AL	31	29	35	53	93	218	230	214
AR	52	38	19	222	215	246	282	394
AZ	54	45	44	117	205	323	413	383
CA	32	40	26	31	233	316	272	226
CO	41	56	15	69	372	260	548	894
CT	30	41	36	49	168	161	194	330
DC	46	N/A	417	85	1000[a]	N/A	165	688
DE	36	32	50	189	1,625	1,700	85	248
FL	21	23	20	24	317	381	154	237
GA	34	52	42	46	199	283	261	336
HI	37	13	14	13	3	80	32	45
IA	60	25	26	49	314	321	228	1,354
ID	35	48	101	54	228	146	100	507
IL	52	34	30	29	255	368	213	707
IN	47	29	50	64	295	378	368	813
KS	42	22	52	68	151	177	272	861
KY	55	32	46	106	151	143	391	697
LA	30	27	39	53	132	76	244	245
MA	22	25	30	29	136	154	144	398
MD	36	40	56	38	581	199	200	263
ME	44	24	30	23	436	148	152	31
MI	31	33	25	32	192	249	234	387
MN	45	55	16	16	354	185	132	552
MO	42	40	39	71	195	265	200	628
MS	11	27	36	39	72	122	203	483
MT	43	172	31	102	588	154	352	500
NC	42	49	45	67	153	182	264	262
ND	69	55	35	75	154	130	45	120
NE	70	29	71	56	125	603	400	152
NH	27	24	28	34	186	248	108	712
NJ	49	31	41	41	483	179	227	476
NM	76	50	71	252	161	191	207	1,315
NV	108	46	43	53	48	401	254	565

Table N.7: Average One-Way Distance

State	Miles to Single-Day Site				Miles to Multiple-Day Site			
	Boating	Fishing	Swimming	Viewing	Boating	Fishing	Swimming	Viewing
NY	32	26	25	37	202	195	194	692
OH	63	38	30	45	265	262	498	778
OK	62	50	46	47	189	244	232	542
OR	31	36	33	51	398	200	97	143
PA	40	38	36	57	296	228	210	391
RI	10	26	18	26				433
SC	15	33	40	60	713	132	200	250
SD	43	35	19	46	352	143	400	740
TN	29	27	24	84	61	888	493	481
TX	40	38	38	65	190	187	261	442
UT	43	66	44	68	235	122	207	598
VA	37	30	39	69	407	159	256	303
VT	41	20	33	50	70		78	334
WA	23	28	20	41	154	198	205	277
WI	34	30	30	33	289	303	104	545
WV	86	30	95	158	338	278	328	429
WY	69	46	32	47	73	56		230

[a] Based on one observation only.
N/A - Not Available

Source: NDS.

N.6 Individual Expenditures per Trip

This analysis estimates the mean total expenditures per person by trip length, recreation activity, and state of residence. Total expenditures for single-day boating, fishing, and viewing trips consist of transportation, entrance fee, and boat rental. Total expenditures for multiple-day boating, fishing, and viewing trips include expenses for transportation, entrance fees, boat rental, and lodging. Transportation includes expenses for plane, train, bus, or ship only, and do not reflect costs associated with operating a car. Expenditures on single-day and multiple-day swimming trips do not include boat rental. Expenditures on single-day and multiple-day trips for all activities do not include bait, tackle, recreational clothing and equipment (e.g., photographic supply and binoculars), boat ownership, or food. Results of the analysis are presented below in Table N.8.

Table N.8: Individual Expenditures per Trip

State	Average Expenditures per Person on Single-day Trips (1993$ per trip)				Average Expenditures per Person on Multiple-day Trips (1993$ per trip)			
	Boating	Fishing	Swimming	Viewing	Boating	Fishing	Swimming	Viewing
AK	$16	$10	$0	$12	$66	$98	$0	$70
AL	$14	$15	$2	$5	$23	$421	$153	$261
AR	$18	$24	$1	$1	$59	$48	$361	$399
AZ	$16	$5	$7	$3	$41	$84	$184	$126
CA	$53	$22	$5	$3	$454	$220	$455	$328
CO	$49	$11	$3	$18	$320	$235	$248	$325
CT	$19	$12	$35	$7	$387	$114	$330	$505
DC[a]	$17	N/A	$2	$3	$2,000	N/A	$200	$354
DE	$6	$18	$2	$2	$43	$63	$325	$120
FL	$22	$22	$2	$4	$376	$852	$234	$375
GA	$19	$17	$8	$28	$147	$275	$279	$249
HI	$22	$7	$0	$0	$110	$0	$118	$75
IA	$8	$2	$1	$2	$119	$662	$340	$488
ID	$21	$0	$1	$1	$54	$29	$63	$118
IL	$37	$9	$2	$1	$342	$333	$241	$495
IN	$18	$10	$3	$14	$299	$321	$175	$661
KS	$19	$3	$2	$2	$89	$175	$178	$518
KY	$18	$2	$35	$18	$340	$180	$117	$298
LA	$50	$14	$1	$1	$186	$58	$251	$245
MA	$19	$13	$18	$3	$89	$197	$309	$274
MD	$49	$51	$2	$36	$116	$178	$300	$288
ME	$2	$2	$1	$2	$329	$44	$143	$22
MI	$26	$7	$2	$4	$227	$125	$379	$255
MN	$10	$6	$2	$1	$198	$160	$99	$261
MO	$26	$11	$2	$9	$164	$122	$278	$352
MS	$14	$26	$1	$1	$52	$169	$181	$329

Table N.8: Individual Expenditures per Trip

State	Average Expenditures per Person on Single-day Trips (1993$ per trip)				Average Expenditures per Person on Multiple-day Trips (1993$ per trip)			
	Boating	Fishing	Swimming	Viewing	Boating	Fishing	Swimming	Viewing
MT	$8	$23	$1	$0	$25	$95	$542	$86
NC	$13	$26	$24	$3	$165	$132	$393	$227
ND	$14	$2	$0	$0	$53	$3	$0	$0
NE	$3	$4	$85	$2	$24	$310	$150	$237
NH	$16	$7	$3	$0	$127	$0	$955	$342
NJ	$32	$44	$13	$7	$360	$168	$631	$414
NM	$15	$3	$22	$32	$73	$78	$41	$218
NV	$25	$1	$1	$4	$104	$25	$554	$116
NY	$25	$29	$5	$8	$242	$76	$298	$459
OH	$26	$15	$8	$22	$403	$239	$560	$465
OK	$11	$22	$2	$3	$173	$314	$137	$268
OR	$15	$5	$22	$1	$429	$51	$543	$248
PA	$23	$21	$19	$9	$275	$310	$275	$399
RI	$23	$16	$3	$2	$0	$0	$0	$240
SC	$27	$12	$2	$7	$576	$201	$731	$265
SD	$5	$6	$0	$2	$248	$54	$10	$715
TN	$26	$4	$0	$14	$458	$49	$329	$315
TX	$152	$12	$2	$3	$151	$138	$324	$349
UT	$25	$2	$4	$13	$164	$10	$117	$419
VA	$10	$23	$1	$243	$175	$116	$317	$319
VT	$6	$1	$6	$2	$100	$0	$22	$372
WA	$11	$19	$13	$1	$266	$170	$217	$165
WI	$10	$5	$3	$8	$425	$135	$468	$308
WV	$46	$2	$14	$3	$250	$275	$209	$356
WY	$5	$5	$0	$22	$85	$17	$0	$114

[a] Average boating expenditures in Washington, D.C. are based on a single observation.
N/A - Not Available

Source: NDS.

N.7 Distribution of Direct Costs for Single-day Trips

This analysis estimates the percent of total expenditures for single-day and multiple-day trips spent on each component of total expenditures. Total expenditures for single-day boating, fishing, and viewing trips consist of:

- transportation,
- entrance fee, and
- boat rental.

Lodging is not included in single-day expenditures. Swimming trip expenditures do not include boat rental. Transportation includes expenses for:

- plane,
- train,
- bus, or
- ship only

and do not include automobile travel costs.

EPA determined the percent of total expenditures for each category by dividing the total amount spent on each category by the total expenditures in a state for a given activity.

Tables N.9 and N.10 present results for single- and multiple-day trips, respectively.

Table N.9: Distribution of Direct Costs for Single-Day Trips

State	Boating (% of total expenditures)			Fishing (% of total expenditures)			Swimming[a] (% of total expenditures)		Viewing (% of total expenditures)		
	Trans[b]	Enter Fee	Boat Rental	Trans	Enter Fee	Boat Rental	Trans	Enter Fee	Trans	Enter Fee	Boat Rental
AK	0%	3%	97%	0%	5%	95%	N/A	N/A	0%	27%	73%
AL	0%	12%	88%	4%	28%	68%	0%	100%	0%	61%	39%
AR	0%	8%	92%	36%	41%	23%	0%	100%	0%	100%	0%
AZ	0%	6%	94%	0%	25%	75%	0%	100%	83%	17%	0%
CA	45%	13%	42%	15%	21%	65%	37%	63%	50%	34%	16%
CO	0%	9%	91%	57%	17%	25%	0%	100%	84%	16%	0%
CT	0%	9%	91%	0%	3%	97%	0%	100%	0%	100%	0%
DC	0%	35%	65%	N/A	N/A	N/A	0%	100%	0%	73%	27%
DE	0%	30%	70%	0%	52%	48%	0%	100%	0%	17%	83%
FL	0%	10%	90%	1%	12%	87%	0%	100%	0%	26%	74%
GA	0%	7%	93%	0%	29%	71%	66%	34%	83%	11%	5%
HI	62%	0%	38%	0%	18%	82%	N/A	N/A	N/A	N/A	N/A
IA	0%	3%	97%	0%	0%	100%	0%	100%	0%	63%	37%
ID	0%	5%	95%	0%	0%	100%	0%	100%	0%	100%	0%
IL	4%	13%	82%	0%	13%	87%	0%	100%	6%	80%	13%
IN	0%	2%	98%	0%	24%	76%	0%	100%	53%	41%	6%
KS	0%	24%	76%	0%	51%	49%	0%	100%	0%	55%	45%
KY	0%	2%	98%	0%	27%	73%	96%	4%	82%	9%	9%
LA	0%	68%	32%	0%	46%	54%	0%	100%	0%	100%	0%
MA	0%	43%	57%	4%	28%	68%	88%	12%	0%	78%	22%
MD	31%	17%	52%	0%	2%	98%	0%	100%	17%	82%	1%
ME	0%	23%	77%	0%	0%	100%	0%	100%	0%	94%	6%
MI	0%	8%	92%	0%	10%	90%	0%	100%	0%	65%	35%
MN	0%	17%	83%	0%	65%	35%	0%	100%	0%	20%	80%
MO	0%	25%	75%	0%	20%	80%	0%	100%	1%	92%	7%
MS	0%	36%	64%	0%	44%	56%	0%	100%	0%	100%	0%
MT	0%	8%	92%	96%	4%	0%	0%	100%	N/A	N/A	N/A
NC	0%	23%	77%	0%	12%	88%	0%	100%	40%	41%	19%
ND	0%	30%	70%	0%	32%	68%	0%	100%	N/A	N/A	N/A
NE	0%	0%	100%	0%	0%	100%	0%	100%	0%	5%	95%
NH	0%	48%	52%	0%	61%	39%	0%	100%	0%	100%	0%
NJ	15%	10%	74%	8%	48%	44%	26%	74%	35%	47%	18%
NM	0%	8%	92%	0%	49%	51%	91%	9%	98%	2%	0%
NV	0%	19%	81%	0%	67%	33%	0%	100%	0%	32%	68%
NY	23%	29%	48%	5%	36%	58%	44%	56%	5%	76%	19%

Table N.9: Distribution of Direct Costs for Single-Day Trips

State	Boating (% of total expenditures)			Fishing (% of total expenditures)			Swimming[a] (% of total expenditures)		Viewing (% of total expenditures)		
	Trans[b]	Enter Fee	Boat Rental	Trans	Enter Fee	Boat Rental	Trans	Enter Fee	Trans	Enter Fee	Boat Rental
OH	28%	6%	66%	7%	14%	79%	0%	100%	43%	11%	46%
OK	0%	27%	73%	58%	9%	33%	0%	100%	0%	0%	100%
OR	0%	17%	83%	0%	25%	75%	0%	100%	0%	87%	13%
PA	0%	11%	89%	0%	22%	78%	94%	6%	49%	41%	10%
RI	0%	0%	100%	0%	1%	99%	0%	100%	0%	100%	0%
SC	0%	66%	34%	0%	10%	90%	0%	100%	95%	2%	3%
SD	0%	19%	81%	0%	39%	61%	0%	100%	0%	100%	0%
TN	26%	0%	73%	0%	22%	78%	0%	100%	98%	2%	0%
TX	0%	2%	98%	0%	20%	80%	0%	100%	0%	33%	67%
UT	0%	42%	59%	0%	60%	40%	0%	100%	0%	84%	16%
VA	9%	25%	66%	0%	25%	75%	0%	100%	20%	80%	0%
VT	0%	8%	92%	0%	0%	100%	0%	100%	0%	100%	0%
WA	0%	18%	82%	45%	16%	39%	0%	100%	17%	56%	28%
WI	0%	19%	81%	1%	20%	79%	2%	98%	48%	36%	16%
WV	0%	33%	67%	0%	0%	100%	78%	22%	88%	6%	6%
WY	0%	47%	53%	0%	53%	48%	N/A	N/A	0%	16%	84%

[a] Swimming expenditures do not include boat rental.

[b] Transportation expenses include expenditures on plane, train, bus, or ship taken on the trip only and do not reflect travel costs.

N/A - Not Available

Source: U.S. EPA analysis.

Table N.10: Distribution of Direct Costs for Multiple-Day Trips

State	Boating (% of total expenditures)				Fishing (% of total expenditures)				Swimming[a] (% of total expenditures)			Viewing (% of total expenditures)			
	Trans[b]	Enter Fee	Lodging[c]	Boat Rental	Trans	Enter Fee	Lodging	Boat Rental	Trans	Enter Fee	Lodging	Trans	Enter Fee	Lodging	Boat Rental
AK	0%	2%	15%	84%	0%	3%	77%	20%	N/A	N/A	N/A	0%	0%	71%	29%
AL	0%	0%	20%	80%	0%	0%	37%	63%	4%	0%	96%	0%	0%	99%	1%
AR	0%	1%	51%	48%	0%	7%	73%	20%	0%	0%	100%	8%	8%	84%	0%
AZ	0%	5%	55%	40%	0%	10%	65%	24%	31%	0%	69%	29%	1%	69%	1%
CA	28%	6%	53%	13%	12%	16%	58%	14%	23%	2%	76%	20%	11%	63%	5%
CO	0%	7%	77%	16%	20%	0%	69%	10%	12%	2%	87%	23%	1%	72%	3%
CT	22%	0%	16%	63%	0%	1%	95%	4%	17%	1%	83%	11%	0%	88%	0%
DC	100%	0%	0%	0%	N/A	N/A	N/A	N/A	0%	0%	100%	22%	6%	42%	30%
DE	0%	0%	77%	23%	0%	0%	100%	0%	8%	0%	92%	0%	1%	99%	0%
FL	10%	1%	71%	18%	0%	2%	16%	81%	0%	2%	98%	7%	5%	88%	0%
GA	14%	7%	51%	28%	8%	4%	69%	19%	0%	0%	99%	9%	9%	77%	5%
HI	0%	0%	91%	9%	N/A	N/A	N/A	N/A	0%	0%	100%	0%	0%	100%	0%
IA	0%	21%	63%	16%	0%	0%	64%	36%	18%	0%	82%	26%	1%	71%	1%
ID	0%	1%	92%	7%	0%	8%	78%	15%	0%	3%	97%	20%	14%	65%	1%
IL	18%	6%	41%	35%	14%	2%	79%	5%	33%	4%	63%	21%	1%	74%	3%
IN	8%	3%	58%	31%	7%	5%	81%	7%	17%	57%	26%	20%	37%	42%	1%
KS	0%	2%	30%	68%	0%	1%	74%	25%	24%	0%	76%	16%	0%	82%	1%
KY	0%	3%	12%	85%	21%	3%	48%	27%	0%	0%	100%	14%	0%	86%	0%
LA	0%	3%	81%	16%	0%	31%	62%	8%	9%	0%	91%	1%	3%	94%	2%
MA	0%	1%	38%	61%	0%	14%	78%	9%	19%	0%	81%	21%	5%	73%	0%
MD	0%	0%	56%	44%	0%	0%	98%	2%	12%	0%	88%	13%	2%	83%	2%
ME	0%	72%	22%	6%	0%	15%	80%	6%	0%	4%	96%	0%	6%	94%	0%
MI	9%	6%	58%	26%	5%	4%	83%	8%	17%	6%	77%	33%	3%	63%	2%
MN	17%	0%	78%	5%	0%	0%	73%	27%	0%	1%	99%	44%	0%	54%	2%
MO	0%	3%	74%	23%	0%	6%	64%	30%	30%	0%	70%	24%	8%	67%	1%
MS	0%	1%	65%	34%	0%	0%	69%	31%	0%	0%	100%	0%	2%	97%	1%
MT	0%	0%	100%	0%	0%	0%	92%	8%	5%	0%	95%	0%	5%	95%	0%
NC	12%	8%	55%	25%	18%	4%	69%	9%	8%	0%	92%	7%	0%	93%	0%
ND	0%	0%	16%	84%	0%	0%	100%	0%	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NE	0%	6%	66%	28%	30%	6%	64%	0%	0%	0%	100%	60%	0%	40%	0%
NH	0%	13%	0%	87%	N/A	N/A	N/A	N/A	9%	0%	91%	0%	0%	100%	0%
NJ	34%	0%	60%	6%	0%	37%	25%	39%	20%	0%	79%	21%	2%	76%	1%
NM	0%	7%	52%	41%	0%	5%	83%	12%	0%	18%	82%	17%	1%	82%	1%
NV	0%	3%	37%	60%	0%	0%	100%	0%	45%	2%	53%	7%	1%	92%	1%

Table N.10: Distribution of Direct Costs for Multiple-Day Trips

State	Boating (% of total expenditures)				Fishing (% of total expenditures)				Swimming[a] (% of total expenditures)			Viewing (% of total expenditures)			
	Trans[b]	Enter Fee	Lodging[c]	Boat Rental	Trans	Enter Fee	Lodging	Boat Rental	Trans	Enter Fee	Lodging	Trans	Enter Fee	Lodging	Boat Rental
NY	20%	13%	58%	8%	0%	5%	75%	20%	9%	1%	90%	16%	0%	82%	1%
OH	8%	2%	49%	41%	5%	1%	79%	15%	6%	24%	70%	17%	0%	79%	4%
OK	16%	0%	62%	22%	0%	81%	19%	0%	18%	4%	78%	30%	1%	68%	2%
OR	4%	1%	43%	52%	0%	2%	87%	11%	41%	0%	59%	5%	3%	91%	1%
PA	37%	4%	36%	23%	1%	1%	61%	37%	19%	1%	81%	9%	0%	89%	1%
RI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	20%	0%	79%	0%
SC	10%	0%	24%	67%	0%	10%	87%	3%	0%	0%	100%	21%	1%	76%	1%
SD	0%	0%	96%	4%	0%	12%	69%	18%	0%	0%	100%	28%	0%	72%	0%
TN	0%	0%	53%	46%	0%	0%	38%	63%	12%	0%	88%	7%	0%	91%	2%
TX	6%	5%	56%	33%	6%	5%	70%	19%	21%	8%	72%	20%	1%	76%	3%
UT	0%	0%	66%	34%	0%	60%	40%	0%	0%	1%	99%	34%	0%	66%	0%
VA	54%	3%	30%	14%	0%	10%	60%	31%	2%	1%	97%	8%	2%	90%	1%
VT	0%	50%	50%	0%	N/A	N/A	N/A	N/A	0%	0%	100%	60%	0%	40%	0%
WA	10%	4%	46%	40%	57%	0%	18%	25%	23%	4%	73%	24%	1%	73%	1%
WI	9%	4%	35%	52%	26%	21%	48%	6%	13%	0%	87%	18%	1%	81%	0%
WV	0%	0%	80%	20%	0%	3%	97%	0%	0%	0%	100%	0%	13%	87%	0%
WY	0%	0%	71%	29%	0%	4%	96%	0%	N/A	N/A	N/A	0%	10%	90%	0%

a Swimming expenditures do not include boat rental.
b Transportation expenses include expenditures on plane, train, bus, or ship taken on the trip only and do not reflect travel costs.
c Total expenses for multiple-day trips include lodging, while total expenditures for single-day trips do not.
N/A - Not Available

Source: NDS; U.S. EPA analysis.

N.8 Profile of Boating Trips

This analysis provides a profile of sample boater characteristics by state of residence. Table N.11 shows distribution of boaters by type of boating in which they participated on their last trip and the source of the boat used on their most recent boating trip.

Boating types include:

- motorboating;
- sailing;
- white water kayaking and canoeing;
- other kayaking or canoeing;
- rowing, rafting, tubing, or floating;
- wind surfing; and
- other.

Boat sources include:

- boaters who used their own boat, including those who indicated using either their own boat or one belonging to someone in their immediate family on their last trip;
- boat renters, including those who either rented or chartered a boat on their last trip; and
- other, including respondents who did not indicate either using their own boat or renting a boat.

Dividing the number of respondents who participated in each boating type on their last trip by the total sample of boaters provided an estimate of the percent participating in each type.

Table N.11: Profile of Boating Trips

State	Total Number of Boaters		Source Boat Used on Last Trip[a] (Percent of Boaters)			Type of Boating on Last Trip[b] (Percent of Boaters)							
	NDS Sample	Sample Weighted	Own	Rent	Other	Motor	Sail	White Water Kayak	Other Kayak	Row	Raft	Wind Surf	Other
AK	14	220,972	36%	36%	29%	71%	0%	21%	7%	0%	0%	0%	0%
AL	39	617,486	51%	21%	28%	79%	0%	8%	0%	0%	3%	0%	10%
AR	25	404,809	48%	20%	32%	88%	0%	0%	0%	0%	4%	0%	8%
AZ	21	461,000	57%	14%	29%	67%	14%	0%	10%	10%	0%	0%	0%
CA	269	5,244,634	31%	23%	46%	66%	14%	2%	1%	1%	4%	0%	11%
CO	27	423,143	44%	22%	33%	70%	4%	4%	4%	4%	7%	4%	4%
CT	32	533,626	41%	34%	25%	50%	22%	6%	9%	0%	6%	0%	6%
DC	4	53,551	0%	50%	50%	50%	50%	0%	0%	0%	0%	0%	0%
DE	10	119,661	60%	10%	30%	80%	10%	10%	0%	0%	0%	0%	0%
FL	152	2,925,614	31%	32%	37%	74%	8%	3%	5%	1%	1%	0%	7%
GA	69	1,156,297	30%	32%	38%	77%	9%	7%	0%	0%	3%	0%	4%
HI	11	189,837	9%	36%	55%	36%	36%	9%	9%	0%	0%	0%	9%
IA	32	426,854	25%	31%	44%	81%	3%	9%	3%	0%	0%	0%	3%
ID	25	291,917	56%	12%	32%	72%	4%	0%	4%	4%	16%	0%	0%
IL	86	1,758,816	34%	28%	38%	66%	5%	2%	6%	0%	6%	0%	15%
IN	62	967,694	35%	26%	39%	84%	10%	2%	0%	0%	0%	0%	5%
KS	18	274,465	44%	22%	33%	83%	0%	0%	6%	11%	0%	0%	0%
KY	35	505,228	54%	17%	29%	89%	0%	0%	3%	0%	3%	0%	6%
LA	38	682,563	47%	18%	34%	87%	3%	3%	0%	3%	0%	0%	5%
MA	58	1,166,524	28%	45%	28%	53%	19%	9%	12%	0%	0%	0%	7%
MD	49	778,917	20%	47%	33%	65%	10%	4%	0%	2%	8%	2%	8%
ME	24	336,758	21%	46%	33%	63%	8%	8%	13%	0%	0%	0%	8%
MI	141	1,867,312	30%	43%	26%	76%	9%	4%	3%	1%	1%	1%	6%
MN	59	910,964	39%	29%	32%	83%	2%	2%	3%	0%	0%	0%	10%
MO	60	938,326	38%	28%	33%	75%	3%	5%	12%	0%	0%	0%	5%
MS	25	385,744	36%	32%	32%	80%	12%	0%	8%	0%	0%	0%	0%
MT	12	153,038	67%	0%	33%	42%	0%	17%	17%	0%	8%	0%	17%
NC	57	881,075	30%	30%	40%	70%	9%	7%	2%	2%	5%	0%	5%
ND	11	138,098	55%	27%	18%	82%	0%	0%	0%	0%	0%	9%	9%
NE	17	266,126	18%	12%	71%	88%	0%	12%	0%	0%	0%	0%	0%
NH	15	225,139	13%	53%	33%	80%	7%	13%	0%	0%	0%	0%	0%
NJ	64	1,207,234	17%	53%	30%	70%	13%	0%	5%	2%	0%	0%	11%
NM	20	260,978	55%	10%	35%	65%	5%	0%	15%	0%	10%	0%	5%
NV	17	348,590	41%	12%	47%	82%	0%	6%	0%	6%	0%	6%	0%
NY	137	2,619,158	21%	50%	28%	64%	11%	1%	6%	4%	2%	0%	12%

Table N.11: Profile of Boating Trips

State	Total Number of Boaters		Source Boat Used on Last Trip[a] (Percent of Boaters)			Type of Boating on Last Trip[b] (Percent of Boaters)							
	NDS Sample	Sample Weighted	Own	Rent	Other	Motor	Sail	White Water Kayak	Other Kayak	Row	Raft	Wind Surf	Other
OH	109	1,473,937	30%	37%	33%	75%	7%	6%	3%	0%	3%	0%	6%
OK	29	540,650	21%	34%	45%	66%	7%	7%	3%	0%	0%	3%	14%
OR	57	702,199	49%	21%	30%	70%	9%	0%	4%	2%	9%	0%	7%
PA	111	1,450,179	28%	40%	32%	72%	6%	1%	4%	2%	1%	1%	14%
RI	9	130,654	33%	56%	11%	33%	44%	0%	11%	11%	0%	0%	0%
SC	34	585,163	53%	21%	26%	71%	3%	6%	9%	0%	0%	0%	12%
SD	11	151,221	18%	36%	45%	82%	0%	9%	0%	0%	0%	0%	9%
TN	67	1,006,355	45%	25%	30%	84%	6%	0%	0%	1%	0%	0%	9%
TX	118	2,805,077	41%	20%	39%	80%	5%	1%	3%	2%	2%	0%	8%
UT	22	316,826	59%	9%	32%	86%	0%	0%	0%	0%	0%	0%	14%
VA	72	1,023,443	36%	43%	21%	57%	22%	1%	8%	0%	1%	0%	10%
VT	8	112,768	50%	50%	0%	50%	13%	13%	13%	0%	13%	0%	0%
WA	114	1,601,852	37%	26%	37%	70%	11%	0%	6%	3%	4%	0%	6%
WI	65	903,611	42%	38%	20%	68%	8%	5%	15%	2%	3%	0%	0%
WV	17	196,359	47%	6%	47%	59%	0%	6%	6%	0%	0%	0%	29%
WY	8	98,550	38%	0%	63%	63%	0%	13%	13%	0%	13%	0%	0%

[a] Own includes those who used their own boat or one belonging to someone in their immediate family.
Rent includes those who rented or chartered a boat.
Other includes those who did not indicate either using own boat or renting a boat.

[b] Kayak includes kayak or canoe; raft includes rafting, tubing, or floating; other includes other or type not indicated.
N/A - Not Available

Source: U.S. EPA analysis; NDS.

N.9 Profile of Fishing Trips

This analysis provides a profile of fishing trips, including angling success rate, average catch, and type of fisheries targeted on the last trip by state of residence. The success rate equals the total number of fishermen who report catching at least one fish on their last trip divided by the total number of fishermen in each state. The average catch equals the total fish caught by all fishermen divided by the total number of fishermen in the state. Average catch therefore includes those who did not indicate catching any fish. Similarly, the percent of fishermen who fished from a boat equals the total number of fishermen who reported fishing from a boat on their last trip, divided by the total number of fishermen. Finally, the percent of fishermen who participated in each type of fishing equals the total number of fishermen who reported fishing in either cold, warm, salt, anadromous, or other water divided by the total number of fishermen. Other includes both those who indicated other and missing values. Results of the analysis are presented below in Table N.12.

Table N.12: Profile of Fishing Trips

State	Sample Weighted Number of Fishermen	Fish Catch on Last Trip[a]		Fished from a Boat on Last Trip (% of fishermen)	Type of Water Fished on Last Trip[b]				
		Average Number of Fish Caught	Success Rate (% of fishermen)		Cold (% of fishermen)	Warm (% of fishermen)	Salt (% of fishermen)	Anadromous (% of fishermen)	Other (% of fishermen)
AK	268,323	9	65%	65%	41%	0%	53%	6%	0%
AL	870,813	7	67%	71%	22%	45%	20%	2%	11%
AR	761,041	7	85%	62%	36%	60%	0%	0%	4%
AZ	790,286	4	67%	39%	44%	47%	3%	3%	3%
CA	5,556,583	5	73%	47%	47%	14%	28%	5%	6%
CO	1,253,757	4	65%	16%	79%	13%	5%	0%	4%
CT	466,922	3	71%	50%	29%	21%	43%	7%	0%
DC	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
DE	119,661	6	70%	50%	20%	20%	60%	0%	0%
FL	3,156,584	5	70%	57%	14%	23%	50%	4%	9%
GA	1,457,940	6	74%	47%	32%	33%	24%	0%	10%
HI	189,837	21	91%	36%	0%	18%	82%	0%	0%
IA	546,907	7	76%	37%	51%	41%	0%	0%	7%
ID	385,331	3	73%	21%	85%	0%	0%	9%	6%
IL	1,942,878	5	74%	44%	38%	45%	4%	2%	11%
IN	1,201,814	6	74%	45%	39%	47%	4%	1%	9%
KS	579,427	6	74%	39%	21%	74%	0%	0%	5%
KY	952,715	5	76%	39%	26%	65%	2%	3%	5%
LA	1,149,580	8	80%	56%	19%	47%	25%	2%	8%
MA	1,086,074	4	72%	43%	39%	19%	30%	2%	11%
MD	842,502	5	77%	62%	38%	17%	38%	0%	8%
ME	308,695	3	68%	55%	64%	18%	18%	0%	0%
MI	2,052,719	6	75%	61%	54%	28%	3%	7%	9%
MN	1,281,526	5	70%	63%	53%	34%	0%	2%	11%
MO	1,141,630	4	74%	37%	51%	36%	3%	3%	8%
MS	586,331	8	82%	55%	24%	58%	13%	0%	5%
MT	293,322	3	78%	22%	87%	9%	4%	0%	0%
NC	1,592,117	10	77%	42%	27%	22%	42%	4%	5%
ND	163,207	4	69%	46%	54%	46%	0%	0%	0%
NE	266,126	9	88%	41%	41%	53%	0%	0%	6%
NH	150,093	2	40%	60%	50%	30%	10%	10%	0%
NJ	1,244,960	5	73%	45%	18%	21%	48%	2%	11%
NM	300,125	3	61%	22%	74%	17%	4%	0%	4%

Table N.12: Profile of Fishing Trips

State	Sample Weighted Number of Fishermen	Fish Catch on Last Trip[a]		Fished from a Boat on Last Trip (% of fishermen)	Type of Water Fished on Last Trip[b]				
		Average Number of Fish Caught	Success Rate (% of fishermen)		Cold (% of fishermen)	Warm (% of fishermen)	Salt (% of fishermen)	Anadromous (% of fishermen)	Other (% of fishermen)
NV	328,084	4	75%	13%	63%	19%	6%	0%	13%
NY	2,236,799	4	80%	49%	46%	19%	26%	2%	7%
OH	1,649,727	5	72%	48%	41%	45%	4%	3%	7%
OK	857,583	6	70%	33%	26%	57%	9%	0%	9%
OR	960,904	3	51%	40%	62%	8%	13%	12%	6%
PA	2,064,218	4	61%	44%	51%	25%	16%	3%	5%
RI	174,205	5	50%	50%	33%	17%	33%	0%	17%
SC	912,165	8	81%	60%	32%	34%	25%	6%	4%
SD	151,221	7	64%	45%	73%	27%	0%	0%	0%
TN	1,141,537	4	76%	46%	36%	51%	5%	3%	5%
TX	4,564,193	5	66%	55%	23%	45%	24%	1%	7%
UT	360,030	3	56%	16%	84%	8%	0%	0%	8%
VA	1,421,449	7	73%	46%	28%	21%	39%	3%	9%
VT	42,288	5	100%	33%	33%	67%	0%	0%	0%
WA	1,250,568	2	56%	60%	49%	8%	22%	15%	6%
WI	1,209,448	9	69%	59%	57%	34%	0%	1%	7%
WV	358,067	6	58%	16%	68%	26%	0%	0%	6%
WY	221,738	4	72%	28%	89%	6%	0%	0%	6%

[a] Missing values for fish catch were included as zero in both the mean and the median.
[b] Other includes both those that indicated other and missing values.
N/A - Not Available

Source: NDS; U.S. EPA analysis.