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REGULATORY IMPACT ANALYSIS FOR THE PROPOSED RULEMAKING ON CORRECTIVE ACTION FOR SOLID WASTE MANAGEMENT UNITS

Prepared for

Office of Solid Waste
Economic Analysis Staff
U.S. Environmental Protection Agency

Prepared by

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PREFACE

This Regulatory Impact Analysis was prepared by ICF Incorporated under the direction of the Office of Solid Waste, U.S. Environmental Protection Agency (EPA). EPA provided substantial sections of the Executive Summary, Chapters 1 through 4, and Chapter 9. ICF wrote the remainder of the report, except for the case studies in Chapter 5, which were prepared jointly by ICF and Sobotka & Company, Inc. EPA also provided review comments on the entire document.

PART 1

ANALYSIS OF PROPOSED CORRECTIVE ACTION PROGRAM

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EXECUTIVE SUMMARY

INTRODUCTION

This regulatory impact analysis (RIA) was performed in conjunction with the development of EPA's proposed rule to require corrective action for releases from solid waste management units at hazardous waste treatment, storage, and disposal facilities.[1] The results of this RIA demonstrate that the proposed corrective action rule is a "major" regulation. Pursuant to the Regulatory Flexibility Act, the Agency also assessed the impact of the proposed rule on small businesses and determined that the rule will not have a significant impact on a substantial number of such businesses.

The proposed regulations analyzed in this regulatory impact analysis are authorized by Sections 3004(u) and (v) of the Resource Conservation and Recovery Act of 1976 (RCRA), as amended by the Hazardous and Solid Waste Amendments of 1984 (HSWA). Section 3004(u) requires that permits issued to hazardous waste management facilities after November 8, 1984 shall require "corrective action for all releases of hazardous waste or constituents from any solid waste management unit at a treatment, storage, or disposal facility seeking a permit under [Subtitle C of RCRA], regardless of the time at which waste was placed in such unit." RCRA Section 3004(v) mandates that EPA require hazardous waste management facilities to undertake corrective action for releases beyond the facility boundary.

Other elements of EPA's corrective action program include the requirements under Section 3008(h) of RCRA and standards contained in Subpart F of 40 CFR Part 264. Section 3008(h), which was added to RCRA as part of the 1984 amendments, authorizes EPA to issue orders requiring corrective action to any facility authorized to operate under RCRA interim status whenever EPA determines that there is or has been a release of hazardous waste into the environment from such a facility. EPA's corrective action program also includes the Subpart F requirements, which were in effect prior to HSWA and address releases to ground water from certain types of land disposal units.

EPA expects that corrective actions at interim status facilities taken under the authority of Section 3008(h) will generally be similar in nature to actions required by the proposed rule. Moreover, the existing Subpart F standards are being revised concurrent with the proposed rule to ensure consistency in the approach taken to corrective action. For the analysis in this RIA, therefore, EPA assumed that the proposed rule, under the authority of Sections 3004(u) and (v), will cover all RCRA corrective action. By making this assumption, the Agency was able to analyze the impact of the proposed rule as a single, uniform corrective action program applied to all types of

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[1] Regulatory impact analyses, mandated by Executive Order 12291, are required for "major" regulations. Major regulations are defined as those likely to result in (1) annual effects on the economy of $100 million or more; (2) a major increase in costs or prices for consumers or individual industries, or (3) significant adverse effects on competition, employment, investment, productivity, innovation, or international trade.

solid waste management units (SWMUs) at all facilities, regardless of permit status. This RIA, therefore, goes beyond the requirements of the Executive Order to analyze just the proposed rule and examines the entire RCRA corrective action program rather than the proposed rule alone.

This RIA is organized into four separate parts, each containing a number of chapters. Part 1 provides an overview of the RIA and the alternatives considered by EPA in developing the proposed corrective action rule. Part 2 presents a quantitative analysis of the proposed rule that focuses on ground-water cleanup. Part 3 contains the economic impact analysis and an overview of Federal facilities while Part 4 summarizes the RIA.

In addition to this main report, four appendices were prepared. Appendix A provides a detailed description of the facility data base used in estimating the effects of the proposed rule. Appendix B discusses the contaminant concentrations used to trigger corrective action in the quantitative simulation described in Part 2. Appendix C describes the methodology used in estimating the economic impacts of the rule. Finally, Appendix D lists the costs and actions of CERCLA Records of Decision used to described typical corrective actions in Chapter 4 of the RIA.

The remainder of this executive summary reviews the methodology and principal results of Parts 1, 2, and 3 of the RIA. This executive summary concludes with a section highlighting the primary conclusions and limitations of the entire RIA.

QUALITATIVE ANALYSIS

In developing the RIA for the proposed corrective action rule, the Agency analyzed both qualitatively and quantitatively several basic alternatives for the rule. The alternatives studied range from a highly conservative "cleanup to background" approach, with very little flexibility in adjusting remedies for site-specific conditions, to an alternative in which cleanups of releases are triggered in limited circumstances only. For the qualitative analysis presented in Part 1 of the RIA, three alternative regulatory strategies were developed and analyzed. Part 1 includes the definition of the problem, a description of the three strategies, and a multimedia analysis of the strategies, including a review of case studies.

Problem Definition

In developing the RIA, EPA assembled data to estimate the potential scope of the RCRA corrective action program. The data used in generating these estimates were obtained primarily from the Agency's existing database on RCRA facilities (the Hazardous Waste Data Management System, or HWDMS), and an analysis conducted for the RIA which examined a sample of 65 RCRA Facility Assessment (RFA) reports. These reports typically are prepared by EPA or the States prior to issuance of RCRA permits. The reports provide preliminary findings as to what releases have or may have occurred and what investigation should be conducted to verify and/or characterize the releases. These 65 RFAs, referred to collectively as the RFA survey, were used to estimate the numbers and types of facilities that may require corrective action. Data from the reports also were used to support modeling for the quantitative analysis of the RIA.

EPA estimates that there are approximately 5,700 facilities regulated under RCRA Subtitle C that are potentially subject to the corrective action authorities of RCRA Sections 3004(u), 3004(v), and 3008(h) and 40 CFR Part 264, Subpart F. The HWDMS classification scheme organizes these facilities into three types: land disposal facilities (i.e., hazardous waste management facilities with a landfill, surface impoundment, waste pile, or land treatment unit), incineration facilities (i.e., facilities that have an incinerator but no land disposal unit), and treatment and storage facilities (i.e., facilities not belonging to either of the above two categories). There are about 1,500 land disposal facilities, 200 incineration facilities, and 4,000 treatment storage facilities.

Prior to the enactment of HSWA, only certain units at land disposal facilities were subject to corrective action. As explained above, HSWA extended corrective action requirements to all SWMUs. Based on the RFA survey, it is estimated that there are roughly 81,000 solid waste management units at RCRA facilities, including some 3,000 land-based hazardous waste management units that were subject to corrective action prior to the 1984 HSWA amendments. Exhibit ES-1 summarizes the effect of HSWA on the scope of EPA's corrective action program.

The number of solid waste management units at individual facilities varies widely, ranging from one to as many as 1,300. Federal facilities, because of their large size, typically contain many more solid waste management units than non-Federal facilities. The RIA estimates that Federal facilities operate an average of 55 SWMUs per facility while non-Federal facilities operate an average of 12 solid waste management units (including hazardous waste management units). Exhibit ES-2 presents the average number of SWMUs subject to corrective action for the different facility types (Federal and non-Federal combined) both before and after the enactment of HSWA.

The types of solid waste management units found at facilities are diverse. More than one-third (36 percent) are tanks used for storage or treatment of wastes. Landfills comprise 16 percent, and surface impoundments 15 percent. The remainder are units such as container storage areas, piles, land treatment units, incinerators and other miscellaneous units. The survey also found a wide diversity within unit categories in terms of size, age, general condition, types of wastes managed, and other factors.

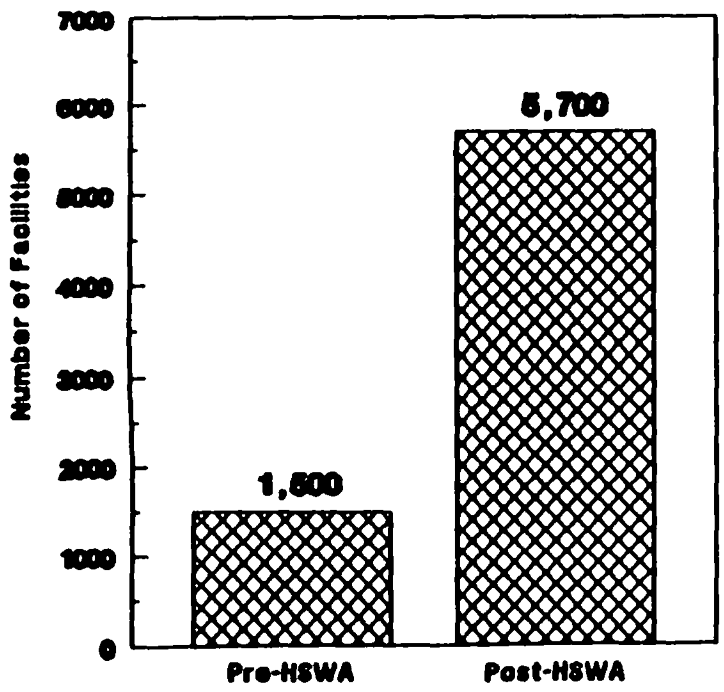
The RIA also estimates that, on average, 62 percent of all facilities have indications of possible releases, based on RFA findings, sufficient to require follow-up remedial investigations (i.e., RCRA Facility Investigations (RFIs)). Typically, facilities which have Subtitle C land disposal units and incinerators are more likely to require RFIs than are treatment/storage facilities (74 percent, 70 percent and 56 percent, respectively). Although the analysis indicates that roughly two-thirds of all RCRA facilities will not require corrective action, the Agency's experience with the corrective action program to date (as confirmed by the RFA survey results), indicates that the

EXHIBIT ES-1

SCOPE OF EPA'S CORRECTIVE ACTION PROGRAM AFTER HSWA

Number of Facilities

Subject to Corrective Action



Number of Units

Subject to Corrective Action

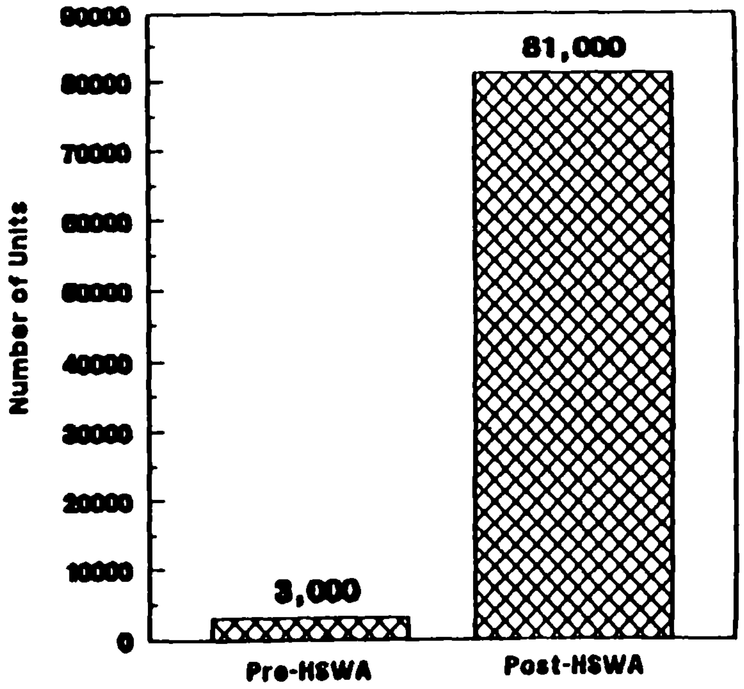


EXHIBIT ES-2

PRIOR TO HSWA, THE TYPICAL FACILITY HAD FEW SWMUs SUBJECT TO CORRECTIVE ACTION

Facilities	Average No. of Units Newly Subject to Corrective Action	Average No. of Land Disposal Units Previously Subject to Corrective Action a/	Average No. of Total Units
Land Disposal	13	2	15
Incineration	16	0	16
Treatment and Storage	14	0	14
All Facilities	15	1	16

a/ Only RCRA-permitted land disposal units were subject to corrective action prior to the enactment of HSWA.

remaining one-third will require some type of corrective action, based on the confirmation of a release in the RFI.

Potential releases of concern most often noted in RFA findings are releases to ground water and soil. Of all facilities, 30 percent have actual or suspected releases to ground water while 34 percent have confirmed or suspected releases to soil. Facilities with confirmed or suspected releases to surface water and air are less common, 17 percent and 7 percent respectively. Finally, based on the results of the models used in the quantitative analysis conducted for the RIA, approximately 31 percent (1,750 RCRA facilities) will have ground-water contamination requiring remediation.

Regulatory Strategies

EPA considered the following three alternative regulatory strategies in developing the proposed corrective action rule:

- Strategy 1: Cleanup to Background Levels As Soon As Practicable For All Facilities;
- Strategy 2: Cleanup to Health-Based Levels, With Flexibility in Timing; and
- Strategy 3: Cleanup to Health-Based Standards Only Where Actual or Imminent Exposure Exists

Each of these strategies is discussed in turn below.

Strategy 1: Cleanup to Background Levels As Soon As Practicable For All Facilities

This strategy represents the most stringent and environmentally conservative option of the three. Regulations modeled after this approach would require complete restoration of all contamination back to the unit boundary as quickly as could be practicably achieved. Contamination would have to be cleaned up to background (i.e., the background concentration of a waste in an environmental medium), which would amount to a "zero release" standard. Under this strategy, extensive source controls would be required, perhaps often involving treatment or destruction of all wastes that could cause future contamination, in order to ensure that solid waste management units would continue to meet the background cleanup standard.

Theoretically, this strategy would achieve the highest degree of protection by reducing risks to human health and the environment. In practice, however, current technologies cannot achieve consistently cleanups to background levels. In addition, the economic impacts of such a regulatory approach would be much greater than the other two options. Strategy 1, therefore, could cause substantially more owners and operators to become insolvent than Strategies 2 or 3, thereby placing additional demands on other funding sources, such as State or Federal cleanup funds.

Strategy 2: Cleanup to Health-Based Levels, With Flexibility in Timing

In broad terms, this strategy would require cleanup of releases to the unit boundary to concentration levels safe for lifetime human exposure (i.e., health-based standards). The timing for achieving these levels would vary depending on a number of site-specific factors, such as the extent and nature of the contamination, exposure potential, availability of technologies, and other factors. Source controls would be required in order to prevent further releases above health-based levels.

Because health-based standards are generally higher than background levels, this strategy would cost less per unit of risk reduction than Strategy 1. Moreover, this strategy would facilitate technically feasible remedies based on site-specific conditions more so than would Strategy 1. Therefore, the economic impacts of this strategy, although substantial, would be considerably smaller than for Strategy 1.

Strategy 3: Cleanup to Health-Based Standards Only Where Actual or Imminent Exposure Exists

Under Strategy 3, corrective actions would be required only if there was evidence of actual or imminent exposure to contaminated media (e.g., contaminated drinking water wells) above health-based standards. Moreover, once triggered, the extent of cleanup would be tied to alleviating that exposure. Cleanup to the unit boundary, therefore, would not be required unless exposure were actually of concern at that point. Required source control measures would be less extensive than under Strategies 1 or 2. Moreover, protection against future exposure to contamination would rely heavily on institutional controls (e.g., security fencing around a contaminated facility to prevent access and exposure).

This regulatory approach would achieve a minimum level of protection, as compared to the other two strategies. By allowing contaminated media to remain contaminated based on current exposure patterns, protection against future exposure could not be guaranteed. Thus, Strategy 3 is the least protective strategy. This strategy would, however, be substantially less costly to owners and operators relative to Strategies 1 and 2.

Based on an evaluation of these three broad regulatory strategies, which is described in more detail below, EPA adopted the framework of Strategy 2 for its proposed corrective action program. EPA developed the proposed corrective action rule within the context of Strategy 2 as the best approach for protecting human health and the environment for releases of hazardous constituents from SWMUs. In general, EPA followed Strategy 2 because it provides an optimum balance in ensuring a high degree of protection of human health and the environment while not placing unnecessary burdens on facility owners or operators.

It should be understood that crafting a comprehensive rulemaking within the broad confines of any of the three alternatives listed above would, of necessity, require addressing a large number of specific policy questions. Thus, a variety of specific regulatory blueprints could be created under any one alternative. This is reflected in the proposed rule, which is generally patterned after Strategy 2, but also contains certain regulatory requirements that could be considered to be a part of Strategies 1 and 3.

Multi-Media Evaluation of the Regulatory Strategies

The RIA also analyzes in Chapter 4 the three regulatory strategies qualitatively by applying them to media-specific hazardous waste release scenarios and to several actual case studies. In doing so, the RIA first discusses the sources, transport, and potential threats of hazardous constituent releases to ground water, soil, surface water, and air and then describes typical corrective actions taken to address such releases. Second, the RIA presents four example facilities, each with a release to one of the four environmental media, drawn from existing RCRA and CERCLA case studies. Finally, the three regulatory strategies are applied to the example release scenarios and then analyzed in terms of their effectiveness in addressing the releases.

The principal conclusion drawn from this qualitative analysis is that Regulatory Strategy 2 is consistently the preferable strategy for each of the media-specific scenarios analyzed in terms of flexibility and cost-effectiveness. In addition to this analysis, the RIA also presents in Chapter 5 a series of case studies involving actual sites with hazardous waste releases and remedies that would be required under the proposed rule. Both the general analysis in Chapter 4 and the direct case study analysis of the rule in Chapter 5 indicate that strategy 2, which correlates to the proposed rule, is generally protective of human health and the environment. Moreover, of the possible regulatory strategies, the proposed rule generally is both protective and the most cost-effective approach.

QUANTITATIVE ANALYSIS

In addition to a qualitative analysis of three regulatory strategies, EPA analyzed quantitatively five regulatory alternatives related to ground water that were considered by the Agency in the development of the proposed corrective action rule. EPA limited this quantitative analysis to ground water, rather than including other media, primarily because modeling tools for other media were not readily available. This RIA, therefore, only examines quantitatively the costs and effectiveness of the regulatory options in terms of protecting ground water. The ground-water regulatory options are analyzed using one of EPA's hazardous waste release, fate and transport, and corrective action models (the Liner Location Model). This model and other such models have been used extensively by EPA to analyze previous hazardous waste regulations.

The basic approach taken in the analysis involved use of the Liner Location Model to simulate each of the five regulatory alternatives as it would be applied at a sample of 65 RCRA facilities. The following section summarizes the methodology used to model the costs and effectiveness of the various regulatory alternatives, details the alternatives themselves, and presents the principal conclusions of the quantitative analysis.

Methodology

As noted above, some 5,700 RCRA facilities are potentially subject to EPA's proposed corrective action requirements. Since it was not possible to study the effects of these requirements at each RCRA facility, a sample of 65 facilities was chosen and characterized. This sample includes 21 land disposal facilities, 41 treatment/storage facilities, and three incineration facilities. Because of the way the sample was selected, these facilities are intended to represent only those facilities at which the RFA will call for an RFI. As explained in Appendix A, the model estimates of the extent and costs of the corrective action program apply to all 5,700 RCRA facilities potentially subject to the corrective action program, not just the sample facilities.

Each of the 65 facilities was characterized based on a review of the information contained in the RFA and, where data were unavailable, based on best professional judgment. This process yielded the number and types of SWMUs at the facility, dates of operation of SWMUs, types and quantities of wastes managed in SWMUs, regulatory status of each SWMU, and other information related to Federal ownership and type of facility. Using EPA's DRASTIC system, the hydrogeology and climatic setting of each facility were characterized.

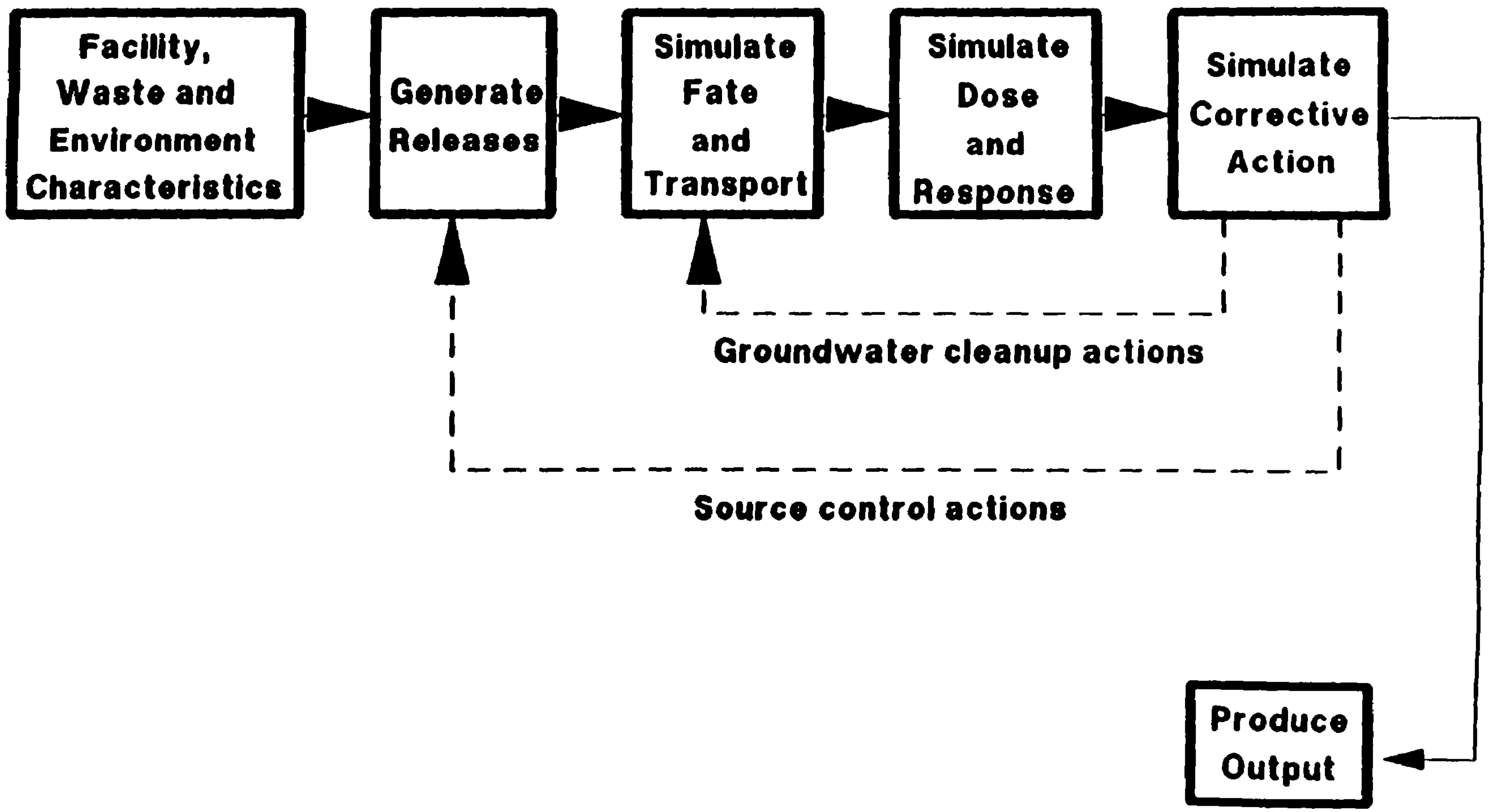
Exhibit ES-3 presents a schematic diagram illustrating the various procedures used in the Liner Location Model (LLM). The LLM begins with the basic characterization of each facility described above. Using these facility characterizations, facility-wide release profiles are generated. Each release profile contains the total mass of each contaminant constituent release in each year of the modeling period. For this analysis, the modeling period extends for 200 years from 1920 to 2119.

After the releases from all SWMUs have been estimated, the fate and transport of the released contaminants in the environment is simulated. If the contaminant concentration at a ground-water monitoring well exceeds a specific level, the LLM simulates the implementation of a corrective action Within the LLM, if corrective action is triggered, the model estimates the costs of the corrective action and adjusts the contaminant concentrations to reflect the impact of the action. The specific remedies simulated by the model include capping, recovery wells, excavation, and excavation with recovery wells. These four remedies were selected to represent the range of costs and effectiveness of available corrective action technologies. Combinations of remedies (e.g., capping with recovery wells) or types of remedies other than those listed here are not used in the model. For some regulatory options, however, institutional controls may be selected in some cases.

In choosing an appropriate remedy for a specific facility, the model evaluates the four ground-water corrective measure remedies using three criteria, including effectiveness, cost, and feasibility. The different remedy selection rules used for each of the five regulatory alternatives are described in detail in the RIA.

EXHIBIT ES-3

OVERVIEW OF THE LINER LOCATION MODEL



Regulatory Options

In conducting the quantitative analysis, a range of regulatory options similar to those presented for the qualitative analysis were analyzed. For comparison purposes, however, the quantitative analysis examined also a "baseline" option, which reflects the pre-HSWA corrective action program. In addition, the Agency developed four regulatory options, two of which were used to approximate the approach of the proposed rule. These options (Options B and C) provide an upper and lower bound to the costs of the proposed rule and reflect the Agency's uncertainty about several of the data and assumptions used in estimating costs, such as the types of remedial measures that will be ultimately implemented. In structuring the modeling logic for this analysis, it was necessary to make certain assumptions and use decision rules which vary slightly from those used in the qualitative analysis. Nonetheless, the broad regulatory alternatives examined in the qualitative and quantitative analyses are generally the same. They are:

- Baseline Scenario
- Option A: Immediate Cleanup to Background
- Option B: Immediate Cleanup to Health-Based Standards
- Option C: Flexible Cleanup to Health-Based Standards
- Option D: Flexible Cleanup Based on Actual Exposure

The quantitative analysis examined each of the five regulatory options in terms of the following criteria: cost, protection of human health and the environment, flexibility in implementation, and technical practicability. This analysis evaluates the effects of each alternative only as it would address contamination of ground water.

Baseline Scenario

This option represents requirements under RCRA prior to enactment of the HSWA corrective action requirements and is used as the basis for comparison of costs and benefits of other options. Only land disposal units regulated under Part 264, Subpart F, were assumed to be subject to corrective action. The corrective action trigger and target concentrations, either the background concentration or a Maximum Contaminant Level, are the same.[2] Only on-site clean-up within the facility boundary is addressed. Ground-water removal and treatment, or capping, are the only corrective action remedies considered.

Option A: Immediate Cleanup to Background

This option is the most stringent of those evaluated. All SWMUs, in addition to regulated land disposal units, are subject to corrective action. Any detectable release to ground water in excess of background levels would

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[2] For modeling purposes, the baseline scenario assumed that cleanup targets would not be established at Alternate Concentration Limits under Subpart F.

trigger action. Moreover, both on-site and off-site contamination must be cleaned up to background levels as soon as practical. Finally, only remedies that include excavation of the source are allowed.

Option B: Immediate Cleanup to Health-Based Standards

This option is intended to represent the upper bound approach to the proposed rule. Under Option B, corrective action would be triggered only if concentrations were detected above a health-based standard, rather than above background concentrations. This option simulates use of four remedies (i.e., excavation, excavation with recovery wells, capping, and recovery cells). Moreover, a remedy is simulated for every facility that triggers corrective action regardless of the practicality or feasibility of the remedy. In addition, unlike the previous option, cleanup of on-site contamination could be deferred until facility closure, or the end of the post-closure period, at which point cleanup to health-based levels would be required.

Option C: Flexible Cleanup to Health-Based Standards

This option is intended to represent the lower bound approach to the proposed rule. As with Option B, it also addresses all SWMUs and uses health-based standards as both trigger and target levels. As in the previous option, owners and operators may defer cleanup of on-site releases until facility closure or the end of the post-closure period. In this alternative, however, owners and operators have considerable flexibility in identifying corrective action remedies. Here, remedies less costly than source control can be chosen if they achieve cleanup targets within a reasonable time frame. As a decision rule to reflect the fact that the problems of scale and other technical difficulties will preclude certain remedies at complex sites, remedies that failed to achieve cleanup in a reasonable period of time (assumed to be about 130 years for this analysis) or that would be extraordinarily expensive (i.e., over $150 million) were rejected as "impracticable." Instead, institutional controls (e.g., security fences or restrictions on water use) would be relied upon to prevent exposure in these cases.[3]

Option D: Flexible Cleanup Based on Actual Exposure

This option is the least stringent of the four post-HSWA scenarios. It is similar to Option C, except that cleanup of off-site exposure could be deferred if there is no actual human exposure to the release. If there is an off-site exposure, corrective action must address the exposure. Again, under this option, there is a flexible approach towards remedy selection, using the same remedy selection rules as Option C.

Effectiveness Results

Exhibit ES-4 depicts the likelihood and timing of corrective action under the regulatory alternatives. As this exhibit illustrates, the analysis

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[3] This approach is not intended to imply that remedies of this scope would never be undertaken in practice, nor to define the limits of technical practicability.

EXHIBIT ES-4

CORRECTIVE ACTION IS DEFERRED FOR OPTIONS C AND D a/

Year in Which Corrective Action is Triggered c/	Baseline	Options b/ A	B	C	D
1	9.7%	25.7%	12.4%	12.4%	12 4%
2-14	0%	2.9%	3.7%	3.7%	2.7%
15-39	3.6%	3.2%	10.2%	10.2%	10.4%
40-133	1.2%	1 1%	4.7%	4.7%	5.4%
Trigger Subtotal	14.4%	32.9%	30.9%	30.9%	30.9%
Never Trigger	85.6%	67.1%	69.1%	69.1%	69.1%

a/ Percentage indicates the distribution of start dates among the total population of facilities potentially affected by the corrective action program (i.e., 5,661 facilities).

b/ Option A: Immediate Cleanup to Background
Option B: Immediate Cleanup to Health-Based Standards
Option C: Flexible Cleanup to Health-Based Standards
Option D: Flexible Cleanup based on Actual Exposure

c/ Year 1 represents the year in which the corrective action program is implemented.

estimated that approximately 31 percent of all RCRA facilities will trigger corrective action in all the post-HSWA options analyzed, while only 14 percent trigger under the baseline pre-HSWA scenario. This reflects the requirement that all SWMUs, not just land disposal units, are subject to corrective action under post-HSWA options. Note that even in the post-HSWA options, approximately two-thirds of the facilities will not trigger corrective action for ground water.

Differences in trigger levels did not result in significant differences in the number of facilities triggering corrective actions. However, differences in target levels for the various regulatory options made a significant difference in how many corrective actions were "successful" in achieving cleanup levels, as is discussed later in this section.

Exhibit ES-4 lists when corrective action is triggered for each of the regulatory options. The analysis demonstrates that, for Option A (Immediate Cleanup to Background), in which corrective action must begin immediately, approximately 26 percent of all existing RCRA facilities would initiate corrective action in the first year of the program. In Options B, C, and D, in which on-site corrective action can be deferred, only about 12 percent of all facilities would initiate corrective action in the first year. The time of trigger is important primarily because the deferral of on-site corrective actions results in lower economic impacts.

Another primary output of the quantitative analysis is the distribution of remedies selected across the five regulatory options. These remedy selection results are presented in Exhibit ES-5. The remedy selection rules for each of the options is detailed in Chapter 6 of the RIA. In general, the selection rules favor reliable, long-term corrective action remedies (e.g., excavation) for the more stringent Options A and B (Immediate Cleanup to Health-Based Standards) and a broader range of remedies and a more flexible implementation approach for Options C (Flexible Cleanup to Health-Based Standards) and D (Flexible Cleanup Based on Actual Exposure). For example, institutional controls, such as security fencing or prohibitions on water use, are allowed for Options C and D only.

Given the model results with regard to facilities triggering corrective action, timing of triggering, and remedy selection, the primary measure of effectiveness generated by the model is the time to reach target concentration. This effectiveness measure represents the length of time required for a corrective action to reduce all contaminant concentrations below the target levels at all wells within 1,500 meters of the unit (i.e., the maximum modeled well distance). This measure was developed because it provides a consistent measure across all remedies and regulatory options. A corrective action, thus, is defined to be effective for modeling purposes if all constituents within 1,500 meters of the unit are cleaned up to their option-specific levels.

Exhibit ES-6 presents the distribution among the baseline scenario and regulatory options of the time required for the facilities that trigger corrective action to reach target levels at all wells within 1,500 meters. The "target not reached" category represents situations where none of the

EXHIBIT ES-5

REMEDY SELECTION VARIES SIGNIFICANTLY AMONG OPTIONS a/

Selected Remedy	Baseline	Options b/ A c/	B	C	D
Excavation	N/A d/	59.0%	3.1%	9.0%	9.8%
Excavation with wells	N/A	20.7%	25.7%	4.6%	3.6%
Recovery wells	28.6%	20.2%	33.4%	15.9%	14.9%
Capping	71.4%	N/A	37.8%	64.8%	65.0%
Institutional Controls	N/A	N/A	N/A	5.7%	6.7%

a/ Percentage indicates the distribution of selected remedies at those facilities triggering corrective action under the baseline scenario and regulatory options.

b/ Option A: Immediate Cleanup to Background
Option B: Immediate Cleanup to Health-Based Standards
Option C: Flexible Cleanup to Health-Based Standards
Option D: Flexible Cleanup based on Actual Exposure.

c/ Option A is structured to require source control. Thus, capping and recovery wells without source control (i.e., excavation) are not allowed. However, for situations where excavation is infeasible, recovery wells alone are simulated.

d/ N/A: Regulatory option does not allow this remedy.

EXHIBIT ES-6

DISTRIBUTION FOR TIMES TO REACH TARGET WITHIN 1,500 METERS VARIES AMONG OPTIONS a/

	Baseline	Option A	Option B	Option C	Option D
Total Percent of All Facilities Triggering Corrective Action	14.4%	32 9%	30.9%	30.9%	30.9%
Duration to Reach Target (Years)	Percentages of All Facilities Where Contaminants Exceed Triggers				
0-10	17.1%	14.7%	23.7%	18.5%	18.5%
11-25	5.5%	7.0%	9.5%	3.1%	3.1%
26-50	9.7%	6.5%	15.9%	22.9%	21.9%
51-75	1.9%	5.5%	6.4%	6.7%	8.0%
76-100	0%	5.1%	1.5%	3.3%	1.8%
101-131	0%	0%	0.8%	1.8%	1.8%
Target Not Reached	65.8%	61.2%	42.2%	38.0%	38.3%
Institutional Controls	0%	0%	0%	5.6%	6.6%
Total	100%	100%	100%	100%	100%

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a/ Option A: Immediate Cleanup to Background
Option B: Immediate Cleanup to Health-Based Standards
Option C: Flexible Cleanup to Health-Based Standards
Option D: Flexible Cleanup based on Actual Exposure

remedies resulted in target levels being reached at all wells within 1,500 meters

Under Options B and C, about 56 percent and 52 percent of the facilities, respectively, are simulated to reach cleanup targets at all modeled well distances within 75 years of initiation of the action. For Option A, the proportion of facilities with corrective action not reaching target concentrations at all wells within 1,500 meters is greater than the percentage for Options B, C, and D, because the target levels for Option A (i.e., cleanup to background) are more difficult to attain than those for the other options (i.e., cleanup to health-based levels). Moreover, a somewhat larger number of facilities take corrective action under Option A than under the other three options.

In summary, based on the results of the quantitative analysis of ground water, about 31 percent of the population of RCRA facilities subject to the corrective action requirements are estimated to require corrective action for ground-water contamination. Moreover, most of these actions appear likely to be initiated prior to the year 2000. Finally, under the options most similar to the proposed rule (i.e., Options B and C), over 50 percent of the facilities undertaking corrective action are simulated to reach cleanup targets at all modeled well distances within 75 years.

Cost Results

The Agency also developed estimates of the costs of corrective action under different regulatory options on a per-facility and national basis. These estimates were derived by the Liner Location Model, which applied standardized unit cost algorithms to the 65 sample facilities comprising the RFA survey. These algorithms were developed based on EPA experience, best professional judgment, and standard construction cost estimation techniques. The results of these cost calculations are summarized below. Note that all of the costs were discounted with a rate of 3 percent and all annualized costs were calculated using a period of 20 years.

Typical facility corrective action costs vary significantly depending upon the specific regulatory option. The cost analysis demonstrates that the most stringent post-HSWA regulatory option, Option A (Immediate Cleanup to Background), is by far the most costly option, with a mean present value cost of over $281 million per facility, and an annualized per-facility cost of about $19 million (at a 3 percent discount rate). On the other hand, Option B (Immediate Cleanup to Health-Based Standards) was estimated to have a mean present value cost of $26.9 million and annualized per-facility costs of $1.8 million. Option C (Flexible Cleanup to Health-Based Standards) was estimated to have a mean present value cost per facility of $6.3 million dollars and annualized per-facility costs of $0.4 million. Option D (Flexible Cleanup Based on Actual Exposure) was estimated to have a mean present value cost of $4.8 million and annualized per-facility costs of $0.3 million. Finally, the baseline per-facility cost is the lowest of all the options at a mean present value cost of $3.8 million and an annualized per-facility cost of $0.3 million.

The total national cost for EPA's corrective action program is influenced by three parameters: the average cost of each action, the number of facilities required to undertake corrective action, and the cost to facility owners and operators of undertaking required investigations. Not all facilities performing RCRA Facility Investigations (RFIs) are assured to perform corrective actions. These investigative costs, therefore, are included only in the national cost estimates and not the per-facility corrective action cost estimates. Moreover, because cost data for RFIs and Corrective Measures Studies (CMSs) are not available, the Agency assumed for the sake of analysis that the typical RFI would cost $300,000 and the typical CMS would cost $100,000. These estimates are based in part on EPA's experience in the Superfund remedial action program. National costs discussed below are presented in incremental terms (i.e., after subtracting the costs of the baseline scenario).

Option A is the most expensive option, with an incremental total cost above the baseline pre-HSWA scenario of $490 billion. This option was estimated to have an annualized cost of $32.9 billion. Among the other regulatory options, the differences in costs are primarily a result of differences in timing of cleanup and in the flexibility afforded in terms of choosing corrective action remedies. Option B was estimated at a total cost of $41.8 billion, with an annualized cost of $2.8 billion. This option is relatively costly, due in part to modeling assumptions as to the types of remedial technologies which would be employed to meet these standards. Option C was among the least costly, with a total cost of $7.4 billion, and an annualized cost of $0.5 billion. The costs under this option are lower because, in general, less expensive technologies are assumed and, for many facilities, final cleanup of contaminated ground water would be deferred for a number of years, thus reducing the present value costs. Option D, where both on-site and off-site cleanup of contamination could be deferred until closure if there was no actual exposure, was somewhat less expensive than Option C. Option D had a total cost of $5.0 billion and an annualized cost of $0.3 billion.

It is difficult, however, to validate these cost estimates using data from the RCRA corrective action program because the program is relatively new. EPA used data from the CERCLA remedial action program, which began in 1981 and is similar in focus to the RCRA corrective action program, to verify these estimates. Using the CERCLA data and correcting for many of the differences between the two programs, EPA estimated that the estimated total cost for the proposed corrective action rule is $12.9 billion, for an average per-facility cost of $4.4 million (this estimate is for total, not incremental costs).

The total cost estimate is higher than the estimate of $10.6 billion in total costs for Option C (calculated as $3.2 billion in baseline costs plus $7 4 billion in incremental costs). The main source of this difference is that the CERCLA-based analysis assumed that a much larger universe of RCRA facilities would require corrective action. Much of the difference in the per-facility costs arises from the fact that the CERCLA-based analysis included many minor (and relatively cheaper) cleanups that were not included in the estimates developed in the RIA analysis.

In sum, the proposed corrective action regulation is most similar to Options B and C. The Agency believes that the results of the quantitative analysis support the proposed rule as being a flexible, cost-effective approach that provides a high degree of protection of human health and the environment.

SUPPORTING ANALYSIS

In addition to the qualitative and quantitative analyses of regulatory alternatives performed for this RIA, EPA performed several supporting analyses, including an analysis of national economic impacts due to the rule, a regulatory flexibility analysis, and an analysis of the corrective action program at Federal hazardous waste management facilities. All three of these supporting analyses are summarized below.

Economic Impacts

With the cost information developed from the quantitative analysis, EPA estimated the financial impacts of the proposed rule on affected firms. These economic impacts were measured in three different ways, including a measure of adverse impacts on facilities, a measure of adverse impacts on firms, and an estimate of corrective action costs left unfunded by responsible parties due to insolvency. Adverse impacts on facilities were calculated as the percentage of facilities that would be unable to cover their corrective action costs required under a given regulatory alternative without facing a high risk of insolvency. The analysis assumed that a firm faces high risk of insolvency when the cost of a corrective action reduces the firm's ratio of cash flow to its total liabilities to less than 10 percent. This ratio, referred to as the Beaver ratio, and the threshold of 10 percent, are commonly used to predict bankruptcy. coverage ratio

Under Option C, an additional 345 facilities, or 7 percent of all facilities, relative to the baseline scenario might be unable to cover their corrective action costs. Option C would result in less economic impacts than Options A or B, however, which could create incremental adverse effects on as many as 18 percent and 10 percent of all facilities, respectively.

In a similar fashion, firm impacts were calculated as the percentage of firms facing adverse impacts. For this measure, it was assumed that an adverse impact on a firm occurs when the corrective action costs required of one or more of the firm's facilities cannot be covered by the firm without placing it in a high risk of insolvency. Again, the insolvency risk measure used is the Beaver ratio. Under Option C, the lower bound rule option, an additional 224, or 9 percent of all firms, relative to the baseline scenario, might face adverse impacts due to corrective action costs. Option C could result in less economic impacts than either Options A or B, however, which incrementally could adversely affect as many as 20 percent and 11 percent of all firms, respectively.

The final measure of economic impacts used for this RIA was a measure of unfunded costs. Unfunded costs are expressed in terms of the predicted total costs left unfunded by facility owners and operators due to insolvency These costs could be faced ultimately by entities other than the immediate owner or operator of the facility, such as the Superfund (provided that the facility would be eligible for Superfund funding), State remedial action funds, or, through price increases, the customers of the firm owning or operating the facility. The results of this analysis are presented in "undiscounted" numbers, since Superfund monies are generally described in undiscounted terms. For scenarios other than the baseline, costs are presented on an incremental basis relative to the baseline.

Under the baseline scenario, it was estimated that 9 percent of all firms owning RCRA facilities would be adversely impacted, creating total unfunded costs of $97 million (undiscounted) over the next 50 years. Option A generated by far the highest level of unfunded costs, totaling $74.2 billion over the next 50 years. Option B results in unfunded costs of over $5.1 billion over the next 50 years. Option C results in unfunded costs of $457 million over the next 50 years. Finally, Option D resulted in a total of $165 million unfunded costs, undiscounted, over the next 50 years.

Based on the RIA analysis, EPA anticipates that the ability to fund corrective action costs will vary between industries. Industries that may have a relatively low ability to pay for corrective actions include sanitary services; coating, engraving, and allied services; and miscellaneous wood products. These industries have relatively low net income levels. Industries that show a particularly high ability to pay include petroleum refining, motor vehicles and motor vehicle equipment, and aircraft and aircraft parts.

Regulatory Flexibility Analysis

The Regulatory Flexibility Act requires Federal agencies to fully analyze the economic effects of regulations on small entities. For this RIA, the Agency assumed that a small business is significantly affected if its excess of cash flow over ten percent of its total liabilities is insufficient to meet corrective action costs (i.e., if it failed the Beaver ratio test), or if its net income is insufficient to meet its corrective action costs. These two tests were chosen because they come close to established EPA criteria for measuring economic impacts. With regard to measuring significant impacts nationally, the Agency established in its guidance for performing regulatory flexibility analyses that a substantial number of small entities are affected if 20 percent or more of all small entities subject to a proposed rule are affected adversely.

Using methodology similar to that used for estimating economic impacts, EPA found that, under the regulatory options intended to represent the proposed corrective action rule, small firms do encounter more severe impacts from the corrective action requirements than large firms. These options result in adverse incremental impacts (i.e., relative to the percentage of firms affected under the baseline scenario) on approximately 9 to 11 percent of small businesses owning RCRA facilities. Based on the Agency's guidelines for implementing the Regulatory Flexibility Act, therefore, the results of the analysis as summarized above suggest that the proposed rule does not impose a significant impact on small entities when considered relative to the impact of the baseline scenario.

Federal Facilities

The RIA discusses Federal facilities as a separate category because, although they constitute only 6 percent of the total RCRA facility universe, they contain more SWMUs per facility (on average, 55 per facility compared with 12 per facility for non-Federal facilities). Corrective action cost at these facilities must be funded with public money.

The Federal facility component of the RCRA universe is not characterized as completely as other components. Consequently, a precise estimate of the number of Federal facilities requiring corrective action is not possible. However, EPA estimated the range of the number of Federal facilities potentially requiring corrective action.

Based on the RIA analysis, EPA estimates that, of the 352 Federal RCRA facilities, between 30 percent and 100 percent are likely to require ground-water corrective action under the proposed rule, with approximately 60 percent representing the most likely estimate (compared to between 17 percent and 23 percent under the baseline). A rough approximation of the costs for these corrective actions, per facility, ranges from $17 million dollars for the baseline scenario to $1.3 billion for Option A (Immediate Cleanup to Background). For Option C (Flexible Cleanup to Health-Based Standards), the mean per-facility cost is estimated to be $29 million, or in annualized terms, about $1.9 million per facility.

The analysis indicates also that total corrective action costs incremental to the baseline for Federal facilities can range widely depending on the regulatory option considered and assumptions about the number of Federal facilities requiring cleanup. The lower bound regulatory option, Option C, is estimated to have a potential total cost of about $6.1 billion and an annualized cost of about $0.4 billion (i.e., total cost incremental to baseline of $5.1 billion or $0.3 billion annually).

This analysis thus concludes that, although Federal facilities comprise only 6 percent of the population affected by the corrective action program, they will incur roughly 40 percent of the total cost of the rule.

CONCLUSIONS AND LIMITATIONS

In conclusion, this regulatory impact analysis was performed to characterize the costs, benefits, and other impacts of EPA's proposed corrective action rule. The general approach taken was to establish alternative regulatory options with varying cleanup targets, types of remedies, and timing. These regulatory options were then compared and contrasted both qualitatively, using hazardous constituent release scenarios and case studies, and quantitatively, using a computer simulation model in order to yield representative costs and benefits. Based on this analysis, the following conclusions were reached:

- The qualitative analysis suggests that the regulatory strategy upon which the proposed rule is based offers a high degree of protection of human health and the environment while not placing unnecessary burdens on facility owners and operators.

- Based on the quantitative analysis, under the regulatory options most similar to the proposed rule, over 50 percent of the facilities undertaking corrective action for ground-water contamination were simulated to reach cleanup targets within 75 years.

- Costs for ground-water corrective action under the proposed rule were simulated to have a lower bound mean present value cost per facility of $6.3 million and an annualized per- facility cost of $0.4 million. Moreover, under this same option, national costs were simulated to be about $7.4 billion, or $0.5 billion on an annualized basis, more than the costs that would have been incurred for corrective action prior to the enactment of HSWA.

- Based on the economic impacts analysis for Option C, an additional 7 percent of all facilities and 9 percent of all firms will face adverse impacts from the corrective action requirements of the proposed rule, leaving a total of $457 million (undiscounted) in corrective action costs left unfunded due to insolvency.

- Based on the regulatory flexibility analysis, the regulatory options most similar to the proposed rule do not impose significant impacts on a substantial number of small entities (i.e., only 9 to 11 percent of entities are adversely affected) when considered relative to the impacts of corrective action requirements prior to the enactment of HSWA.

- Finally, while Federal facilities comprise only 6 percent of all RCRA facilities, these facilities could incur up to 40 percent of the total cost of the rule.

In reviewing the results presented by this executive summary, a number of key limitations to the analysis and assumptions made in the quantitative analysis and supporting analysis should be considered. These limitations and assumptions, which are discussed more thoroughly where appropriate throughout the RIA, are summarized below. In general, these limitations fall into three categories: effectiveness, costs, and supporting analyses.

Effectiveness

- Effectiveness measures the degree to which a particular option achieves the cleanup target. It should not be viewed as a measur of potential ground-water protection benefits.

- Because the RIA simulated releases to ground water only, the effectiveness of the regulatory options in addressing releases to other environmental media is likely to vary somewhat from the estimates presented in the RIA.

- Due to modeling constraints, the performance of simulated remedies may diverge somewhat from the actual performance and effectiveness of such remedies. For instance, in the model, caps are simulated to fail in 35 years and recovery wells are assumed to be 95 percent effective in removing ground-water contamination. In practice, the life of caps and the efficiency of recovery wells will vary from site to site, depending on local factors, such as hydrogeologic conditions.

- Because only four remedies were simulated, the model may not accurately reflect the broader range of remedies available in practice. Moreover, the model uses simplified remedy selection rules in selecting among the range of remedies. In contrast, under the proposed rule, detailed studies would be used as the basis for selecting among corrective measure remedies.

- In all cases, it was assumed for modeling purposes that background contaminant concentrations are zero. It is likely that, at some RCRA facilities, background concentrations are not equal to zero. Because concentrations must reach the detection limit before corrective action can be triggered, it will take longer to detect a release if background concentrations are zero than it would if ground-water supplies were already contaminated to a level higher than the detection level. As a result, the RIA may underestimate the likelihood of triggering corrective action for all options.

Costs

- Because the RIA models the entire corrective action program (i.e., by including RCRA Section 3008(h) and a revised Subpart F program in addition to the Subpart S rule authorized by Section 3004(u)), the costs of the Subpart S rule itself are overestimated.

- The quantitative analysis assumes that the target cleanup level is equal to the trigger level. Because the proposed rule actually allows the target cleanup level to be set at a point higher than the level at which action is first initiated, the analysis may have over estimated costs.

- The remedy selection rules used for the model only approximate the proposed rule and are not as flexible as the rule, thus potentially overestimating costs

- Because the quantitative analysis modeled releases to ground water only, this analysis underestimates the costs of corrective action

- For modeling purposes, remedies were simulated only once for a given release scenario (i.e., not for additional future releases), thus potentially underestimating costs

- Because of modeling limitations, the RIA does not simulate the use of Alternate Concentration Limits (i.e., site-specific cleanup standards set under Subpart F). Thus, the RIA may overestimate the cost of the baseline scenario and underestimate the incremental cost of other options.

- The RIA simulates off-site land disposal of excavated wastes. However, the additional costs of treating land-disposal wastes to the Land Disposal Restrictions (40 CFR Part 268) were not included in the cost estimates. Moreover, incineration of excavated wastes was not simulated. As a result, the RIA may significantly underestimate costs for the options that select excavation remedies.

- The model did not estimate the costs of institutional controls where they were selected. As a result, the RIA may underestimate costs for the options that select institutional controls.

- The RIA derives the costs of RFIs and CMSs from lower-bound estimates of similar Superfund investigation steps. If, in practice, the investigative costs for RCRA corrective actions diverge from these lower-bound estimates, then the accuracy of the cost estimates would be reduced.

- Using Superfund remedial action program data, total national costs for the proposed corrective action rule were estimated to be $12.9 billion (non-incremental to baseline), compared to $10.6 billion to $45 billion in total national costs (non-incremental) for the proposed rule in this analysis.

Supporting Analyses

- Because the economic impact analysis does not simulate the availability of alternate funding sources, such as payouts from financial assurance mechanisms, corporate parents, price increases, Superfund, or State cleanup funds, the RIA may overestimate the economic impacts of the proposed rule.

- In the economic impacts and regulatory flexibility analyses, corrective action costs are not simulated to vary with the financial size of the firm required to take corrective action. Therefore, the RIA may underestimate the economic impacts of the proposed rule on small firms.

- Federal facility costs are estimated using a very imprecise methodology that involves extrapolating from smaller private facilities to very large Federal facilities. Actual costs observed at Federal facilities may differ significantly from those estimated in the RIA.

1. INTRODUCTION

The Environmental Protection Agency (EPA) prepared this Regulatory Impact Analysis (RIA) in order to assess the costs and benefits of alternative approaches to addressing releases from solid waste management units (SWMUs) at facilities managing hazardous wastes.[1] Under Executive Order 12291 (issued February 17, 1981), a Regulatory Impact Analysis is required for every major Federal regulation. Executive Order 12291 defines a major rule as one that is likely to result in: (1) an annual effect on the economy of $100 million or more; (2) a major increase in costs or prices for consumers, individual industries, Federal, State, or local government agencies, or geographic regions; or (3) significant adverse effects on competition, employment, investment, productivity, innovation, or on the ability of United States-based enterprises to compete with foreign-based enterprises in domestic or export markets The results of this RIA demonstrate that the proposed corrective action rule is a "major" rule.

Regulatory Impact Analyses ensure that Federal agencies consider the trade-offs between costs and benefits of proposed regulations. This RIA quantifies, to the extent possible, the costs to society of alternative regulatory approaches to cleaning up hazardous waste facilities, the economic impacts on such facilities caused by compliance with the proposed regulations, and the benefits of increased protection of human health and the environment derived from the alternative approaches. By developing and organizing information on costs, benefits, and economic impacts of proposed regulations, this RIA is intended to assist EPA decision makers assess alternative approaches to regulating hazardous waste release problems.

The proposed regulations analyzed in this RIA are authorized by Sections 3004(u) and (v) of the Resource Conservation and Recovery Act of 1976 (RCRA), as amended by the Hazardous and Solid Waste Amendments of 1984 (HSWA). Section 3004(u) requires that permits issued to hazardous waste management facilities after November 8, 1984 require "corrective action for all releases of hazardous waste or constituents from any solid waste management unit at a treatment, storage, or disposal facility seeking a permit under [Subtitle C of RCRA], regardless of the time at which waste was placed in such unit." Section 3004(v) mandates that EPA require hazardous waste management facilities to undertake corrective action for releases beyond the facility boundary.

EPA codified the provisions of Section 3004(u) by incorporating the statutory language in 40 Code of Federal Regulations (CFR) Part 264, Subpart F (50 FR 28702, July 15, 1985). EPA codified Section 3004(v) by adding 40 CFR 264 100(e) and 264.101(c) to the existing regulations (52 FR 45788, December

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[1] Throughout this RIA, the term "release" refers to the release of hazardous wastes or hazardous constituents to the environment.

1, 1987). The proposed rule is intended to replace these codifications of statutory language with a detailed regulatory program for corrective action that includes investigative requirements, cleanup standards, and implementation procedures.

The proposed corrective action rule, based on RCRA Sections 3004(u) and (v), is just one element of EPA's corrective action program. Other elements include the requirements under Section 3008(h) and standards contained in Subpart F of 40 CFR 264. RCRA Section 3008(h), added to the statute by HSWA, allows EPA to issue orders requiring corrective action to any facility authorized to operate under RCRA interim status (i.e., facilities that have not received a final Part B permit) whenever EPA determines that there is or has been a release of hazardous waste into the environment from such a facility. Finally, EPA's corrective action program also includes the Subpart F requirements that existed prior to HSWA, which regulate releases to ground water from regulated land disposal units at permitted facilities.[2]

For this RIA, the Agency assumed that the proposed rule, under the authority of Sections 3004(u) and (v), will cover corrective action at all RCRA facilities regardless of their permit status or the types of waste management units present. By making this assumption, EPA was able to analyze the impact of the proposed rule as a single, uniform corrective action program applied to all types of units at all facilities. As noted earlier, EPA is required, under Executive Order 12291, to analyze proposed rules and the alternatives considered in their development. This RIA, however, analyzes more than just the proposed rule; it examines the entire RCRA corrective action program. This important assumption is explained briefly below.

HSWA created a statutory requirement that a RCRA permit must address all releases to all media from all solid waste management units located at the facility and the proposed rule specifically addresses such releases at <u>permitted</u> RCRA facilities, except for releases to ground water from regulated land disposal units subject to Subpart F. EPA is also authorized, under RCRA Section 3008(h), to require corrective action at RCRA interim status facilities. Concurrent with the proposed rule, EPA is also proposing revisions to the Subpart F corrective action standards. The purpose of these revisions is to ensure that units regulated under Subpart F and units regulated under the proposed rule are treated consistently with respect to ground-water releases.

Consequently, this RIA considers the effects of the proposed rule on <u>all</u> facilities in the RCRA universe based on the following two assumptions:

1. Section 3008(h) corrective action orders at all interim status facilities will require corrective actions that are essentially identical to those imposed at permitted facilities under the proposed rule; and

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[2] Regulated units are defined in 40 CFR 264.90(a) as waste piles, surface impoundments, land treatment areas, and landfills that received hazardous wastes after July 26, 1982.

2. Subpart F will be revised concurrently with the proposed rule so that regulated land disposal units will be subject to the same standards as those in the proposed rule.

The RIA is organized into four separate parts, each containing a number of chapters. Part 1 contains Chapters 1 through 5 and provides an overview of the RIA and the proposed corrective action rule. The scope of the hazardous waste cleanup problem is discussed in Chapter 2. Chapter 3 presents the various regulatory strategies and approaches considered by EPA in designing the proposed rule. The qualitative effects of these alternative approaches to corrective action for each environmental media (i.e., soil, air, surface water, and ground water) are discussed in Chapter 4. Finally, Chapter 5 describes several case studies illustrating how the proposed rule may be implemented.

Part 2 contains Chapters 6 through 9 and presents the quantitative analysis of the proposed rule with respect to ground-water cleanup. Chapter 6 explains how the Liner Location Model (LLM) was used to analyze five regulatory scenarios. Chapter 7 analyzes the effectiveness achieved through ground-water cleanup by each regulatory alternative. Then, the costs of implementing each corrective action alternative are analyzed in Chapter 8. Finally, the estimated costs are compared to the experience of the Superfund program in Chapter 9.

Part 3 contains Chapters 10, 11, and 12, the supporting analyses to the RIA. In general, these supporting analyses are based on the results of the Liner Location Model (LLM) analysis, and so primarily address corrective action to ground water, although impacts of correcting releases to soil, surface water, and air are discussed also. The economic impact of the alternatives on firms is evaluated in Chapter 10. Chapter 11 evaluates the effect of the proposed rule on small entities (i.e., small businesses), as required by the Regulatory Flexibility Act. Chapter 12 assesses the effect of the regulatory alternatives on Federally-owned or -operated hazardous waste facilities

Part 4 consists of Chapter 13, the summary of the entire RIA.

In addition to this main report, four appendices were prepared for this RIA. Appendix A provides a detailed description of the facility data base. Appendix B discusses the hazardous waste concentrations that trigger corrective action at facilities. Appendix C describes the methodology used in estimating the economic impact of the rule. Finally, Appendix D lists the costs and actions of CERCLA Records of Decision used to describe typical corrective actions in Chapter 4 of the RIA.

2. PROBLEM DEFINITION

Congress significantly expanded the scope of EPA's corrective action program in the Hazardous and Solid Waste Amendments of 1984. Prior to the enactment of HSWA, only certain land disposal units at permitted facilities were subject to ground-water cleanup provisions. As explained in Chapter 1, HSWA now requires EPA to ensure that corrective action is taken for releases to all media, from all SWMUs, at all types of RCRA facilities, as necessary to protect human health and the environment.

The proposed corrective action rule is designed to establish a comprehensive regulatory framework for releases to all media from all SWMUs. It will establish national consistency for implementing corrective actions, including evaluating releases, initiating corrective action, and meeting cleanup standards. Finally, the rule establishes standards for States seeking authorization to conduct the Section 3004(u) corrective action program. This chapter briefly describes the size and scope of the regulatory problem to be addressed by the proposed rule.

2.1 THE PROBLEM

As of April 1987, EPA's Hazardous Waste Data Management System (HWDMS) identified 5,661 RCRA Subtitle C facilities that are potentially subject to the corrective action provisions of HSWA.[1] Of the 5,661 facilities, 5,309 (94 percent) are classified as "non-Federal facilities," which include privately-owned facilities, State and municipal facilities, and non-profit facilities. The distinction between Federal and non-Federal facilities is important because Federal facilities are typically larger and have more SWMUs per facility than privately-owned facilities; moreover, the types of hazardous waste managed at Federal facilities tend to be less common (e.g., radioactive waste mixed with hazardous waste).

Based on the HWDMS classification scheme, the RCRA Subtitle C facility population is composed of three types of facilities:

1. **Land disposal facilities**, which are defined as hazardous waste management facilities with a landfill, surface impoundment, waste pile, or land treatment unit;

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[1] The number of facilities subject to corrective action may change as facilities obtain permits or stop managing hazardous wastes. This estimate is based on the facility population at the time the RIA commenced; the number of facilities currently subject to corrective action provisions may be greater or smaller.

2. Incineration facilities, which are defined as those facilities that have an incinerator but no land disposal unit; and

3. Treatment and storage facilities, defined as all hazardous waste management facilities that do not belong to either of the above two categories.

Exhibit 2-1 shows the distribution of facilities by each type; the majority are non-Federal storage and treatment facilities.

To create a facility data base for this RIA, EPA analyzed RCRA Facility Assessments (RFAs) for a sample of 65 Subtitle C facilities, referred to as the RFA survey. Based on the Agency's analysis of these data and other available information, EPA found an average of 12 SWMUs per non-Federal facility and an average of 55 SWMUs per Federal facility.[2] Across all types of facilities, the average number of SWMUs is 16. Exhibit 2-2 shows the frequency distribution of the number of SWMUs per non-Federal facility. Because only 6 of the 65 RFAs used to create the facility data base are from Federal facilities, there is no similar exhibit for Federal facilities.

Analysis of the facility data base also indicates that about 3,000 units were subject to corrective action before the enactment of HSWA and that an additional 78,000 have become subject to corrective action regulations as a result of HSWA.[3] Exhibit 2-3 shows that, prior to the enactment of HSWA, the typical facility had very few SWMUs subject to corrective action under RCRA. Similarly, Exhibit 2-4 illustrates the proportions (relative to the total SWMU population subject to regulation by HSWA) of different types of SWMUs at land disposal and treatment and storage facilities. The majority of units (about 95 percent) have been subject to corrective action requirements only since the enactment of HSWA. The approximately 5 percent that were subject to these requirements before HSWA were land disposal units at land disposal facilities.

About one-third of the total SWMU population are tanks used for treatment or storage of hazardous waste. Landfills and surface impoundments together constitute approximately another third of all SWMUs while container storage units make up 14 percent of the total. The remaining 24 percent are divided among transfer stations, waste piles, incinerators, injection wells, recycling units, and other units. Appendix A provides a complete description of this analysis and the resulting data base.

All hazardous waste management facilities have the potential of releasing hazardous wastes or constituents into the environment during their operating lifetime. In many cases, moreover, units may release to several media simultaneously. For example, hazardous constituents from surface impoundments may leach into ground water, ultimately reach an outlet to surface water or drinking water supplies, and release volatile constituents to

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[2] Chapter 12 of this report contains detailed information on corrective action for Federal facilities.

[3] Note that only a portion of these facilities, however, will require facility investigations or corrective measures for releases.

EXHIBIT 2-1

THERE ARE ABOUT 5,700 FACILITIES AFFECTED BY CORRECTIVE ACTION PROVISIONS

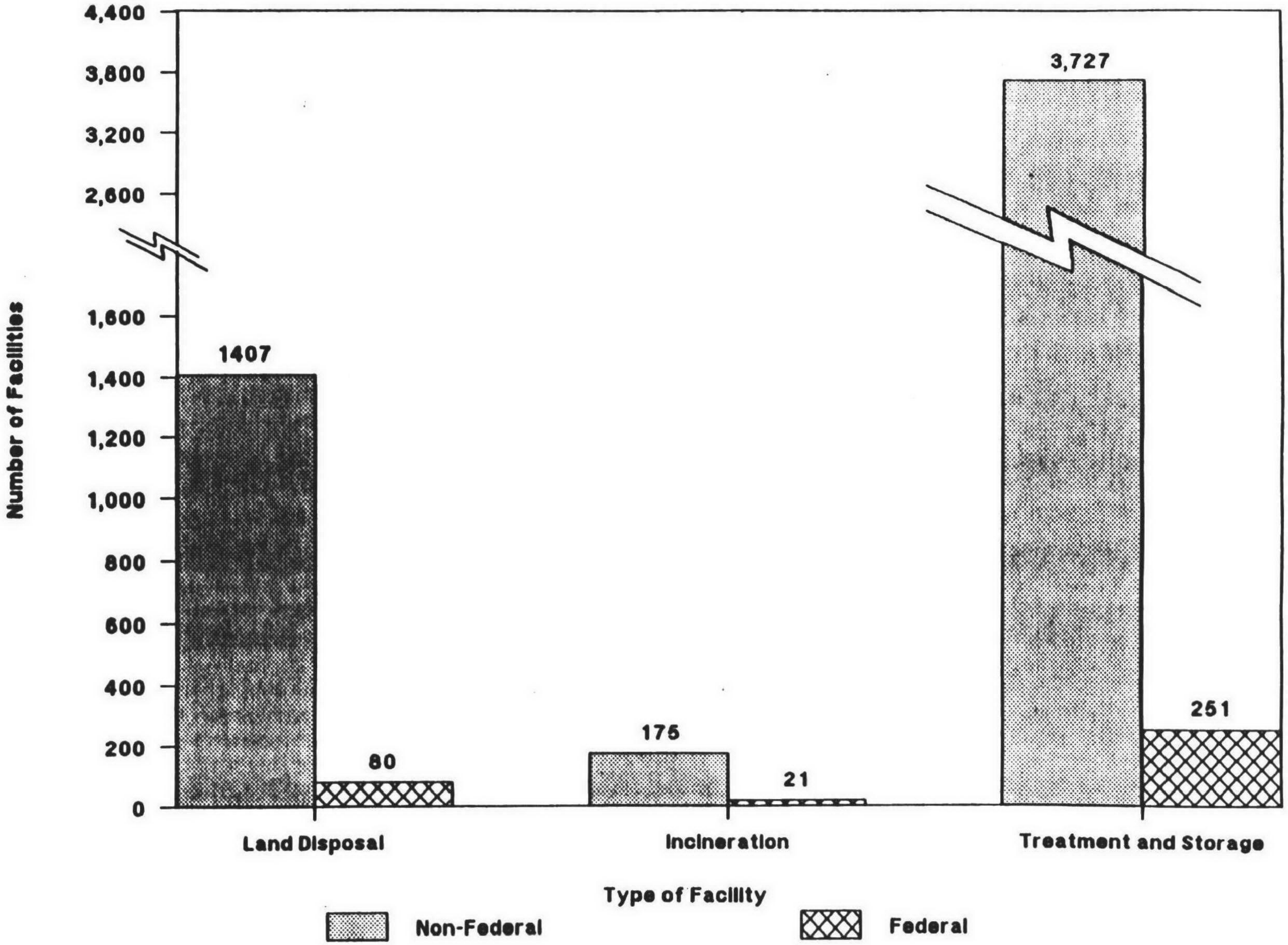
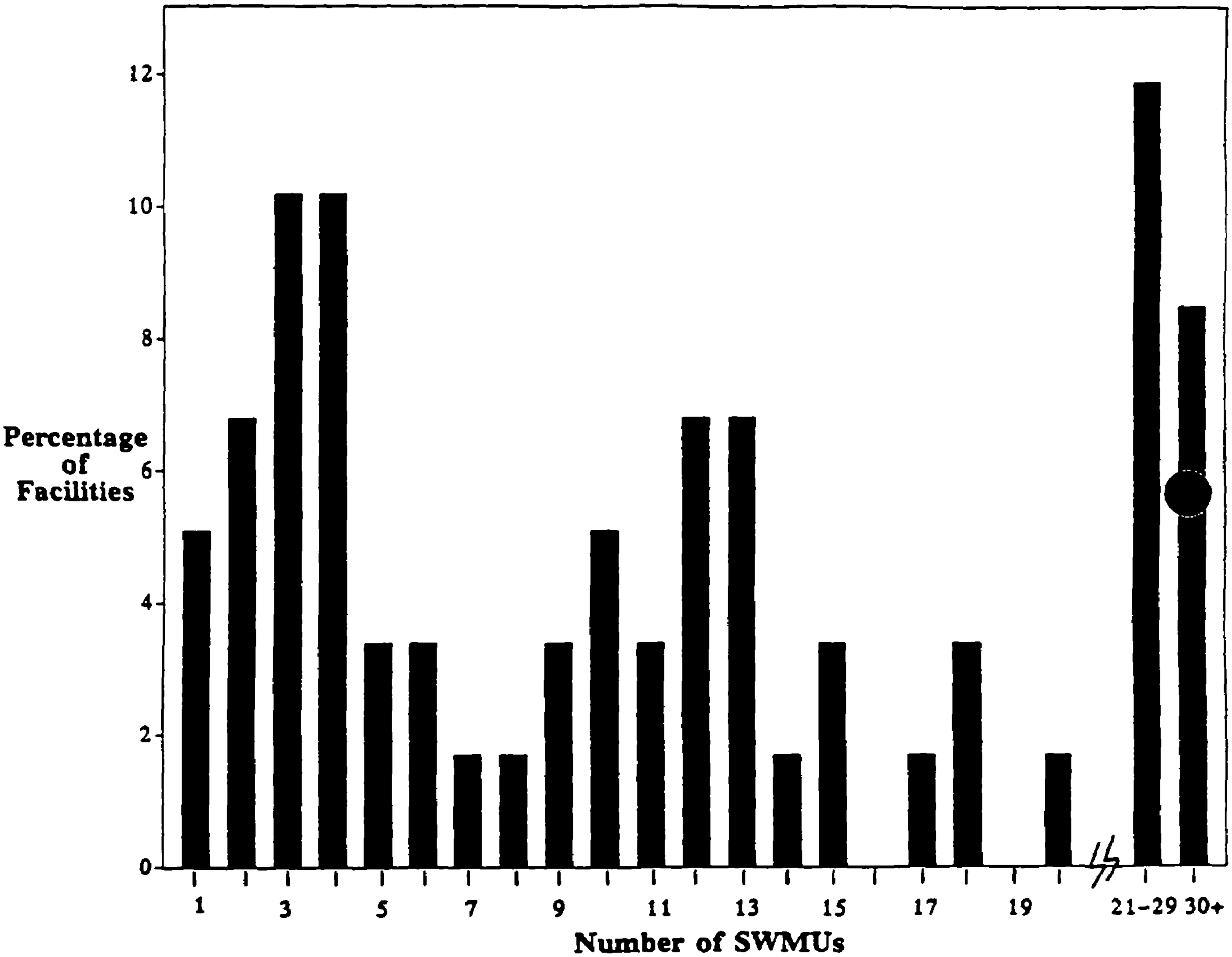


EXHIBIT 2-2

THE NUMBER OF SWMUS PER NON-FEDERAL FACILITY VARIES WIDELY, FROM 1 TO OVER 30



Source: ICF Incorporated, September 1987.

EXHIBIT 2-3

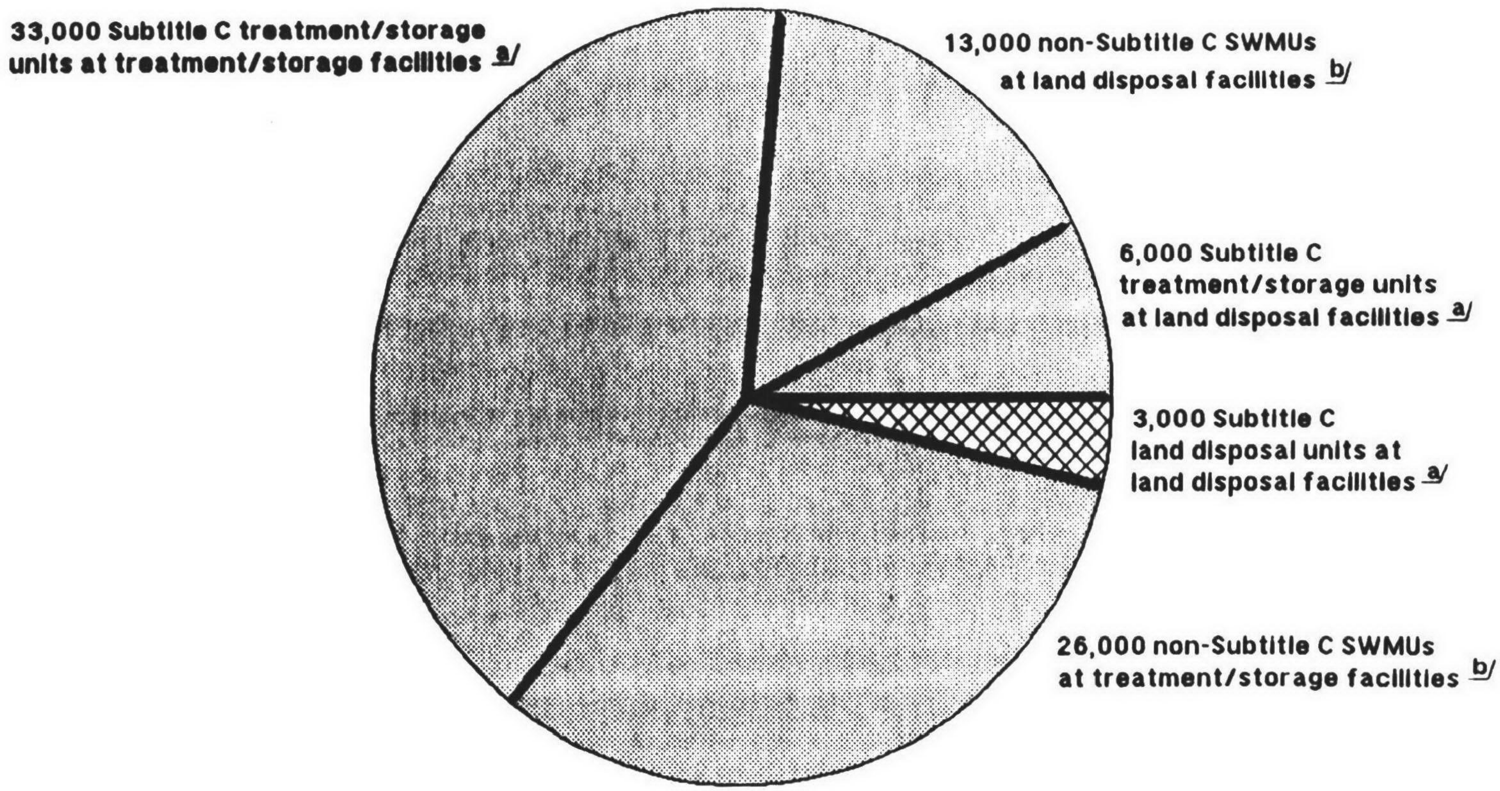
PRIOR TO HSWA, THE TYPICAL FACILITY HAD FEW SWMUs SUBJECT TO CORRECTIVE ACTION

Facilities	Average No. of Units Newly Subject to Corrective Action	Average No. of Land Disposal Units Previously Subject to Corrective Action a/	Average No. of Total Units
Land Disposal	13	2	15
Incineration	16	0	16
Treatment and Storage	14	0	14
All Facilities	**15**	**1**	**16**

a/ Only RCRA-permitted land disposal units were subject to corrective action prior to the enactment of HSWA.

EXHIBIT 2-4

Almost all waste management units now subject to corrective action were not regulated by Subpart F before HSWA.



Waste management units subject to corrective action only after HSWA

Waste management units subject to corrective action prior to HSWA

a/ Subtitle C units are defined as active hazardous waste management units generally subject to RCRA Subtitle C design and operating standards.

b/ Non-Subtitle C units include closed units and other units generally exempt from the RCRA Subtitle C design and operating standards.

the atmosphere. Humans may be exposed to hazardous constituents through several exposure pathways: by drinking contaminated ground or surface water, breathing contaminated air or dust, ingesting contaminated soils, or coming into direct contact with wastes.

Because the regulated community is so large (composed of about 5,700 facilities and over 80,000 SWMUs), the range of corrective actions required at these facilities will be diverse. Several Federal facilities subject to the corrective action requirements are large sites at which unusual wastes have been placed in hundreds of SWMUs. Some RCRA corrective action facilities, including some Federal facilities, will be similar in scope and complexity to large Superfund sites and will require complex remedial actions. Currently, about 150 RCRA facilities are on the Superfund National Priorities List.

In contrast, most RCRA facilities will have minor release problems requiring relatively simple corrective actions. Contamination at some of these sites will need to be addressed immediately in order to reduce risks to human health and the environment while other sites will not require immediate action. The corrective action program, therefore, has been designed to be flexible enough to address a wide range of site conditions, procedural situations, and cleanup needs.

In order to determine the overall need for corrective action, available data and ground-water models were used to estimate the number of facilities subject to each step of the corrective action process. Based on this information, EPA estimates that about 3,500 (62 percent) of the 5,661 facilities potentially subject to the corrective action requirements under HSWA will require a RCRA Facility Investigation (RFI). In addition, EPA estimates that about 50 percent of all facilities conducting an RFI (approximately 30 percent of the total regulated community) will require corrective action for ground-water contamination.[4] Consequently, of the approximately 3,500 facilities that must perform RFIs, about 1,750 are estimated to require corrective action. This estimate only considers those facilities that have triggered corrective action due to ground-water releases, however, based on a ground-water simulation model. The actual number of corrective actions required is likely to be higher when releases to other media are accounted for. Exhibit 2-5 shows how many facilities are estimated to require ground-water corrective action. EPA further estimates that, of the approximately 1,750 facilities requiring corrective action, about 40 percent may require immediate corrective action (i.e., beginning in 1987).[5]

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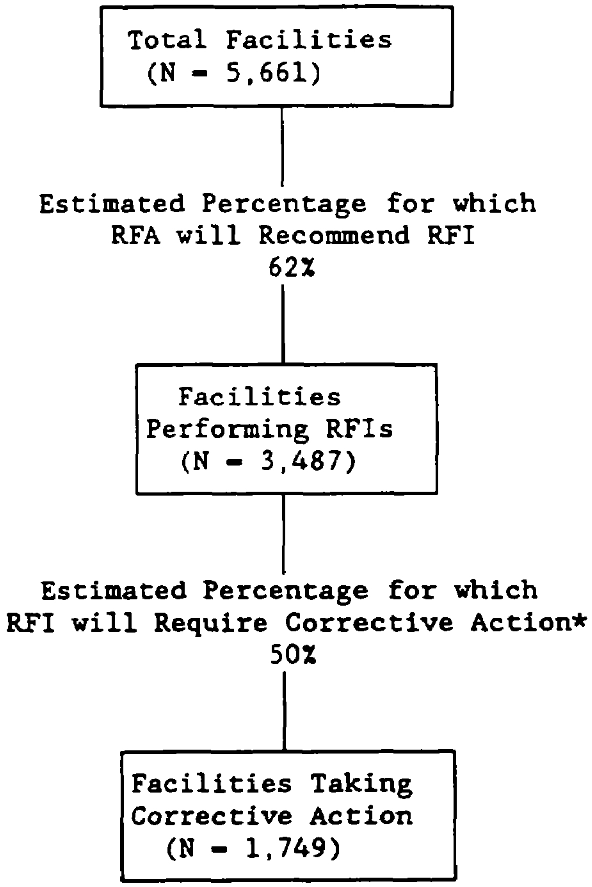
[4] See Chapters 6 and 7 for a complete description of how these estimates are derived.

[5] The bulk of this RIA was developed in 1987. The analysis, therefore, used 1987 as the assumed first year of the HSWA corrective action program. While the rule will not be proposed until after 1987, the analytic results are not so sensitive that this discrepancy will significantly affect the overall results.

EXHIBIT 2-5

ABOUT 31 PERCENT OF ALL FACILITIES WILL REQUIRE GROUND-WATER CORRECTIVE ACTION



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* Estimated number of facilities requiring corrective action based on ground-water cleanup only.

2.2 NATIONAL EXTENT OF HAZARDOUS CONSTITUENT RELEASES TO THE ENVIRONMENT

This section presents an overview of the national extent of releases to all media from hazardous waste management facilities. This overview is based upon data gathered from the RCRA Facility Assessment (RFA) survey and the National Priority List (NPL) data base of candidate sites for CERCLA cleanup.

No precise estimates are currently available concerning the number of facilities that have released hazardous constituents to soil, ground water, surface water, or air. The information gathered for this RIA from the RFA survey and the NPL data base, however, provides a valid basis for generally estimating the size of the national population of facilities that are releasing or have released hazardous constituents to these media and would be subject to corrective action requirements.

The RFA survey contains information characterizing 65 RCRA facilities that have undergone a RCRA Facility Assessment and that were required to prepare follow-up RCRA Facility Investigations. Assuming that facilities not required to perform RFIs are not releasing significant quantities of hazardous waste constituents to the environment, this data base provides the best available information concerning the current status of hazardous waste management and release events requiring corrective action at RCRA facilities. This section also presents the NPL data describing release events from CERCLA sites as corroborating evidence of the extent of the national problem. The NPL data base contains information on 951 facilities (as of the date of this analysis) that have been identified as priority sites for CERCLA cleanup.

The information contained in the RFA survey indicates that roughly 30 percent of all RCRA facilities (1,710 of 5,661) may have releases to ground water requiring corrective action. In comparison, based upon reported NPL information, 73 percent (695 of 951 sites) of the NPL sites reported releases to ground water. This apparent discrepancy in percentages is expected, however, since releases would necessarily have been discovered at a facility to place the facility on the NPL, and a greater emphasis has been placed on ground-water releases in the Superfund program.

The RFA survey indicates also that roughly 34 percent of all RCRA facilities (1,920 of 5,661) are releasing or have released hazardous constituents to soil. Although the NPL data base does not explicitly track hazardous constituent releases to soils, the information on releases to ground water provide a general indication of the extent of releases to soil, as well. Hence, the NPL data base indicates that approximately 73 percent of NPL sites have soil contamination.

Based on the RFA survey, approximately 17 percent of all RCRA facilities are releasing hazardous constituents to surface water (980 of 5,661 facilities). In comparison, according to the NPL data base, 42 percent (397 of 951 sites) of the NPL sites reported releases to surface water.

Finally, the information contained in the RFA survey indicates that approximately 370 facilities are releasing hazardous constituents to air, or roughly 7 percent of all RCRA facilities. In comparison, based upon reported NPL scores, 14 percent (137 of 951 sites) of the NPL sites reported releases to air.

Overall, both the RFA and NPL data indicate that a potentially significant proportion of the sites or facilities managing hazardous waste have released or are releasing hazardous constituents to soil, ground water, surface water and air, and that there is a significant need, therefore, for corrective action to address releases to these media.

2.3 CONCLUSIONS

Congress clearly mandated that EPA require owners and operators of hazardous waste management facilities to implement corrective action to protect human health and the environment. In developing these corrective action requirements, EPA recognized that the universe of facilities is both large and diverse. As a result, the corrective action rule is designed to provide considerable flexibility to address releases to all media from a wide variety of releasing units.

Approximately 1,750 facilities will require ground-water corrective action to protect human health and the environment. The remedies selected and the timing of corrective action are described in Chapter 6 of this RIA.

3. REGULATORY STRATEGIES

This chapter discusses the general regulatory approaches, or strategies, that EPA considered in developing the proposed corrective action rule. As noted in Chapter 2, the Congressional mandate of RCRA Section 3004(u) limits EPA's discretion in developing its corrective action program. Under this section of RCRA, EPA is required to address corrective action for releases from solid waste management units (SWMUs) at facilities seeking a RCRA permit. Although Executive Order 12291 urges Federal agencies to consider both regulatory and non-regulatory alternatives when developing new regulations, non-regulatory approaches (e.g., tax incentives) were not considered in developing the corrective action regulations. The general regulatory options that were considered in developing the corrective action rulemaking are described below.

3.1 REGULATORY STRATEGIES

This section describes the three broad regulatory strategies EPA considered in developing the proposed corrective action rule. Each strategy represents a distinctly different approach to implementing cleanups at RCRA facilities. These strategies focus on several key issues relevant to addressing contamination at a RCRA facility, including the levels to which the affected media will be cleaned up, the timing of cleanup requirements, and the flexibility to address site-specific situations. The three strategies are:

Strategy 1. Cleanup to background levels as soon as practicable for all facilities;

Strategy 2. Cleanup to health-based levels, with flexibility in timing; and

Strategy 3. Cleanup to health-based standards only where actual or imminent exposure exists.

These strategies represent a range of different approaches that EPA considered in developing its corrective action program. The first strategy represents a very stringent approach to corrective action that entails complete restoration of all contaminated media to their condition prior to the release while, under the third strategy, only contamination that constitutes an actual threat to an exposed human population or environmental receptors would be addressed. The second strategy represents a "middle ground" in terms of stringency. It requires corrective action whenever contamination exceeds health-based levels, allowing flexibility in implementing cleanups according to site-specific conditions.

EPA's analysis of these three strategies is described briefly below. In analyzing the three strategies, a number of comparative features were assessed, including:

- Protection of human health and the environment;
- Cleanup to either background or health-based levels;
- Timing of initiation of corrective action;
- Location of the points of compliance;
- Cost to the regulated community;
- Source control to prevent future releases;
- Consistency with CERCLA cleanup objectives; and
- Technical practicability.

3.1.1 Strategy 1: Cleanup To Background Levels As Soon As Practicable for All Facilities

The objective of Strategy 1 would be to restore all contaminated media to background levels as soon as possible. The point of compliance for determining the extent of cleanup for each medium would generally be measured at the unit boundary. Under this strategy, very extensive source control measures would typically be required in order to ensure a high degree of reliability over the long term for ensuring against any future releases in any concentration. Such source controls would presumably often involve substantial excavation of units and contaminated soils for treatment (e.g., incineration). Such actions would be required of owner/operators as expeditiously as possible; little flexibility in timing would be allowed. This strategy would rely on a simple, consistent standard (i.e., cleanup to background concentrations for all constituents) to achieve the maximum amount of cleanup possible and provide the greatest degree of protection to human health and the environment.

Cleanup Levels: Under this strategy, cleanup levels would be established at the "background" concentration levels for all media. Few, if any, site-specific adjustments to this standard would be allowed. It should also be noted that in some situations, background concentrations may actually exceed health-based levels, and thus, requiring cleanup to such levels may not achieve the goal of yielding "drinkable" ground water.

Timing: Cleanups would take place as soon as possible under Strategy 1. Owners and operators would be required to achieve cleanup targets, as well as implement all other remedy requirements (e.g., source controls) as expeditiously as possible. The exact timing requirements for a facility would still be established on a case-by-case basis, based primarily on technological capabilities; actual or potential exposure to contamination, and the ability of owners and operators to control such exposure, would play little role in establishing timing requirements for implementing remedies and achieving cleanup targets.

Points of Compliance: This strategy would require that compliance with cleanup standards be achieved at the unit boundary for all media. This also represents the most conservative approach environmentally by minimizing the locations where exposures to releases could occur. This approach would impose a particularly stringent standard for releases to the air medium (see the discussion in the preamble to the proposed rule on points of compliance for air releases).

Cost: By imposing very stringent cleanup requirements, Strategy 1 would impose much higher costs on the regulated community than the other two regulatory strategies. This would cause more severe economic impacts (i.e., bankruptcy of owners and operators), which in turn would impose substantially greater burdens on the Superfund program to cleanup of those facilities.

Source Control: Very substantial source control measures would be required under this strategy in order to ensure against future releases that would exceed the background cleanup standard. It can be assumed that these source control measures would more often rely on the use of treatment technologies such as incineration to comply with source control requirements than would Strategies 2 and 3, and substantially greater volumes of material would be subject to such treatment. In addition, for any wastes deposited or left in place, highly effective containment structures would be applied to protect against migration of contaminants in the future.

Consistency With CERCLA: Strategy 1 would be the least consistent with the CERCLA remedial action program among the three strategies by imposing a background cleanup standard, and allowing only minimally site-specific adjustment factors to influence cleanup decisions. This could create a significant "disconnect" between the two programs.

Technical Feasibility: Cleanup to background levels would be technically infeasible, in many cases, due to site-specific circumstances. In addition, as the precision of analytic detection methods increases, background levels may be measured at increasingly lower levels (e.g., parts per trillion). The effective cleanup standards thus would become more stringent over time. Cleanup standards under Strategy 1 would be technically much more difficult to attain, therefore, in comparison to the health-based standards that would be required under Strategies 2 and 3.

Protection: Theoretically, this strategy would provide the highest possible degree of protection of human health and the environment by adopting what would in essence be a "zero risk" standard for cleanup. Realistically, however, achieving such a standard would often be impossible due to technical and other limitations.

3.1.2 Strategy 2: Cleanup To Health-Based Levels, With Flexibility in Timing

The general objective of this strategy is to allow considerable flexibility in tailoring remedial requirements to site-specific conditions, with cleanup standards tied to health-based concentrations in all media. This approach would be expected to yield a high degree of protection of human health and the environment, while minimizing unnecessary economic impacts.

The strategy would allow considerable flexibility in timing, with cleanups deferred in some cases where owners and operators can assure that exposure to contamination, as well as further significant environmental degradation, will not occur. Cleanup of contamination would generally be required to the unit boundary, with some limited exceptions such as for releases to air, where the point of compliance could be established to reflect more realistic exposure conditions. In setting cleanup standards themselves, site specific factors would be considered in setting the levels, and some adjustments would be made in situations where cleanup to health-based levels would not be a sensible remedial requirement (e.g., for reasons of technical impracticability). In achieving remedial goals under this strategy, extensive source control requirements would often be required.

Cleanup Levels: Cleanup levels would be health-based standards that could be adjusted on a site-specific basis. These levels would represent the scientific consensus about cleanup standards that are protective of human health and the environment based on very conservative exposure assumptions.

Timing: Flexibility in timing is a key characteristic of Strategy 2. Cleanups could be conducted immediately, phased in over time, or deferred depending on site-specific characteristics. For example, cleanups could be phased in by first implementing source controls and then treating and disposing the contaminated materials as capacity becomes available. Flexibility in timing would generally be available only where no significant risk would be created by deferring cleanups; in general, cleanup of off-site contamination would not be deferred. Thus, Strategy 2 would be more flexible than Strategy 1, which requires cleanups as soon as possible.

Points of Compliance: Compliance with cleanup standards generally would be measured at the unit boundary under Strategy 2. Exceptions to this could be made in some cases, such as for air releases from operating units, where compliance with health-based levels might be required at locations that would reflect more realistic exposure conditions at or beyond the facility.

Cost: Although the costs associated with implementing Strategy 2 would be substantial, it would be considerably less costly than Strategy 1. This is primarily because health-based standards are generally higher than background levels, and therefore are less costly to attain with current technologies. In addition, the flexibility in timing allows owners and operators to spread more costs over time, and would accordingly be expected to cause considerably fewer bankruptcies than Strategy 1, and correspondingly lesser demands on Superfund resources.

Source Control: Extensive source controls would often be required under Strategy 2. However, the volumes of materials that would need to be subjected to incinerator or other extensive treatment processes could be presumed to be relatively less than for Strategy 1, since the standard for controlling future releases (health-based vs. background) is somewhat less stringent.

Consistency With CERCLA: Strategy 2 would be more consistent with EPA's current approach under the CERCLA remedial action program than either Strategies 1 or 3. The goals of the two programs would be consistent, emphasizing source control and long-term remedies. Moreover, both programs provide flexibility to meet site-specific cleanup situations. Such consistency is desirable because both RCRA and CERCLA may potentially apply to particular sites and because EPA intends that environmental problems should be addressed similarly under the two programs.

Technical Feasibility: Strategy 2 would provide flexibility to both the Agency and facility owners and operators in selecting the most appropriate remedy. Waivers (e.g., for technical infeasibility) would accommodate site-specific problems while protecting human health and the environment. For example, where complete cleanup is not technically feasible, other methods to reduce exposure to contaminants could be required, such as institutional controls (e.g., restricting access to the site).

Protection: Strategy 2 would ensure a high level of protection of human health and the environment. Achieving health-based standards would minimize human health risks from carcinogens and non-carcinogens. In addition, Strategy 2 would be more protective of the environment than Strategy 3, because it would reduce the risks of future exposure to releases and prevent degradation of environmental resources (e.g., ground water of drinkable quality) regardless of whether human exposures actually occur.

3.1.3 Strategy 3: Cleanup To Health-Based Standards Only Where Actual or Imminent Exposure Exists

While the goal of this strategy is similar to Strategy 2, Strategy 3 would not require cleanup unless there were actual human exposure to releases above health-based levels, or actual threats to environmental receptors. If there were no exposed populations or threats to the environment, no cleanup would be required. For example, ground-water contamination would generally not be remedied unless people were drinking the water. Source controls, however, would be required to prevent continuing releases from degrading environmental resources. This approach would use risk factors, such as the location of exposed populations, current and future use patterns, and environmental fate and migration of contaminants, to estimate human exposure to releases. Cleanups would have to meet health-based standards at the point of human exposure to contaminants. Strategy 3 would control future exposures largely by relying on institutional controls.

Under Strategy 3, for example, an owner of a leaking hazardous waste treatment tank would have to conduct a risk assessment of the site to determine the extent of human exposure to the release. If the release exceeded health-based standards in nearby ground-water drinking wells (i.e., the point of compliance), the owner would have to implement corrective action expeditiously to reduce the contamination below the health-based standards. For instance, the tank owner could replace the leaking tank, begin a ground-water remedy, and provide nearby residents with bottled water until contamination in the ground water falls below the health-based levels.

Cleanup Levels: Cleanups under Strategy 3 would be to health-based standards (i.e., similar to Strategy 2) where exposure exists above these levels. These levels are equal to or higher than the background cleanup standards required under Strategy 1. Adjustments (e.g., technical impracticability) would be allowed on a case-by-case basis, as under Strategy 2.

Timing: Cleanups would be required as soon as possible after determining that human (or environmental) exposure to contaminants above health-based standards exists. Where no human exposure or significant threats to the environment exist, cleanup would not be required.

Points of Compliance: Compliance with cleanup standards would be measured at the points of human exposure (i.e., where people are exposed to contamination above health-based levels). Depending on the proximity of the exposed population, contamination could extend a considerable distance beyond the facility boundary before compliance with health-based standards would be required. This approach could be difficult to implement, since estimates of human exposure to releases often must rely on technically complex fate and transport modeling procedures and are open to substantial debate, potentially delaying cleanup actions.

Cost: Strategy 3 would entail the least cost among the three regulatory strategies. Nonetheless, Strategy 3 could result in more costly cleanups in cases where contamination is spreading quickly, thus producing a more extensive cleanup at the time when remedial measures finally begin.

Source Control: Under Strategy 3, source control would be required only if necessary to achieve the cleanup standards at the point of exposure or to prevent continuing releases from degrading environmental resources (e.g., ground water). Thus, in this respect, Strategy 3 would be less stringent than either Strategies 1 or 2.

Consistency With CERCLA: The concept of triggering cleanup of contamination only where actual exposure problems exist is not compatible with current CERCLA remedial requirements. This strategy would create a significant disparity in the degree of cleanup -- and ultimately, protection -- between the RCRA and CERCLA programs.

Technical Feasibility: Strategy 3 would be expected to be the strategy that would least often encounter problems of technical feasibility, if only because considerably fewer remedies would be required, and less rigorous cleanup standards would be applied. Thus, this strategy could be considered the most "doable" of the three.

Protection: Strategy 3 would protect human health by requiring cleanup to health-based standards where exposure above such levels exists. It would be considerably less protective of human health and the environment, however, than the other strategies. Since contamination would be allowed to remain, prevention of future exposure to the contamination would often not be guaranteed. In addition, this strategy would allow considerable resource damage (e.g., polluted aquifers) to remain uncorrected and thereby unusable for future generations.

3.2 CONCLUSIONS

Based on an evaluation of these three broad regulatory strategies, EPA adopted the framework of Strategy 2 for its proposed corrective action program. This strategy was used as the context for developing the proposed rule, for several reasons. Of paramount concern was the need to develop a regulatory approach which satisfied the RCRA statutory mandate of protection of human health and the environment. EPA believes that Strategy 2 is highly protective, and offers a level of protection roughly equivalent to Strategy 1. Strategy 3, by allowing substantial resource damage to remain unaddressed, and by relying heavily on the use of institutional controls and projections of future exposure patterns, was rejected as being not sufficiently protective.

The corrective action process is designed to allow decision makers to design remedies to fit the particular circumstances at the facility. EPA is persuaded that Strategy 2 offers an optimum degree of flexibility in tailoring sensible cleanup requirements to site-specific conditions (see above discussions on points of compliance, timing, cleanup levels, and technical feasibility). Strategy 1, in contrast, would establish cleanup requirements in a manner much less sensitive to facility-specific conditions.

In terms of cost, Strategy 1 would be expected to have much greater costs and associated economic impacts than either Strategies 2 or 3. This presumption was confirmed in the quantitative analysis performed for this RIA (see following chapters). EPA believes that imposing costs of this magnitude on the regulated community to obtain what would likely be at best a marginal effect on the environmental and human health benefits produced by the corrective action program, would be unnecessary and unwise public policy. Further, by causing relatively fewer economic impacts, Strategy 2 is expected to create correspondingly fewer additional burdens on the Superfund program, since more owners and operators will be able to bear the costs of cleanup.

Finally, Strategy 2 represents a regulatory approach that is designed to be compatible with the CERCLA program, in terms of yielding similar remedies for similar environmental problems. This consistency between cleanup programs is another important objective of the Agency in developing the RCRA corrective action program.

4. CORRECTIVE ACTION FOR EACH ENVIRONMENTAL MEDIUM

4.1 OVERVIEW

This chapter addresses corrective action for hazardous waste releases to all environmental media: ground water, soil, surface water, and air. In Chapter 3, three regulatory strategies were described which outline alternate approaches available to the Agency under HSWA to develop the proposed corrective action rule. This chapter builds upon that discussion by analyzing how the alternative regulatory strategies would affect corrective action for releases to each of the environmental media. Each medium is discussed separately in Sections 4.2 through 4.5. These media-specific discussions include a description of release mechanisms, transport pathways, exposure scenarios, and corrective measures under the alternative regulatory strategies. Finally, the approach adopted in the proposed rule for each of the media is compared to the regulatory strategies.

In the media-specific sections, the general regulatory strategies are applied to an example facility requiring corrective action to illustrate how the broad strategies would influence the conduct of a cleanup in a specific situation. Because the regulatory strategies describe only general approaches to corrective action, however, the example cleanups encompass certain assumptions concerning the course of a corrective action. The clean-up approaches described, therefore, do not represent all possible approaches under the respective regulatory strategies, but are intended to depict the general differences among the strategies.

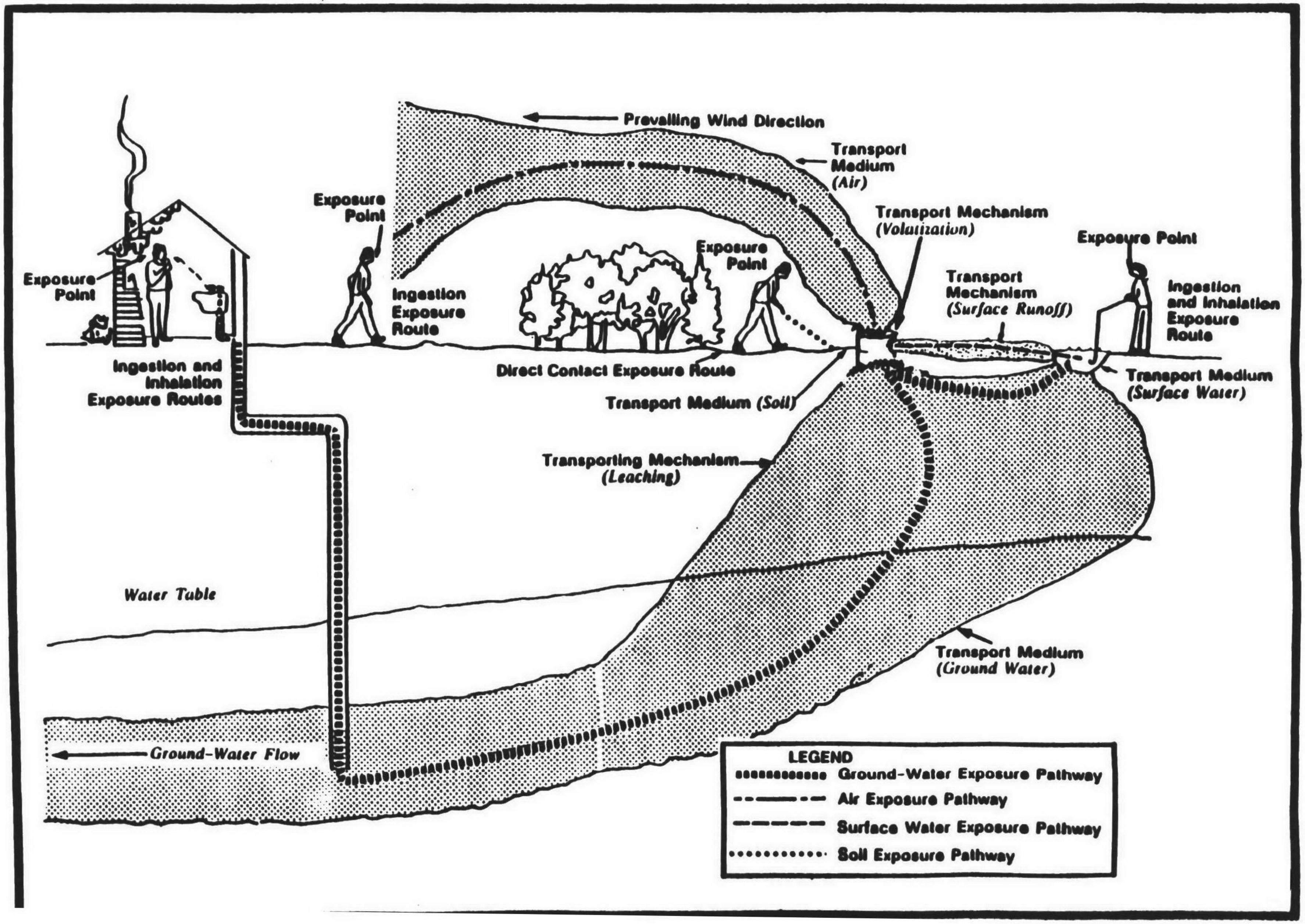
Exhibit 4-1 illustrates many of the factors governing corrective action discussed in this chapter and some of the exposure pathways that will be addressed by the proposed rule. As illustrated in the exhibit, the extent of the threat to human health and the environment from hazardous waste or constituent releases is a function of several factors. In general, these factors include: (1) the source and release mechanisms (e.g., volatilization of hazardous organics); (2) the environmental transport medium (e.g., air); (3) the distance to potentially exposed populations (e.g., the presence of a nearby residential neighborhood); and (4) the route and duration of human exposure and the toxicity and concentration of the contaminant at the time of exposure (e.g., inhalation of carcinogenic volatile organics). These topics are discussed further in the sections addressing the environmental media.

4.2 CORRECTIVE ACTION FOR RELEASES TO GROUND WATER

This section discusses the potential sources, transport mechanisms, and resulting risks from releases to ground water. The section also describes typical corrective action activities that could be employed to address releases to ground water under the alternative regulatory strategies described in Chapter 3 and then discusses the approach encompassed in the proposed rule.

EXHIBIT 4-1

RELEASES CAN LEAD TO EXPOSURES THROUGH ALL ENVIRONMENTAL MEDIA



4.2.1 Releases to Ground Water: Sources, Transport, and Potential Threats

Hazardous constituent releases from solid waste management units (SWMUs) may contaminate ground water through several pathways. For example, water may infiltrate into a SWMU and produce leachate containing hazardous constituents which may then move into ground water. In addition, direct releases to ground water can occur when the water table comes into contact with the hazardous materials in the SWMU. This may happen if the materials are actually buried below the water table or, under certain circumstances, when the water table is drawn up into the SWMU itself, thus bringing the water into direct contact with hazardous materials. In any of these situations, soluble hazardous constituents may enter the ground water directly.

Indirect releases occur when contaminants are released to another medium and migrate into ground water. Indirect releases generally involve releases to soil, from which constituents leach into ground water, or as releases to surface waters that are connected hydrologically to ground water. The extent of leaching or migration after a release from soil or surface water to ground water will depend both on site characteristics (e.g., porosity of the soil, depth to the water table, ground-water flow patterns, etc.) and on the characteristics of the released constituents (e.g., viscosity, ability of the constituents to degrade or persist, etc.).

The types of SWMUs that may release hazardous constituents directly or indirectly to ground water include the following: underground injection wells, surface impoundments, landfills, land treatment units, container storage areas, tank systems, and waste piles.

Just as contaminants may migrate from soil or surface water into ground water, contaminants released to ground water may migrate to other media as well. For example, volatile constituents in ground water may release hazardous gases into the unsaturated soil zone above the water table. Likewise, contaminants in one aquifer may flow into other, interconnected aquifers or into hydrologically connected surface waters. Again, the extent of migration will depend primarily on both site and hazardous constituent characteristics. In many cases, the extent of migration also may be affected by human activities, such as the placement of irrigation or drinking water wells that affect ground-water flow patterns.

Human exposure to contaminated ground water primarily occurs through the withdrawal of water from wells for domestic use or irrigation. Hence, ingestion and dermal contact through bathing or during irrigation activities are the primary routes of exposure. Exposures also occur when contaminants migrate to surface waters that are ingested or used for bathing. Moreover, contaminants may enter surface water ecosystems or agricultural systems, through the use of contaminated ground water for irrigation, and bioaccumulate in organisms that are eventually consumed by humans (e.g., shellfish or grain crops).

Depending on the constituents present in the ground or surface water and their concentrations, such exposures may result in human health effects ranging from acute illness or dermal irritation to chronic disease. In addition to these environmental and human health threats, releases to ground water pose other environmental threats such as the contamination of wetland ecosystems.

4.2.2 Typical Activities to Correct Releases to Ground Water

Corrective action to address releases to ground water will involve activities to control the source of the release and activities to remediate existing contamination. Because ground water can flow at relatively slow rates, typically ranging from tens of feet to as little as inches per year, constituent concentrations at any given location may remain high for long periods of time if left unaddressed. In contrast, because ground water also can flow at very high rates (e.g., hundreds to thousands of feet per), a release can travel quickly and affect large areas. Remediation may be critical in both of these situations.

The Agency anticipates that corrective action activities taken to address hazardous waste releases to ground water will be similar to the activities employed for Superfund cleanups. A summary of Superfund activities to remediate ground water contamination, described by CERCLA Records of Decision (RODs), is presented in Appendix D. As this exhibit illustrates, activities designed for source control may include:

- Excavation and treatment or off-site disposal of SWMU materials or contaminated soil from which leachate is entering ground water;
- Removal and off-site disposal of lagoon sediments and liquids;
- Installation of slurry walls and other systems to intercept migrating constituents;
- Leachate treatment and off-site disposal;
- Installation of impervious caps to prevent infiltration of water that can cause leaching; and
- Surface water diversion, treatment, and monitoring.

Ground-water remediation and assessment activities may involve:

- Pumping contaminated ground water;
- Treating the ground water and either reinjecting it into the aquifer or diverting it into a nearby surface water;
- Replacing contaminated drinking water supplies with alternative sources; and
- Ground-water monitoring.

Note that because releases to ground water often involve, or occur in conjunction with, releases to other media, activities taken at a site often address more than one medium. For example, excavation of contaminated soil may constitute both the remediation of a release to soil and the control of a ground-water contamination source. The information presented in Appendix E, therefore, represents the kinds of corrective action activities taken at sites with releases to ground water rather than activities taken strictly to address ground-water releases alone.

4.2.3 Analysis of Alternative Regulatory Strategies to Address Ground-Water Contamination

The alternative strategies presented in Chapter 3 vary in their requirements, especially with regard to the extent of cleanup. The following discussion compares corrective action for ground-water contamination at an example facility under these alternative regulatory strategies.

Example Facility

The example facility contains a RCRA waste pile unit and is located in a remote area. Currently, portions of the facility property are being mined for sand, gravel, and peat deposits. From 1967 to 1978 paint sludge was dumped in a landfill that was created originally as a gravel pit. The SWMU is approximately one-half acre in area and as deep as 30 feet in several places. There are two hardened layers of paint sludge and a layer of five-gallon paint buckets. Finally, layers of paint mixed with sand are present at various depths. Altogether, the volume of waste material from which leachate is being released to the ground water is roughly 15,000 cubic yards.

Because this site is remote, the ground water currently is not used as a drinking water source or for other purposes. However, the ground water is a potential drinking water source. Organic contaminants that have been detected in on-site and downgradient monitoring wells indicate the migration of contaminants from the landfill into the ground water. The types of contaminants monitored include: volatile organic compounds (VOCs), organics, inorganics, base-neutral compounds, TCE, toluene, xylene, and metals. Those contaminants found in concentrations greater than health-based standards include: benzene, chloroform, methylene chloride, chlordane, and heptachlor. No significant surface water or air contamination was detected at the facility.

Corrective Measures Under the Regulatory Strategies

The following discussion describes the corrective measures that might be followed at the example facility and the resulting benefits under the alternative regulatory strategies.

Strategy 1: Cleanup to Background Levels As Soon As Practicable For All Facilities

This strategy would require the immediate cleanup of the ground water to bring contaminant concentration levels down to background levels at the edge of the landfill unit. Site-specific adjustments in the cleanup standards or the timing of remediation would not be allowed under this strategy.

Potential Corrective Measures: The corrective measures required by this strategy would include excavation of the entire 15,000 cubic yards of contaminated waste and soil followed by treatment on-site. Also, the strategy would require the sinking of monitoring and recovery wells along the unit boundary to monitor the contamination plume and the installation of a treatment system to remove, treat, and reinject (or divert to a surface water) the treated water until contaminant levels at the edge of the landfill were essentially zero (i.e., background levels given no other sources of contamination).

Benefits Analysis: This regulatory strategy would impose a corrective action program that is highly protective of human health and the environment. Source control would be employed immediately to prevent future releases to ground water. Furthermore, the requirement to clean up existing ground-water contamination to background levels represents the most stringent standard possible.

These extensive cleanup requirements, however, may entail considerable costs and may be very difficult to complete. The imposition of these costs may not be justifiable when one considers that the contaminated ground water does not currently pose a threat to human populations. Moreover, only a subset of the contaminants detected in the ground water exceed health-based standards. Because these standards are designed to be protective of human health and the environment, cleaning up to background may not significantly improve environmental protection despite imposing prohibitive costs. Furthermore, even if the costs were incurred, cleaning ground water to background constituent levels is technically difficult and for certain constituents may be impracticable.

Strategy 2: Cleanup to Health-Based Levels, With Flexibility in Timing

This strategy is designed to be fully protective of human health and the environment by requiring cleanup to health-based standards (e.g., maximum contaminant levels, reference doses, or risk specific doses) rather than background levels, depending on site-specific exposure pathways. Under this strategy, the Agency also could allow the use of interim remedies and institutional controls rather than strictly requiring immediate remediation. The remedy would have to be completed, however, prior to the completion of facility closure.

Although the ground water underlying the example facility is not currently used as a drinking water source, it is a potential source. The corrective action program required under this strategy, therefore, would include, first, the cleanup of the contaminated material and soils in order to prevent future releases. Second, this strategy would require ground-water treatment to bring the contaminants at concentrations above health-based standards down to those standards at the edge of the unit boundary.

Potential corrective measures: The corrective measures would include capping and closing the unit, thereby isolating the entire 15,000 cubic yards of contaminated waste and soil and the removal of any remaining material outside the unit for treatment or off-site disposal. In this case, a cover would control continuing releases adequately. If a cover could not control the release, then more extensive source control might be required (e.g., excavation). Also, the strategy would require the sinking of monitoring and recovery wells along the contamination plume and the installation of a treatment system to remove and treat the water until the contaminant levels for benzene, chloroform, methylene chloride, chlordane, and heptachlor (i.e., those contaminants in concentrations greater than health-based standards) were below their respective standards.

Benefits analysis: This strategy would be fully protective of human health and the environment by treating the ground water to health-based standards. Isolation of the contaminated wastes and soils also would prevent future releases to the ground water. Relative to the first strategy, this second strategy would be less costly and more technically practicable for two reasons. First, for virtually all contaminants, treating ground water to reach background concentrations would be very difficult and, therefore, far more expensive than the lower level of treatment required to reach health-based standards. Second, requiring that health-based standards be achieved at the edge of the unit imposes less rigorous remediation than requiring compliance at all points in the contaminant plume. Hence, this second strategy is fully protective of human health, but is more practicable and therefore less costly than the first approach.

Strategy 3: Cleanup to Health-Based Standards Only Where Actual or Imminent Exposure Exists

The requirements of this strategy are similar to Strategy 2 in that cleanup of the ground water must be to health-based standards. Moreover, interim remedies and institutional controls also would be allowed under this strategy by the Agency during the active life of the unit until permanent remedies could be completed prior to closure. Unlike the health-based approach, however, compliance with these cleanup standards need only be met at the point of actual exposure. If the Agency determined that site-specific conditions make exposure to contamination unlikely, then corrective measures beyond source control may not be required. Ground-water remediation would not be required as long as there were no potentially exposed populations in the area. However, the hazardous materials would be consolidated and capped in order to prevent further contamination from occurring.

Potential corrective measures: Because the ground water underlying the example facility is not currently used as a drinking water source or for other purposes during which exposure to contaminants could occur, the corrective action program for this facility would not include remediation of the ground water. However, some measure of source control would be required to prevent the continuing release from further degrading the ground-water resource. This approach represents a conditional remedy, contingent upon the exposure pathways that may develop in the future (e.g., placement of a drinking water well in the aquifer that would trigger ground-water cleanup).

Benefits analysis: As with the health-based strategy, this strategy is designed to be fully protective of human health and the environment. However, implementation of corrective action is contingent upon the presence of a potentially exposed population. The aquifer underlying the example facility is not a current drinking water source, but is a potential source. Hence, of the three strategies, this strategy is the least expensive in the short term because neither extensive source control nor ground-water remediation is undertaken. However, the presence of a potentially exposed population in the future may trigger more extensive and expensive ground-water treatment than would be necessary if taken in the short term. Therefore, implementation of this strategy may yield short-term savings at the expense of potentially significant long-term resource damage and ground-water cleanup costs.

Comparison and Analysis of Strategies for Ground-Water Corrective Action

In sum, Strategy 1 offers the greatest protection of human health and the environment in terms of reducing contaminant concentrations throughout the aquifer. Requiring such stringent remediation may impose unnecessary burdens, however, especially since remediation to background levels may be impracticable, and because it is unlikely that drinking water wells will be placed within the facility boundary. Strategy 3, on the other hand, may overlook potential future exposure pathways and, thereby, result in delayed remediation that could be considerably more extensive than efforts required at present. Strategy 3 also does not account for the loss of the ground-water resource, regardless of whether actual exposures occur. Because Strategy 2 would require source control and the remediation of the contaminated ground water to health-based standards beyond the point where exposure would likely occur (i.e., the unit boundary), this strategy would be fully protective of human health and the environment. Furthermore, it would not impose overly stringent and potentially impracticable remediation requirements where exposure to the ground water is not likely to occur.

4.2.4 Corrective Action for Releases to Ground Water Under the Proposed Rule

This section describes the approach to corrective action for ground-water contamination contained in the proposed rule.

The proposed rule establishes 40 CFR Part 264, Subpart S requirements for the cleanup of releases to ground water. The current requirements for addressing releases to ground water are found in 40 CFR Part 264, Subpart F, which require corrective action for releases from regulated land disposal units only.[1] In general, the proposed rule modifies the existing Subpart F approach for correcting releases to ground water by addressing releases from all SWMUs and by shifting the emphasis of corrective action from ground-water pumping and treatment to more comprehensive cleanups, including source control.

Under the proposed rule, ground-water cleanup will be required to reach MCLs, where available, or to health-based standards (e.g., Reference Doses or RfDs). The point of compliance for cleanup under the proposed rule includes the entire contaminant plume. This may include areas that extend beyond the

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[1] The current Subpart F requirements also will be amended by a companion Notice of Proposed Rulemaking to the Subpart S proposal.

facility boundary in those cases where the plume has migrated off site and the owner or operator is able to gain access to the off-site property.

The rule proposes that the final remedy control the source of releases so as to reduce or eliminate ground-water releases that may cause a threat to human health and the environment. The timing of the source control may be deferred, however, depending on the characteristics of the particular site. The purpose of this source control requirement is to ensure that future releases to ground water are prevented.

The proposed rule generally adopts an approach similar to Regulatory Strategy 2. This approach calls for remediation of ground water to health-based levels at the unit boundary regardless of current exposure patterns and source control to prevent further degradation of the ground-water resource.

4.3 CORRECTIVE ACTION FOR RELEASES TO SOIL

Cleanups of hazardous constituent releases to soil are needed both to prevent current exposure to the contamination and to allow for future use of the contaminated property. Human exposure to soil contamination may occur either through direct dermal contact with the contaminants or ingestion of the hazardous constituents in the soil. Furthermore, indirect exposures may occur following transport of the contaminants from the soil to other environmental media. The characteristics of the releases and exposure threats addressed by corrective action, the remedies available under the proposed rule, and alternative regulatory strategies to address soil contamination are discussed below.

4.3.1 Releases to Soil: Sources, Transport, and Potential Threats

The typical types of solid waste management units (SWMUs) that may release hazardous constituents to soil include the following: surface impoundments, landfills, waste piles, land treatment units, container storage areas, tank systems, incinerators, and underground injection wells. The proposed corrective action rule also addresses routine or systematic releases of hazardous constituents to soil from units not meeting the definition of SWMU.

Such past and current releases may result from mishandling of wastes or the disposal of wastes into unlined or open areas, thereby allowing hazardous constituents to infiltrate directly into the soil. Moreover, water-soluble hazardous constituents may be leached from waste piles, unlined landfills, or contaminated surface soils, leading to further soil contamination and potential contamination of other environmental media (i.e., air, ground water, and surface water).

Exposure to the hazardous constituents in contaminated soils may occur under two general scenarios: (1) direct contact with the soil, or (2) indirect contact with hazardous constituents transported from the soil to other environmental media. Direct or proximate exposures are more likely to involve on-site workers or visitors and may involve dermal contact or ingestion. Soil ingestion is often associated with specific behavior patterns of children. However, for active, controlled sites with little off-site soil contamination, children may not have ready access to contaminated soils. Therefore, soil ingestion may not be a serious problem.

Typical off-site, direct exposure routes also include ingestion, inhalation, and dermal contact. Contaminated soils may be tracked or windblown off-site and accumulate where direct human exposure may occur. Such exposures could involve inhalation of contaminated dust particulates blown into the air or dermal contact with accumulated contaminants. Exposure could also occur through ingestion, if soil contaminants migrate off site.

The transport of contaminants from soil to other environmental media depends upon certain site-specific conditions such as soil characteristics, topography, adsorptivity of the hazardous constituents to soil particles, and hydrologic conditions (e.g., rainfall, water table level, etc.). Surface soil contaminants also may be spread through wind-induced dispersion, or through human activities such as vehicle-induced saltation of soil particles and movement of contaminated equipment.

Indirect exposure to contaminated soils may occur through a number of routes. For example, contaminated soils may be carried into surface waters as sediments and expose bottom dwelling plant and animal life. Contaminated sediments can remain toxic for long periods of time, occasionally recirculating in the water as a result of turbulence caused by storms, dredging, or recreational activities. Moreover, surface water or wetlands may be drained for development, thus exposing the contaminated sediments and increasing the likelihood of human exposure. Contaminated soils also may be transported to and accumulate in agricultural areas via wind dispersion or surface run-off. Such contaminated soils may then become concentrated in crops and livestock through bioaccumulation. Finally, soil contaminants also may leach into ground water and contaminate drinking water supplies

In sum, releases to soil pose a potential exposure threat through a variety of pathways. For example, a release of hazardous constituents to soil may leach into ground water, be transported by runoff into surface water, or volatilize into the air. Therefore, although it is important to note the risks from direct human or environmental exposure to a soil release, the movement of that release to other media also may pose an exposure threat both at the time of the release and in the future.

4.3.2 Typical Activities to Correct Releases to Soil

The design of an appropriate corrective action to address a release to soil will depend primarily on the potential routes of hazardous constituent exposure to human populations, the current and future uses of the site itself, and the current and potential uses of areas surrounding the site.

Because releases to soil may present a threat to human health and the environment through the potential to migrate to other media, site-specific characteristics (e.g., location, topography, and hydrologic conditions) and the current and future uses of a site are critical considerations in determining the appropriate corrective measure for a release to soil. For example, sites with highly toxic constituents, highly vulnerable ground water or surface water nearby, or large populations with ready access may warrant immediate, permanent remedies, such as waste excavation and treatment or incineration. On the other hand, remote sites with low contaminant concentrations and migration potential or limited human contact may be addressed adequately with institutional controls (e.g., prevention of public access or land use restrictions) and site containment, such as waste consolidation and capping.

The Agency anticipates that the types of corrective action activities employed to correct soil contamination at particular sites will be similar to the activities encountered for Superfund cleanups. Appendix D provides details of the corrective action activities taken at a sample of CERCLA sites and the costs of those activities. This summary, compiled from Records of Decision, indicates that corrective action activities typically employed to alleviate or prevent the effects of soil contamination include:

- Excavation and removal of soils for incineration, treatment, and/or disposal;
- Treatment of soils in place to remove or immobilize contamination; and
- Capping contaminated surface soils to prevent direct contact and limit hazardous constituents from leaching to ground or surface waters.

Note that these activities will effectively remediate other media, as well, because releases to soil often can migrate. The summary presented here, therefore, represents the kinds of corrective action activities taken at sites with releases to soil, rather than the types of activities taken to remediate releases to soil alone.

Because corrective action activities vary considerably from site to site, as described above, the cost of remediation for a site is also highly variable. Appendix D illustrates this variation. In general, costs appear to be a function largely of the volume of soil requiring corrective action, although transport of contaminated soils over long distances prior to disposal also may result in high costs.

4.3.3 Analysis of Alternative Regulatory Strategies to Address Soil Contamination

The strategies described in Chapter 3 vary in their requirements, especially with regard to the extent of soil cleanup and the timing of cleanup. This section compares the timing and level of cleanup associated with corrective action implemented to address soil contamination at an example facility under the regulatory strategies. The example is based upon a description of a "real world" site, which has been modified for the purpose of this analysis.

Example Facility

The example facility encompasses 120 acres and contains a closed 60-acre landfill unit. The owner/operator also operates a second landfill on the facility, which is a RCRA regulated unit. The closed landfill operated from 1958 to 1980 and is currently capped with a layer of clay. Wastes disposed in the unit include municipal and industrial sludges, spent solvents, and pesticide containers. A RCRA Facility Investigation indicated that this unit released hazardous organic constituents, including benzene, dichloroethane, and dichloromethane, into an area surrounding the northeast side of the unit. This release resulted in the contamination of three acres of surface soils (encompassing 7,260 cubic yards) outside the unit itself. Approximately 15 percent of the contaminated soils contain concentrations of organic contaminants in excess of health-based standards. The site is currently active, and therefore exposure of off-site individuals to the area of contamination is controlled. No significant surface water, ground-water, or air contamination was detected at the facility.

Corrective Action Measures Under the Regulatory Strategies

This section describes the corrective measures that would be followed at the example facility and the resulting benefits under the regulatory strategies.

Strategy 1: Cleanup to Background Levels As Soon As Practicable For All Facilities

This alternative would effectively require cleanup of all contaminated soil to the unit boundary to background constituent concentrations.

Potential corrective measures: The corrective measures required under this alternative would involve excavation to remove all contaminated soil, followed by treatment of the contaminated soil on-site. The activities are as follows:

1) Excavate all contaminated soil;

2) Treat the soil on-site in a mobile treatment unit;

3) Backfill the site with the treated soil, cover with a layer of topsoil and revegetate; and

4) Maintain the site for 30 years.

The costs involved in excavating, treating, and disposing of 7,260 cubic yards of soil would be high compared to the corrective measures under regulatory Strategies 2 and 3 discussed below.

Benefits analysis: The corrective action under this alternative is intended to be a complete cleanup of the site to prevent all future exposures to the contaminated soil. However, such an extensive level of cleanup may be neither technically practicable nor warranted in all cases. Because the soil contamination at this site does not affect any other media, the main exposure threat is through direct contact with the soil. If the site remains controlled or if there are no populations within the vicinity of the facility, then such direct exposures may be unlikely. Furthermore, because the majority of the soil at the site contains concentrations of contaminants which are below health-based standards, exposure to much of the soil at the site would not produce significant adverse health effects. As a result, the high cost of requiring complete soil excavation and treatment may not be justifiable.

Strategy 2: Cleanup to Health-Based Levels, With Flexibility In Timing

When determining an appropriate corrective measure for the site under this strategy, the Agency may consider the likely exposure patterns and tailor the cleanup level to an appropriate health-based standard. As a result, only the contaminated soil which exceeds the health-based standard at the site would be excavated. In addition, conditional remedies may be used, such as institutional controls, to prevent exposures during the operating life of the facility, followed by completion of the remedy at closure.

Potential corrective measure: The corrective measure under this strategy would address only the soil that contained concentrations of contaminants in excess of health-based standards. The remedy would be conducted on a multi-year basis with a conditional remedy instituted to prevent exposures while the remedy was underway. The activities under this strategy are as follows:

1) Install security fence around contaminated site and maintain for the active life of the facility (assumed to be ten years);

2) Excavate all soil with contaminant concentrations in excess of health-based standards;

3) Treat the soil on-site in a mobile treatment unit;

4) Backfill the site with non-hazardous treatment residue and cover with topsoil;

5) Cap the remaining contaminated soils with a two foot layer of topsoil;

6) Revegetate the entire site; and

7) Maintain the site (mow, erosion control, rodent control) for 30 years.

Approximately 975 cubic yards of soil would be extracted from the site under this alternative. The cost for soil excavation, treatment, and site cover and maintenance would be less than the costs under Strategy 1, but would still be high compared to Strategy 3.

Benefits analysis: The clean-up approach under this alternative would address all contaminated soils that could potentially produce adverse health effects through direct contact. However, this alternative would not require cleanup of soils that do not pose a significant health risk. Such soils would instead be covered to restrict contact, even though exposures would not impose a significant risk. In addition, this alternative would allow remedies to be phased in as long as institutional controls at a site would prevent harmful exposures. At sites such as the example facility, which are active and could effectively prevent exposures through the use of inexpensive security measures, the corrective action could be implemented over a several year period so long as it were completed prior to closure of the facility.

Strategy 3: Cleanup to Health-Based Standards Only Where Actual or Imminent Exposure Exists

Under this strategy, the need for and type of corrective measure conducted at a facility would be determined based upon a risk analysis of the site. The Agency would determine the risk associated with the most likely exposure scenarios at a facility and design the corrective measure accordingly. If the Agency finds that the characteristics of the site make exposure to the contamination unlikely, then corrective measures may not be required. For example, if a contamination site were located within a controlled industrial complex, exposure to the contaminants could be limited and site remediation would not be required. If control of the site were not feasible and therefore exposure were likely, cleanup to health standards could be required.

Potential corrective measures: In the case of the example facility, the corrective measure could involve either no action or simply consolidating and covering the contaminated soils to prevent direct exposure.

The activities involved in soil consolidation and cover would include the following:

1) Consolidate the soils that contain concentrations of contaminants in excess of health-based levels;

2) Cover the area containing the contaminated soils with a two foot layer of topsoil;

3) Revegetate the entire area; and

4) Maintain the site for thirty years.

The present value for these activities would be low compared to Strategies 1 and 2. The low cost of this strategy reflects the absence of soil excavation and disposal activities.

Alternatively, if the Agency determined that the population patterns surrounding a site and controls at the site would effectively prevent exposure to the contaminants, no corrective action could be required under this strategy. Hence, the cost of corrective action under this strategy could be essentially zero for some sites.

Benefits analysis: Although this strategy represents the least cost option for owners and operators, it also provides for the lowest level of assurance of protection for human health and the environment. There is no guarantee that current assumptions concerning likely exposure scenarios will not change over time. As a result, any contamination left in place could eventually result in health damage, especially if soil concentrations in excess of health-based standards were left in place. In addition, this strategy may not address adequately movement of contaminants from soil to other media and resulting indirect exposures. Finally, leaving the waste in place would inherently involve resource damage and a loss of beneficial future uses of the area containing the contaminated soil.

Comparison and Analysis of Strategies for Soil Corrective Action

Although Strategy 1 theoretically may be more protective than Strategies 2 and 3, cleaning up all contaminants to background levels may not be feasible at many sites. Moreover, such a level of cleanup may not be necessary to adequately protect human health and the environment. In contrast, the purely risk-based approach described under Strategy 3 may not be sufficiently protective if land uses surrounding a site change with time and direct exposures become more likely. The third strategy also may not account for other environmental degradation or transport of contaminants from soil to other media. Hence, Strategy 2 is more protective by virtue of its requiring corrective action to address contamination in concentrations above certain threshold levels and is practicable in terms of achieving cleanup to health-based levels.

4.3.4 Corrective Action for Releases to Soil Under the Proposed Rule

The general extent and severity of the soil contamination problem addressed under RCRA §3004(u) and the activities that may be involved in correcting this problem have been outlined above. This section describes the approach to corrective action for soil contamination contained in the proposed rule.

The proposed corrective action rule is designed to provide the Agency with the flexibility to tailor the timing of corrective measures at facilities with soil contamination based on the threat to human health and the environment posed at these facilities through either direct exposure or cross-media impacts. Specifically, the rule proposes to allow consideration of current and anticipated future land use patterns when setting media cleanup standards for soil during remedy selection. In addition, the proposed rule would allow the use of conditional remedies that protect human health and the environment during the term of the permit, with implementation of the final remedy phased-in prior to closure.

Soils may pose a threat through the direct ingestion route, either through consumption of soils or through inhalation of windblown soil particulates. Under the proposed rule, the owner/operator would be required to assess these exposure routes and compare likely exposure levels to health-based standards. If deeper soils are contaminated, the proposed rule may require that the RFI include an analysis of the risks posed by migration of hazardous constituents through the soil to other media, such as underlying ground water or hydraulically connected surface water. If the Agency determines, based on these investigations, that contaminated deep soil is not adversely affecting other media under current or projected future use scenarios, the Agency could require the owner/operator to place in the facility deed, or other appropriate instrument, a notice of residual contamination; active source control and remediation of the contaminated medium, however, would not be routinely required in this situation.

A Corrective Measures Study (CMS) typically will be required if action levels are exceeded or if it is determined that either surficial or deep soils are adversely impacting other media. The proposed rule allows the Agency flexibility to choose a final remedy which cleans up contaminated soil to levels consistent with current and plausible future patterns of land use at or near the facility. For example, where access to an area would be unrestricted upon closure, cleanup of contaminated soil generally would be required to levels appropriate for residential development (i.e., direct contact). In such a situation, exposure assumptions which assume a residential use pattern with long-term contact to soils contaminated with carcinogens, as well as soil ingestion by children of both carcinogens and non-carcinogens, might be most appropriate to use when setting media cleanup standards. The proposed rule also requires that the final cleanup standard for soils must be achieved at any point where direct exposure to the soils may occur.

In certain situations, the Regional Administrator may select a conditional remedy that would not necessarily be the final remedy for the facility, but would protect human health and the environment from exposure to contaminated soil. For example, where an owner/operator can control direct access to the contaminated soil, an appropriate conditional remedy for the site might be the cleanup of contamination to a level consistent with current exposure, together with permit conditions ensuring that use patterns did not change. In this case, the owner/operator may be required to use institutional controls (e.g., fences or other physical barriers) to prevent significant direct exposures to contaminated surficial soil, or to implement engineering controls to control the source of the release to surficial and/or deep soils prior to implementation of the final remedy at closure.

As described above, the proposed corrective action rule generally adopts the approach outlined under Regulatory Strategy 2. This approach is protective of human health and the environment by requiring cleanups of soil contaminated at concentrations in excess of health-based standards. Furthermore, the approach allows for the use of conditional remedies which may delay cleanups and reduce costs, so long as adequate and protective institutional or other controls are used on a temporary basis.

4.4 CORRECTIVE ACTION FOR RELEASES TO SURFACE WATER

This section discusses the potential sources, transport mechanisms, and resulting risks from releases to surface water; describes representative corrective action activities that may be employed to address surface water releases; and outlines the proposed rule and alternative regulatory strategies for the rule that this RIA has identified.

4.4.1 Releases to Surface Water: Sources, Transport, and Potential Threats

The severity of the threat to human health and the environment resulting from surface water contamination is a function of the source of the release, the extent of contaminant transport in surface water, the distance to a potentially exposed population, and the route and duration of human and environmental exposure. Each of these factors is discussed separately below.

Hazardous waste releases to surface water arise from four primary sources: direct releases to the water; continuous or intermittent overland contaminant discharges flowing into waterways; seepage of hydrologically connected contaminated ground water into surface water; and deposition of contaminants from the air. Direct releases may occur as a result of vehicular accidents involving carriers of hazardous waste, illegal dumping, or the release or overflow of wastewater from an impoundment or lagoon. Overland and ground-water flow also may transport leached hazardous constituents to surface waters over time. The rate and quantity of contamination increases with increased rainfall or flooding. Finally, air transport can lead to the deposition of contaminants in surface waters. Volatile organics and contaminated particulate matter may tend to disperse in the atmosphere, however, and reduce the expected concentrations of constituents deposited downwind.

Sources of hazardous constituent releases may arise from a variety of SWMUs including the following: surface impoundments, landfills, waste piles, land treatment units, container storage areas, tank systems, incinerators, and underground injection wells.

Mechanisms influencing the transport, extent, and impact of contamination depend upon factors such as the volume, temperature, and flow pattern of the water and the characteristics of the released constituents. Some contaminants are dispersed far downstream along with the surface water discharge. Other contaminants tend to fall out of the water into the sediments of the stream or lake. Such contaminants may continue to be released from the sediments back into the water over the long term, however, through chemical processes and turbulence or through the disturbance of the sediments by bottom-feeding fish and other organisms. The presence and composition of plant and animal life in the water also affects the fate of hazardous constituents through bioaccumulation and biological degradation.

Exposure to hazardous constituent releases to surface water occur through several pathways. Bioaccumulation (or biological magnification) is the process in which toxic materials are absorbed by vegetation and small animals and then passed along the food chain in ever increasing concentrations. Animals living in contaminated water concentrate soluble contaminants in their fatty tissues. As a result, many hazardous constituents can become concentrated in fish and shellfish at levels higher than those found in the surrounding water. Ultimately, the animals at the end of the food chain, such as fish and humans, become exposed to high concentrations of contaminants. Such exposures may pose a serious health risk due to the high concentration of constituents frequently found in animals living in contaminated surface water.[2]

Human exposure following releases to surface water also occurs either through withdrawal of contaminated surface water or in-stream contact with the water. Typical withdrawal exposure points and routes include: drinking water ingestion and contact with water used for cooking or bathing, consumption of agricultural crops irrigated with contaminated water or livestock fed contaminated water, and exposure to contaminated water withdrawn for industrial use. In addition, individuals are exposed to contaminated water during recreational use both through dermal contact and ingestion.

4.4.2 Corrective Action Activities to Address Releases to Surface Water

The preceding section characterized the problem of surface water contamination by providing an overview of release and exposure pathways and the resulting health risks. This section discusses the activities involved in corrective action for releases to surface water.

The choice of an appropriate corrective action design to address a release to surface water at a given site will depend primarily on the potential routes of hazardous constituent exposure to human populations. Because releases of hazardous contaminants to surface water often occur initially as releases to other media (e.g., releases to soil resulting in contaminated runoff or contaminated sediments and releases to hydrologically connected ground water), corrective action activities taken to remediate surface water contamination or to prevent additional surface water contamination also may involve remediating other media. Moreover, the potential for human exposure may indicate the appropriate extent of remediation. For example, surface water which contains contaminated sediments and which is used heavily as a drinking water supply or for recreational activities may require extensive water treatment and sediment excavation to protect the water supply and to control the sediment source. Likewise, surface water in a remote area contaminated by natural conditions (e.g., high turbidity), and therefore not a suitable drinking water source, may be remediated sufficiently by containing the release source (e.g., soil surface runoff controls) and applying institutional controls (e.g., prohibition of recreational activities). In general, a wide range of corrective action activities may be required to adequately address a release to surface water, depending on the characteristics of the release source and the potential for exposure of human populations or environmental receptors to contaminants.

The Agency anticipates that the types of corrective action activities engendered by the proposed rule will be similar to those activities encountered at Superfund cleanups. Examples of these activities are outlined in Appendix D. This summary was compiled using Records of Decision for the sites. As the summary indicates, the corrective actions typically employed to alleviate or prevent surface-water contamination include:

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[2] U.S. EPA, "Superfund Public Health Evaluation Manual," EPA/540/1-86/060. October 1986.

- Excavation, treatment, or consolidation of bottom sediments;
- Wetland restoration and revegetation;
- Construction of surface water diversions (i.e., levees, dikes, dams, or drainage ditches);
- Removal of contaminated surface soil to avoid leaching by surface runoff;
- Extraction, treatment or drainage of ground water which may drain to surface water;
- Capping soils or landfills to avoid contamination by surface runoff; and
- Water sampling and monitoring.

Note that many of these activities, while addressing releases to surface water, also address releases to other media. This summary of activities, therefore, represents the kinds of corrective action activities taken at sites with contaminated surface water, rather than activities strictly designed to clean up surface waters alone.

Because the typical corrective action activities taken to remediate hazardous waste releases to surface water vary greatly, costs for typical corrective action activities differ as well, as the summary of activities and costs in Appendix D illustrates. In general, the corrective action costs for a site with contaminated surface water appear to be driven most significantly by the extent of soil or sediment excavation required; the extent of surface water diversion required; the need for ground-water drainage or extraction; the need for a cover or cap; and the size of the contaminated area.

Based on the corrective action activities described in Appendix E, the more costly actions tend to involve extensive sediment excavation, surface-water diversion, and ground-water treatment. Because of the variety of factors that influence the cost of a corrective action, however, it is difficult to predict what a "typical" corrective action addressing surface-water contamination might cost.

4.4.3 Alternative Regulatory Strategies to Address Surface Water Contamination

The following discussion compares the level of cleanup required and points of compliance associated with corrective action at an example facility involving a release to surface water that would be implemented under the alternative regulatory strategies presented in Chapter 3. Although the timing of the remedy was raised as an important issue in the preceding sections describing strategies for ground water and soil corrective actions, for surface water there is no feasible way to differentiate among regulatory strategies based upon the timing of the remedy due to the nature of the medium. In contrast with ground water, contaminated surface water moves and dissipates very quickly. Therefore, surface-water contamination remediation relies more on source control than treatment of the medium itself.

Example Facility

A hypothetical facility that has experienced hazardous constituent releases to surface water is described below. The example is based upon a description of a "real world" site, which has been modified for the purpose of this analysis.

This example involves a 23 acre chemical manufacturing facility situated along the marshlands of a tidal river. Assorted waste containers, open steel drums, and manufacturing debris have been stored on site in an open impoundment approximately 50 yards from the river during the facility's ten years of operation. Two reported incidents involving the rupture of two 500-gallon storage tanks containing paint thinning agents and solvents occurred as a result of flood events during these years. These events, combined with leaching of soluble hazardous constituents from the surface impoundment, resulted in PCB, organic solvent, and heavy metal (including lead, cadmium, and chromium) contamination of the river water and sediments. The receiving stream does not discharge to ground water in the area of the contamination. Significant ground-water contamination, therefore, has not been detected at the site. At the time of the facility investigation, contaminant concentrations in the water did not exceed drinking water standards or other applicable health-based standards, but high concentrations of organics and heavy metals were found in the sediments and wetland soils immediately downstream from the facility. A drinking water intake is located one mile downstream from the facility.

Corrective Action Measures Under the Regulatory Strategies

This section describes the corrective measures that could be followed at the example facility and the resulting benefits under the regulatory strategies.

Strategy 1: Cleanup to Background Levels As Soon As Practicable For All Facilities

This strategy would require source control to prevent further contamination and would effectively require treatment of the water and dredging of sediment and wetland soils to remove contamination, where practicable. Due to the nature of the surface-water medium, contamination generally does not remain in place within the water column for extended periods of time. Consequently, source control is the primary corrective measure to address surface water contamination. Nonetheless, although the example described above involves releases to a river which would dissipate quickly, still water bodies such as ponds and lagoons could tend to retain contaminants in the water column for longer periods of time. If contaminants remain in the water body, treatment techniques are available to remove the contaminants, including liming and the use of polymers as contaminant precipitants.

Potential corrective measure: The corrective measure would focus on removing contaminants from the water system, including constituents in the water column, sediments, and wetland soils. Presumably, only very low levels of contaminants would remain in the water itself, because the river flow would continually cleanse the water column. Therefore, water treatment would yield little environmental benefit. However, contaminants would remain in the sediments and these contaminated sediments could continue to leach hazardous constituents into the water over time. These contaminants also could bioaccumulate in fish and shellfish and result in adverse health effects through consumption. Hence, the major corrective measure undertaken at this facility would involve source control to prevent any future releases to the water, followed by limited sediment and wetland soil dredging and disposal off-site. Such dredging would be conducted, however, only if the environmental damage caused by the dredging were not greater than the harm caused by leaving the contamination in place.

Benefits analysis: If this corrective measure were completed successfully, it would effectively remove the sources of future contamination from the site. However, removal of all contamination from such a site would prove very difficult, costly, and damaging to the environment. Contaminants can disperse over a large area in a water system. Therefore, a potentially large volume of sediments and soils would have to be dredged from the site, thereby causing environmental damage from the dredging itself. Furthermore, many contaminants become relatively immobile in sediments. Hence, they do not return to the water column in high concentrations. Once dredged up, however, the process can resuspend contaminants and lead to additional exposures in the water column. Finally, removing all contaminants from a water system may not be warranted on the basis of human health protection. If contaminants are present in low concentrations in the water (as in the case of the example facility), the contaminant concentrations may not exceed drinking water or ambient water quality standards. Hence, under this strategy only such treatment would be required that would provide human health benefit, while not adversely damaging the environment.

Strategy 2: Cleanup to Health-Based Levels, With Flexibility In Timing

This strategy mandates source control to prevent further contamination and cleanup of water systems to prevent exposures above health-based levels anywhere within the water body, and specifically at the point of entry of the contaminant. Because contaminant concentrations in the water were measured at levels below health-based standards, additional activities beyond source control, such as water treatment and sediment dredging, would not be required. In this case, sediment resuspension or bioaccumulation in bottom-feeding fish is not expected to lead to damage to human health and the environment.

Potential corrective measure: No corrective measure beyond source control would be required at this facility. Hence, no water treatment or sediment excavation would be required.

Benefits analysis: Because sediment removal and water treatment is not required under this strategy, the costs and environmental damage resulting from such activities would be precluded. However, if long term contamination and bioaccumulation of contaminants in fish emerged as a problem, it could be addressed through institutional controls which would limit exposure to the contaminated fish.

Strategy 3: Cleanup to Health-Based Standards Only Where Actual or Imminent Exposure Exists

This strategy requires corrective action only to limit contaminant concentrations at actual points of exposure, such as drinking water intakes. Because the contaminant concentrations in the water column are very low and virtually non-detectable at the drinking water intake, no action would be required at this site. Limited action might be required, however, if environmental damage were severe. In that instance, source isolation or removal might be required to prevent further environmental damage.

Potential corrective measure: No action.

Benefits analysis: By only requiring corrective action to correct measurable exposures above health-based levels, this approach is less likely to require action than Strategies 1 or 2 and is, therefore, less costly. However, this strategy is also least protective. It does not address incidental human exposures in the water body or bioaccumulation. Potential future contamination of the drinking water source caused by resuspension of the bottom sediments (e.g., during a storm event) also might not be addressed. Environmental degradation is not addressed in this instance, because such degradation is not severe. If environmental degradation were a problem, however, source control could be required under this strategy. Furthermore, in certain situations, this strategy could allow for discharges of hazardous constituents into a surface water to continue so long as the discharge dissipated before reaching a point of contact, such as a drinking water intake, or was present at a low concentration.

Comparison and Analysis of Strategies for Surface Water Corrective Action

Due to the nature of the medium, source control should generally prove to be an adequate corrective measure to address surface water contamination. In most cases, water treatment and extensive sediment dredging would not be required because contaminants tend to become isolated in sediments, which generally limits exposures above health-based standards. Strategy 1 does not account for this characteristic of the medium by requiring water treatment and sediment removal when such activities might not be warranted on the basis of human health and environmental protection. However, in some circumstances, limited sediment removal may be needed to prevent possible future contamination of the water body and to reduce bioaccumulation problems and environmental damage. Focusing only on measuring health-based concentration levels at readily identifiable points of exposure, such as drinking water intakes as described under Strategy 3, may overlook other points of exposure and one time events that could lead to damaging exposure episodes. Strategy 2 avoids this problem by assessing contaminant concentrations at all points in the water column. Furthermore, while Strategy 2 would rely on source control as the primary corrective measure for surface water, limited sediment removal could be required under the strategy to prevent bioaccumulation problems or resuspension of contaminated sediment.

4.4.4 Corrective Action for Releases to Surface Water Under the Proposed Rule

The proposed corrective action rule addresses human health risks posed by direct exposure to contaminated surface water from a variety of sources, including ingestion of water and consumption of aquatic organisms. The proposed approach also reflects the fact that concentration levels protective of humans based on such intakes often may be insufficient for protection of aquatic life or sensitive ecosystems. It does so by relying on State Water Quality Standards (WQS), which explicitly factor in the State-designated uses of the surface water and the sensitivity of the environmental system, and on Federal Water Quality Criteria, which consider human and environmental exposure to contaminated surface water, in determining action levels which are protective of human health and/or aquatic life.

If action levels in surface water samples have been exceeded, or if other investigations indicate that contaminated sediments pose a threat to human health or the environment, a CMS may be required. The proposed rule provides the Agency with the flexibility to consider potential uses of the surface water and all potential routes of human exposure to contamination, as well as exposure of sensitive environmental species or systems, when setting media cleanup standards at remedy selection. The Regional Administrator will specify the locations where surface water or sediment samples must be taken to monitor surface water quality, and demonstrate that compliance with surface water cleanup standards has been achieved.

This approach adopted by the proposed rule is similar to the approach described under Regulatory Strategy 2 above. As with Regulatory Strategy 2, the proposed rule focuses on source control as the best means of preventing contamination of surface waters, but acknowledges the need for "in-stream" corrective measures such as sediment dredging in isolated circumstances.

4.5 CORRECTIVE ACTION FOR RELEASES TO AIR

This section specifically assesses corrective action to address hazardous constituent releases to air. The section describes air release sources, transport mechanisms, and exposure pathways, as well as resultant human health risks. Representative corrective measures to address air releases are also described, followed by a discussion of the manner in which releases to air are addressed by the proposed corrective action rule.

4.5.1 Releases to Air: Sources, Transport, and Potential Threats

As demonstrated in studies prepared by EPA,[3] air releases of volatile organic compounds (VOCs) are known to occur from hazardous and nonhazardous waste units. Evidence from states such as California indicates that SWMUs can be a significant source of VOCs, such as chloroform. The level of exposure to such air releases experienced by a population will depend upon the amount of

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[3] U.S. Environmental Protection Agency, "Analysis of Air Emissions and Controls at Municipal Landfills," prepared for the Office of Air and Radiation by Radian Corporation, July 1987.

hazardous constituents released, the fate and transport of those constituents, and the proximity of the potentially exposed populations. Health risks resulting from exposure will depend on the duration of exposure (i.e., acute or chronic) and the toxicity and concentration of the contaminants.

The two most typical types of release of hazardous waste or hazardous constituents to air are the volatilization of organic compounds and the generation and transport of airborne dust particles from contaminated surface soils or waste piles.[4]

Releases to air may occur from a variety of SWMUs including the following: surface impoundments, open tanks, landfills, land treatment units, waste piles, container storage areas, incinerators, and non-RCRA wastewater treatment ponds.

Typical VOCs, which arise from SWMUs such as surface impoundments, include benzene, toluene, chloroform, and other organic solvents. Many of these VOCs are known or suspected carcinogens, or may cause other detrimental health effects. Organic solvents are found at many units and facilities. These volatile compounds either may be emitted directly to the air from uncontrolled waste management sites or migrate from the subsurface.

Dust or particulate emissions also may serve to transport a variety of adsorbed hazardous constituents. For example, hazardous organic and metal constituents may adsorb onto soil or dust particles and become airborne through wind erosion or by the movement of heavy machinery over a waste management unit.

The mechanisms influencing the transport of constituents in the air to a point of exposure include wind movement (i.e., air flow patterns), the natural dispersion of constituents in the atmosphere, wash-out of constituents from the air through rainfall or deposition, and the decay of certain constituents over time. Constituents that are adsorbed onto soil or dust particles, transported through air, and subsequently deposited also may lead to additional soil or surface water contamination downwind from a unit. Finally, the height of the release to the surrounding area can have a significant effect on the distance over which contaminants are transported and dispersed; higher air releases tend to be dispersed further.

As a general rule, populations in proximity to a release site tend to receive higher acute and chronic exposures than more distant populations. However, populations located far downwind of a release site also may receive potentially threatening exposures over the long term, depending on airflow patterns.

Potential air exposure points may range from nearby residential to commercial or industrial areas. For example, in one case, a local school was temporarily closed as a result of chemical air releases from a facility. In a second case, several VOCs were detected in an adjacent residential community

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[4] U.S. Environmental Protection Agency, Superfund Public Health Evaluation Manual, EPA/540/1-86/060, October 1986.

and were, at times, present in quantities above the National Air Emission Standards. The first case also demonstrates that local areas are especially vulnerable to exposure if located in valleys characterized by temperature inversions, where a release would be held stationary and close to the ground for long periods of time. Due to dispersion, however, air releases generally have a shorter residence period at the point of exposure relative to soil or water releases. Reductions in hazardous constituent release levels, therefore, will generally lead to prompt reductions in air pollutant concentrations.

The primary route of exposure to humans following an air release is inhalation.[5] Exposures may be characterized as either acute or chronic. Acute exposures involve the presence of high volumes of contaminants over short durations of time and, depending on the toxicity and concentration of the contaminant, can lead to health effects ranging from eye and throat irritation to death. Chronic exposures involve exposure to relatively low volumes of contaminants over long periods of time, which, depending upon the toxicity and concentration of the released constituents, can lead to degenerative diseases (such as cancer, kidney and liver disfunction, and blood disorders).

4.5.2 Typical Activities to Correct Releases to Air

The appropriate corrective action for a release to air will depend primarily on the potential routes of hazardous contaminant exposure to human populations and the types of contaminants being released. Moreover, because contaminant concentrations diminish relatively quickly as a release disperses, the frequency with which corrective actions are taken will be a function of the point chosen to trigger corrective measures studies and corrective actions.

The typical route of exposure from a release to air is direct exposure such as inhalation and dermal irritation. Therefore, the threat of an air release, relative to releases to other media, is primarily a function of the proximity of human activities surrounding a site. For example, toxic releases to air at sites surrounded by large, permanent populations may require rigorous source controls (such as reducing the VOCs in wastewaters entering a surface impoundment).

The Agency anticipates that the types of activities taken for RCRA corrective actions may in some cases be similar to the activities taken at Superfund sites to remediate air releases. In addition, however, many RCRA corrective actions will involve controls on operating units which will limit the generation of hazardous particulates and volatile organic compounds. Such activities at active units may simply involve process changes which lower the concentrations of VOCs in waste management units or limit their volatilization in the atmosphere. Further examples of Superfund remedial activities for air releases are outlined in Appendix D. This summary was compiled from Records of Decision prepared for the CERCLA sites. Although many of the activities completed at Superfund sites to remediate air releases

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[5] U.S. EPA, Superfund Public Health Evaluation Manual, October 1986.

would not be appropriate for active RCRA units, some of the ROD actions are illustrative of probable corrective action activities:

- Limiting the placement of wastes into or covering surface impoundments;
- Waste pile stabilization; and
- Installation of gas ventilation and collection systems.

Note that a number of activities designed to control the source of an air release are in fact remedial activities for other media (i.e., soil, ground water, and surface water). Because the corrective action activities described in Appendix D address the remediation of media other than air, this summary represents the types of activities taken at sites with releases to air rather than the typical activities required to clean up air alone.

4.5.3 Analysis of Regulatory Strategies to Address Air Contamination

The regulatory strategies described here correspond with the general strategy descriptions in Chapter 3. When applying the regulatory strategies to the air medium, the major distinction among the strategies involve differences concerning constituent concentrations in air which trigger action and the point of compliance for measuring the constituent levels. The air medium differs significantly from the other media, and this difference influences the choice of an appropriate regulatory strategy. Releases to air dissipate quickly, relative to the other media. Therefore, source control alone is the only reasonable action available to addresses air releases. Cleanup of the medium itself is not a viable option. Hence, the main question when addressing air releases is whether source control is needed at a particular site and when such controls should be instituted. Determining where the point of compliance should be set and what trigger levels should be measured at that point are the critical determinants of the need for and frequency of corrective action. In the following discussion, the manner in which the different regulatory strategies would govern corrective action for air releases are described by applying the strategies to an example facility.

Example Facility

The example facility contains an active surface impoundment unit. Manufacturing wastewaters containing solvents and other organic wastes are treated in the impoundment. A RCRA Facility Investigation at the facility measured concentrations of dichlorobenzene, trichloroethylene, and benzene in the air beyond the facility boundary in concentrations that exceeded health-based air level standards. As a result, a corrective measures study (CMS) was instituted at the facility. Based upon monitoring and modeling data, the CMS found that the air concentrations did not exceed health-based standards in the vicinity of the nearest residence, which is located 1200 yards from the facility boundary. No other residences or population gathering places are located within this 1200 yard radius of the facility.

Corrective Measures Under the Regulatory Strategies

This section describes the corrective measures that would be followed at the example facility and discusses the resulting benefits under the regulatory strategies. The only activity generally available to address air contamination involves source control.

Strategy 1: Background Levels at the Unit Boundary

Under Strategy 1, corrective action would be triggered if constituent concentrations were measured at the unit boundary in excess of background levels. This approach is analogous to regulatory Strategy 1 for ground water.

Corrective action would be triggered for the unit at the example facility because the background levels for the VOCs are exceeded at the unit boundary.

Potential corrective measure: The volatile emissions are from an active unit. Therefore, reducing either the volume of the wastes or the volatility of the constituents should serve as the most effective remedy. Controlling the source through either removal or capping would not be a viable option for this unit. Instead, covering the surface of the wastes in the impoundment to reduce contact with the air or waste treatment to reduce the volatility of the constituents are the only viable options. Other controls might include reducing the volume of the most volatile or hazardous constituents or closing the impoundment and switching to other treatment processes, such as in tanks. However, reducing the emission of VOCs to background levels probably could be accomplished only if the unit were closed.

Benefits analysis: The stringency of this strategy would force most units which manage VOCs to close or severely curtail their management practices. By triggering corrective measures at background levels at the unit boundary, this strategy is highly protective because it ensures that no off-site exposures would occur. However, at many facilities air remediations would be triggered even when there exists only a limited chance of human or environmental exposure. Furthermore, because air releases disperse rapidly, even releases that move beyond the unit are unlikely to cause chronic and excessive human or environmental exposures, unless the constituent is released in high concentrations and populations are in close proximity to the unit. Therefore, this strategy is extremely protective, but also very burdensome.

Strategy 2: Health-Based at Facility Boundary

This strategy would set corrective action process triggers and cleanup target concentrations for hazardous constituents in air at health-based levels, with the point of compliance set at the facility boundary. This approach is analogous to regulatory Strategy 2 for ground water.

Under this strategy, typical corrective actions for air could entail covering the releasing unit, treating wastes prior to their storage or disposal in these units, or excavating and treating the source of the air release.

Corrective action would be triggered at the example facility because air emissions exceed the applicable health-based standard at the facility boundary.

Potential corrective measures: The emissions emanate from an active unit. As with Strategy 1, therefore, reducing either the volume of the wastes or the volatility of the constituents should serve as the most effective remedy. Covering the surface of the wastes in the impoundment to reduce contact with the air or waste treatment to reduce the volatility of the constituents may serve as adequate controls. Other controls might include reducing the volume of the most volatile or hazardous constituents or closing the impoundment and switching to other treatment processes, such as in tanks. Although the corrective measures used under Strategies 1 and 2 are similar, the strategies would differ in terms of the frequency with which the measures are applied and the extent of source control needed at the site.

Benefits analysis: This strategy triggers a corrective measure if health-based concentrations are exceeded at the facility boundary. Note that by triggering corrective measures at the facility boundary, many facility air remediations would be triggered even when actual human or environmental exposures above health-based levels are not occurring. In addition, this alternative implies chronic exposure at the facility boundary to air releases, an unlikely scenario given that air releases typically disperse rapidly. As a result, this strategy is protective, but may trigger corrective measures when a unit is not causing harmful exposures.

Strategy 3: Health-Based at the Maximum Exposed Individual (MEI)

This strategy would require corrective measures to address air releases only if there were actual exposures to individuals in excess of health-based standards. Hence, this alternative is analogous to the risk-based approach described under Strategy 3 for ground water.

The actions taken to address air releases under this alternative would not differ from those described under Strategies 1 and 2. However, the need for corrective action activities would be triggered less frequently. Under Strategy 3, corrective actions for air releases could entail covering the releasing unit or treating wastes prior to their storage or disposal. Source controls, such as excavation and consolidation of contaminated materials, are generally not involved in addressing air contamination problems because the source levels dissipate over time.

Because this alternative requires corrective measures only if actual exposures of individuals to contaminant air concentrations in excess of health-based standards are demonstrated, corrective measures would not be required for the example facility.

Potential corrective measures: No action.

Benefits analysis: This strategy differs from Strategies 1 and 2 with regard to the frequency with which corrective measures would be required and the extent of source control mandated once the need for corrective measures is triggered. Hence, Strategy 3 would impose lesser burdens on the regulated community. It is less stringent than Strategies 1 and 2, but this strategy is still protective of human health and the environment by prohibiting exposures at the MEI at levels that exceed health-based standards. This strategy does not explicitly account for environmental or property damage. Nonetheless, placing the point of compliance at the MEI should ensure that releases which affect environmental receptors will be addressed through corrective action.

Comparison and Analysis of Regulatory Strategies for Air Releases

Each of Strategies 1, 2, and 3 outline an approach that is protective of human health. The strategies differ in stringency, however, and in the burden placed on the regulated community, which is measured in terms of the frequency with which corrective measures are triggered. For example, Strategy 1 is most stringent and burdensome and would theoretically trigger the most corrective measures. Strategy 2 is also protective, but would trigger corrective measures less frequently. Finally, Strategy 3 also prohibits exposure to constituents at levels above health-standards and is therefore protective, but would be less likely to trigger corrective measures when they are not needed to protect human health and the environment. Hence, Strategy 3 is least burdensome.

In addition, however, because Strategy 3 would trigger corrective action only when human health is clearly threatened, the strategy does not control exposures at levels below the health-based standards or transient exposures. On the other hand, setting the compliance point for the corrective action trigger and target level at the facility boundary is more protective, but such an approach also would impose costs for corrective action when no populations are actually at risk. Therefore, using the MEI as the point of compliance for triggering corrective action imposes lesser burdens and should still be protective due to the nature of the medium.

4.5.4 Corrective Action for Releases to Air Under the Proposed Rule

Releases to air from solid waste management units present a unique remediation situation. First, unlike releases to other media, air releases from SWMUs impact human and environmental receptors within a short time period after the release, but also disperse rapidly. In addition, corrective measures controlling the source of the air releases stop adverse exposures within a similarly short time frame. Corrective action for air contamination typically will not involve "cleanup" of the contaminated medium, but rather source control to minimize future releases. The Agency anticipates that source control measures for air may include: covering a surface impoundment so that volatile organics will not be emitted, or treating wastes before they are placed in a unit which is releasing hazardous constituents to air.

Under the provisions of the proposed rule, the owner/operator will first compare air monitoring or modeling data collected during the RFI at the facility boundary (or another location closer to the unit if necessary to protect human health and the environment) to action levels for specified hazardous constituents, assuming exposure through inhalation of air contaminated with the hazardous constituents. The action levels for air are based on standard air exposure assumptions typically used by the Agency in risk assessments (i.e., 20 meters^3 per day for a 70 kilogram adult for a 70 year lifetime).

If action levels are exceeded at the facility boundary, the owner/operator would then measure, model, or otherwise estimate air concentrations at the most exposed individual (MEI), or other point of exposure determined by the Agency to be protective of human health and the environment. Again, the owner/operator would compare facility-generated concentration data against action levels in order to allow the Agency to determine the need for corrective measures to address air releases.

If air releases are of concern, the proposed rule provides the Agency with the flexibility to set the point of compliance for hazardous constituent releases to air at the location of the MEI or at a compliance point other than the MEI. For example, where environmental receptors are threatened by air releases between the facility boundary and the MEI, the Agency may specify that the owner/operator demonstrate compliance with facility-specific air cleanup standards at the location of the most exposed environmental receptor.

A population shift into the area located between a point of compliance that was based on the MEI point of exposure and the facility boundary would result in human exposures above health-based levels. In this situation, a permit modification could require additional source controls to reduce exposure levels. Similarly, if at any time during the life of the permit air concentrations exceed the action level at the MEI, the owner/operator would be required to notify EPA and any individuals who may be subject to exposure to the contaminated air.

By generally adopting the approach outlined in Strategy 3, the proposed rule encompasses a protective and reasonable approach for triggering air release remediation. In addition, the proposed rule contains provisions that allow the point of compliance to be moved to account for varying exposure assumptions and uncertainty in exposure modeling. In so doing, the standard may be made more protective and may account for environmental damage or transient exposures. As a result, the rule is sufficiently flexible to account for circumstances that threaten human health and the environment.

5. ILLUSTRATIVE EXAMPLES OF THE CORRECTIVE ACTION REGULATORY STRATEGY

5.1 INTRODUCTION

This section presents three hypothetical case studies which illustrate the application of the proposed corrective action regulatory strategy to specific contamination problems. These case studies have been developed to demonstrate how the proposed regulation works, show how the alternative strategies considered by the Agency in developing the regulation would have worked, and identify some of the differences in results that would be achieved under the proposed regulation and alternative strategies.

The hypothetical case studies have been designed to illustrate a range of complexities of site problems and solutions and to demonstrate some of the variation that may occur in selecting remedies because of the flexibility built into the proposed regulations. The case studies are not designed to provide guidance on selecting corrective measures for actual facilities. The corrective measures selected in these case studies should not be construed to be models for corrective measures at actual facilities that may appear similar to these hypothetical sites. Appropriate corrective measures for actual facilities can only be determined by a site-specific analysis of numerous location, waste, solid waste management unit (SWMU), and release parameters which affect remedy selection.

Each case study provides background information on the facility, solid waste management units, wastes, and releases. Then, the studies illustrate the steps of the investigation and remedy selection process outlined in the proposed rule, providing summary, hypothetical results of a RCRA Facility Investigation (RFI) and Corrective Measures Study (CMS) at each facility. A selected remedy for each case is identified and a brief discussion of why the remedy was selected, based on criteria in the proposed rule and site-specific parameters, are provided. These discussions illustrate the types of tradeoffs that may occur when selecting corrective measures. Estimated costs for the remedial actions are provided for purposes of comparison. These cost estimates are based on rough calculations and take into account some site-specific cost factors particular to each case study facility. These cost estimates should not be construed as generally applicable to or representative of corrective action costs at actual facilities; costs of actions at actual facilities vary greatly according to site-specific factors, such as local availability of necessary materials. Each study concludes with a qualitative discussion of the benefits of the corrective action.

Each case study discusses corrective measures that might have been selected for the facilities under two other regulatory strategies considered in developing the proposed regulation -- the Maximum Protection Scenario (i.e., cleanup to background levels as soon as practicable for all facilities) and the Exposure-Based Scenario (i.e., cleanup to health-based standards only where actual or imminent exposure exists). For each case, corrective measures are identified that would probably satisfy requirements under the alternative approach; also provided are estimates of the costs of the corrective measures (for comparison with costs of the corrective measures selected under the proposed rule). We also present some of the differences in benefits that might accrue as a result of the different actions.

5.2 HYPOTHETICAL FACILITY ONE -- AIRCRAFT RESEARCH TECHNOLOGIES

5.2.1 Background

Aircraft Research Technologies (ART) is a 30-acre industrial plant that manufactures airplane parts. The plant generated hazardous wastes from the operation of a wastewater treatment facility between 1950 and 1977. These wastes, consisting of chromium bearing waste sludge, were placed in a landfill during the operation of the wastewater treatment facility. In 1977, ART closed the landfill and the wastewater treatment facility because water conservation and process changes significantly reduced volume and concentrated the wastes. Currently, the operator stores hazardous waste in two tanks and then ships the waste, periodically, to an off-site disposal facility. The two hazardous waste storage tanks are operating under RCRA interim status; ART has applied for a RCRA permit for these tanks.

Location

ART is located in a rural area about 2.5 miles south of a small city. The entire facility is surrounded by scattered farm residences, the closest being located within one-half mile of the facility boundary.

The surface soil at this site is a silty clay loam and is generally characterized as reddish, moderately well-drained, deep, and medium-textured. The surface soils extend to a depth of 30 feet and are underlain by low permeability silty clay soils. These silty clay soils extend to a depth of 160 to 200 feet in the plant area and are underlain by an aquitard. The water table at the site is at a depth of 40 feet. Flow in the surficial aquifer is slow (10m/yr) and to the southwest. The aquifer is the primary supply of water for rural domestic and agricultural uses in the area. The small city to the north of the plant uses a different source for its water supply. The closest downgradient domestic water supply wells are located about one-half mile from the plant's western boundary.

The region has an average annual precipitation of 37 inches. A small stream is located outside the facility's southeast corner; however, the majority of the 30-acre site, including the waste management area, slopes to the west and is in a different drainage area. Wastewater discharged from the treatment plant entered this stream until 1977.

Solid Waste Management Units

The waste management area at the facility covers approximately 10 acres. The area contains an inactive landfill, a concrete foundation from a disassembled wastewater treatment unit, and two waste storage tanks.

- The landfill was used from 1950 to 1977 for the disposal of semi-solid and solid waste. The landfill covers approximately one and a half acres with waste material deposited at depths up to five feet below the surface. The landfill has not been properly closed (i.e., capped).

- The wastewater treatment units have been disassembled and the equipment has been removed. The tank foundations remain.

- The two waste storage tanks have been used since 1977 to hold hazardous waste which is periodically transported to an off-site disposal facility. The operator has applied for a RCRA permit for these tanks.

There are no regulated land-based units at ART, and therefore, there were no ground-water monitoring wells at the facility until the RCRA Facility Investigation was performed.

The waste generated at the site consisted primarily of waste sludge from the plant's wastewater treatment facility. The sludge (hazardous waste number D007) contains chromium. None of the other types of waste in the landfill is known to contain hazardous constituents.

5.2.2 RCRA Facility Investigation Results

A RCRA Facility Assessment (RFA) was performed by the EPA Regional Office as part of the review process for ART's RCRA permit application. The RFA identified the landfill as a potential source of release of hazardous wastes and/or constituents. No releases were identified from the waste storage tanks.

As a result of the RFA, the operator was required to perform a RCRA Facility Investigation (RFI) in the permit schedule of compliance. The operator developed and submitted a plan for the RFI outlining the overall approach to the RFI, and the processes to be used in characterizing the nature, direction, rate, movement, and concentration of releases from the landfill SWMU. The plan also included procedures for assessing risks to human health and the environment. The RFI focused on evaluating potential chromium releases because it was the only Appendix VIII constituent suspected at the site. Upon approval of the plan, the operator proceeded with the RFI; the results are detailed below.

Release Characterization

The RFI confirmed the release of hazardous constituents from the landfill to both ground water and to soil. Sampling results from the RFI are as follows:

- Soil -- chromium was detected in soil directly below the landfill. About 80 percent of the total chromium in the waste was found to be in the more toxic hexavalent state.

- Ground water -- ground-water sampling results showed a plume of chromium contamination radiating in a southwesterly direction from the landfill.

The maximum concentrations detected in the RFI were

▪ Subsurface soils --	total chromium = 1,000 mg/kg hexavalent chromium = 800 mg/kg
▪ Ground water --	total chromium = 750 ug/l hexavalent chromium = 632 ug/l

These contaminant levels exceed action levels for ground water. The action level for ground water, based on the maximum contaminant level of 0.05 ppm, was substantially exceeded immediately downgradient from the landfill, within the facility boundary. The slow flow of the aquifer (10m/yr), and the slow rate at which chromium migrates, limited the area covered by the contaminated plume to within 300 feet of the landfill.

Contaminant levels in soil were also high. However, because the soil contamination was below the landfill, there was no potential threat of direct exposure to contaminated soil, and the action level for direct exposure was not considered applicable. The owner/operator was required, however, to analyze the potential risk through other media (e.g., ground water) posed by chromium migration from deep soil.

No releases of hazardous constituents to air or surface water were identified during the RFI.

Health and Environmental Assessment

Given the location of the facility and the localized extent of the contamination in the soil and ground water, it is unlikely that any exposure had occurred before the discovery of the contamination. The extent of contamination is illustrated in Exhibit 5-1.

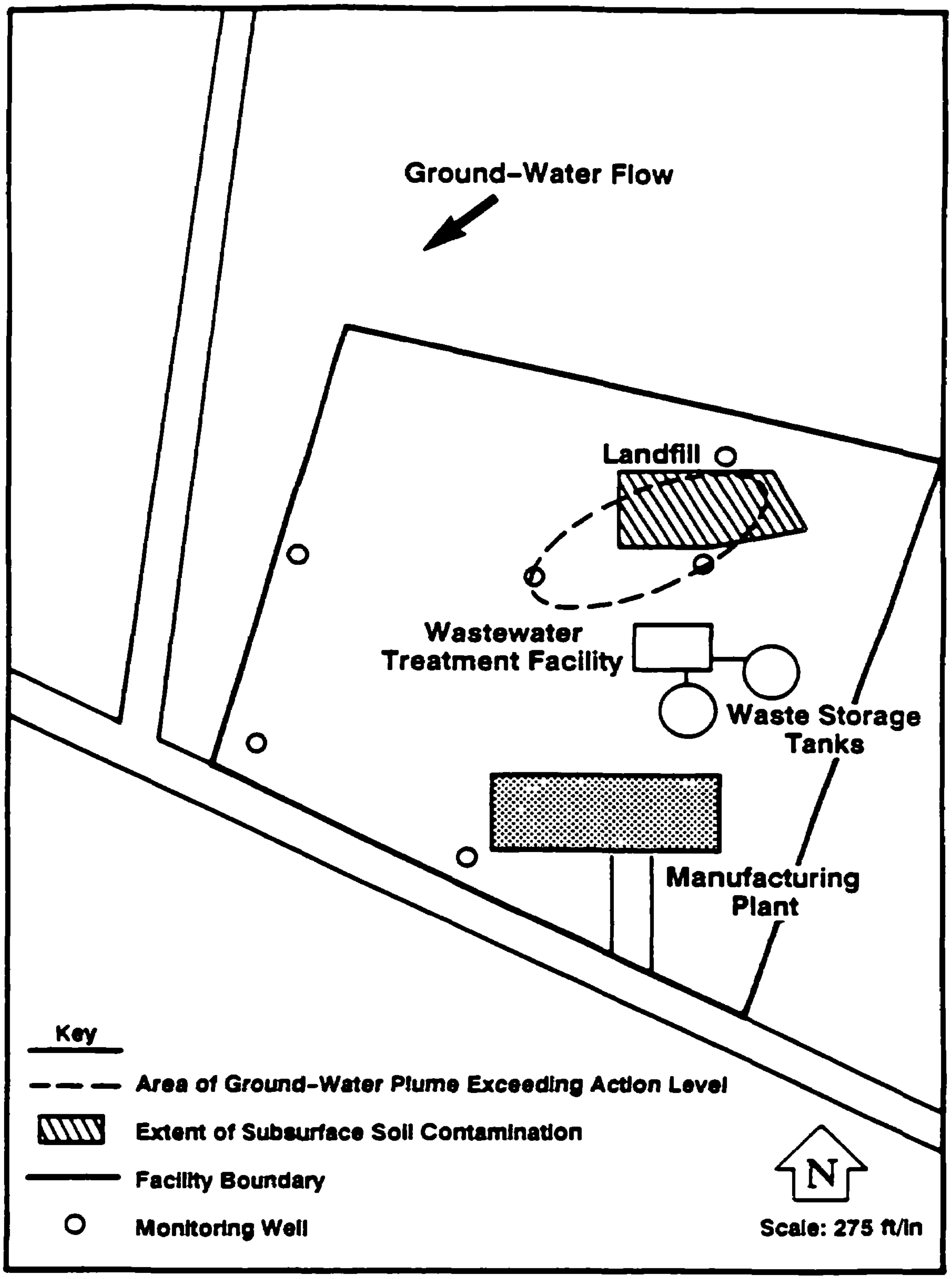
ART's contractor evaluated the extent of contaminant releases and potential routes of contaminant exposure to assess possible future exposures to constituents from the landfill. The results of this assessment are as follows:

- Soil -- Exposure to the levels of chromium in soil at the landfill through ingestion or direct contact is highly unlikely, particularly since the contamination was only detected in subsurface soil and the facility is not readily accessible to the public or wildlife.

- Ground water -- The ground water immediately below and downgradient from the landfill is not a source of drinking water for the facility or the nearby

Exhibit 5-1

Extent of Contamination at ART



residences. Although the aquifer is used as a rural domestic and agricultural water supply, the nearest intake is a half-mile from the boundary of the facility. At the current rate of flow (10m/yr), it would take over 100 years for the contaminated plume to reach the intake. Also, chromium moves much more slowly than the ground water due to adsorption to soil. Because of the slow rate of flow in the aquifer and the slow movement of chromium, exposure to hexavalent chromium through drinking water is not likely to occur, given present conditions at and near the facility.

With no current exposure, the contamination at this site does not pose a direct threat to human health or the environment. The soil contamination does not extend beyond the landfill and the ground-water plume is still a significant distance from the facility boundary. Also, the contamination does not have the potential to migrate rapidly off site, either in the soil or in ground water. The only potential for future exposure would be if the aquifer at the landfill site were tapped for a drinking water source at some point. The probability of such an event is low since ART is likely to occupy the site for an extended period of time. Given these conditions, interim measures were not required.

5.2.3 Corrective Measures Study

The ground-water action level for hexavalent chromium was exceeded at the site, triggering the Corrective Measures Study (CMS) requirements. EPA required ART to evaluate two options in the CMS. ART submitted a CMS plan to EPA which detailed the overall approach and objectives of the study, techniques to be used, and a completion schedule for the CMS.

Upon approval of the plan, ART's contractor evaluated performance, reliability, ease and timing of implementation, media and cross-media impacts, and the appropriateness of the remedial technology. The results of the CMS are described below.

Selected Remedy

Because of the limited current extent of the contamination at ART, the relatively low risk of current or potential future exposures, and the expectation (supported by ground-water modeling studies of the contaminant plume's migration) that very limited movement of the plume will occur over the next several years, a conditional remedy was selected for the ART facility. The remedy selected for ART has four components:

- Source control -- a RCRA cap on the landfill to prevent future migration of the contaminants in the landfill.

- Institutional controls on ground-water use -- ART must prevent use of contaminated ground water originating from the site through control over ground-water withdrawals. Because the plume is completely within the boundaries of the ART plant, and there is a substantial buffer between the plume and the plant boundary, ART can control ground-water use in the contaminated area and prevent nearby withdrawals that might cause the plume to migrate.

- Ground-water monitoring -- ART must continue to monitor ground water to determine future growth or movement of the plume. If monitoring results indicate that significant further degradation of the aquifer is likely to occur, EPA would reopen the permit to require additional remedial measures to prevent or mitigate such damage.

- Financial responsibility -- ART must provide financial assurance for complete implementation of the final remedy.

The selected remedy is protective of human health and the environment; there are no current exposures and contamination is entirely within the facility boundary. The remedy prevents further significant degradation by controlling the source of the release and controls are in place to prevent exposures during the operating life of the facility. Monitoring will allow EPA to evaluate in the future whether further significant degradation is occurring. Financial assurance demonstrates that the company will be able to afford the costs of remediating the facility contamination.

Costs and Benefits

The only major cost involved in the selected remedy is the cost of installing and maintaining the RCRA cap. This cost is on the order of $500,000 for a landfill of this size (one and one-half acres). Operation, maintenance, and capital replacement costs could exceed $100,000 over the time period of the remedy. The costs of ground-water monitoring are minimal, amounting to approximately $70,000 in capital costs plus a small addition for operation and maintenance.

In terms of benefits, the remedy selected ensures that there will be no exposure to contaminated ground water or to the landfill itself. Although the ground water contaminant plume is relatively small, the remedy will result in the eventual restoration of the contaminated ground water to a usable state.

5.2.4 Corrective Actions Under Alternative Regulatory Approaches

The corrective measure selected and discussed above was chosen based upon the proposed corrective action regulatory option ("Flexible Cleanup to Health-Based Standards," or Strategy 2 -- see Chapter 3). The corrective measures selected would be different under alternative regulatory scenarios designed to achieve a greater or lesser degree of protection to human health and the environment. In the following sections, we discuss corrective measures that would be selected under the two alternative regulatory approaches considered by the Agency, as outlined in Chapter 3 of this document. These alternatives are:

- Strategy 1 -- Cleanup to background levels as soon as practicable for all facilities;
- Strategy 3 -- Cleanup to health-based standards only where actual or imminent exposure exists.

Strategy 1: Cleanup to Background Levels As Soon As Practicable For All Facilities

Under Strategy 1, the remedy for the ART facility would likely entail more extensive source controls and cleanup of the affected media to background concentrations as soon as practicable. In this case study, the specific result of this regulatory strategy would be to require the owner/operator to implement the following source control measures: excavation of wastes and contaminated soil; treatment to reduce the toxicity and/or mobility of the hazardous constituents in the wastes and soil; and redisposal of the treatment residues. Additionally, the owner/operator would be required to implement an aggressive pump-and-treat system as expeditiously as practicable to restore the affected ground water to its "background" purity. The pump-and-treat method would, in this case, restore the aquifer in less time (estimated at 10 years based on site-specific modeling) than required for the natural attenuation and dilution relied upon in the selected remedy.

The source and ground-water control measures that would be required under the Maximum Protection Scenario would entail an estimated $7,000,000 in capital costs. With operation and maintenance costs included, the total net present value of the remedy over its operating period would be over $10,000,000.

The main benefit of this more stringent approach is the restoration of the ground water to usable quality in a shorter time period. Since no current or anticipated future uses of the ground water are affected by the current contamination, this benefit would appear to be small based on current knowledge.

Strategy 3: Cleanup to Health-Based Standards Only Where Actual or Imminent Exposure Exists

In contrast to the above example, Strategy 3 would require minimal action at ART because no exposures are occurring or likely to occur in the foreseeable future. The action required under the Exposure-Based Scenario would be limited to ground-water monitoring of the movement of the plume to ensure that any migration threatening ground-water wells would be detected in time to allow actions to be taken to prevent exposures. No source control would be put in place and the ground water would not be restored.

The cost for monitoring alone would be less than $70,000, making this the least costly alternative. This alternative would provide only assurance against future exposures. This option provides no benefits beyond those benefits outlined in the selected remedy and does not provide the benefit of a restored aquifer until the contaminant source is depleted and the plume dissipates through natural processes.

5.3 HYPOTHETICAL FACILITY TWO -- ELECTROMECHANICAL PRODUCTS AND TESTING, INC.

5.3.1 Background

Electromechanical Products and Testing, Inc. (EMPTI) is a 45-acre electrical equipment manufacturing plant constructed in the mid-1950s. The plant manufactures several types of electrical equipment, including capacitors, transformers, and small motors. Operations performed at the plant include machining and metals fabrication, electroplating, solvent degreasing, product assembly, and painting.

Wastes generated from plant operations include solvent and metal contaminated wastewaters, concentrated solvent wastes, cooling and machining oils, and paint wastes. Process wastewaters are treated in a surface impoundment and then discharged to a small publicly owned treatment works (POTW). Non-hazardous cooling and machining oils are evaporated on site. Concentrated solvent wastes and sludges are packed in drums and shipped off site for recycling or disposal.

Location

EMPTI is located in a predominantly rural area and is bordered on the south and east by farmland, with several farm residences located within one-half mile of the facility boundary. The EMPTI plant is bounded on the north and west by a community of 5,000 people. A residential subdivision is located within 600 feet of the northwestern border of the plant. An elementary school serving the subdivision is 500 feet from the plant boundary. The local economy is based on agriculture and light industry, and EMPTI is a major local employer.

The area is a flat, arid alluvial plain composed of inter-bedded sands, silts, gravels, and clays. Several water bearing units combine to form a large surficial aquifer system within these inter-bedded deposits. This aquifer system extends in depth from 40 to 400 feet below the surface and is the primary supply of water for domestic, agricultural, and industrial uses in the community. Horizontal permeabilities in this aquifer range from 10^{-4} to 10^{-3} cm/sec; vertical permeabilities range from 10^{-6} to 10^{-5} cm/sec. Around the EMPTI plant, horizontal ground-water flow is moderately rapid (approximately 100m/yr) and primarily from the southeast to northwest. A downgradient municipal water supply well for the community is located approximately 450 feet west of the facility boundary. A few private domestic wells serve the surrounding farm residences.

The surficial aquifer is underlain by a clay aquitard extending approximately from 400 to 600 feet below the surface. Water bearing units underlying this aquitard contain a confined saline aquifer which is not usable for domestic, agricultural, or industrial purposes.

The region is arid, with an average annual precipitation of 16 inches and an average annual evapotranspiration of 40 inches. The nearest surface water is a river located one-half mile east of the plant. There is no surface drainage from the facility to any surface water body.

Solid Waste Management Units

The plant has several RCRA permitted waste management units used for storing and treating hazardous waste generated during manufacturing. These units are:

- Tank and drum storage units for holding waste solvents and sludges prior to off-site disposal.

- A double-lined surface impoundment used to treat process wastewaters.

The plant also has several other operating or closed solid waste management units. These units cover approximately 15 acres and are as follows:

- Three closed lagoons used from the 1950s until 1980 for storing, treating, and disposing of process wastewaters and sludges. These units cover about five acres. They have not been properly closed (i.e., capped); however, there is no standing water remaining in them.

- One operating lagoon used since the 1950s for the disposal (by evaporation) of non-hazardous machine coolants, cutting oils (which generally contain about 95 percent water and 5 percent oil) and cooling waters. This lagoon covers five acres.

- Five landfill trenches used from 1958 to 1978 for disposing of solid wastes, including paint sludges, electroplating sludges, sludges from vapor degreasers, paint solvents, other waste solvents, rags, and other plant wastes. The trenches cover five acres and have been covered with about a foot of soil.

Wastes managed at EMPTI have contained trichlorethylene, methylene chloride, varsol, toluene, xylenes, methyl ethyl ketone, methanol, and other solvents. Waste polychlorinated biphenyls (PCBs) from transformer and capacitor production were disposed of in rags, transformer and capacitor casings, and other wastes. Additionally, wastewater-treatment and electroplating sludges disposed in the impoundments and landfill contained a variety of metals, including nickel, cadmium, and copper.

5.3.2 RCRA Facility Investigation Results

The EPA Regional Office conducted a RCRA Facility Assessment (RFA) of the EMPTI plant during the review of EMPTI's RCRA Part B permit application.

The RFA results indicated that the following SWMUs were potential sources of hazardous waste and/or constituent releases:

- The three closed lagoons that had been used for treating, storing, and disposing of process wastewaters.

- The "regulated unit" surface impoundment used for treating process wastewaters.

- The operating lagoon used for disposal of coolants, cooling water, and cutting oils.

- The five landfill trenches used for solid waste disposal.

As a result of the RFA, EMPTI was required to conduct a RCRA Facility Investigation (RFI) under the permit schedule of compliance. EMPTI developed and submitted a plan for the RFI which provided for sampling and other investigations necessary to characterize the nature, direction, rate, movement, and concentration of possible contaminant releases from these SWMUs. Upon approval of the plan by EPA, EMPTI carried out the RFI. The RFI results are summarized below.

Release Characterization

The RFI results demonstrated that SWMUs at EMPTI were releasing hazardous constituents to the air, soil, and ground water. The following releases were identified.

- Air -- trichloroethylene was found in air samples taken at the plant and on adjacent property to the northeast.

- Soil -- PCBs, cadmium, and nickel were found in surficial soils surrounding the three closed lagoons. PCBs, trichloroethylene, methylene chloride, dichloroethylene, cadmium, and nickel were found in deeper soils under these lagoons. Trichloroethylene, methylene chloride, and dichloroethylene were found in soils under the landfill trenches.

- Ground water -- trichloroethylene, methylene chloride, dichloroethylene, and vinyl chloride were found in ground water downgradient of the landfill trenches and closed lagoons.

A magnetometer survey conducted during the RFI revealed 25 magnetic anomalies in the landfill trenches. These were assumed to be drums that could become sources of solvent releases if allowed to remain in the landfill.

It was determined that the lagoon used for management of cooling oils was not a source of releases of hazardous constituents.

Concentrations of the contaminants found and their action levels specified in the facility's permit are shown, by medium, in Exhibit 5-2 The following contaminants were found to have been released at concentrations exceeding action levels:

- Air -- trichlorethylene, released from the treatment surface impoundment.

- Soils -- PCBs in soil surrounding the closed lagoons exceeded action levels for exposure through direct ingestion of the contaminated soil. Additionally, soil under the closed impoundments and landfill contained sufficient contaminants to be of concern as a source of ground-water contamination.

- Ground water -- trichloroethylene, methylene chloride, dichloroethylene, and vinyl chloride. Trichloroethylene and methylene chloride were determined to be released by leaching from the closed lagoons, the landfill trenches and contaminated soil under the lagoons. Dichloroethylene and vinyl chloride were determined to be present as a result of the degradation of trichloroethylene.

Health and Environmental Assessment

EMPTI's site investigation contractor assessed the extent of contaminant releases and evaluated potential routes of exposure to released contaminants through monitoring at potential exposure points and through migration modeling. The principal routes of exposure evaluated were air and ground water.

The contractor monitored air quality at nearby residences and at the elementary school, and determined the prevailing wind direction and velocity. The contractor periodically sampled the municipal water supply well downgradient of the plant and installed and sampled additional ground-water monitoring wells to delineate the extent of ground-water contamination.

The results of the monitoring and data evaluation indicated the following:

- Air -- Levels of trichloroethylene in exceedance of action levels were measured at the facility boundary approximately 50 percent of the time. The prevailing wind direction was easterly.

- Ground water -- the municipal supply well was contaminated with trichloroethylene, dichloroethylene, and vinyl chloride at concentrations below the action level. Extrapolation of future contaminant migration indicated that concentrations in the well would exceed action levels in one to two years.

EXHIBIT 5-2

COMPARISON OF MAXIMUM CONTAMINANT CONCENTRATIONS AT EMPTI TO ACTION LEVELS

CONSTITUENTS

MEDIUM	Trichloro-ethylene	Methylene Chloride	Dichloro-ethylene	Vinyl Chloride	PCB's	Nickel	Cadmium
Ground Water:							
Maximum Level Observed (mg/l)	0.5	0.9	0.4	0.3	N.D.	N.D.	N.D.
Action Level (mg/l)	0.005	0.0047	0.007	0.002	-	-	-
Soil:[1]							
Maximum Level Observed (mg/kg)	10.6	12.3	1.1	N.D.	22.4	120.5	15.1
Action Level (mg/kg)	64.0	93.0	12.0	-	0.091	1,600.0	U R.[2]
Air:[3]							
Maximum Level Observed (ug/m^3)	0.45	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Action Level (ug/m^3)	0.27	-	-	-	-	-	-

1 **Action levels are not applicable because concentrations were observed in subsurface soils for which there was no plausible route of exposure through direct contact. No surface contamination was observed for contaminants other than those for which action levels are provided.**

2 **This soil action level was under review at the time of preparation of this document.**

3 **Measured at the eastern boundary of the facility property.**

N.D. -- **Not Detectable**

The results of the investigation are shown on Exhibit 5-3.

Based on these results, the EPA Regional Office determined that interim measures were necessary at EMPTI to address the potential problem of contamination of the drinking water supply well. EMPTI was required to close and replace the well. EMPTI drilled a new well, connected it to the municipal system, and sealed the old well. EMPTI also supplied an alternative water source until the new system was operable.

Additionally, the Regional Office determined that wind-blown soil from the closed lagoons posed a plausible route of exposure to contaminated surface soil and required EMPTI to sample surface soil near the school and in the subdivision. The results of this sampling were negative; no surface soil contamination was found.

5.3.3 Corrective Measures Study

In the CMS, several remedial alternatives were evaluated for addressing the ground water contamination, including an assessment of a number of different approaches to controlling the source of the contamination. In addition, measures that could be effective in controlling the air emissions from the operating surface impoundment were examined.

Selected Remedy

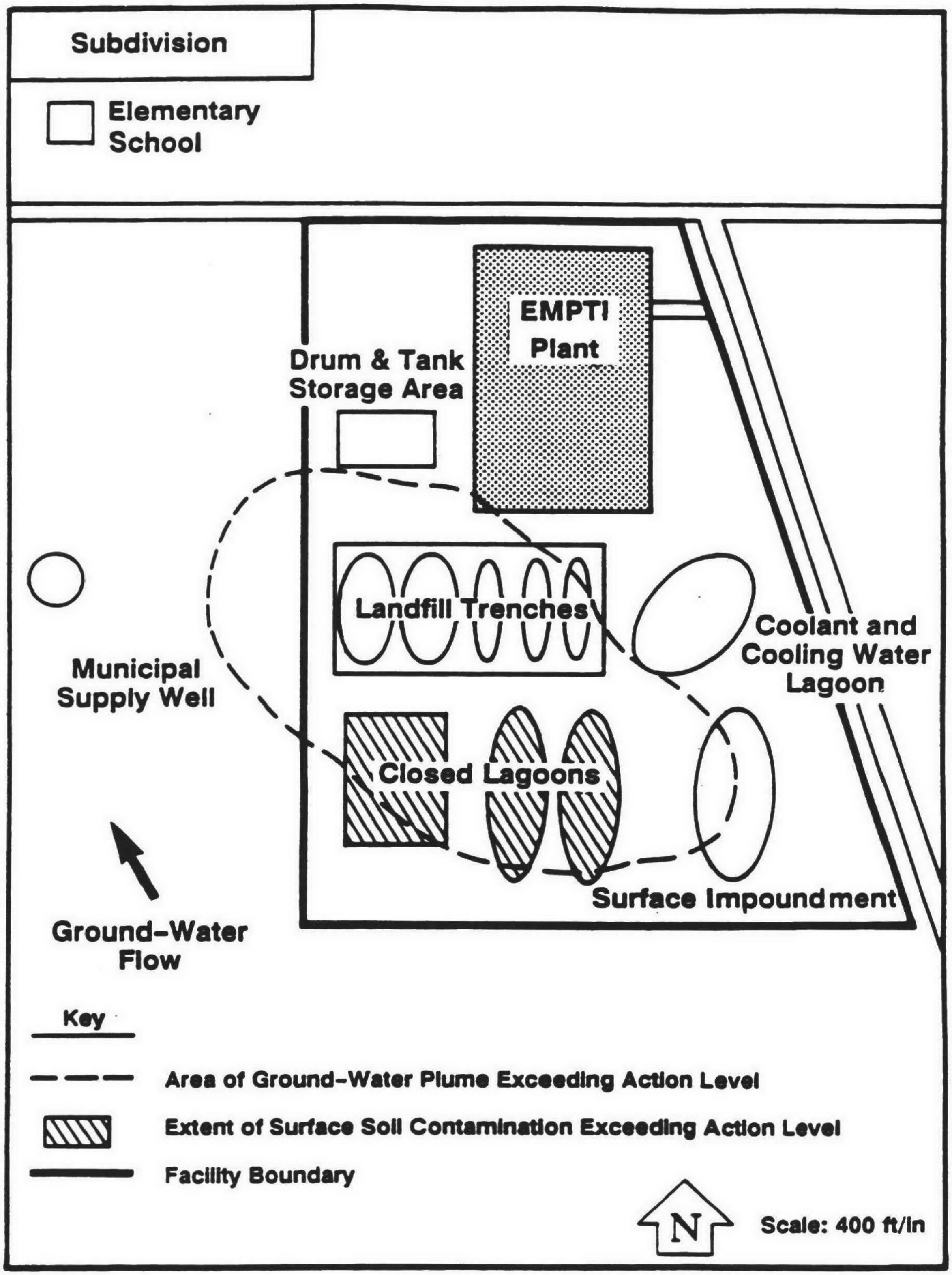
In selecting the remedy for the facility, EPA designated an area circumscribing the three "closed" lagoons as a corrective action management unit (CAMU). Since the wastes in the three old lagoons were essentially identical, and since the soil surrounding the units was also contaminated, the decision was that it would be sensible to treat this area as a single remedial unit for the purpose of implementing source control measures. The selected remedy required EMPTI to excavate the sludges from each of the impoundments, treat those wastes through a stabilization process, and consolidate them into a single nearby clay-lined area that was formerly the middle lagoon. A clay-soil cap over the disposal area was also required.

More specifically, the remedy selected by EPA for implementation at the EMPTI site consisted of the following corrective measures:

- Source control:
  - A 10-acre clay-synthetic cap was required to be installed over the .landfill trenches and closed lagoons. The contractor's study estimated that, following the removal of any remaining liquid drummed solvents, the cap should minimize future releases of contaminants from the landfill and lagoons by effectively eliminating percolation through the wastes and contaminated subsurface soil. Also the cap should also eliminate the possibility of direct contact with the wastes and surrounding contaminated soils.

Exhibit 5-3

Extent of Contamination at EMPTI



- Excavation and off-site disposal of 25 buried drums discovered in the landfill trenches during the RFI.

- Ground-water remediation:

  - Installation of a ground-water withdrawal system consisting of eight well points to remove contaminated ground water.

  - Pumping and treatment of contaminated ground water with activated carbon. Treated ground water would be discharged under the facility's existing NPDES permit, along with the treated process wastewaters already discharged under the permit.

- Ground-water monitoring:

  - Installation of twelve additional monitoring wells throughout the plume area.

  - Sampling and analysis, on a quarterly basis, throughout the corrective action period to determine progress in meeting cleanup objectives and evaluate the effectiveness of the action.

- Air:

  - Although air releases above action levels were detected at the facility boundary, levels of concern were not detected at residences or at the nearby school. Therefore, actual corrective action for air releases was not required. Continued periodic monitoring of air emissions was required, however, and under the terms of a permit condition, EMPTI is required to notify EPA if changes in land use surrounding the facility trigger the need to reconsider remedies for the air releases.

EMPTI's contractor estimated, through use of a site-specific model, that the ground-water cleanup would probably require operation of the pump-and-treat system for 20 to 30 years, with a significant possibility that the required operating period could be longer. EMPTI has provided appropriate financial assurances for this duration. We have assumed that the cleanup would be achieved in 30 years for purposes of estimating corrective action costs.

The selected remedy minimizes potential human and environmental exposures to contaminants by controlling the sources of releases and removing contamination that has been released to ground water. The remedy also protects against direct contact exposure to contaminants remaining at the facility. The alternative does not pose significant risks to the local population during construction, in part because it does not involve excavation of contaminated wastes and soil. Excavation of contaminated wastes and soil, considered as an alternative in the CMS, would liberate buried volatile organics and could result in significant short-term exposures and risks The excavated drums will be managed off-site in compliance with applicable RCRA standards.

Based on the contractor's hydrogeologic investigations, it was concluded that no technically proven methods are more likely to achieve the ground-water standard at this site than pumping and treating. However, innovative technologies under development (such as in-situ bioremediation) could eventually prove more effective.

The remedy does require long-term maintenance of the RCRA cap covering the wastes left in the impoundments and the landfill. However, maintenance should not be extensive because of the arid nature of the region, and EMPTI has committed resources necessary to maintain the site by establishing a suitable financial assurance instrument.

Costs and Benefits

The estimated cost for performing the selected remedy is approximately $5 million in capital costs and $100,000 per year in operation and maintenance costs. The major capital expense for the corrective action is the cap over the trenches and the closed lagoons; this accounts for about 90 percent of the cost. The major cost component for operation and maintenance costs is operation of the ground-water treatment system. We have assumed a 30 year operation and maintenance period for the ground-water pumping and treatment system, and that the cap will not need replacement; however, the withdrawal system may need to operate longer than 30 years to achieve the media cleanup standards.

Benefits from the selected action occur in two categories: resource use and other benefits:

- The principal resource use benefit accrued as a result of the action is availability of current and future water supply. The action prevents the spread of contamination in ground water in the area, preserving ground water beyond the limits of the plume for current and future use as a water supply.

- Other benefits of the action are the preservation of existence and bequest values of the ground water. Because of the arid nature of the region, ground water would be expected to be valued highly both as a current source of water and as a source of water for future generations. Local residents would be expected to place a high value on maintaining ground water in an uncontaminated state, even if it is not currently used as a water source. Thus, returning the contaminated ground water to an uncontaminated state, and preventing contamination of a larger volume of ground water, would restore and preserve existence and bequest values that would be lost if contaminants were allowed to remain.

5.3.4 Corrective Actions Under Alternative Regulatory Approaches

The corrective measure selected and discussed above was chosen based upon the proposed regulatory option for corrective actions. The corrective measures selected for EMPTI would be different under alternative regulatory approaches which are designed to achieve a greater or lesser degree of protection of human health and the environment than the proposed option. In the following sections we discuss the corrective measures that might be required at EMPTI under the two major regulatory approaches EPA considered in developing the proposed rule.

Strategy 1: Cleanup to Background Levels As Soon As Practicable For All Facilities

Under this Strategy, EMPTI would be required to use extensive treatment to control contaminant sources, i.e., the landfill and closed lagoons. Source control would probably require the removal, treatment, and redisposal of most, if not all, wastes and soil contaminated above background levels. A ground water pump-and-treat system would be installed. In addition, technology such as air-stripping with carbon absorption (or the equivalent) would be required to control air emissions.

We have estimated the incremental costs of removing wastes and contaminated soil and transporting them off-site for treatment and redisposal, and the cost associated with air treatment. We have assumed that approximately a third of the wastes would require treatment, and that the remainder could be placed in landfills without treatment. We estimate that the incremental cost of performing the maximum protection alternative at EMPTI would be approximately $100 million. Treatment alone accounts for about one third of the incremental cost. Excavation and transportation are the next most expensive components, with each contributing about 20 percent of the cost.

The incremental benefits provided by this type of remedy, although difficult to quantify, would be in EPA's opinion very small. The contaminated ground water that would be restored to drinkable levels under the selected remedy would be marginally purer, but not necessarily more valuable as a resource. The likely remedy under Strategy 1, however, would be expected to be more reliable over the long term in preventing further releases of concern. This is somewhat offset under the selected remedy by the requirements specified in the permit for extended monitoring to detect future releases, and maintenance requirements for the caps.

Strategy 3: Cleanup to Health-Based Standards Only Where Actual or Imminent Exposure Exists

A remedy at EMPTI under Strategy 3 would likely consist of providing an alternative water supply to the existing supply well and some limited capping to minimize further releases to ground water. Access to plant grounds would be controlled in order to prevent any future exposures through direct contact with contaminated soil. The estimated cost of these measures is approximately $200,000.

This alternative does not provide any of the resource use benefits provided by the selected measure because ground-water contamination would not be cleaned up. It also does not provide benefits in the form of preserved existence or bequest value of ground water.

5.4 HYPOTHETICAL FACILITY THREE -- OFFSITE WASTES, Ltd.

5.4.1 Background

Offsite Wastes, Ltd., (OWL) comprises a 150-acre site owned and operated by an environmental waste management firm. The owner/operator currently operates a 40-acre RCRA Subtitle C regulated landfill at this site. Only one other solid waste management unit (SWMU) exits at this site: a 60-acre landfill that rises about 100 feet above the surrounding topography and contains approximately 6 million cubic yards of waste. This unit was in operation from the late 1950s until 1980. Solid and liquid hazardous wastes and other hazardous substances have been disposed in this SWMU.

Location

The OWL facility is located in a mixed-use area near the southern edge of the suburban community of Bridgetown (population 30,000). The surrounding land-use is residential to the east and north; light industrial to the south along the Route X corridor; and agricultural to the west and northwest. A recreational area lies about 3,500 feet north of the facility along Berry Lake. Because of contamination, the recreational area, which was once popular for fishing, swimming, and water sports, has been reduced over the years to a picnic area. Berry Lake no longer supports any fish, and the park authorities have closed the lake to swimming.

Berry Run is a stream that originates in the southwest and flows northward along the western edge of the landfill, draining into Berry Lake. From Berry Lake, Berry Run flows into the Woodbine River approximately 3,000 feet further downstream. One quarter mile from the confluence of Berry Run and the Woodbine River is the Bridgetown drinking water intake.

The closest homes to the site are part of the Berry Lake Subdivision and are about 2,000 feet from the northeast toe of the inactive landfill. Fifty people reside in this subdivision. A second subdivision lies to the southeast. Several isolated residences lie in the agricultural area to the northwest, across Berry Run.

The site is located in the Atlantic Coastal Plain Region and overlays six geologic formations. Sand and gravel, sand, and sandy clay comprise the majority of sediments in these formations. Within these formations are two aquifers separated by a clay/sandy-clay aquitard approximately 70 to 100 feet thick. In the area of the facility, this aquitard is located at a depth of approximately 100 to 120 feet below natural surface elevations and is composed of sandy clays with permeabilities of 1 x 10^{-6} cm/sec. There is a small amount of flow from the upper to the lower aquifer through this aquitard. Some local wells (in the Berry Lake Subdivision, which is not serviced with municipal water from Bridgetown) are developed from the upper aquifer. The lower aquifer is an important source of municipal water for Wytheville (population 15,000) which lies about one mile south of the OWL facility.

The surficial aquifer is unconfined to semi-confined. Ground water in this aquifer generally flows north to northwest. The inactive landfill is situated directly over this aquifer, and in some areas, contacts the saturated zone. The mean seasonal high water table under the landfill is 10 to 12 feet below natural surface elevation. Estimated ground-water flow velocity is between 15 and 60 meters per year; permeability coefficients for deposits composing this aquifer vary from 5 x 10^{-5} to 5 x 10^{-3} cm/sec.

The lower aquifer is confined and ground water flows to the south, towards the Wytheville municipal well field. The ground-water flow rate in this aquifer is slow, estimated to be 8 meters per year; the permeability coefficient of deposits in this aquifer is approximately 3 x 10^{-5} cm/sec.

The climate of the area is moist, with average annual precipitation of 45 inches and average annual evapotranspiration of 30 inches per year. The average temperature is 55°F.

Solid Waste Management Units

The regulated operating unit was opened in 1980. Total estimated capacity of the unit is 4 million cubic yards; currently, 1 million cubic yards have been disposed in the unit, covering 10 of the unit's 40 acres. The unit was subdivided in 1985; the filled cells were capped, and a composite liner and leachate collection system was constructed for the remaining 30 acres. The composite liner is composed of a three-foot thick clay bottom liner and 40-mil thick synthetic top liner, separated by a drainage layer. Since that time, an additional 250,000 cubic yards of waste have been disposed in the lined section.

The 60-acre inactive landfill operated from 1958 until April 1980. During the summer of 1980, a cap composed of six inches of clay covered by a topsoil layer was installed. This unit extends from a depth of 10 to 20 feet below grade to a height of 100 feet above grade and contains an estimated 6 million cubic yards of waste.

Wastes disposed of in this inactive unit include sludges from municipal and industrial waste treatment facilities, municipal solid waste, and a variety of industrial wastes including spent solvents (F001, F002), pesticide formulations, wood preserving sediment and sludge (K001), off-specification products, and debris. Additionally, residues from a veterinary pharmaceutical firm were disposed in the unit for a five-year period between 1975 and 1980.

5.4.2 RCRA Facility Investigation Results

The EPA Regional Office conducted a RCRA Facility Assessment (RFA) of the OWL site as part of the Part B permit process when OWL applied for an operating permit. Based upon evidence of surface water contamination obtained during the RFA, the requirement to conduct a RCRA Facility Investigation (RFI) was included in a permit schedule of compliance, issued as part of OWL's RCRA permit. The RFA also noted the potential for contamination in other media; hence, the RFI also addressed releases to ground water, soil and sediments, and air. OWL's RFI results are summarized below.

Release Characterization

No releases from the operating regulated unit were identified in performing the RFI. The following releases from the closed landfill were identified in soil, surface water and sediments, ground water, and air:

- Ambient air samples taken at the perimeter of the unit showed very low concentrations of methylene chloride and 1,2-dichloroethane. Beyond the perimeter of the landfill, contaminant levels fell below detection limits.

- Analysis of soil obtained from borings in the unsaturated zone beneath the unit showed contamination with phenol, methylene chloride, 1,2-dichloroethane, and pentachlorophenol.

- During the RFI, OWL noted several leachate seeps on the west and northwest slopes of the landfill. Leachate from these seeps contaminated about 10 acres of surface soil between the landfill and Berry Run. Pentachlorophenol and phenol were found in the soil down to one foot below the surface.

- After conducting ground-water sampling, benzene, 1,2-dichloroethane, methylene chloride, and phenol were found in the surficial aquifer. Sampling in the deeper aquifer downgradient of the facility indicated that there is no contamination in this aquifer from the units.

- Water quality analyses of samples taken from Berry Run and Berry Lake found significant levels of hazardous constituents including benzene, phenol, and pentachlorophenol.

- Sediments sampled in Berry Run and Berry Lake showed pentachlorophenol contamination.

The concentration of the contaminants found and their action levels specified in the facility's permit are shown, by medium, in Exhibit 5-4. The

EXHIBIT 5-4

COMPARISON OF MAXIMUM CONTAMINANT CONCENTRATIONS AT OWL TO ACTION LEVELS

	CONSTITUENTS				
MEDIUM	Benzene	1,2-dichloro-ethane	Methylene Chloride	Phenol	Pentachloro-phenol
Ground Water:					
Maximum Level Observed (mg/l)	1.8	0.35	3.1	4.5	N.D.
Action Level (mg/l)	0.005	0.005	0.0047	1.4	-
Surface Water:					
Maximum Level Observed (mg/l)	0.03	N.D.	N.D.	1.4	0.069
Action Level (mg/l)	0.005	-	-	1.4	1.1
Soil:					
Maximum Level Observed (mg/kg)	N.D.	30.0	15.3	0.6	3000
Action Level (mg/kg)	-	7.7	93.0	3,200	2,400
Air:[1]					
Maximum Level Observed (ug/m^3)	N.D.	0.002	0.0006	N.D.	N.D.
Action Level (ug/m^3)	-	0.038	0.25	-	-

[1] Measured at unit boundary of inactive landfill. Operating regulated unit had no detectable releases to air.

N.D. -- Not detectable.

following contaminants were found to be released at concentrations at or exceeding their action levels:

- Air -- none.

- Soil -- 1,2-dichloroethane, pentachlorophenol from leachate from the inactive landfill percolating through or over soils.

- Ground water -- benzene, 1,2-dichloroethane, methylene chloride, phenol due to leachate from the inactive unit migrating into the ground water and ground water contacting about 10 acres of waste deposited below the high water table. Monitoring results for the upgradient regulated unit confirmed that the contamination originates from the closed landfill.

- Surface water -- benzene, phenol from leachate flowing over ground and reaching surface water and discharge of contaminated ground water into surface water.

- Sediments -- pentachlorophenol in surface water preferentially adsorbed onto the sediment particles.

Health and Environmental Assessment

In the RFI, OWL's scientists assessed the extent of the releases and evaluated the potential for exposure to the releases in each of the affected media. Their investigation identified the following areas with the potential for exposure to contaminants released from the inactive unit:

- Soil -- There is no direct exposure potential to the unsaturated zone soil under the inactive landfill; however, contaminants in this soil may migrate into ground water. Surface soil contaminated by leachate and runoff has the potential for direct contact even though the facility has restricted access.

- Ground water -- The plume extends about 1,500 feet to the north and laterally to the northeast. It is cutoff by Berry Run to the northwest and discharges into the Run. Although the plume extends towards the Berry Run Subdivision, the plume does not reach any residential wells. At the current rate of expansion, it will take about 10 years to reach the nearest wells, through lateral expansion of the plume.

- Surface water -- Berry Run and Berry Lake do not support aquatic life; therefore, exposure through fish consumption is not presently possible. Swimming has been prohibited by the authorities, limiting dermal exposure; however, accidental exposure to contaminated surface water is possible. Berry Run and Berry Lake have never been sources of drinking water. None of the contaminants from the OWL site has been detected in the surface water intake for Bridgetown. (A surface water area of approximately 3 acres contacts contaminated sediments.)

Presently, the only potential exposure is by accidental contact with contaminated surface water and sediments in Berry Run and Berry Lake. Because of this potential, additional restricted access to Berry Run and Berry Lake was initiated as an interim measure.

The extent of the releases is shown in Exhibit 5-5.

5.4.3 Corrective Measures Study

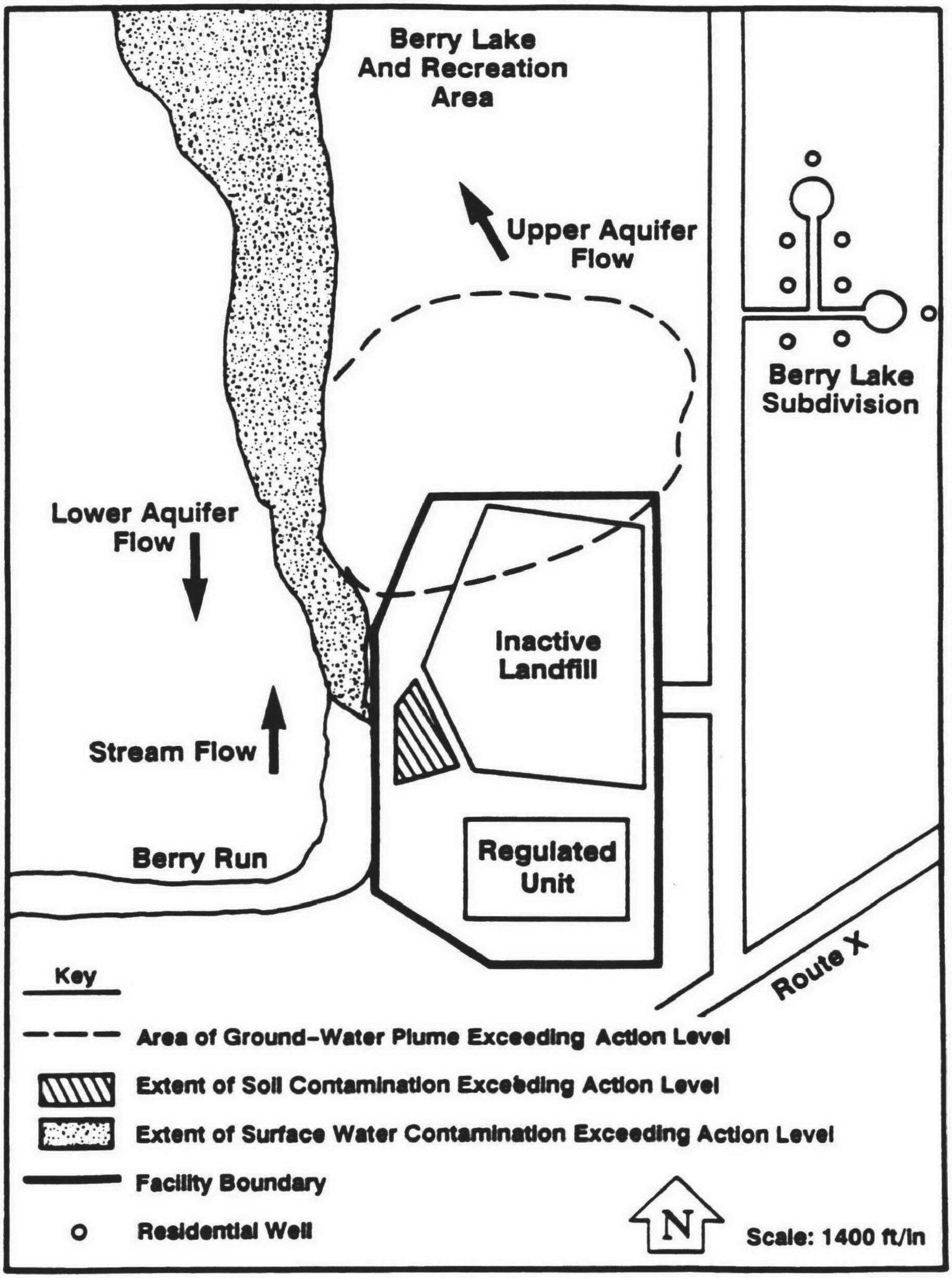
The EPA Regional Office requested OWL to conduct a Corrective Measures Study (CMS) after results from the RFI indicated that action levels were exceeded in the following media: soil, ground water, and surface water. Based on the results of the CMS, the following remedy was selected.

Selected Remedy

- Twenty well points were installed to lower the water table below the inactive landfill and to capture ground-water contaminants.
- Contaminated ground water was treated by the addition of chemical oxidants. Treated ground water was discharged to Berry Run.
- Ground-water monitoring was in place over the area of the plume.
- A diversion ditch was constructed to prevent run-on to the south side of the inactive landfill.
- Contaminated surface soil was excavated and consolidated into the inactive landfill.
- A cap meeting RCRA §264.310 minimum technology standards was installed over the inactive landfill.
- Berry Run was temporarily diverted and sediments from the stream bed were excavated.
- Contaminated sediments were dredged from Berry Lake and a temporary dewatering impoundment was installed. Supernatant water was collected and a system designed for ground-water treatment was put in place. Dried sediments were disposed of in the regulated unit.

Exhibit 5-5

Extent of Contamination at OWL



The proposed remedy is intended to control the source of the releases, capture and treat the contaminated ground water, and restore surface water quality. Capping as a source control was selected over other options (e.g., excavation and treatment of waste in the inactive landfill), because the size of this unit and limited treatment and disposal capacity made such actions infeasible. The selected measures, over the time that it takes to implement the action, will eliminate exposure to surface water and soils and reduce, to an acceptable degree, the potential for future exposure to contaminated ground water. Ground-water modeling efforts predict that contaminant concentrations over the whole plume area will fall below the media cleanup standard within 20 years. The cap and the pump-and-treat controls are well established corrective actions indicating a high degree of reliability. The removal of sediment from both Berry Run and Berry Lake is a reliable measure because it prevents further contamination of the surface waters. Water treatment alone is not always sufficient to bring surface water quality to an acceptable level. The wells and treatment unit should operate for 20 years prior to replacement. The cap is estimated to need replacement after 40 years.

Costs and Benefits

The corrective measures for OWL's solid waste management unit are estimated to cost close to $60 million in initial capital costs, the majority of which is the cost of the large cap required for a site of this size. Annual operation and maintenance costs are estimated to be $4 million, plus any additional capital replacement costs.

Once implemented, the chosen corrective measures would produce a number of benefits by preventing further degradation of soil, ground water, and surface water, and by actually restoring surface water quality. In an uncorrected state, environmental problems at the site would continue to worsen considerably. Because the damage is potentially severe, the corrective action provides substantial benefits:

- Health -- The remedy eliminates the potential for any future exposure to the contamination at or near the site and to contaminated drinking water. It can be assumed that contamination of the residential wells in the Berry Lake subdivision would be detected, and that upon detection an alternative supply would be put in place. However, the remedy eliminates any potential health damages that could occur from drinking water prior to detection.

- Use value -- Because the corrective measures restore the quality of drinking water in the area, a major benefit of the remedy is preserving the use value of the water resources. Once the surface and ground water are returned to a usable state, these resources are once again available for future drinking water use. By making these water sources available for future use, the corrective measures save the cost of developing alternative supplies.

- Recreation value -- The corrective measures will restore the recreational area at Berry lake once the water quality is improved to levels that will allow fishing, swimming, and boating. Once the surface water is no longer contaminated, it is expected that wildlife will return to the area. The value of these resources for recreational use is restored. Because the recreational area was once very large and provided a recreational area for thousands of nearby residents, this benefit is likely to be substantial.

- Non-use value -- As with all types of natural resources, people place a value on preserving a resource in its natural state and preserving the option to use the resource in the future. The chosen remedy will return the area (stream, lake, and aquifers) to its natural state over time and provide such a benefit.

5.4.4 Corrective Actions Under Alternative Regulatory Approaches

The corrective measures selected and discussed above were chosen based upon the proposed regulatory option for corrective action. The selected measures would be different under regulatory scenarios that were anticipated to achieve either a greater or lesser degree of protection for human health or the environment. In the following section we discuss briefly corrective measures that would be selected under alternative regulatory approaches considered in the development of the corrective action standards. These alternatives are the Maximum Protection Scenario and the Exposure-Based Scenario.

Strategy 1: Cleanup to Background Levels As Soon As Practicable For All Facilities

Under Strategy 1, OWL would probably be required to perform much more extensive remediation. This would require all of the remediation steps in the chosen remedy, with the addition of requiring removal of the highly contaminated waste areas from the inactive landfill. This entails identification of "hot spots," excavation, treatment (assumed to be incineration), and disposal of the residuals.

The corrective measures for OWL's solid waste management unit under the maximum protection alternative are estimated to cost $250 million in initial capital costs. Approximately two thirds of the total cost (approximately $200 million) would be attributable to excavation of hot spots and on-site incineration. Annual operation and maintenance costs are estimated to be $4 million, as in the chosen remedy.

This type of remedy would decrease the length of time necessary to attain the ground-water cleanup standard, but modeling efforts predict that time reduction would be insignificant (18 years instead of 20). Identification, excavation, and treatment of the hot spots would delay capping the landfill for at least a year. Preventing infiltration by capping was found to be more effective in reducing migration of contaminants to the ground water than reducing contaminant content of the landfill. The time to recapture released contaminants in the ground water, which would not be affected by the excavation requirement, is the major factor in the time period necessary to reach the media protection standard.

Strategy 3: Cleanup to Health-Based Standards Only Where Actual or Imminent Exposure Exists

Under this regulatory strategy, OWL's remediation efforts would likely be limited to the following corrective measures:

- Installation of a single layer clay cap over the landfill.
- Maintaining restricted access to the stream and lake indefinitely.
- Monitoring the movement of the ground-water plume and of the surface water contamination.
- Replacing the water supply to the Berry Lake Subdivision only when the wells show signs of contamination.

The present value capital costs of these remedies is less than $20 million. Annual operation and maintenance costs are expected to be less than $500,000 dollars.

The exposure-based alternative provides no incremental benefit over the chosen remedy, and in fact, provides no benefit other than maintaining the access restrictions, thereby reducing the likelihood of accidental contact with the contamination. None of the resources is restored to a usable state. Because the resources have not been restored there is no resource use benefit, and no preservation of option value, existence value, or bequest value.

PART 2

QUANTITATIVE ANALYSIS OF GROUND-WATER CORRECTIVE ACTION

6. APPROACH TO QUANTITATIVE ANALYSIS

EPA quantitatively analyzed five regulatory alternatives related to ground water that were considered by the Agency in the development of the proposed corrective action rule. This chapter describes the overall approach to the analysis while Chapters 7 and 8 present the results of the analysis.

EPA limited its quantitative analyses to ground water, rather than including other media, primarily because modeling tools for other media were not readily available. This RIA, therefore, only examines quantitatively the costs and effectiveness of the regulatory options in terms of protecting ground water. The ground-water regulatory options are analyzed using one of EPA's hazardous waste release, fate and transport, and corrective action models (the Liner Location Model). This model and other such models have been used extensively by EPA to analyze previous hazardous waste regulations. The focus of previous hazardous waste regulations, however, has been the protection of ground water.

The basic approach taken in the analysis involved use of the Liner Location Model to simulate each of the five regulatory alternatives as it would be applied at a sample of 65 RCRA facilities. This chapter first describes the facility data base used in the RIA in Section 6.1. Section 6 2 then describes the model used to simulate ground-water contamination and corrective action costs. The parameters used to distinguish among the simulated regulatory alternatives are discussed in Section 6.3. The remaining Section, 6.4, defines the five regulatory alternatives modeled in the RIA.

6.1 FACILITY DATA BASE

As explained in Chapter 2, there are over 5,600 RCRA facilities potentially subject to EPA's proposed corrective action requirements. Since it was not possible to study the effects of these requirements at each RCRA facility, a sample of facilities was chosen and characterized. The development of the facility data base is described in detail in Appendix A; this section briefly explains how the data base was developed.

Because of the detailed nature of the RIA, EPA had to obtain a significant amount of information on each facility included in the sample. Required information included data on the types of waste management units at the facility, the dates of operation of each unit, the types of wastes handled, and the quantities of waste handled. A number of data sources for this information were considered, including Part A and Part B permit applications, RCRA inspection reports, responses to Regional requests for information on solid waste management units (SWMUs), and RCRA exposure assessments. None of these data sources was readily accessible and available in a consistent format for use in this RIA. Consequently, RCRA Facility Assessments (RFAs) were chosen as the primary source of information for the

RIA. RFAs generally represent a compilation of several data sources on individual facilities. Further, because RFAs are prepared as part of EPA's existing corrective action process, they tend to include a great deal of information relevant to the analysis of corrective action regulations.

Two factors limited the group of facilities in the sample. First, the sample was limited by the fact that, as of April 1987,[1] RFAs had been completed at 624 facilities. Second, of these RFAs, 437 called for the next step in the corrective action process, the RCRA Facility Investigation (RFI). The other 187 facilities were determined not to require corrective action. EPA assumed that facilities for which the RFA did not recommend an RFI pose negligible environmental and human health damages. A sample was thus drawn from the 437 facilities where the RFA indicated the need for the RFI. Because EPA has placed a priority on completing RFAs at land disposal facilities, a significant fraction of the available RFAs are for land disposal facilities; a simple random sample of the available RFAs would thus not have produced a representative sample. Consequently, EPA stratified the sample based on facility type. As a result, the proportions of land disposal (26.3 percent), treatment/storage (70.2 percent), and incineration facilities (3.5 percent) in the sample are approximately the same as in the population of RCRA facilities assumed to require an RFI.

The final sample includes 65 facilities, of which 21 are land disposal, 41 are treatment/storage, and three are incineration. Because of the way the sample was selected, these facilities are intended to represent only those facilities at which the RFA will call for an RFI. As explained in Appendix A, these facilities are believed to represent about 62 percent of all facilities. At the other 38 percent of all facilities, environmental damages and corrective action costs are all assumed to be negligible.

Analytic results related to the entire population of RCRA facilities presented in Chapters 7 and 8 thus include an adjustment for the fact that, in addition to the effects observed at facilities represented in the sample, there will be no impacts on those facilities (i.e., those where an RFI is not required) not represented in the sample. In calculating the number of facilities undertaking corrective action, for example, a two-step process was used. First, it was determined that roughly 50 percent of the facilities in the sample, i.e., those with RFIs, would trigger corrective action. Second, because the sample represents only the 62 percent of all facilities likely to receive an RFI, the proportion of all facilities triggering corrective action was calculated as 50 percent of 62 percent, or 31 percent. This adjustment assumes that facilities that do not require an RFI will also not trigger corrective action. As a result, the calculations accurately represent all facilities potentially subject to the corrective action program, not just those where an RFI is required.

Each of the 65 facilities was characterized based on a review of the information contained in the RFA and, where data were unavailable, based on best professional judgement. This process yielded the following parameters:

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[1] The sample of facilities was drawn in April 1987.

- Number and types of SWMUs at the facility;
- Dates of operation of SWMUs;
- Types and quantities of wastes managed in SWMUs;
- Regulatory status of each SWMU; and
- Other information related to Federal ownership and type of facility.

Using EPA's DRASTIC system, the hydrogeology and climatic setting of each facility were also characterized by locating the geographic coordinates of the facility within a particular DRASTIC setting. Each DRASTIC setting was defined in terms of depth to ground water, net infiltration, saturated and unsaturated zone permeabilities, and ground-water velocity. The facilities in this data base were then analyzed as described in the following section.

6.2 MODELING OF GROUND-WATER CONTAMINATION AND CORRECTIVE ACTIONS

The quantitative analysis of ground-water regulatory options in this RIA uses a computer simulation model developed by EPA. This model, the Liner Location Model (LLM), simulates ground-water contamination at hazardous waste management facilities. The LLM was developed several years ago by EPA's Office of Solid Waste to analyze the costs and risks of various hazardous waste design and operating regulations. The LLM was modified for use in this RIA and has been used to estimate effectiveness and corrective action costs for contaminated ground water. As shown in Exhibit 6-1, the LLM consists of several parts, each of which is briefly described below.[2]

6.2.1 Facility, Waste, and Environment Characteristics

The LLM begins with a basic characterization of each facility to be analyzed. This information, which describes the operation of all SWMUs at the facility, the types and quantities of wastes managed, and the facility hydrogeologic and climatic setting, is used as an input to the model. For this RIA, the facility data base described in Section 6.2 provided all information necessary for facility characterization.

6.2.2 Releases of Hazardous Wastes

Based on the facility characterization, a facility-wide release profile is generated. This release profile contains the total mass of each contaminant constituent released in each year of the modeling period. For this analysis, the modeling period extends for 200 years from 1920 to 2119. The facility-wide release profile is calculated by summing, on an annual basis, the release of each constituent from each individual SWMU at the

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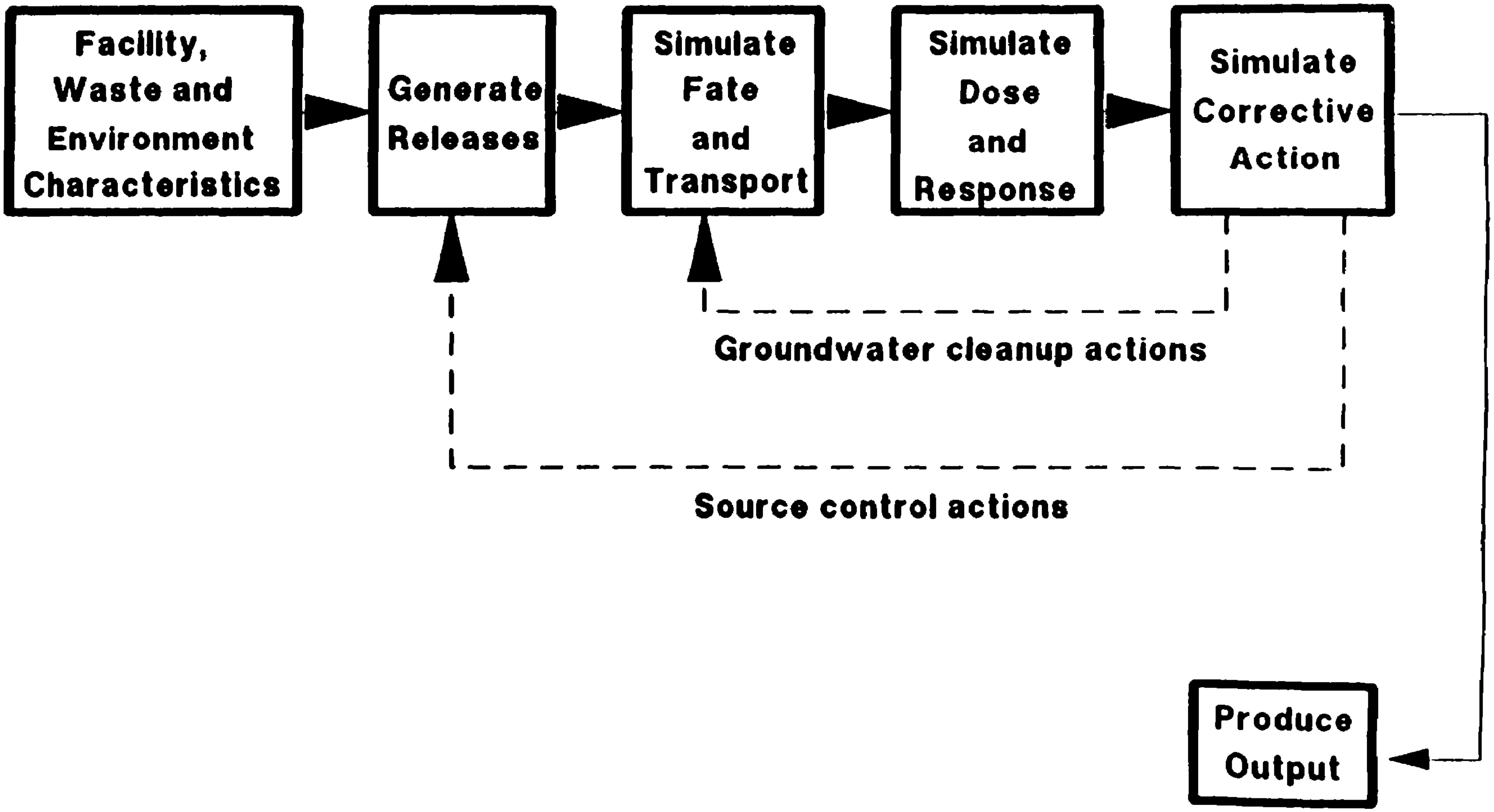
[2] See also U.S. EPA, "The Liner Location Risk and Cost Analysis Model: Phase II Report," prepared by ICF Incorporated, March 1986.

EXHIBIT 6-1

OVERVIEW OF THE LINER LOCATION MODEL



facility. The approach used to estimate releases from a specific SWMU depends on the SWMU type and, as described below, is based on methodologies developed by EPA in support of previous rulemaking efforts.

For releases from landfills and surface impoundments, releases are calculated by a stochastic Monte Carlo simulation model that estimates the timing and magnitude of the contaminant release. These release profiles are time dependent and the annual quantity of waste released may change over time. Because of its stochastic nature, the simulation model produces a range of release profiles which are clustered into relatively homogenous groups. A release profile is then developed to represent each cluster. A weight, or probability, for each of the representative release profiles is then derived based on the likelihood of all profiles contained in the cluster. For this RIA, EPA selected from among these representative profiles the release profile with the greatest quantity of waste released that had a relative weight of at least ten percent. Releases from landfills and surface impoundments are simulated to continue until a mass balance calculation indicates that no contaminant mass remains in the unit.

Releases from tanks are simulated in a similar fashion based on the results of EPA's Hazardous Waste Tank Failure Model (HWTFM).[3] The HWTFM is also a stochastic model and generates several release profiles for each of several different tank technologies. For each technology, these release profiles are clustered and representative profiles are developed for each cluster. A single profile is then selected from among the representative profiles. The selected profile is the one with the greatest quantity released and a relative weight of at least ten percent. These profiles were estimated for an assumed 20 year operating life. Consequently, the profiles must be adjusted based on the different reported operating lifetimes for the tanks located at facilities in the sample data base. For tanks in operation less than 20 years, the release profile is truncated at the year of closure and releases are set to zero. For tanks operating for more than 20 years, the annual quantity of waste released every year after year 20 is assumed to be the average annual profile quantity estimated for years between 15 and 20 years.

Releases from land treatment units, waste piles, and injection wells are estimated based upon the RCRA Risk-Cost Analysis Model (also known as the W-E-T model).[4] For each of these unit types, the W-E-T model estimates a constant annual release during the unit's operating life. After unit closure, EPA assumed that releases drop to 10 percent of the constant release and continue releasing at that rate until all mass in the unit is depleted.

For other units, including container storage areas, waste recycling units, and incineration units, simple algorithms were developed that estimate the quantity of waste released as a function of the unit's throughput. EPA

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[3] See U.S. EPA, "Hazardous Waste Tank Risk Analysis, Draft Report," prepared by ICF Incorporated and Pope-Reid Associates Incorporated, June, 1986.

[4] See U.S. EPA, "The RCRA Risk-Cost Analysis Model, Phase III Report," Appendix D, prepared by ICF Incorporated, March, 1987.

also developed a method for estimating the quantity of waste released to the unsaturated zone from a systematic spill of waste on the ground.

6.2.3 Simulation of Fate and Transport

After the releases from all SWMUs have been aggregated into a single facility-wide release profile, the fate and transport of the released contaminants in the environment is simulated. Movement of contaminants downward through the unsaturated zone is simulated using a modified version of the McWhorter-Nelson Wetting Front Model that accounts for the degradation of constituents and the delay associated with movement in the unsaturated zone. Once contaminants reach the aquifer, their movement is simulated using a two-dimensional random-walk particle tracking model (adapted from Prickett, et al, 1981).[5] The concentration of each contaminant at each of several down-gradient wells is then calculated.

6.2.4 Simulation of Corrective Action

If the contaminant concentration at a ground-water monitoring well exceeds a specific level, the LLM simulates the implementation of a corrective action. Within the LLM, if corrective action is triggered, the model estimates the costs of the corrective action and adjusts the contaminant concentrations to reflect the impact of the action. The specific remedies simulated by the model are:

1. Capping - Wastes in the unit are capped to prevent infiltration of precipitation. Capping is assumed to be up to 100 percent effective in reducing the concentration of contaminants measured in the ground-water contaminant plume for 35 years. After 35 years, the model assumes that the cap will immediately fail.

2. Recovery wells - Ground-water recovery wells pump and treat contaminated ground water. Recovery wells are generally assumed to be 95 percent effective in reducing the concentration of contaminants in the plume (i.e., the concentration of a hazardous constituent is reduced 95 percent once the wells become fully effective). Contaminant concentrations at exposure wells located within the plume are, however, reduced by an amount less than 95 percent.

3. Excavation - All wastes and the liner system are excavated from the disposal unit. Excavation is assumed to be 100 percent effective in eliminating the release of wastes to the unsaturated zone. Non-land based units and associated wastes (e.g., tanks) are assumed to be excavated as well, using assumptions on

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[5] Prickett, T.A., T.C. Haymick, and L.G. Lonquist. 1981. "A 'Random Walk' Solute Transport Model for Selected Groundwater Quality Evaluations." Bulletin #65, Illinois State Water Survey.

average tank volumes. The model assumes that all wastes excavated from units are disposed off-site.

4 Excavation with recovery wells - The remedy is assumed to be 100 percent effective at eliminating the release of wastes to the unsaturated zone, but the effectiveness of the wells in reducing contaminant concentrations is generally assumed to be 95 percent, as noted above.

These four remedies were selected to represent the range of costs and effectiveness of available corrective action technologies. No other combinations of remedies (e.g., capping with recovery wells), or types of remedies, than those listed here are used in the model.

6.2.5 Remedy Selection

The model evaluates the four ground-water corrective measure remedies and chooses a single remedy for each facility using three criteria. They are:

1. Effectiveness - Measures the number of years after corrective action is triggered that are required for the remedy to achieve the corrective action target level at all wells located within 1,500 meters of the unit boundary. In some regulatory options, it is sometimes the case that one or more of the modeled remedies require more than 132 years (i.e., beyond the end of the model's time horizon) to achieve the target level. The effectiveness of such remedies is set at 132 years and the fact that the target was not met is noted by the model.[6]

2. Cost - Measures the net present value cost of implementing the corrective measure remedy (discounted at three percent to 1987). Chapter 8 of the RIA discusses how the costs for ground-water corrective action are calculated.

3. Feasibility - Measures the technical feasibility of implementing a particular corrective action technology. Remedies that are inappropriate for particular releases from units are not selected (e.g., source control remedies are not selected if all wastes have been released from the unit).

Different remedy selection rules are used for each of the five regulatory alternatives described in Section 6.4. These rules are based on the three criteria listed above.

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[6] The assumptions used in measuring the effectiveness of the modeled remedies are discussed in Chapter 7.

After the model has simulated the release of contaminants, the fate and transport of those contaminants in ground water, and the costs and effects of corrective action, it produces a wide range of output that can be studied in order to assess the costs and benefits of various regulatory options.

6.3 PARAMETERS USED TO DEFINE GROUND-WATER REGULATORY ALTERNATIVES

The simulated regulatory alternatives differ with respect to several key model parameters:

- Units regulated;
- Regulated media;
- Corrective action trigger;
- Corrective action target;
- Point of compliance; and
- Extent of contamination.

Each of these parameters is described in turn below.

The units regulated differ among options. Under the baseline scenario, for example, only active land disposal units that received hazardous waste after July 26, 1982, known as "regulated units," are assumed to be subject to the pre-HSWA RCRA Subpart F regulations (i.e., standards in effect prior to 1984 and prior to imposition of §264.101 requirements). Under Options A through D, however, HSWA is assumed to extend corrective action to all solid waste management units (SWMUs).

Of note is that only about 4 percent of all 83,000 solid waste management units were subject to Subpart F requirements before HSWA. These units are simulated to be subject to corrective action both in the baseline and in Options A through D. The remaining 96 percent of all units that were not previously required to address contaminant releases are assumed to be subject to corrective action requirements only in Options A, B, C, and D.

The regulated media can potentially include air, ground water, surface water, and soil. Prior to the enactment of HSWA, only releases to ground water were regulated under RCRA; after enactment, releases to all media are regulated. The quantitative analysis conducted in the RIA is generally limited to corrective action for ground-water contamination. Thus, the regulatory options analyzed in Chapters 7 and 8 are defined in terms of ground-water corrective action only and therefore underestimate the number of facilities with other types of releases regulated by the corrective action requirements.

The corrective action trigger used in the model is the ground-water contaminant concentration that the model uses to initiate cleanup. The trigger concentration may vary with the stringency of the simulated regulatory option. Depending on the option being simulated by the model, corrective action can be triggered by a release that exceeds one or more of the following: a ground-water protection standard,[7] a release in excess of a background concentration,[8] or a release in excess of a health-based standard. In our analysis, the choice of a trigger concentration is closely linked to the decision about where to monitor for compliance, as described below. The specific triggers used in the model are listed in Appendix B. The model also assumes for all options that the effects of corrective measure remedies start one year after contaminant concentrations in excess of the applicable trigger level are detected, based on an assumption that ground-water remedies take one year to plan, construct, and implement.

The corrective action target is the contaminant concentration that the corrective action must be designed to achieve in the model. When the target concentration is reached, the simulated corrective action is considered successful. Due to modeling limitations, all options are analyzed assuming that the target level is equal to the trigger level.[9] As with the corrective action trigger, a determination must also be made about where to monitor for compliance with the corrective action target.

The point of compliance is the physical point at which the corrective action trigger and target levels are measured in the model. Depending on the simulated option, several points of compliance are used in the model, including:

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[7] The ground-water protection standard is a regulatory concept that is discussed later in this chapter, under the baseline scenario definition.

[8] Note that the model assumes for all scenarios modeled that background levels are zero. As a result, the RIA may underestimate the likelihood of triggering corrective action for all options and may overestimate the cost of the baseline scenario and Option A, which both require cleanup to background.

[9] This assumption may not directly reflect the implementation of the proposed rule. Under the proposed rule, the corrective action target would be set by the Director (i.e., the Director of the State environmental agency or the EPA Regional Administrator) on a case-by-case basis at levels that are protective. In setting the target, the Director may consider:

- Multiple contaminants in the medium;
- Exposure threats to sensitive environmental receptors;
- Other site-specific exposures or potential exposures to contaminated media; or
- The reliability, effectiveness, practicability, or other relevant factors of the remedy.

The analysis included in the RIA is not, however, sufficiently detailed to discern those situations in which target adjustments would be applied.

- The edge of the waste management area (an imaginary line circumscribing the waste management unit or units - assumed to be 10 meters from the unit boundary);
- The facility boundary (the property line of the hazardous waste management facility - assumed to be 200 meters from the unit boundary); and
- The point of human exposure (the point of potential human contact with the contaminated medium - generally assumed to be 600 meters from the unit boundary).

The point of compliance in the model is tied to the trigger for some options. For example, because corrective action is triggered by human exposure in excess of a health-based standard under Option D, the point of compliance is at the point of human exposure. Due to dispersion and attenuation of contaminants in ground water, as the point of compliance is moved closer to the unit boundary, the likelihood of a corrective action being triggered in the model for a given contaminant concentration is increased.

The extent of contamination determines whether off-site corrective action is required in the model. Prior to HSWA, off-site corrective action was not required under Subpart F. Based on RCRA Section 3004(v), however, Options A through D are assumed to include off-site cleanup, although the timing of the off-site action varies among options.

6.4 DEFINITION OF GROUND-WATER REGULATORY ALTERNATIVES

This section describes each of the five regulatory alternatives used in the quantitative analysis of ground-water contamination for this RIA. Its major purpose is to focus on the modeling assumptions used in defining the five alternatives. All of the differences between the five simulated options and the proposed corrective action rule are not, therefore, described. Where pertinent, however, comparisons between the proposed rule and the RIA are drawn and implications for modeling results are discussed.

The RIA considers the following regulatory alternatives for addressing ground-water releases:

- Baseline Scenario;
- Option A: Immediate Cleanup to Background;
- Option B: Immediate Cleanup to Standards;
- Option C: Flexible Cleanup to Health-Based Standards;
- Option D: Flexible Cleanup based on Actual Exposure.

The baseline scenario described in this chapter represents the requirements under RCRA that were in effect prior to codification of the HSWA corrective action requirements. The remaining four regulatory options (i.e., Options A through D) represent different approaches to implementing the corrective action requirements of Sections 3004(u), 3004(v), and 3008(h) of RCRA as well as concurrent changes to the existing Subpart F corrective action program for regulated land disposal units. The proposed rule is actually designed to address corrective action only under the authority of RCRA Sections 3004(u) and (v) (i.e., by addressing waste management units not already regulated at permitted facilities and releases to non-ground-water media from regulated units). The procedures established in the rule for Section 3004(u) (e.g., establishing media protection standards and selecting corrective measure remedies) are, however, likely to be similar to those procedures used in implementing corrective action orders under RCRA Section 3008(h). Furthermore, EPA is planning to revise the existing Subpart F corrective action program for land disposal units at permitted facilities to be consistent with the proposed rule. Therefore, the analyses done for the RIA address the entire RCRA corrective action program (i.e., Sections 3004(u), 3004(v), 3008(h) and the existing program for regulated units).

In short, each of the regulatory options (other than the baseline scenario) analyzed in the RIA assumes a single corrective action program that is uniformly applied to all types of units at all RCRA Subtitle C facilities. Each regulatory alternative is described in turn below.

6.4.1 Baseline Scenario

The baseline scenario is intended to represent the RCRA corrective action regulations in effect prior to the codification of the 1984 HSWA corrective action provisions and is the scenario against which the costs and benefits of the other options are compared. In developing the proposed corrective action rule, EPA did not consider an approach that followed the baseline scenario because it would not have been consistent with the Congressional mandate in HSWA.

Under the baseline scenario, EPA assumed that only land disposal units (i.e., the subset of SWMUs that includes surface impoundments, waste piles, land treatment units, and landfills) that received hazardous waste after July 26, 1982, are regulated under the Subpart F regulations and only contamination of ground water is regulated. Although only land disposal units managing waste after January 26, 1983 were subject to Subpart F before HSWA, current EPA data on such facilities are based on land disposal units that received wastes after July 26, 1982. Thus, this cutoff date is used for the RIA.

The simulated corrective action target is either background (i.e., the background concentration of a waste in ground water) or an MCL (i.e., a Maximum Contaminant Level, defined as health-based concentration limits established for hazardous constituents under the Safe Drinking Water Act) and is assumed to be the same as the trigger.[10] For this scenario, EPA assumed that only on-site cleanup (within the facility boundary) is required. Moreover, based on earlier work done by the Office of Solid Waste, it was assumed that the facility boundary is 200 meters down-gradient of the unit boundary. Finally, the analysis assumes that ground-water removal and treatment must be a part of any corrective action in the baseline scenario, except when it is technically impracticable.

In addition, under the simulated baseline scenario, ground-water contamination may exist further than 10 meters from the unit boundary since ground-water monitoring is assumed to begin in 1987 even though facilities may have been in operation for several years before this date. Releases prior to 1987 thus may have spread to further well distances. Therefore, the model searches for contamination above the trigger level by examining ground water contaminant concentrations at points between the 200 meter well, assumed to be at the facility boundary, and the unit boundary. The monitoring well then is located at the first on-site well at which contamination above the trigger level is detected. Of note is that if the monitoring well is located at any distance other than 10 meters, then contamination has been detected and corrective action will begin in 1987.

Remedy selection rules were developed for each option in the model using the selection criteria discussed above (i.e., effectiveness, cost, and feasibility). The remedy selection rules are applied to each facility modeled in each option. The selection rules are designed so that only one remedy is selected at each facility. In the RIA model, the remedy selection rules for the baseline scenario are:

Rule 1. If recovery wells reach the target within the modeling timeframe, select recovery wells.

Rule 2. If recovery wells are technically impractical (i.e., target concentrations are not reached within the modeling time period) and if capping is feasible (i.e., contaminants remain in the unit), select capping. If not, select recovery wells.

6.4.2 Option A: Immediate Cleanup To Background

This option is the strictest option among those considered in this RIA. It would provide for maximum protection of human health and the environment.

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[10] Under the Subpart F regulations, the owner or operator may also request that an ACL (i.e., Alternate Concentration Limits, defined as a site-specific health-based standard that will not adversely affect human health and the environment) be used as the ground-water protection standard. ACL's are determined on a site-specific basis. Since the Liner Location Model is not currently structured to allow simulation of the use of ACL's, <u>this RIA does not consider the use of ACL's under any of the regulatory alternatives</u>. As a result, the RIA may overestimate the cost of the baseline scenario.

In comparison to the baseline, it would cover all SWMUs rather than just regulated land disposal units. Any detectable release to ground water in excess of background levels would trigger immediate corrective action and source control remedies (i.e., excavation or excavation with recovery wells) would be required. The rationale for the option is that requiring strict cleanup to background levels using source control remedies would provide the greatest degree of protection to human health and the environment. Source control corrective action remedies would be required on the grounds that on-site containment of wastes may cause future releases and require additional cleanups.

Because of previous waste management activities at a facility, contamination may already exist in the first year of the corrective action program. The model is thus structured to mimic the investigative process of the RFI to locate all contamination at a facility. Under Option A, the model begins searching for contamination in 1987 at the well located 1,500 meters from the unit boundary and continues inward toward the unit until contamination above the trigger level is measured at a particular well distance. The monitoring well is then located at this well distance and corrective action is begun in 1987. If there is no simulated contamination beyond the 10 meter well in 1987, then the 10 meter well is used as the monitoring well. The difference between the baseline scenario and Option A is that, under the baseline scenario, the search for contamination simulated to occur in 1987 does not consider off-site contamination while, due to RCRA Section 3004(v), Option A includes an analysis of contamination up to 1,500 meters down-gradient (i.e., the limit of the model's estimation of contaminant concentrations).

The remedy selection rules for Option A are:

Rule 1. Consider only remedies that provide source control (i.e., excavation or excavation with wells). If all wastes have been released from the unit or if excavation is otherwise infeasible, source control is not necessary (i.e., select recovery wells).

Rule 2. If both excavation and excavation with wells reach target within the modeling timeframe, select the remedy with the shortest duration.

Rule 3. If both remedies have the same duration and achieve the target, select the remedy with the least cost.

Rule 4. If neither remedy reaches the target within the modeling timeframe, select the remedy with the least cost.

6.4.3 Option B: Immediate Cleanup To Health-Based Standards

In contrast to Option A, corrective action under Option B would be triggered in the model based on a health-based standard (i.e., MCLs, RfDs, or RSDs at specified risk levels) rather than a release in excess of background levels.[11] Option B provides an upper bound estimate of the costs of the Agency's proposed corrective action rule. Specific triggers (e.g., RfDs, RSDs, and MCLs) used in the model are listed in Appendix B. Generally, the triggers are derived in the following fashion:

- For carcinogens, Risk Specific Doses (RSDs) calculated to produce 10^{-4} risk levels were used in the analysis. An RSD is a chemical-specific concentration level that results in a specified risk level for an individual ingesting contaminated water over a 70-year lifetime. An RSD is calculated using chemical-specific potency scores developed by the Agency's Carcinogen Assessment Group (CAG) and an assumed water consumption rate of 2 liters per 70 kilogram adult per day. For constituents lacking a CAG potency score, best professional judgement was used to set the trigger.

- Agency-approved Reference Doses (RfDs) were used for systemic toxicants. These effects are most commonly characterized as malfunctions of various organ systems. An RfD is calculated by adjusting a "no observed adverse effect level" using an uncertainty factor. Uncertainty factors are selected on a chemical-specific basis, and typically, the smaller the uncertainty concerning the health data, the smaller the adjustment. For constituents lacking an approved RfD, best professional judgement was used to set the trigger level.

Unlike Option A, Option B would allow owners and operators to defer cleanup of releases that remain on-site (as would Options C and D). The model assumes that, for land disposal facilities, on-site corrective action would be delayed until the end of the post-closure period while, for treatment and storage facilities, cleanup would be postponed until closure. Corrective action for releases that have migrated off-site is assumed to take place immediately upon detection.

The rationale for Option B is that no one is likely to be exposed to on-site releases while the facility is operating or in its post-closure period. Thus, corrective action for such releases may be postponed. After the post-closure period or if the releases migrate off-site, people may be exposed to hazardous waste constituents and corrective action is assumed to begin

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[11] While the proposed rule provides that the health-based cleanup standards may be set on a site-specific basis, the model used a more simple approach to allow consistency. These health-based triggers and targets are intended to represent the cleanup standards set under the proposed rule.

immediately. The model also assumes that corrective action would be triggered by any release in excess of a health-based standard. The health-based standard would not be limited to MCLs, as discussed above.

The model assumes that the ground-water point of compliance would be the facility boundary (i e., 200 meters from the unit boundary) during the operating life of the facility. Subsequent to facility closure, at treatment and storage facilities, the point of compliance would be moved to the edge of the waste management area (i.e., 10 meters from the unit boundary). For land disposal facilities, the simulated point of compliance would change from the facility boundary to the edge of the waste management area at the end of the post-closure care period.

Again, the model simulates the investigative process by checking in 1987 for contamination beyond the point of compliance. Monitoring for contamination in 1987 begins at the 1,500 meter well and moves inward until contamination above the trigger level is detected. However, the model does not search in 1987 for on-site contamination (i.e., contamination within 200 meters of the unit boundary). If no contamination is detected off-site, the monitoring well is set at 200 meters until closure or post-closure, whichever applies, at which time the model looks for on-site contamination and moves the monitoring well to the 10 meter well.

All four remedies are considered in Option B (i.e., excavation, excavation with wells, capping, and recovery wells). The remedy selection rules used to simulate Option B are:

Rule 1. Select the remedy with the shortest duration to achieve target from among those that reach target within the modeling timeframe.

Rule 2. If several remedies have the same duration and achieve the target, select the remedy with the least cost.

Rule 3. If all remedies fail to reach the target within the modeling timeframe, select the remedy with the least cost.

6.4.4 Option C: Flexible Cleanup To Health-Based Standards

Option C is generally intended to provide a lower bound estimate of costs and effectiveness of the Agency's proposed corrective action rule. Options B and C are similar in that both would allow owners and operators to defer cleanups of releases that remain on-site until facility closure or the end of the post-closure period and would allow selection of all modeled remedies. The key distinction between these two options is that, under Option C, a great deal more flexibility is allowed in the remedy selection process Facilities are allowed to forego expensive corrective actions that do not produce tangible cleanup benefits on the condition that institutional controls are in place to prevent exposure to contaminated ground water.

Institutional controls are methods used to prevent human exposure to hazardous waste releases, such as legal or physical barriers. For instance, institutional controls could include providing bottled water to replace contaminated ground water, erecting a fence around a facility to prevent people from entering, or placing restrictions on future land use in the facility deed. The model selects institutional controls in cases where either: (1) no remedies reach the cleanup target within the model time horizon and capping is infeasible, or (2) where no remedies cost less than $150 million.

The costs of selecting institutional controls, however, are assumed to be zero in the model. The costs of some institutional controls, such as legal restrictions, are negligible in comparison to the costs of other corrective action remedies. Moreover, institutional controls are selected infrequently in the model. By assuming zero costs for institutional controls, the RIA may tend to underestimate the costs of Option C (and Option D, which also allows for institutional controls) in comparison to other options.

Under Option C, remedies are also limited to those with costs below $150 million. The Agency expects that, in practice, cleanup costs could actually be greater in rare instances at some facilities, such as those undergoing corrective action for releases to multiple media or facilities in close proximity to exposed populations. A limitation on ground-water corrective action costs is, however, necessary for modeling purposes. Without such a limit, the model would select remedies that would actually be infeasible in practice due to site conditions or technical constraints (e.g., excavations could be selected by the model for the entire area of very large sites whereas, in practice, excavations may only be performed for limited portions of such sites).

Finally, the model selects the least costly remedy for Option C from among those that reach the cleanup target within the modeling period. In contrast, remedies are selected under Option B among those that reach the target within the shortest duration without regard for cost. In other words, Option C uses a more flexible approach to selecting remedies than Option B. This assumption was chosen to approximate the site-specific approach taken in the proposed rule, which would allow local flexibility in choosing among protective remedies.

The remedy selection rules used to simulate Option C are:

Rule 1. If no remedies reach the target within the modeling timeframe and capping is feasible and costs less than $150 million, select capping. Otherwise, implement institutional controls.

Rule 2. If one or more remedies reach the target within the modeling timeframe but no remedy costs less than $150 million, implement institutional controls.

Rule 3. Select the remedy with the least cost from among those which reach target and which costs less than $150 million (i.e., excavation plus wells, excavation, recovery wells, or capping.)

Because these remedy selection rules are somewhat more complex for Option C than the preceding options, these rules are depicted graphically in Exhibit 6-2.

As with Option B, the model checks for existing contamination in 1987. In subsequent years, during the facility operating life (and post-closure, if applicable), monitoring is at the facility boundary. After this period, monitoring is performed at the unit boundary.

Under the proposed rule, however, the remedy selection process may differ because the Regional Administrator has the discretion to select remedies that meet the remedy selection standards of proposed §264.525(a) (i.e., remedies must meet cleanup standards, control the source of releases, and comply with standards for management of wastes). In addition, the Regional Administrator may consider several remedy selection criteria, including:

- Long-term reliability and effectiveness;
- Reduction of toxicity, mobility, or volume;
- Short-term effectiveness;
- Implementability; and
- Cost.

Thus, the proposed rule remedy selection standards and criteria provide for more thorough consideration of site-specific characteristics than do the remedy selection rules used in the model. The model remedy selection rules, however, are intended to roughly approximate the remedy selection process under the proposed rule.

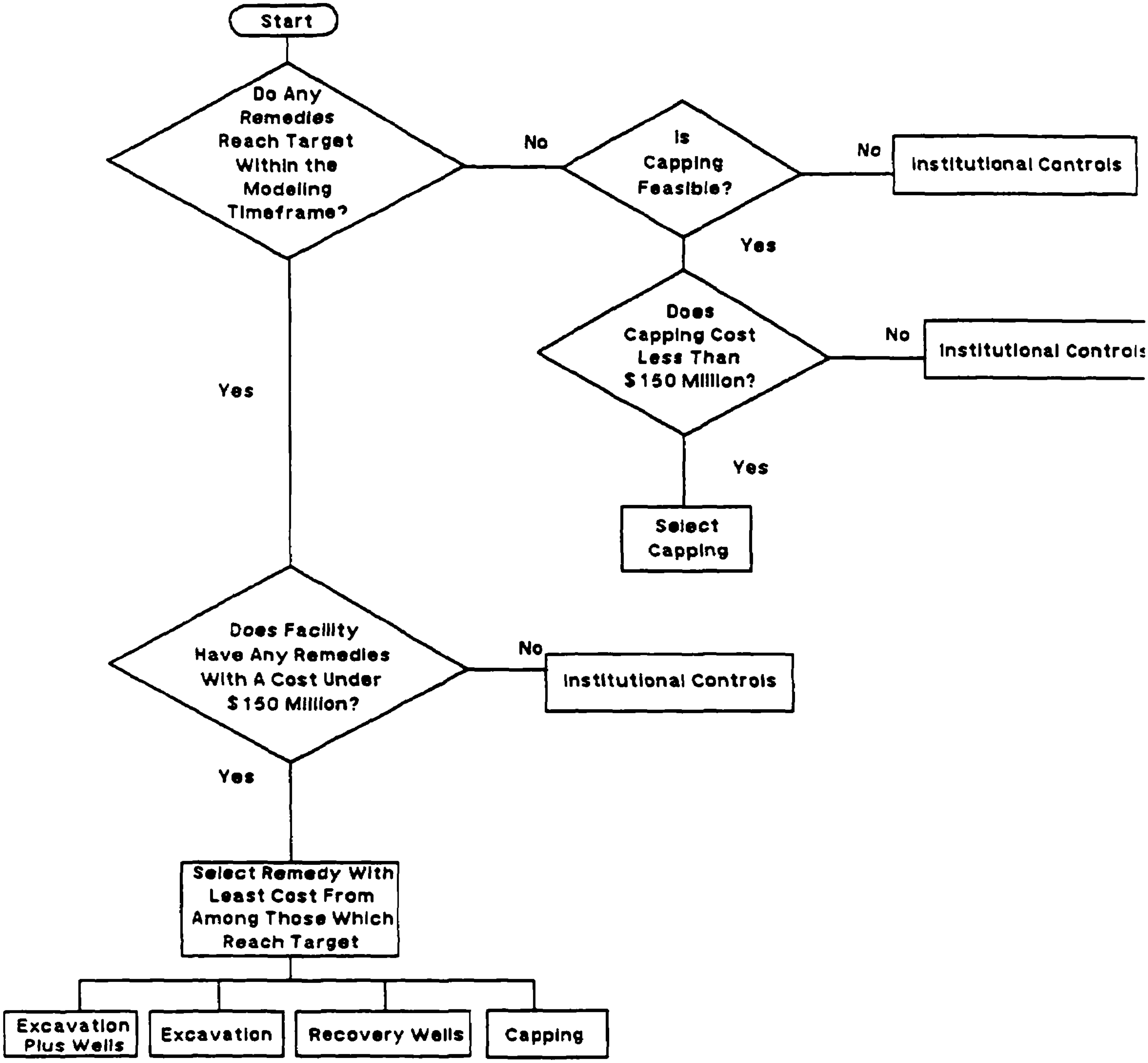
Finally, under the proposed rule, the speed of initiation of corrective action as well as the speed of its completion would be set by the Director and could be based on several factors, including the extent of waste management capacity, the availability of technology, and other relevant factors. This option would allow EPA or States and the owner or operator flexibility in determining the timing of corrective action. Thus, the remedy simulated under Option C for a facility may not be the same as that actually selected in practice, though these remedy selection rules are intended to roughly approximate the types of decisions made under the proposed rule.

6.4.5 Option D: Flexible Cleanup Based on Actual Exposure

This option is the most flexible of the regulatory options. It is similar to Options B and C in that on-site cleanup is assumed to be deferred until closure or the end of the post-closure period (depending on whether the facility is a land disposal facility). It is different in that off-site cleanup is also assumed to be deferred if there is no actual human exposure to

EXHIBIT 6-2

Remedy Selection Flow Chart For Options C and D



the release. Thus, although the remedy selection rules are the same for Options C and D, the point of compliance modeled is different.

The rationale for Option D is that human exposure to hazardous wastes arises from exposure to releases, therefore, exposure (rather than releases) should be regulated. Under this approach, releases likely to cause exposures are assumed to be immediately cleaned up while cleanup of other releases would be deferred. While human exposure to contamination during the period of deferral is, by definition, unlikely, environmental contamination may persist until corrective action is undertaken.

The RCRA statutory mandate to protect human health and the environment precluded EPA from analyzing a more flexible risk-based option. As discussed in Chapter 3, the Agency constrained its analysis to options that fulfilled this Congressional mandate. As a result, human exposure is limited under Option D by requiring on-site cleanup to health-based standards at closure (or the end of the post-closure period).

The model also assumes that, during a facility's operating life (and throughout the post-closure period, if applicable), corrective action would be triggered by actual human exposure to hazardous waste releases with concentrations in excess of health-based standards (as defined for Options B and C). After a facility had closed (or after the end of the post-closure period, if applicable), the same health-based standard would be used but it would be applied in the model at the edge of the waste management area rather than at the point of exposure.

Until the point of compliance reverted to the edge of the waste management area (at closure or at the end of the post-closure period, depending on the type of facility), the point of compliance would be the actual or threatened human exposure point. For each facility, this point is determined based on available data.[12] The point of compliance was modeled at the 10 meter exposure well for 3 percent of the facilities, at the 600 meter well for 83 percent of the facilities, and at the 1,500 meter well for 14 percent of the facilities.

The investigative phase of the corrective action program is simulated in a manner similar to that used in Options A, B, and C. The model looks for contamination in 1987 beginning at the 1,500 meter well and moves upgradient to the exposure point. If contamination above the trigger level is detected at wells near or down-gradient of the exposure point, then corrective action is triggered. If no contamination is detected at the exposure point, the monitoring well is set at the assumed exposure point until closure or post-

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[12] The data base for the RIA was obtained from a sample of RCRA Facility Assessments (RFAs). In some cases, the RFAs noted the nearest human exposure points. This RFA data, where available, was used in calculating the human exposure point under Option D. If such data were not available, the model assumed that the human exposure point was 600 meter from the unit boundary. The 600 meter point is not based on average human exposure points but is only a modeling assumption. See Appendix A for detailed information on the facility data base.

closure, whichever applies, at which time the monitoring well is moved to the 10 meter well.

The remedy selection rules in the model for the exposure-based approach are the same as those for Option C (see Exhibit 6-2):

Rule 1. If no remedies each the target within the modeling timeframe and capping is feasible and costs less than $150 million, select capping. Otherwise, implement institutional controls.

Rule 2. If any remedies reach the target within the modeling timeframe but no remedies cost less than $150 million, implement institutional controls.

Rule 3. If any remedies reach the target within the modeling timeframe and any remedy costs less than $150 million, select the remedy with the least cost from among those which reach target (e.g., excavation plus wells, excavation, recovery wells, or capping.)

The key assumptions used in the RIA for the five regulatory assumptions are listed in Exhibit 6-3.

EXHIBIT 6-3

GROUND-WATER CORRECTIVE ACTION REGULATORY ALTERNATIVES AS SIMULATED IN THE RIA

	Units Regulated	Trigger and Target Levels	Point of Compliance	Initiation of Action	Types of Remedies
1. Baseline Scenario	Active land disposal units	Groundwater protection standard (i.e., back-ground or MCL)	Edge of waste management area (10 meter well)	Immediate upon detection	Recovery wells or capping
2 Option A	All SWMUs	Release in excess of background	Edge of waste management area (10 meter well)	Immediate upon detection	Excavation, or excava-tion with wells (re-covery wells allowed if excavation is infeasi-ble)
3 Option B	All SWMUs	Release in excess of health-based standard	Facility boun-dary during operating life, then edge of waste manage-ment area (10 meter well)	Immediate if con-tamination off-site, otherwise defer to closure or end of post-closure	Excavation, excavation with wells, recovery wells, or capping
4 Option C	All SWMUs	Release in excess of health-based standard	Facility boun-dary during operating life, then edge of waste management area (10 meter well)	Immediate if con-tamination off-site, otherwise defer to closure or end of post-closure	Excavation, excavation with wells, recovery wells, cap-ping, or institu-tional con-trols
5. Option D	All SWMUs	Actual or threatened exposure in excess of health-based standard	Exposure point during operat-ing life, then edge of waste management area (monitor-ing point varies depend-ing on RFA data)	Immediate if con-tamination at point of exposure, other-wise defer to closure or end of post-closure	Excavation, excavation with wells, recovery wells, cap-ping, or institu-tional con-trols

7. RESULTS OF QUANTITATIVE ANALYSIS OF GROUND-WATER REGULATORY OPTIONS

This chapter presents the results of the quantitative analysis of the ground-water regulatory options presented in Chapter 6. The basic approach used starts with a sample of RCRA facilities that will be subject to the proposed corrective action requirements. The extent of ground-water contamination at these facilities and the effectiveness of corrective actions is simulated using a modified version of EPA's Liner Location Model (LLM). The LLM produces several results related to the types of corrective actions taken at facilities and the effectiveness of these corrective actions.

This chapter summarizes these results in terms of the likelihood that corrective action will be initiated, the type of remedy selected, the time required to implement corrective actions, and an effectiveness measure that reflects the success of corrective action in cleaning up particular sites.[1]

The analysis of the ground-water regulatory options suggests that approximately 31 percent of the population of RCRA facilities require ground-water corrective action under the 4 regulatory options. Under Options B (Immediate Cleanup to Health-Based Standards) and C (Flexible Cleanup to Health-Based Standards), more than 80 percent of the actions were fully implemented within 75 years. Of those facilities undertaking corrective measures, the selected remedy was successful in attaining the cleanup goals within 1,500 meters of the source within 75 years for over 50 percent of the facilities under Option C.[2]

7.1 LIKELIHOOD OF INITIATING CORRECTIVE ACTION

The likelihood of corrective action is expressed as the percentage of facilities that trigger corrective action in a particular year over the 200-year modeling period.[3] Facilities trigger corrective action when contaminant concentrations in ground water exceed specific trigger levels assumed for a particular regulatory option. For example, under Option A (Immediate Cleanup to Background), corrective action is triggered as soon as contaminant concentrations are detectable at the monitoring well.

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[1] The costs of corrective action were also estimated. These estimates are discussed in Chapter 8, Ground-Water Corrective Action Costs for Non-Federal Facilities, and Chapter 12, Federal Facilities.

[2] The 1,500 meter distance was used because it is the maximum distance simulated by the LLM.

[3] In the context of the LLM, each facility is simulated to initiate corrective action no more than once in one modeling period.

The timing of corrective action (i.e., the initiation of corrective actions) differs among the regulatory options. Under Options B (Immediate Cleanup to Health-Based Standards), C (Flexible Cleanup to Health-Based Standards), and D (Flexible Cleanup based on Actual Exposure), EPA assumed that corrective action for releases that have not migrated off-site may be deferred until facility closure. As a result, although the number of facilities triggering corrective action may be similar among particular options, the timing of corrective action may differ.

Under Option A, 33 percent of the population of RCRA facilities subject to the corrective action requirements (i.e., about 5,660 facilities) trigger corrective action for ground water. Approximately 31 percent of the population of RCRA facilities trigger corrective action under Options B through D, compared to only 14 percent triggering under the pre-HSWA Subpart F requirements of the baseline scenario. The percentage of facilities that trigger and initiate corrective action under the baseline scenario and each of the regulatory options is listed in Exhibit 7-1. Under Option A, most actions are simulated to begin in the first year of the corrective action program, while under Options B through D, about half of the actions are deferred until after the year 2000.

Exhibit 7-2 graphically compares the number of facilities that trigger corrective action in the baseline scenario and each regulatory option. More than twice as many facilities trigger corrective action under the 4 regulatory options (i.e., A through D) compared to the baseline scenario. The reasons for the difference in the likelihood of triggering corrective action among the regulatory options are:

- Options A through D trigger action more often than does the baseline because they are assumed to regulate releases from all SWMUs, not just those from regulated land disposal units as under the baseline scenario. As explained in Chapter 2 of the RIA, the number of units subject to corrective action has increased by a factor of more than 20 from about 3,000 units before HSWA to over 80,000 after HSWA.

- Option A triggers at slightly more facilities because it requires cleanup to background, while Options B, C, and D are somewhat less stringent and only require cleanup to health-based levels.

- Options B and C are identical with respect to the likelihood and timing of corrective action because they both involve the same assumptions about trigger levels and points of compliance; these options differ only in terms of the remedies selected.

EXHIBIT 7-1

CORRECTIVE ACTION IS DEFERRED FOR OPTIONS C AND D a/

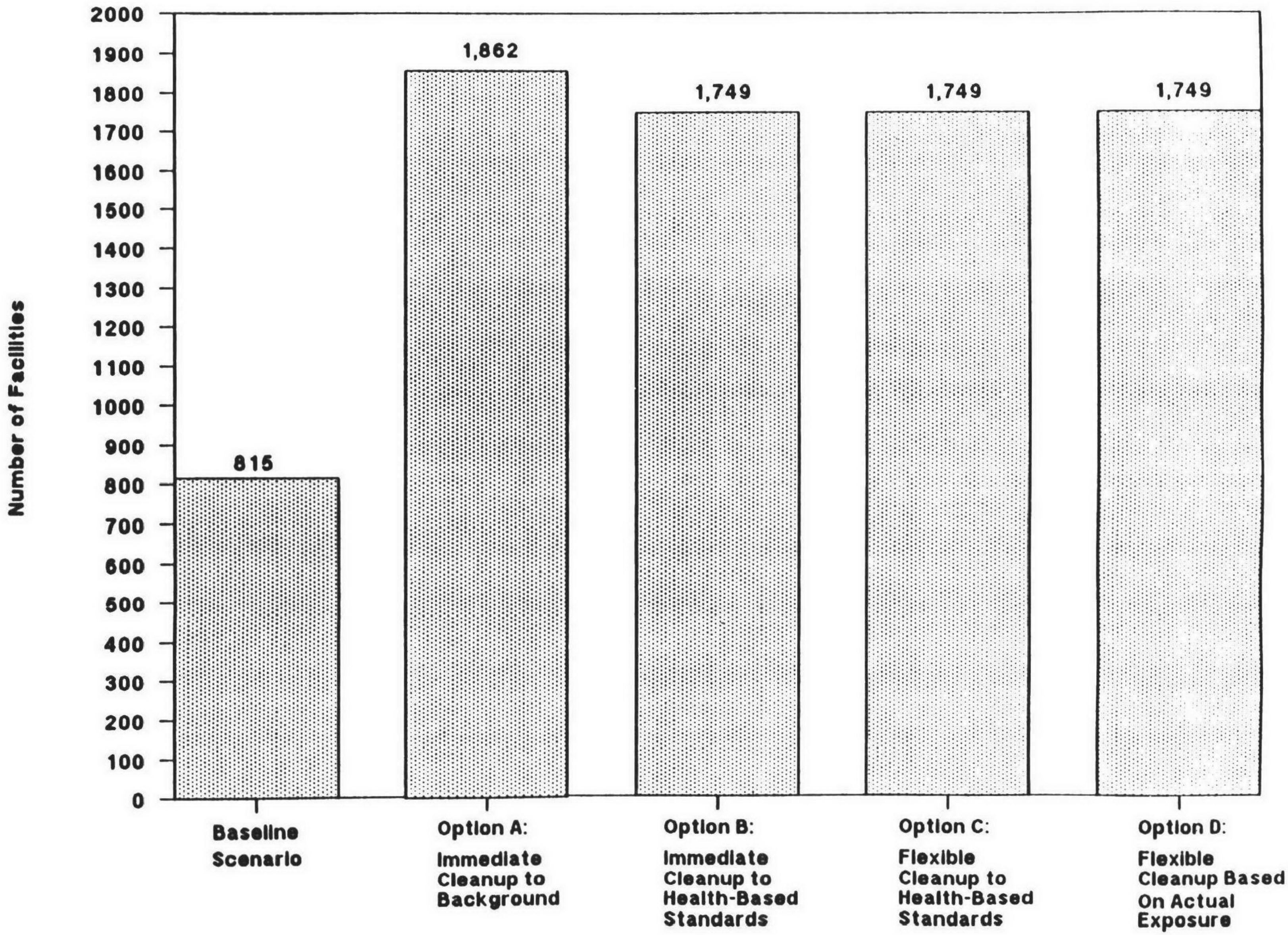
Year in Which Corrective Action is Triggered	Baseline	Options b/ A	B	C	D
1987	9.7%	25.7%	12.4%	12.4%	12.4%
1988-2000	0%	2.9%	3.7%	3.7%	2.7%
2001-2025	3.6%	3.2%	10.2%	10.2%	10.4%
2026-2120	1.2%	1.1%	4.7%	4 7%	5.4%
Trigger Subtotal	14.4%	32.9%	30.9%	30.9%	30.9%
Never Trigger	85.6%	67.1%	69.1%	69.1%	69.1%

a/ Percentage indicates the distribution of start dates among the total population of facilities potentially affected by the corrective action program (i.e., 5,661 facilities).

b/ Option A: Immediate Cleanup to Background
Option B: Immediate Cleanup to Health-Based Standards
Option C: Flexible Cleanup to Health-Based Standards
Option D: Flexible Cleanup based on Actual Exposure

EXHIBIT 7-2

SIGNIFICANTLY MORE FACILITIES TRIGGER CORRECTIVE ACTION AFTER HSWA*



* al number of Federal and non-Federal RCRA TSDFs subject t rrective actions is estimated to be 5,661.

- Option D triggers corrective action at an identical number of facilities as Options B and C because it triggers corrective action at the same health-based concentration levels. The only difference among these options is that, under Option D, the initiation of corrective action is delayed for releases that do not threaten off-site exposure points until after facility closure (or the end of the post-closure period, if applicable).

The timing of corrective action under each of the regulatory options is presented graphically in Exhibit 7-3. Under Option A, where corrective action for all releases must begin immediately, 25.7 percent of the facilities trigger corrective action in 1987. In contrast, under Options B, C, and D, where corrective action may be deferred until facility closure (or the end of the post-closure period, as applicable), approximately 12 percent of facilities trigger corrective action in 1987. As a result, the costs associated with corrective action are incurred later in the modeling period under Options B, C, and D than compared to Option A. As explained in Chapter 8, the opportunity to defer action accounts, in part, for the lower present value costs of Options B, C, and D compared to Option A.

7.2 DISTRIBUTION OF REMEDIES SELECTED

Four remedies are modeled: excavation, excavation with wells, recovery wells, and capping. Under Options C and D, institutional controls are sometimes simulated when technical constraints severely limit the effectiveness of these 4 remedies. Each of these remedies and the method by which the model selected among them for a facility are discussed in more detail in Chapter 6. The remedies selected under the baseline scenario and each regulatory option are presented in Exhibit 7-4.

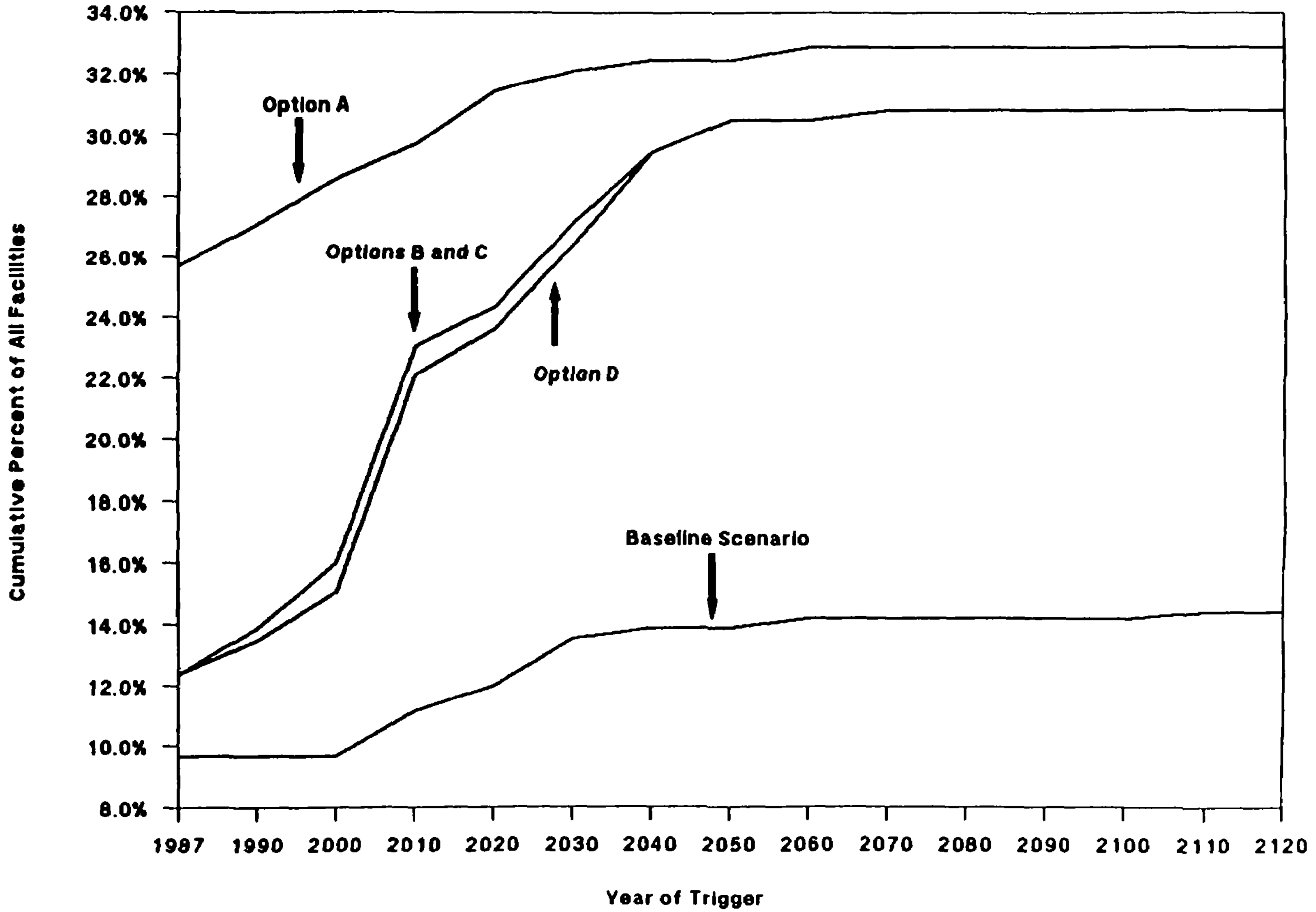
Under the baseline scenario, only 2 remedial alternatives (capping or recovery wells only) are candidates for the selected remedy. Recovery wells are selected at about 29 percent of the facilities. Recovery wells is the selected remedy in cases where the wells succeed in reducing concentrations at all wells within 1,500 meters to below trigger levels within the modeling time horizon.[4] Capping is selected at about 71 percent of the facilities under the baseline. Capping is the selected remedy when recovery wells fail to be effective within the modeling time horizon. However, in situations where capping is not feasible (because all of the contaminants have been released from the unit by the time the release is detected), recovery wells is the selected remedy regardless of its effectiveness.

For purposes of the LLM simulation under Options A and B, the remedy selected for a particular site is based on the effectiveness of the corrective

[4] See Section 7.4 for a more detailed explanation of the measure of effectiveness.

EXHIBIT 7-3

CORRECTIVE ACTION IS DELAYED UNDER OPTIONS C AND D



Option A Immediate Cleanup to Background
Option B: Immediate Cleanup to Health-Based Standards
O C: Flexible Cleanup to Health-Based Standards
(D: Flexible Cleanup based on Actual Exposure

EXHIBIT 7-4

REMEDY SELECTION VARIES SIGNIFICANTLY AMONG OPTIONS a/

Selected Remedy	Baseline	Options b/ A c/	B	C	D
Excavation	N/A d/	59.0%	3.1%	9.0%	9.8%
Excavation with wells	N/A	20.7%	25.7%	4.6%	3.6%
Recovery wells	28.6%	20.2%	33.4%	15.9%	14.9%
Capping	71.4%	N/A	37.8%	64.8%	65.0%
Institutional Controls	N/A	N/A	N/A	5.7%	6.7%

a/ Percentage indicates the distribution of selected remedies at those facilities triggering corrective action under the baseline scenario and regulatory options.

b/ Option A: Immediate Cleanup to Background
Option B: Immediate Cleanup to Health-Based Standards
Option C: Flexible Cleanup to Health-Based Standards
Option D: Flexible Cleanup based on Actual Exposure.

c/ Option A is structured to require source control. Thus, capping and recovery wells without source control (i.e., excavation) are not allowed. However, for situations where excavation is infeasible, recovery wells alone are simulated.

d/ N/A: Regulatory option does not allow this remedy.

action and the cost of the corrective action. The RIA assumes that Option A requires remedies with long-term reliability. Thus, under Option A, excavation or excavation with recovery wells is selected at about 80 percent of the facilities. However, in situations where excavation is not feasible (because all of the contaminants have been released from the unit by the time the release is detected), recovery wells alone is the selected remedy (i.e., at about 20 percent of the facilities under Option A). Under Option B, only about 29 percent of facilities are simulated to use excavation or excavation with recovery wells. In contrast to Option A, Option B does not require only remedies with long-term reliability. Therefore, recovery wells are selected at about 33 percent of facilities and capping is selected at about 38 percent of facilities.

Option C (Flexible Cleanup to Health-Based Standards) and Option D (Flexible Cleanup Based on Actual Exposure) are assumed to allow any of the 4 remedies used in the model or institutional controls. The proportions of remedies selected are similar under both Options C and D. Under Options C and D, remedies with long-term reliability (i.e., excavation and excavation with recovery wells) are selected at about 10 percent of facilities. Recovery wells are selected at about 15 percent of facilities and capping is selected at about 65 percent of facilities. Institutional controls are selected only about 6 percent of facilities under Options C and D.

7.3 TIME TO IMPLEMENT CORRECTIVE ACTION

This section presents the analysis of the time necessary to implement corrective action at specific facilities. The duration of a corrective action depends on the type of remedy, the extent of contamination, and the cleanup level. For excavation and capping, the duration is always assumed to be 1 year.

For recovery wells, the duration is dependent on the target concentration at the monitoring wells and the regulatory option. For Option A (Immediate Cleanup to Background), pumping must continue until the target has been achieved for 5 consecutive years. For example, if pumping begins in 1990, and the target concentration is reached in year 2000 and stays below target, pumping must continue through year 2004. Alternatively, if the concentration increases above the target again in 2002, pumping must continue even longer. For the baseline scenario and Options B, C, and D, pumping must continue while the concentration remains below target for 3 consecutive years. Option A (Immediate Cleanup to Background) is the most stringent modeled option (i.e., this option would provide the maximum protection of human health and the environment) compared to the other options. Consequently, a more stringent additional pumping period (i.e., 5 years) was assumed for this option. The targets must be met at all wells within the point of compliance before a recovery well corrective action is simulated to be terminated.

The modeled point of compliance is the facility monitoring well (i.e., a well located at a certain distance from the waste management area).[5] The determination of the monitoring well location is based on the regulatory option. The methodology used to determine the point of compliance for each regulatory option is explained in Chapter 6.

Exhibit 7-5 presents the durations for corrective actions required under each of the regulatory options. The proportion of facilities associated with corrective actions of 1 year represent the facilities undertaking excavation or capping. All other time categories represent facilities operating recovery wells or a combination of recovery wells and excavation. The "ongoing at end of modeling time horizon" category represents those facilities undertaking recovery well operations where the corrective action was still ongoing at the end of the 200 year model time horizon (i.e., the target could not be reached by the year 2120).

In general, under the baseline and Options A and B, recovery wells that are still in operation at the end of the model period represent facilities where the capping and excavation actions were infeasible due to the release of all the contaminants from the facility prior to detection. (In those cases where capping or excavation was feasible but all remedies were incapable of reaching target levels, capping, with a duration of 1 year, was usually selected because of its cost.) Under Options C and D, the remedy selection rules are generally structured to allow the use of institutional controls in situations where none of the available remedies is able to achieve corrective action targets within the modeling period. Thus, the "institutional controls" category in Exhibit 7-5 represents those facilities for which an engineering remedy was foregone.

As shown in Exhibit 7-5, a significant proportion of the actions have relatively short durations. Under Options B and C, for example, 64 percent and 82 percent of the facilities, respectively, undertake actions of less than 25 years. For all options, less than 11 percent of the facilities are simulated to be in corrective action for more than 100 years. Under Option B, in fact, only about 6 percent of the actions are assumed to last more than 75 years.[6]

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[5] In the proposed rule, the ground-water points of compliance represent the entire area of contamination, therefore, meeting the cleanup standards at the points of compliance corresponds to cleaning up the entire plume. For modeling purposes, one modeled point of compliance is used to represent the most downgradient point of contamination. Contaminants upgradient of this point are assumed to require cleanup. Any contaminants that migrate beyond this point after an action is initiated are not simulated to be cleaned up.

[6] Under the proposed rule, EPA has made provisions for situations where corrective action is technically impracticable. Based on the standards in proposed 40 CFR 264.525(d)(2)(iii) and 264.531, adjustments in the required remedy can be made in cases where technical factors make a complete remedy infeasible. To the extent that such adjustments are made, the quantitative results provided above may overestimate the length of time associated with recovery well actions.

EXHIBIT 7-5

DISTRIBUTIONS FOR DURATIONS OF CORRECTIVE ACTIONS VARIES AMONG OPTIONS a/

	Baseline	Option A	Option B	Option C	Option D
Total Percent of All Facilities Triggering Corrective Action	14.4%	32.9%	30.9%	30.9%	30.9%
Time to Implement Remedy b/ (Years)	Percentages of All Facilities Where Contaminants Exceed Triggers				
1	71.4%	59.0%	40.9%	73.8%	74.8%
2-10	11.0%	7.5%	18.8%	7.2%	7.2%
11-25	2.2%	6.0%	3.9%	1.0%	1.0%
26-50	4.4%	6.5%	17.0%	7.7%	6.7%
51-75	0%	6.3%	6.4%	2.8%	1.8%
76-100	0%	4.6%	2.3%	0.8%	0.8%
101-131	0%	1.0%	0.0%	1.0%	1.0%
Ongoing at end of modeling time horizon	11.0%	9.2%	10.8%	0.0%	0.0%
Institutional Controls	0%	0%	0%	5.7%	6.7%
Total	100%	100%	100%	100%	100%

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a/ Option A: Immediate Cleanup to Background
Option B: Immediate Cleanup to Health-Based Standards
Option C: Flexible Cleanup to Health-Based Standards
Option D: Flexible Cleanup based on Actual Exposure

b/ Excavation: Assumed to take 1 year to implement.
Capping: Assumed to take 1 year to implement.
Excavation with recovery wells: Time to implement depends on contaminant concentrations.
Recovery wells: Time to implement depends on contaminant concentrations.

The duration of a corrective action is not, however, a consistent measure of effectiveness among all options because capping and excavation are always modeled to have a duration of 1 year. Because these 2 remedies are source control actions, contamination may persist for many years beyond the completion of the action. In addition, for recovery wells, the duration is the time required for the target to be reached at the modeled point of compliance inside the area of contamination where the recovery wells are located. Because recovery well operations are modeled to be at most 95 percent effective in removing contaminants, the remaining contamination may still result in the trigger concentrations being exceeded downgradient of the modeled point of compliance. Over time, in the model the plume area effectively increases, but the modeled point of compliance does not change.[7] Duration is therefore not a good measure of effectiveness because, for some facilities, corrective action will terminate following cleanup within the point of compliance, even though contamination may still exist beyond the point of compliance.[8] Consequently, an additional measure of effectiveness to analyze the effectiveness of corrective actions was developed. This measure is discussed in the next section.

7.4 TIME TO REACH TARGET CONCENTRATION WITHIN 1,500 METERS

This effectiveness measure represents the length of time required for a corrective action to reduce all contaminant concentrations below the target levels at all wells within 1,500 meters of the unit (i.e., the maximum modeled well distance). This measure was developed because it provides a consistent measure across all remedies and regulatory options, and it provides an indication of the effectiveness of corrective actions within a standard area. A corrective action is thus defined to be effective if all constituents within 1,500 meters of the unit are cleaned up to their option-specific levels.

Exhibit 7-6 presents the distributions among the baseline scenario and regulatory options for the time required for the facilities with corrective actions to reach target levels at all wells within 1,500 meters. The "target not reached" category represents situations where none of the remedies resulted in target levels being reached at all wells within 1,500 meters. As discussed in Chapter 6, the "institutional controls" category represents situations where remedies do not reach target and are infeasible or where the costs of remedies exceed $150 million.

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[7] The plume area is defined as the area of contamination where the trigger concentration is exceeded.

[8] This situation should be regarded as a model limitation. In the model simulation, corrective actions are initiated only once (i.e., if contamination is detected following termination of a corrective action, correction action is not restarted) and recovery well operations are not expanded to clean up contamination beyond the modeled point of compliance. This limitation results in an underestimation of the effectiveness of corrective actions in controlling ground-water contamination. In reality, the recovery wells would probably be moved further downgradient such that more contaminants would be controlled and recovered.

EXHIBIT 7-6

DISTRIBUTION FOR DURATIONS TO REACH TARGET WITHIN 1,500 METERS VARIES AMONG OPTIONS a/

	Baseline	Option A	Option B	Option C	Option D
Total Percent of All Facilities Triggering Corrective Action	14.4%	32.9%	30.9%	30.9%	30.9%
Duration to Reach Target (Years)	Percentages of All Facilities Where Contaminants Exceed Triggers				
0-10	17.1%	14.7%	23.7%	18.5%	18.5%
11-25	5.5%	7.0%	9.5%	3.1%	3.1%
26-50	9.7%	6.5%	15.9%	22.9%	21.9%
51-75	1.9%	5.5%	6.4%	6.7%	8.0%
76-100	0%	5.1%	1.5%	3.3%	1.8%
101-131	0%	0%	0.8%	1.8%	1.8%
Target Not Reached	65.8%	61.2%	42.2%	38.0%	38.3%
Institutional Controls	0%	0%	0%	5.6%	6.6%
Total	100%	100%	100%	100%	100%

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a/ **Option A:** **Immediate Cleanup to Background**
Option B: **Immediate Cleanup to Health-Based Standards**
Option C: **Flexible Cleanup to Health-Based Standards**
Option D: **Flexible Cleanup based on Actual Exposure**

Under Option B, about 56 percent of the facilities are simulated to reach cleanup targets at all modeled well distances within 75 years of initiation of the action. Under Options C and D, about 51 percent attain cleanup targets in the same period. For Option A (Immediate Cleanup to Background), the proportion of facilities with corrective action not reaching target concentrations at all wells within 1,500 meters is greater than the percentage for Options B, C, and D, because the target levels for Option A (i.e., detection limits) are lower than those for the other options.[9] These facilities that did not reach target levels represent situations where the cleanup of contaminants to target concentrations may be difficult to achieve. Moreover, under Options C and D, those facilities with institutional controls also represent situations where corrective action was unable to attain cleanup targets.

There are numerous factors affecting the ability of the modeled facilities to reach ground-water target concentrations. These factors include physical phenomena likely to affect results in the field and model limitations. These factors are discussed here. The procedures in the proposed rule for facilities where cleanup levels cannot be met due to site characteristics are also presented.

Factors that affect the potential for cleanup of contaminants in the subsurface environment include the chemical and physical properties of the contaminants, the characteristics of the subsurface environment, and, most importantly, the interaction between the two factors.[10] Together, these factors determine how far released contaminants will spread, how quickly contaminants will move in the subsurface environment, how long contaminants are likely to remain in the ground water, and the potential for cleanup operations to remove the contaminants from the subsurface environment. For example, heavy metal contaminants may adsorb to soils while moving through the unsaturated zone or onto aquifer material once in the ground water. The presence of clay minerals would increase the likelihood of this adsorption process occurring. The ultimate fate of the contaminants would depend on the irreversibility of the adsorption process. If the contaminants did not desorb from the surrounding clay material, cleanup would be extremely difficult.

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[9] The success of Options B, C, and D (which share the same health-based triggers) in achieving cleanup is not strictly comparable to the success rate for Option A (which requires cleanup to background) because Options B, C, and D have lower cleanup goals (i.e., less stringent target concentrations) than Option A. Moreover, a somewhat larger number of facilities take corrective action under Option A than under the other three options.

[10] Physical and chemical properties of the contaminants include solubility, density, viscosity, and degradability. Subsurface environment properties include the presence of karst formations or highly fractured bedrock underlying a facility. Specific ground-water properties include velocity and hydraulic conductivity.

Within the context of the model analysis, there are several additional reasons why not all facilities are simulated to attain target levels within 1,500 meters. The model results reflect:

- The choice of the removal efficiency of 95 percent for recovery well operations. Under actual field conditions, this efficiency level may be significantly lower or may approach 100 percent. If this efficiency level is understated in the model, then more facilities would be able to achieve complete cleanups than simulated by the model while, if the efficiency is overstated, less facilities would reach target.

- Situations where constituent concentrations are so high that the modeled 95 percent efficiency of recovery well operations is insufficient in reducing the constituent concentrations below target concentrations. Such situations are particularly likely to occur at facilities with extensive and widespread contamination resulting from large scale hazardous waste activities, a long history of operation, or both.

- Situations where the plume area continued to increase after initiation of corrective action such that contamination exist at wells down-gradient of the modeled point of compliance. For such situations in the model, an action could be terminated even though the presence of contamination downgradient of the point of compliance suggests that the action has not been fully effective.

- Situations where the 200-year modeled time horizon limits the continuation of recovery well operations. While these situations did not occur frequently in the model analysis, for corrective actions simulated to occur late in the modeling period, the time remaining in the simulation may be insufficient to complete the action.

Finally, it is important to recognize that the proposed rule addresses situations where cleanup does not appear to be technically practicable. Specifically, there are 2 provisions in the proposed rule that provide for alternate approaches in these situations:

- Proposed 40 CFR 264.525(d)(2)(iii) allows EPA to determine that remediation of a release is not required when it is technically impracticable. In such cases, the facility owner/operator could be required to undertake source control, reduce exposure to the contaminated medium, or remediate to concentration levels which are technically practicable.

- Proposed 40 CFR 264.531 allows EPA, in situations where the facility's best efforts to implement the selected remedy prove unsuccessful, to require the owner/operator to examine alternative technologies or to determine that complete cleanup is not technically feasible. For example, if a ground-water recovery system does not appear to be performing as expected, it may be possible to utilize alternate remedies that are more effective. However, in cases where EPA determines that complete cleanup is not technically feasible, then the facility will not be required to meet the cleanup standards but may be required instead to implement institutional controls that prevent exposure to contaminated ground water.

7.5 CONCLUSION

In short, based on the results of the quantitative analysis of ground water, about 31 percent of the population of RCRA facilities subject to the corrective action requirements are estimated to require corrective action for ground-water contamination. Moreover, most of these actions appear likely to be initiated prior to the year 2000. Under the options designed to represent the proposed rule (i.e., Options B and C), over 50 percent of the facilities undertaking corrective action are simulated to reach cleanup targets at all modeled well distances within 75 years. About 6 percent are assumed to use institutional controls because of the limited effectiveness of available remedies.

8. GROUND-WATER CORRECTIVE ACTION COSTS FOR NON-FEDERAL FACILITIES

This chapter analyzes the ground-water corrective action costs that would be incurred by non-Federal facility owners and operators under the corrective action program. Costs at Federal facilities are estimated in Chapter 12. In summary, this analysis of the costs of the corrective action program suggest that costs are likely to increase significantly over the baseline scenario. Under the lower bound option of the proposed rule, total costs are estimated to increase nationwide by $7.4 billion. On an annualized basis, this increase is approximately $500 million.

The chapter first describes the methodology for estimating costs at individual facilities. Results are then presented as typical per-facility costs for each regulatory alternative and as total national costs.

8.1 DERIVATION OF UNIT COST ESTIMATES

The total estimated cost to the regulated community of EPA's corrective action program is estimated in this RIA based on the costs of each step in the cleanup process. Accordingly, this section describes the estimation of these costs.

8.1.1 Costs of Investigation

As explained in Chapter 2, the EPA corrective action program is divided into several steps. The first 3 steps are the RCRA Facility Assessment (RFA), the RCRA Facility Investigation (RFI), and the Corrective Measures Study (CMS). These steps are of an investigative or analytic nature and are distinct from the actual implementation of the corrective action.

EPA is responsible for conducting RFAs and plans to do so over the coming years at all RCRA facilities. Because EPA undertakes the RFA, the facility owner or operator is unlikely to face significant costs in this phase of the corrective action process. Accordingly, the cost of the RFA is not included in the estimates of total corrective action costs.

Should the RFA suggest the need for further analysis at a facility, EPA may direct a facility owner or operator to undertake an RFI. Because the specific steps of the RCRA corrective action program are a relatively recent addition to the program, there is little information on the costs to the regulated community of each step. Given, however, that the RFI is similar in scope and content to the Remedial Investigation (RI) phase of the Superfund cleanup program, available data on the cost of the RI were reviewed. In doing so, it was determined that RI costs may range widely. Based on conversations with contractors associated with the CERCLA program, RI costs were estimated to range from $300,000 to $1,300,000 per site. In general, an assessment of environmental threats at the typical RCRA facility is likely to cost less than a similar assessment at the typical uncontrolled Superfund site because sampling and monitoring activities may have been performed at RCRA facilities (e.g., RCRA land disposal facilities must comply with ground-water monitoring and hydrogeologic characterization requirements to obtain a RCRA permit).

Moreover, information on the wastes disposed or handled on-site may be more readily available for a RCRA facility than a Superfund site due to the record-keeping requirements under RCRA. Accordingly, RFI costs are assumed to be lower than Superfund RI costs. For the purposes of this RIA, therefore, the cost of a RFI is assumed to be the same as the lower bound estimate for a Superfund RI, or $300,000.

If, based on the results of the RFI, EPA determines that contaminant concentrations in the environment exceed the health-based standards specified in the proposed rule, an owner or operator may be compelled to undertake a Corrective Measures Study. Again, EPA's experience in the Superfund program was used to develop an estimate of the cost of the CMS. A CMS is roughly analogous to the Feasibility Study (FS) done at each Superfund site. Available information suggests that the cost of a FS may range from $100,000 to $200,000. Because the specific requirements for a CMS are somewhat less prescriptive than for a FS and, given the earlier assumption that RCRA facilities are likely to be less complex sites than Superfund sites, the estimated CMS cost is taken from the low end of the range of FS costs; that is, the typical CMS is assumed to have a cost of $100,000 to the RCRA facility.

8.1.2 Costs of Corrective Action

After the CMS has been completed, EPA may select a particular corrective action alternative from among those studied in the CMS. The facility owner or operator is then responsible for implementing the particular remedy. As described in Chapter 6, this RIA has analyzed the costs and effectiveness of 4 corrective action remedies that address ground-water contamination:

- Capping;
- Recovery wells;
- Excavation; and
- Excavation with recovery wells.

Other remedies have been used in the Superfund remedial program and are likely to be used in the RCRA corrective action program; nonetheless, these 4 remedies were selected to be representative of the range of available remedies. As discussed in Chapter 6, for Options C and D, the RIA assumes that institutional controls will be selected in lieu of 1 of the 4 remedies in cases where remedies do not reach target and are infeasible or where all remedies exceed $150 million to implement.

In the analysis done for the RIA, the Liner-Location Model (LLM) was used to estimate the cost of each of these actions for facilities in the data base simulated to trigger corrective action using standardized algorithms.[1] These algorithms were developed based on EPA experience, best professional judgment, and standard construction cost estimation techniques. Within a model run, the LLM computes the cost of each remedy available for a particular facility; based on a series of remedy selection rules, the model chooses a

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[1] Liner Location Risk and Cost Analysis Model: Phase II Report, Appendix, March 14, 1986, prepared by ICF Incorporated, hereinafter cited as Phase II Report.

single remedy for each facility. The remainder of this section describes the cost calculations for each remedy, while Section 8.2 presents cost estimates for those remedies that were actually selected.

Capping involves the placement of a relatively impermeable layer (i.e , 2 feet of clay and a synthetic layer) over the top of the particular SWMUs subject to corrective action. The costs of capping reflect the costs of site preparation, materials, installation, and indirect costs such as engineering design, inspection and testing, overhead and profit, contingencies, and a health and safety allowance. As modeled, the cost of the cap is a function only of the total surface area of the unit, with total costs equal to $71.40 per square meter.[2]

Recovery wells are used to withdraw contaminated ground water for the purposes of treatment. As modeled for this RIA, the cost of recovery wells reflects both the installation and operation of the wells and the construction and operation of an appropriately sized effluent treatment system. The costs of this remedy reflect a complex set of several calculations.[3] In general, though, the recovery well remedy simulated by the LLM involves several steps. First, a series of detection wells are drilled to delineate the plume and to provide a method for assessing the performance of the remedy while it is underway. Next, the actual recovery wells are installed along with the required infrastructure such as pumps, piping, and electrical lines. Based on the estimated volume of water to be recovered, a treatment plant of sufficient capacity is constructed. After adding the same types of indirect costs associated with capping, the model calculates the first year cost of the remedy. Finally, the model estimates the annual cost of operating the recovery well and treatment plant systems. This annual cost is then incurred in each year that the remedy is underway. In general, the remedy is continued until contaminant concentrations reach the target levels associated with the particular regulatory alternative being analyzed.

Excavation involves the removal and off-site disposal of all contaminated wastes within the SWMUs subject to corrective action. Costs reflect various preparatory activities, the actual excavation of the wastes, transportation to an off-site landfill, and landfill disposal costs. A series of indirect capital costs such as engineering design and inspection and overhead are then added to the direct capital costs. The cost of excavation at a particular site is a function of both the surface area and the volume of material excavated.[4] The total cost of the excavation is estimated as $95.04

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[2] Capping costs consist of two components. The first is the direct costs, estimated at $34 per square meter. Direct costs are based on data provided by Sobotka and Company, Inc. in a memorandum dated August 9, 1985. The second component is indirect costs, estimated at 110 percent of the direct cost. Indirect costs, which include engineering, testing, overhead, health and safety, and contingencies, are drawn from the Phase II report.

[3] See Phase II Report.

[4] The costs of off-site disposal were developed based on prices prevailing at the time the model was developed; such costs do not include the increased prices associated with limitations on disposal capacity brought about by EPA's

times the surface area (in square meters) plus $574.56 times the volume of waste (in cubic meters).[5]

Excavation with Recovery Wells involves a combination of 2 specific remedies. Its costs are estimated based on the algorithms for each of the 2 remedies. The cost of the excavation portion of the remedy is the same as when excavation by itself is simulated. The cost of the recovery well action, however, differs depending on whether excavation has been included. The reason for the difference is that the excavation is often successful in significantly reducing the total contaminant mass released to ground water and, thus, the duration over which the recovery wells must be operated.

8.1.3 Estimation of Costs Per Facility

After the Liner-Location Model has simulated each of the remedies that are available at a particular facility in a manner that is consistent with the particular regulatory alternative being analyzed (e.g., certain remedies are not allowed for some alternatives), the LLM estimates the following 3 key parameters for each of the simulated remedies:

- Effectiveness;
- Cost; and
- Feasibility.

As described in Chapter 6, these parameters are then used in conjunction with a series of remedy selection rules to assign a particular remedy to a specific facility. The selected remedies and their cost may vary among the regulatory alternatives for several reasons:

- The set of allowable remedies and the rules for selecting remedies are not the same for each alternative (e.g., institutional controls may be selected under Options C and D);

- Some facilities trigger corrective action under some alternatives but not under others;

- The triggers and targets for corrective actions may vary between alternatives and the same facility may be simulated to use a different remedy under each of 2 alternatives. Even if the same remedy were simulated, its costs might vary due to differences in the start and end years.

Land Disposal Restrictions Program (LDRP) or the costs of treating land disposed waste using Best Demonstrated Available Technology, as required by the LDRP. As a result, the model may underestimate costs for the options that select excavation remedies.

[5] See Phase II Report.

8.1.4 Discounting

Because the costs of the corrective action may be incurred over time, we discounted these costs to a consistent basis to allow for comparison. Three different discount rates were considered for use in this analysis: 3 percent, 5 percent, and 9.49 percent. A rate of 3 percent reflects standard assumptions used in other Office of Solid Waste Regulatory Impact Analyses; 5 percent is the rate used in the recent CERCLA National Contingency Plan (NCP) RIA; and 9.49 percent represents the weighted average cost of capital calculated in the economic impacts chapter of this RIA. Although there is no single correct discount rate, the 2 lower rates are meant to reflect a social discount rate which might be appropriate for a societal investment in a public good such as environmental protection. These rates are arguably represented by the after-tax real rate of return on risk-free savings. The weighted average cost of capital measures the return on private investment by firms in the regulated community.

Although 3 discount rates were considered, a single rate of 3 percent has been chosen for the remainder of the analysis. Unless otherwise noted, all discounted results are calculated using a 3 percent rate. The primary reason for using a single rate is to simplify the analysis and because of the general insensitivity of the relative performance of the regulatory alternatives to the discount rate. This insensitivity results largely from the fact that a significant proportion of corrective action costs are incurred in the first several years of the program and are relatively unaffected by the discount rate. The 9.49 percent rate is discarded on the grounds that it is more appropriate for assessing private, rather than social, investments.[6] The rate of 5 percent is not used because it generates results quite close to those of 3 percent. Because the 3 percent rate is generally consistent with many other analyses of various regulatory elements of the RCRA program that have already been done, it is used as the sole discount rate.

8.2 RESULTS FOR COSTS PER FACILITY

This section presents results on the estimated per-facility cost of corrective action at non-Federal facilities for each regulatory alternative. It is divided into 2 subsections. The first explains how costs vary among regulatory alternatives while the second evaluates the effect of facility characteristics (such as age or number of SWMUs) on costs.

8.2.1 Per-Facility Costs by Regulatory Alternative

This subsection discusses the mean and annualized per-facility cost by each regulatory alternative and notes that Option A is by far the most costly option.

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[6] The rate of 9.49 percent is, however, used throughout the economic impacts analysis presented in Chapter 10 to represent the weighted average cost of capital. As explained in Chapter 10, this rate measures the cost of funds to firms and is appropriately used when simulating a firm's internal financial decision making.

Mean Per-Facility Cost

As demonstrated by Exhibit 8-1, the simulated corrective action cost incurred by the typical non-Federal facility varies significantly among the regulatory alternatives under consideration. The highest cost per facility occurs under Option A, which has a mean per-facility cost of over $281 million when discounted at 3 percent. Such costs are not surprising given the stringency of this alternative. Under this alternative, corrective action is triggered sooner, lasts longer, and involves more expensive remedies than with the other regulatory scenarios.

Option C was estimated to have a mean cost of $6.3 million. Options C and D have low per-facility costs because of the associated remedy selection rules. Under Options C and D remedy selection hinges primarily on costs when faced with a choice of more than 1 effective remedy. Also, institutional controls (the costs of which are not calculated in the model) are enacted when the selected remedy exceeds a cost of $150 million. In comparison, the mean per-facility cost of the baseline scenario ($3.8 million) is somewhat lower than the costs associated with all regulatory options. The lower baseline costs are due in part to the fact that the baseline scenario assumes cleanup on-site only, while Options A through D assume both on- and off-site cleanup. Moreover, as noted in Chapter 7, the baseline scenario selects inexpensive remedies (e.g., capping) in comparison to some options, which may select expensive remedies. For instance, excavation and excavation with recovery wells is selected at about 80 percent of the facilities under Option A.

Annualized Per-Facility Costs

We examined the annualized cost of the typical per-facility corrective action cost because the costs of corrective action will be incurred over time and because firms in the regulated community may be expected to spread costs over time through internal and external financing methods. The process of annualizing these costs involves amortizing costs using a certain interest rate and a specific time period (a 20 year period is used in this analysis). We have computed annualized costs using a 3 percent interest rate, the baseline discount rate used throughout this RIA. The annualized per-facility cost of corrective action at a typical non-Federal facility is presented in Exhibit 8-2. For the lower bound proposed rule option (i.e., Option C), annualized costs are approximately $422 thousand at a 3 percent discount rate.

8.2.2 Effect of Facility Characteristics on Costs

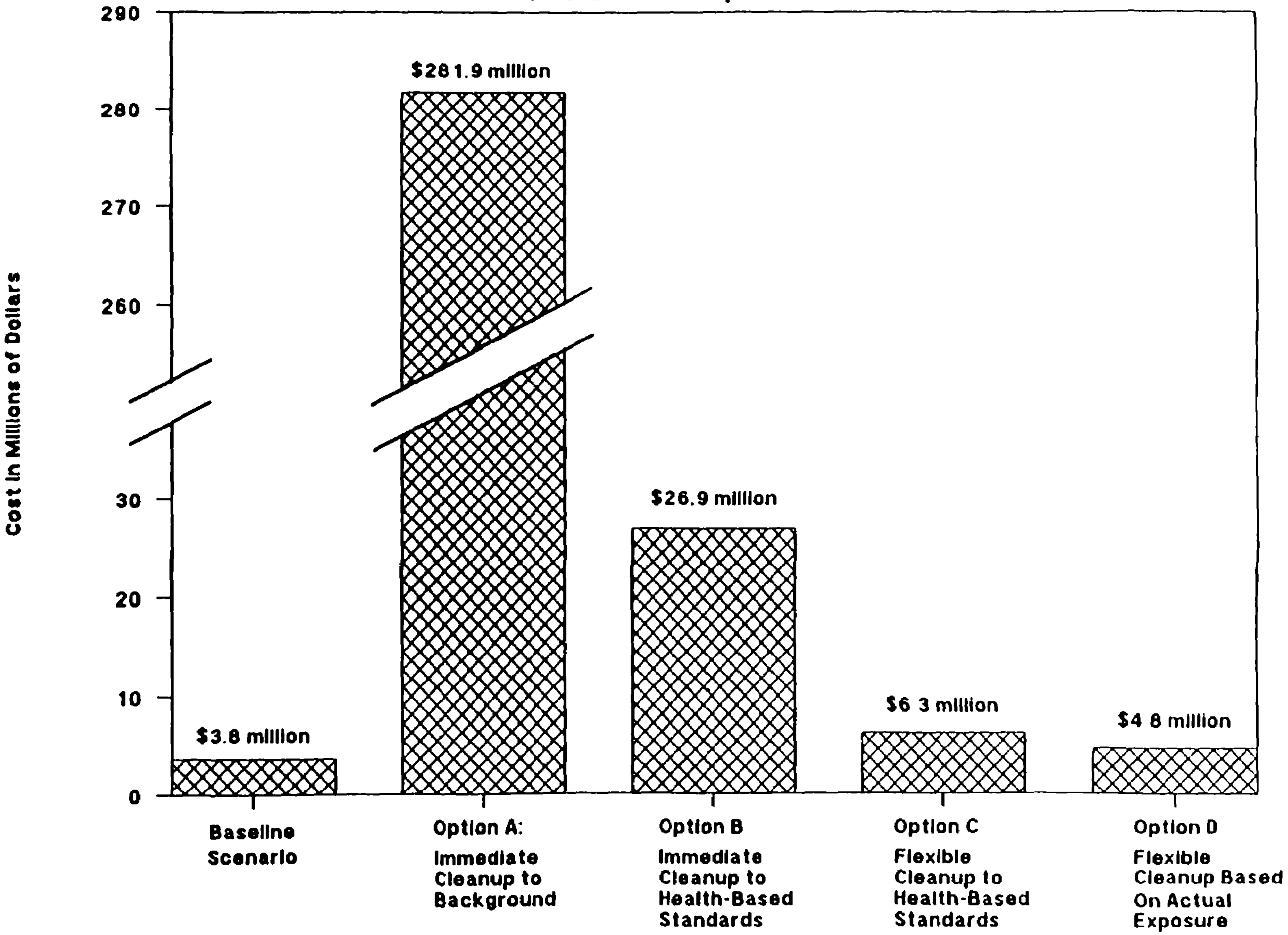
In addition to analyzing the mean per-facility cost for the entire population of facilities, we also considered the effect of 3 facility characteristics on costs:

- Facility age,
- Number of SWMUs at facility, and
- Ground-water flow field setting.

EXHIBIT 8-1

Mean Cost Per Facility Is Greatest For Option A*
(Non-Federal Facilities)

(Discount rate of 3 percent)



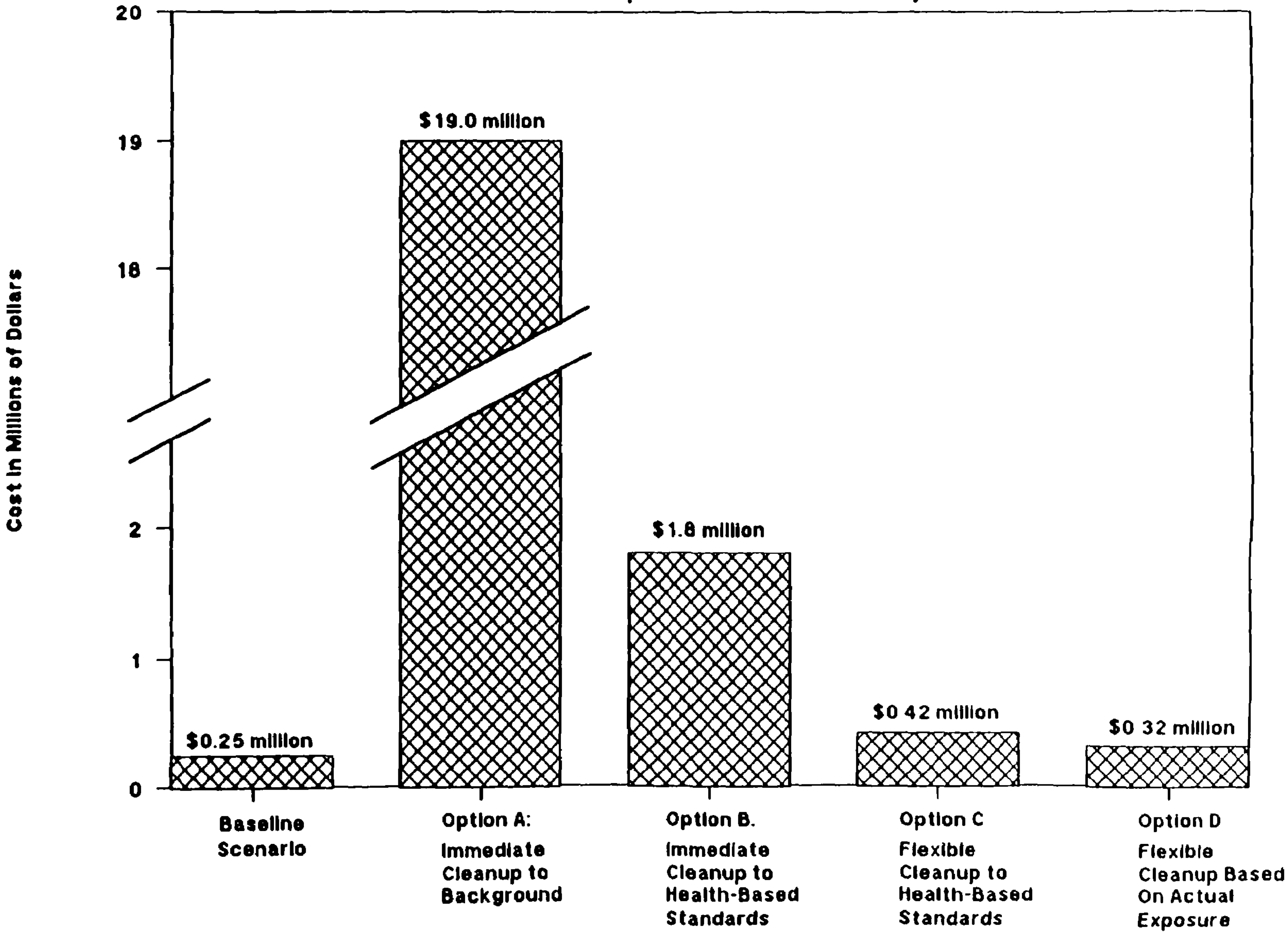
* Costs include implementation of corrective action only, do not include RCRA Facility Investigation or Corrective Measures Study

EXHIBIT 8-2

Annualized Mean Cost Per Facility Is Greatest For Option A*

(Non-Federal Facilities)

(Discount rate of 3 percent annualized over 20 years)



There were no clear patterns associating these 3 facility characteristics with corrective action costs. Older facilities showed a tendency to have higher corrective action costs. The mean cost under Option C (Flexible Cleanup to Health-Based Standards), for example, for facilities that were between 11 and 20 years old was $698,000, while facilities with an age between 21 and 30 years had a mean cost of $1.5 million. The relationship between facility age and mean per-facility cost was somewhat erratic, however, suggesting that factors other than age have a more direct influence on costs. Such factors include the extent of contamination, the nature of the particular SWMUs to be addressed, and the remedy selected for the facility.

Similarly, the per-facility costs are only somewhat influenced by the number of SWMUs at the facility. Again, the relationship was generally in the expected direction; facilities with 6 to ten SWMUs faced a mean cost of $1.8 million under Option B (Immediate Cleanup to Health-Based Standards) while facilities with between eleven and twenty units had an estimated mean cost of $7.9 million. These costs did not, however, vary uniformly with respect to the number of SWMUs either within a single regulatory alternative or across all 4 regulatory options.

There are several reasons why the number of SWMUs may not directly affect the cost results. Most importantly, not all SWMUs pose an equal threat to the environment. A single large surface impoundment of several acres may be much more likely to trigger a major corrective action than 1 small above-ground tank. Similarly, even if an action is triggered, response costs for small units are likely to be lower than for big units. And, for a remedy that does not include source control (e.g., recovery wells), costs are driven primarily by the extent of the contaminant plume. While it is certainly likely that as the number of SWMUs at a facility increases, potential plume sizes will also increase, the relationship is not direct. Finally, the cost estimating methodology of the model does not account for economies of scale in corrective actions.

We also examined the degree to which the particular ground-water flow field setting influenced the mean corrective action cost. These flow fields are defined in detail in Appendix A. As with the other factors discussed above, there was no clear pattern of costs among ground-water settings.

In short, it seems that several factors have the potential to affect corrective action costs, including the nature and extent of the contamination, the hydrogeologic characteristics of the site, the time period over which contaminants have been released, the nature of the waste management practices leading to the release, and the particular corrective action remedy selected. While these factors are simultaneously incorporated in the facility-by-facility cost simulation that produced the mean per-facility cost shown in Section 8.2.1 above, it is not possible, given the data available from the model outputs, to isolate the effect of these various facility-specific factors.

8.3 RESULTS FOR TOTAL NON-FEDERAL COSTS

The total national non-Federal cost for EPA's corrective action program represents an interaction of 3 important parameters: the average cost of each action, the investigative costs of the RFI and CMS, and the number of facilities required to undertake corrective action. Section 8.1 explained our calculation of average corrective action costs for each regulatory alternative. After briefly summarizing the number of facilities subject to corrective action, this section describes our estimation of the total costs of the corrective action program for non-Federal facilities. Results for the costs of corrective action at Federal facilities are presented in Chapter 12.

8.3.1 Background

As explained in Chapter 7, the number of facilities that trigger corrective action varies among the regulatory alternatives analyzed. Exhibit 8-3 again summarizes how many facilities undergo corrective action in each of several time periods. In general, the baseline scenario has significantly fewer facilities with corrective action because, prior to the enactment of HSWA, only regulated land disposal units were subject to corrective action. Option A (Immediate Cleanup to Background) has the highest number of facilities with corrective action, an unsurprising result given its stringent nature. Options B, C, and D all have the same number of facilities undertaking corrective action because each involves eventual cleanup to the same level (i.e., a health-based target measured at the 10 meter well).

8.3.2 National Non-Federal Costs

Exhibit 8-4 presents the total national non-Federal costs of each regulatory option relative to the baseline scenario (i.e., the baseline scenario cost of $3.2 billion is subtracted from each option to obtain the total incremental cost of the option). For those facilities that trigger corrective action, the costs of the investigative phases of the corrective action process (i.e., the RFI and CMS) have been added to the total costs associated with the actual implementation of the corrective action. CMS costs are simulated to occur in the same 10 year period in which corrective action is triggered. RFI costs are assumed to be incurred in the first 20 years; half in the first decade and half in the second decade. Exhibit 8-5 depicts the investigative costs for each option. Those RFI and CMS costs, described in Section 8.1.1, are combined with the mean per facility costs and multiplied by the number of facilities that trigger corrective action to obtain the total national costs shown in Exhibit 8-4.

Option A (Immediate Cleanup to Background) is, by far, the most expensive of the alternatives analyzed and has an incremental cost of over $490 billion. This result occurs because about 80 percent of the facilities are simulated to selected excavation or excavation with recovery wells, which are often the most expensive remedies considered by the model, and because the stringent trigger levels cause more than 100 additional facilities to trigger when compared to Options B, C, and D. The least cost alternative (although by only a slight difference) is Option D (Flexible Cleanup Based on Actual Exposure) with a cost of $5.0 billion.

EXHIBIT 8-3

TIMING OF CORRECTIVE ACTION VARIES ACROSS REGULATORY ALTERNATIVES

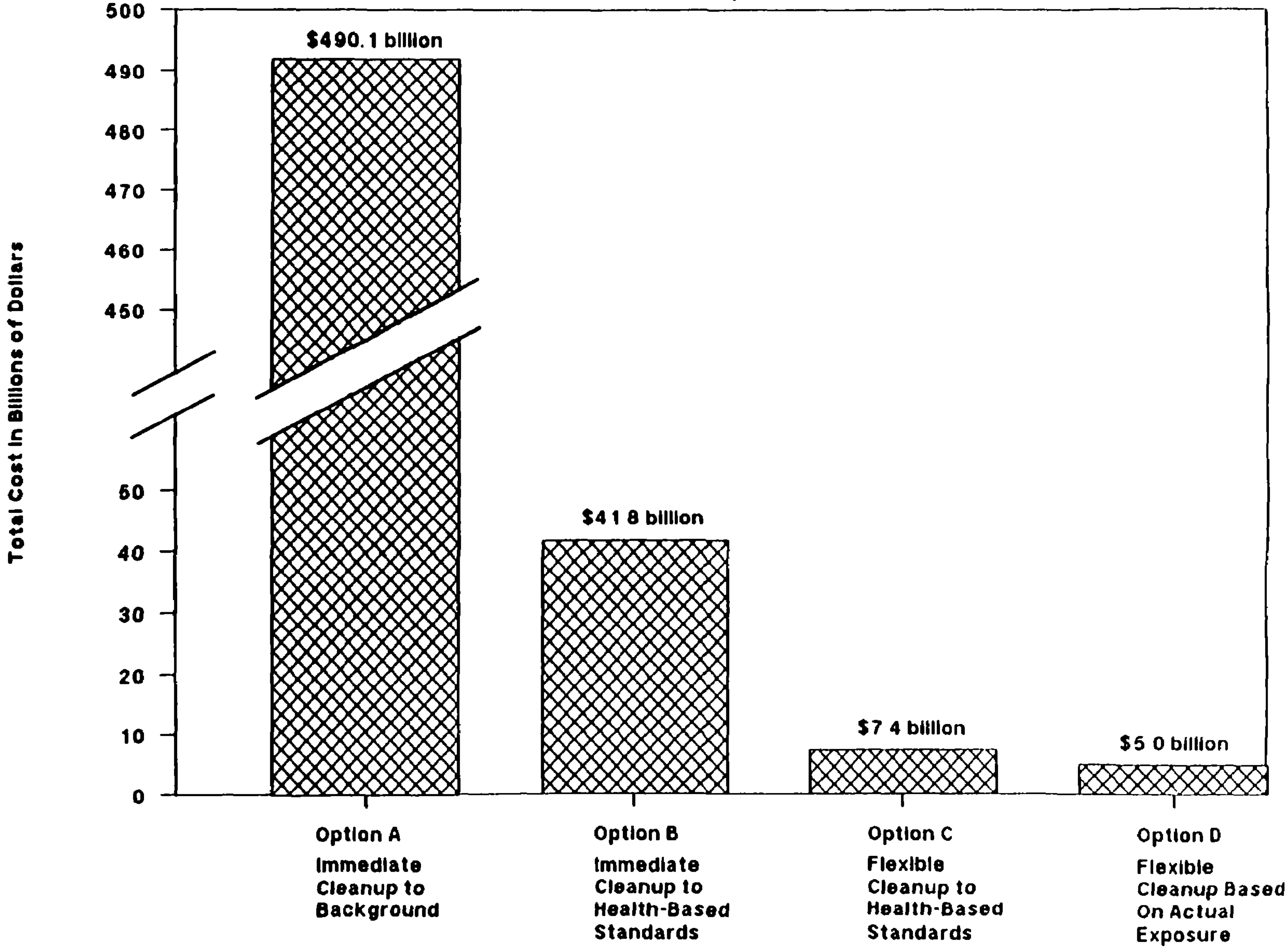
Corrective Action Timing	Number of Non-Federal Facilities Requiring Corrective Action Under Each Alternative				
	Baseline Scenario	Option A: Cleanup to Background	Option B: Immediate Cleanup to Health-Based Standards	Option C: Flexible Cleanup to Health-Based Standards	Option D: Flexible Cleanup Based on Actual Exposure
1987					
Engineering remedy	515	1,364	658	621	606
Institutional Controls	NA a/	NA	NA	37	53
1988-2000					
Engineering remedy	0	154	196	180	118
Institutional Controls	NA	NA	NA	16	27
2001-2025					
Engineering remedy	191	170	542	499	522
Institutional Controls	NA	NA	NA	43	32
2026-2120					
Engineering remedy	64	58	250	250	288
Institutional Controls	NA	NA	NA	0	0
	770	1,747	1,646	1,646	1,646

a/ NA: Institutional controls may not be selected for this option.

EXHIBIT 8-4

Total National Costs Relative to Baseline Vary Among Options*
(Non-Federal Facilities)

(Discount rate of 3 percent)



* Include RFI, CMS, and implementation of corrective action

EXHIBIT 8-5

RFI AND CMS COSTS FOR EACH REGULATORY OPTION (in millions)

Option	RFI and CMS Costs
Baseline Scenario	$286.6
Option A: Immediate Cleanup to Background	$876.9
Option B: Immediate Cleanup to Health-Based Standards	$845.9
Option C: Flexible Cleanup to Health-Based Standards	$845.9
Option D: Flexible Cleanup Based on Actual Exposure	$843.1

Option C has an incremental cost of $7.4 billion [7] Options B (Immediate Cleanup to Health-Based Standards) and D have incremental costs of $48.1 billion and $5 billion, respectively. The difference between the costs of these 3 scenarios and Option A is due to the postponement of many corrective actions taken immediately under Option A, and the level to which cleanup must be performed. The difference between the costs of Options C and D compared to Option B is attributable to the flexibility used in remedy selection described in Section 8.2.1. For example, remedies involving excavation (i.e., more costly remedies) are selected at about 29 percent of facilities under Option B compared to about 14 percent under Option C. Similarly, less expensive remedies, such as capping, are selected at about 38 percent of facilities under Option B but at about 65 percent of facilities under Option C.

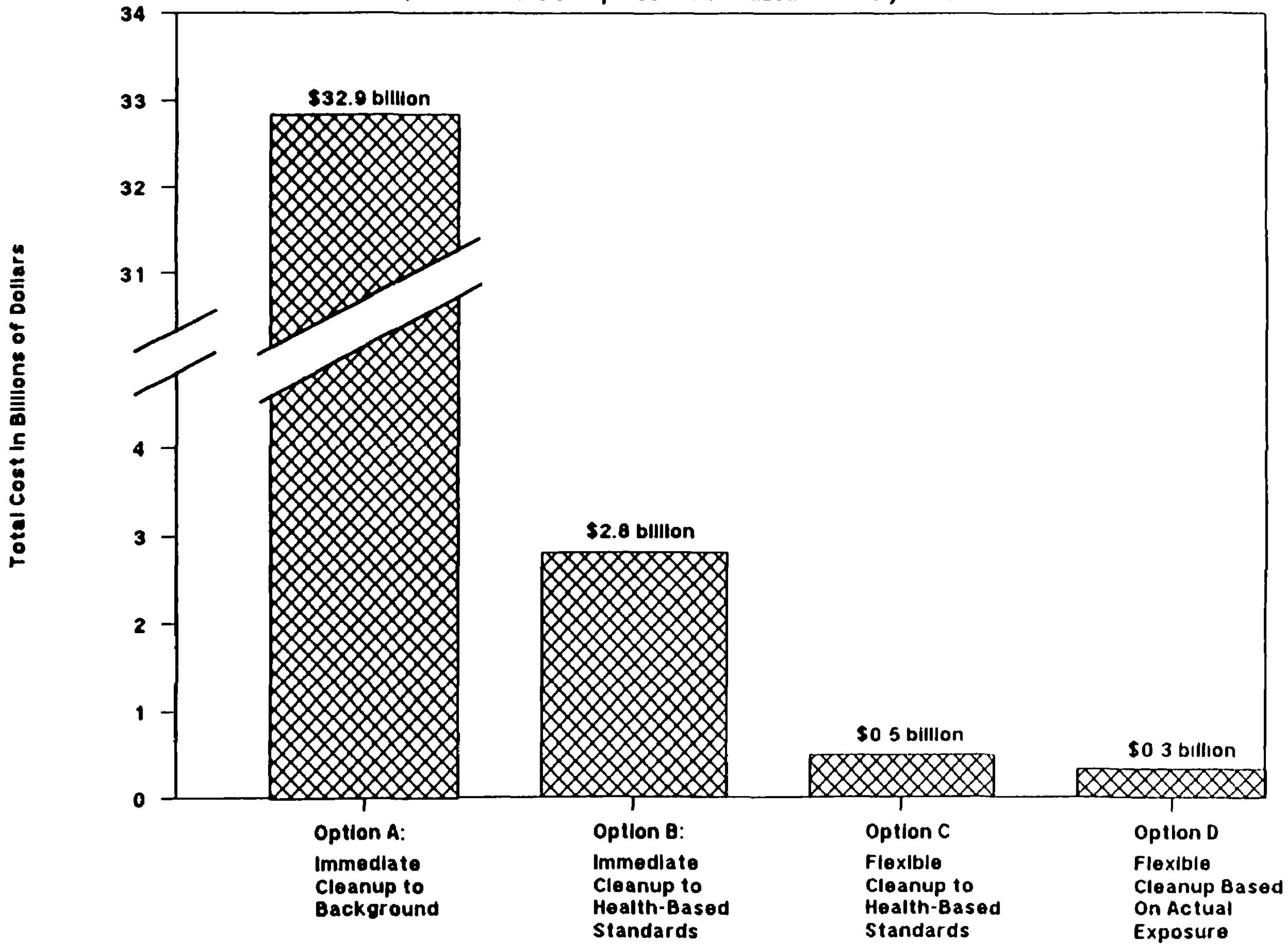
Exhibit 8-6 presents the annualized national costs associated with the corrective action relative to the baseline. These results show that implementation of the RCRA corrective action program may generate annual costs of approximately $500 million (Option C, Flexible Cleanup to Health-Based Standards) to $2.8 billion (Option B, Immediate Cleanup to Health-Based Standards). As with total national costs, this cost is a result of the specific modeling assumptions used in the analysis to reflect each regulatory alternative. To the extent that a significant number of facilities are allowed to use interim remedies, to postpone corrective action, or to use institutional controls in lieu of prohibitively expensive cleanup technologies, the costs of implementing the corrective action program may be closer to those of Option C than to the other options modeled.

[7] The total non-incremental cost of Option C is $10.6 billion (i.e , $3.2 billion in baseline plus $7.4 billion incremental to baseline costs).

Annualized National Costs Relative To Baseline Vary Among Options*

(Non-Federal Facilities)

(Discount rate of 3 percent annualized over 20 years)



* Costs include RFI, CMS, and implementation of corrective action

9. COMPARISON OF SIMULATED COSTS TO CERCLA EXPERIENCE

Based on results from the Liner-Location Model (LLM), Chapter 8 estimated that the incremental costs incurred at non-Federal facilities under the proposed RCRA corrective action rule could range from $7 4 billion to $41 8 billion, for a total national cost of between $10 6 billion to $45 billion (i e., the baseline is $3 2 billion). The RCRA corrective action program is relatively new, it is difficult, therefore, to evaluate these results using existing RCRA data. The CERCLA remedial action program, begun in 1981, is similar in focus to the RCRA corrective action program and provides data that can be used to assess the Chapter 8 estimates. CERCLA sites and RCRA facilities differ considerably, however, and several adjustments are necessary before making such a comparison. This chapter presents the relevant CERCLA remedial action cost estimates and develops a methodology to compare these estimates to those derived in Chapter 8 using the LLM.

In response to the Superfund Amendments and Reauthorization Act of 1986 (SARA), EPA developed proposed revisions to the National Contingency Plan (NCP). The NCP provides guidelines, operating procedures, and responsibilities for response actions under CERCLA. In developing the revisions to the NCP, EPA prepared a Regulatory Impact Analysis (RIA) which estimated the costs associated with post-SARA remedial and removal actions.[1] Although the methodology used in the NCP RIA differs from that used in this RIA and involves a different EPA program, the cost estimates in the NCP RIA provide the basis for a useful check on the Chapter 8 estimates.

9.1 DEVELOPMENT OF CERCLA COST ESTIMATES

The NCP RIA estimated the costs associated with a typical cleanup that complied with the provisions of SARA. These costs were based on a sample of Superfund Records of Decision (RODs). The RODs represent actual remedial actions selected for sites (both fund-lead and enforcement-lead), and provide cost projections based on detailed engineering plans.

The cost estimates in the NCP RIA were derived from data contained in RODs that were signed between FY 1982 and FY 1986. The NCP RIA restricted its analysis to 30 RODs because of the alternatives considered and the format of the data presented in some of the RODs. The NCP RIA stated that there was no information to determine the extent to which this sample is representative of all ROD sites.

The NCP RIA estimated that, based on these RODs, treatment-based CERCLA remedies incur, on average, $17.2 million in capital costs and $340,000 in annual operations and maintenance (O&M) costs per site; containment-based

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[1] U.S. EPA, "Regulatory Impact Analysis in Support of the Proposed Revisions to the National Oil and Hazardous Substances Pollution Contingency Plan," Office of Solid Waste and Emergency Response, prepared by ICF Incorporated, 1988.

CERCLA remedies incur, on average, $4 5 million in capital costs and $610,000 in O&M costs per site. The NCP RIA assumed that 80 percent of the post-SARA remedies are treatment-based and 20 percent are containment-based. This yields a weighted, per-site average cost of $14 7 million in capital costs and $394,000 in O&M costs.

The cost estimates in the NCP RIA and in Chapter 8 cannot be compared directly. As explained in Section 9.2, however, the NCP RIA estimates can be used to check the Chapter 8 estimates. There are three major factors that affect this process. First, the NCP RIA considers costs for contamination of all media, whereas the quantitative analysis in Chapter 8 considers only ground-water contamination Second, the NCP RIA cost estimates are only for operable units; there may be more than one operable unit at a single site.[2] The Chapter 8 cost estimates are for the entire RCRA facility. Third, the typical Superfund site is likely to require more complex cleanup activities than the typical RCRA facility. The methodology presented in this chapter attempts to correct for the third factor (i.e., the complexity of the cleanup), but the appropriate data to correct for the other two factors were not available.

9.2 METHODOLOGY FOR ADJUSTING CERCLA COST ESTIMATES

With certain adjustments, the NCP RIA cost estimates can be used to project the costs associated with RCRA corrective action activities.[3] This section presents a methodology to apply the CERCLA cost estimates to RCRA facilities and calculate total and per-facility costs for non-Federal facilities.

Categorization of RCRA Sites

There are currently 5,309 non-Federal RCRA facilities. As discussed in Chapter 2, based on preliminary RCRA Facility Assessment (RFA) findings, approximately 62 percent, or 3,292 facilities, are projected to require a RCRA Facility Investigation (RFI). In Chapter 8, about half of these facilities are assumed to require corrective action for ground-water contamination. For the purposes of this analysis, another 40 percent are assumed to require corrective action for contamination of other media, such as surface water, air, and soil. The modeling effort described in Chapter 8 only considered

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[2] In the remedial process, a typical Superfund site may be broken down into components, or operable units. For example, one operable unit may address the source of contamination at a site, while another operable unit addresses a contaminated ground-water plume. RODs, therefore, may provide costs either for an entire site or for a single operable unit at a site.

[3] Certain aspects of the LLM model were compared with algorithms and data used in the Superfund Cost of Remedial Action (CORA) model. The CORA model incorporates CERCLA experience to date, best engineering judgment, and a computer-assisted decision-making algorithm used to guide Superfund remedy selection. Based on this comparison, a few limited revisions to the LLM were made to reflect knowledge gained in the CERCLA program.

ground-water contamination; EPA believes that many facilities may have contamination of other media that is not necessarily associated with ground-water contamination. Thus, for the purposes of this analysis, approximately 90 percent, or 2,962, of these 3,292 facilities are assumed to require corrective action of some sort.

In order to apply the CERCLA cost estimates to these RCRA facilities, key assumptions must be made regarding the magnitude and complexity of the contamination, and hence the cleanup, at the facilities. Corrective action at RCRA facilities is likely to range from relatively inexpensive activities that address minor contamination to very large scale cleanups Based on EPA's experience with the RCRA program and a qualitative analysis of the RFAs included in the sample survey, approximately 20 percent of the facilities requiring corrective action are assumed to involve remedial actions of a magnitude equivalent to that of a Superfund site, 30 percent are assumed to involve substantial (i.e., of a magnitude equivalent to half that of a Superfund site) remedial actions, and the remaining 50 percent are assumed to involve minor cleanup activities. These calculations are summarized in Exhibit 9-1.

Not all cleanups are likely to take place in the first year of the corrective action program. For the purposes of this analysis, the timing is assumed to be the same as that estimated by the LLM. The projected timing of RCRA corrective action is presented and analyzed in Chapter 7. The same timing assumptions are used in this analysis.

Cost Estimates for Categorized RCRA Facilities

For the purposes of this analysis, the costs associated with a Superfund-like cleanup of RCRA facilities are assumed to equal those estimated in the NCP RIA (i.e., $14.7 million in capital costs and $394,000 in O&M costs). This analysis assumes that a substantial cleanup will incur capital and O&M costs equal to half of those incurred in a Superfund-like cleanup.

The Superfund removal costs incurred from FY 1985 through FY 1987 can be used to estimate the minor cleanup costs. Conversations with EPA Superfund personnel indicated that the removal actions, other than "classical emergencies," undertaken during this period incurred average costs of approximately $325,000. This analysis uses that estimate as a proxy for the costs incurred by a minor cleanup. There are no O&M costs associated with a minor cleanup.

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[4] The timing assumptions contained in Exhibit 7-1 (for Options B and C) have been simplified by further assuming that corrective actions will be initiated at the midpoint of the indicated time periods and that the distribution over time will be the same for each category of RCRA facility.

Exhibit 9-1

Categorization of RCRA Facilities Requiring Corrective Action[5]

Category of Facility	Proportion[6]	No. of Facilities
Superfund-like Cleanup	20 %	592
Substantial Cleanup	30 %	889
Minor Cleanup	50 %	1,481
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Total	100.0 %	2,962

[5] The totals in this and all other exhibits in this chapter have been corrected for rounding errors.

[6] These proportions are of the number of RCRA facilities requiring corrective action; they do not include the 2,347 facilities that will not require corrective action.

The present value (using a 3.0 real interest rate) of the capital costs with ten years of O&M is $18.1 million for the Superfund-like cleanup and $9.1 million for the substantial cleanup. The present value cost of the minor cleanup is simply $325,000 because all the costs are incurred in the first year. Applying these present value estimates to the time distributions in Exhibit 7-1, and calculating the weighted average yields the present value cost of each of the three types of remedial actions. These calculations are summarized in Exhibit 9-2.

9.3 RESULTS AND CONCLUSIONS

Based on these estimated costs for the three types of remedial actions, and the number of RCRA facilities expected to fall into each of the three categories, the estimated total costs for the proposed corrective action rule are $12.9 billion, for an average per-facility cost of $4.4 million. These results are summarized in Exhibit 9-3.

The NCP-derived total cost estimate of $12.9 billion falls between the Chapter 8 estimates of $10.5 billion (Option C) to $45 billion (Option B). The per-facility costs differ as well: the NCP-derived per-facility estimate is $4.4 million compared to the range of $6.3 million to $26.9 million estimated in Chapter 8. Most of the difference between the per-facility estimates arises from the fact that this analysis includes many minor (and relatively cheaper) cleanups that were not included in the estimates developed in Chapter 8

There are a number of limitations that should be considered in comparing these two estimates. First, the estimates presented in Exhibit 9-3 are very sensitive to the assumptions regarding the categorization of sites presented in Exhibit 9-1. As Exhibit 9-4 demonstrates, plausible ranges for the cost estimates in Exhibit 9-3 are $7.6 to $18.1 billion for total costs, and $2.6 to $6.1 million for per-facility costs. Second, as discussed in Section 9.2, this analysis does not correct for the fact that NCP RIA considers costs for contamination of all media, whereas Chapter 8 considers only ground-water contamination, nor does this analysis correct for the fact that the NCP RIA cost estimates are only for operable units.

On balance, however, this analysis demonstrates that the methodology used in Chapter 8 appears to have produced a reasonable approximation of the actual costs associated with EPA's proposed corrective action program.

Exhibit 9-2

Calculation of Cleanup Costs (in millions)

Category of Facility	Capital Cost	O&M Cost	Present Value of 10 Years of O&M Plus Capital Cost	Weighted Average Cost Per Facility[7]
Superfund-like Cleanup	$14.7	$0.394	$18.1	$12.1
Substantial Cleanup	7.4	0.197	9.1	6.1
Minor Cleanup	0.3	None	0.3	0.2

[7] The weighted average cost per facility reflects the effects of discounting the costs at 3.0 percent to incorporate the timing of the initiation of corrective action as presented in Chapter 7.

Exhibit 9-3

Present Value Cost Estimates of RCRA Corrective Actions Based on NCP Estimate (in millions)

Category of Facility	Weighted Average Cost Per Facility	Number of Facilities	Total Cost
Superfund-like Cleanup	$12.1	592	$ 7,163 1
Substantial Cleanup	$6.1	889	5,402.1
Minor Cleanup	$0.2	1,481	322 2
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Total (2,962 facilities)	$4.4	2,962	$12,887 4

Exhibit 9-4

Sensitivity Analysis of Site Categorization (in millions)

Category of Facility	Lower-bound		Upper-bound	
	Percentage of Facilities	Total Cost	Percentage of Facilities	Total Cost
Superfund-like Cleanup	10%	$3,581.5	30%	$10,744.6
Substantial Cleanup	20%	3,601.4	40%	7,202.7
Minor Cleanup	70%	451.1	30%	193.3
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Total (2,962 Facilities)	100%	$7,634.0	100%	$18,140.7
Per-facility Average Cost		$2.6		$6.1

PART 3

SUPPORTING ANALYSIS

10. ECONOMIC IMPACTS

Previous chapters of this analysis have established the range of potential corrective action costs for which treatment, storage, and disposal facility (TSDF) owners or operators may be responsible under various corrective action regulatory scenarios. This chapter measures the economic impacts of these regulatory costs on the firms affected by the rule. Specifically, this part of the analysis estimates the degree to which affected firms may encounter significant financial difficulties when attempting to pay for the corrective action costs at their facilities under the regulatory options assessed in the quantitative analysis for the RIA (see Chapter 6 for a description of the regulatory options).

EPA's corrective action program will require owners or operators of TSDFs to absorb the costs of corrective action. By placing the burden on owners or operators, this approach ensures that the costs of cleanups are not passed to future generations when the extent of contamination and level of costs may be much more substantial. On the other hand, as demonstrated in Chapter 8, the costs of corrective action can be quite large and may add significantly to the costs of doing business for affected firms. Results may include reduced profitability for firms owning hazardous waste facilities, changes in the structure of affected industries by limiting firm entry or hastening firm exit, changes in firm decisions related to prices and outputs, and changes in consumer demand for products produced by firms generating hazardous waste.

Because the corrective action regulations have the potential to affect thousands of firms, each producing a variety of goods and services that are bought and sold in a myriad of markets, a complete analysis of potential economic impacts is not within the scope of this RIA. Instead, as an approximation of economic impacts, this chapter concentrates on the financial impacts of the regulation on affected firms. Economic impacts are, however, discussed in qualitative terms in Section 10.1.2.

In summary, the analysis of the financial impacts of the corrective action rule indicates that the baseline and four regulatory options vary significantly in terms of the potential impacts on firms, facilities, and alternate sources of funding for corrective action. Option A (Immediate Cleanup to Background) leads to the highest level of economic impacts; as compared to the baseline, an additional 20 percent of firms may experience adverse impacts from corrective action requirements under this option. Option B (Immediate Cleanup to Health-Based Standards), may lead to adverse impacts for an additional 11 percent of firms. Under Options C and D (Flexible Cleanup to Health-Based Standards and Flexible Cleanup Based on Actual Exposure, respectively), an additional 9 percent of firms may experience some adverse impacts due to corrective action costs. For this analysis, a firm is assumed to experience adverse impacts if the firm faces a significantly higher risk of bankruptcy (as measured by a bankruptcy predictor known as the Beaver ratio test) due to corrective action costs.

In terms of facility impacts, Option A again leads to the highest level of economic impacts.[1] Under this option, an additional 18 percent of facilities over the baseline level of 5 percent may be unable to cover their corrective action costs. Options B and C lead to an additional 10 percent and 7 percent, respectively, of facilities that may be unable to cover their costs. Under Option D, an additional 7 percent of facilities may be unable to fund their corrective actions.

If a firm cannot cover its corrective action costs, alternate sources of funding may have to be tapped to perform the corrective action. EPA estimates that the potential burden on alternate sources of funding for corrective action ranges from an additional $74 billion over the next 50 years (undiscounted) for Option A to an additional $160 million for Option D. Option C, which represents the lower bound estimate of the proposed rule, could result in an additional burden of $460 million over the next 50 years (undiscounted).

The approach for estimating these impacts is summarized in Section 10.1; Section 10.2 provides more detailed results of the analysis. The conclusions are presented in Section 10.3 along with key limitations to the results.

10.1 METHODOLOGY

This section describes the approach for estimating financial impacts of the corrective action rule. Sections 10.1.1 through 10.1.4 correspond to the four major steps of the analysis as follows:

(1) Section 10.1.1 identifies the firms affected by the rule and discusses the financial data used for this analysis.

(2) Section 10.1.2 describes the estimation of the ability of affected firms to pay for a range of potential costs using different measures of ability to pay; one ability-to-pay test is selected for use in the detailed analysis of financial impacts.

(3) Section 10.1.3 discusses the calculation of after-tax present value and annualized costs for corrective actions from the corrective action cost data presented in previous sections.

[1] Facility impacts differ from the firm impacts described in the previous paragraph because the number of facilities owned by a single firm varies widely, from 1 to over a hundred.

(4) Section 10.1.4 describes a stochastic computer model that EPA used to estimate financial impacts based on firms' ability to pay for corrective action costs.[2]

10.1.1 Universe of Firms Examined

As described in Chapter 1, the corrective action rulemaking is assumed to affect owners or operators of all RCRA facilities regardless of permit status. The analysis does not reflect facilities that came into operation after April 1987 and thus does not consider impacts on new facilities. To characterize the universe of facilities for the economic impact analysis, EPA used information from ICF's firm/facility/financial data base (F3DB). The F3DB is described in detail in Appendix C. This section briefly describes the F3DB and discusses the limitations of the data base for this economic impact analysis.

The F3DB links active TSDFs identified by EPA's Hazardous Waste Data Management System (HWDMS) with their owners and operators, and maintains financial data on a substantial fraction of firms owning RCRA facilities. This analysis of economic impacts uses information on owners or operators of the 3,945 active TSDFs for which financial information was available as of October 1986.

Using the F3DB for this analysis entails limitations that should be considered when interpreting the results presented in later sections of this chapter. As detailed in Appendix C, the major limitation is that the data base has complete financial information on owners or operators of only 3,945 facilities, whereas the total number of facilities owned and operated by for-profit firms is currently estimated to be 5,208. In addition, financial information for a portion of the firms examined was not available from the data sources that were consulted; rather, financial information for some privately-held firms were imputed from industry average data according to Standard Industrial Classification (SIC) code and firm size. Finally, although the F3DB contains only one year of financial data, firms' performance may vary from year to year. Predicting the future impacts of corrective action costs based on one year of data may affect the accuracy of the results.

10.1.2 Ability-to-Pay Analysis

A firm's ability to pay for regulatory costs is best defined as the availability of financial resources to cover those costs. This section discusses EPA's quantitative analysis of firms' ability to pay for potential regulatory costs, as well as a qualitative analysis of economic factors that

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[2] The approach used in this Regulatory Impact Analysis does not use the model developed by OSW to analyze the impacts of the proposed financial assurance for corrective action rulemaking (the FACA Model) for two reasons. First, this effort focuses on ground-water modeling and remedy selection; the FACA Model makes several simplifying assumptions in these areas. Second, the FACA Model is a dynamic model that assesses corporate financial decision-making on an extremely detailed level. Thus, the model is highly resource intensive to use; the model used for this analysis is based on a more simplified approach.

may affect firms' ability to pay. The quantitative analysis established an appropriate ability-to-pay test for use in the assessment of financial impacts presented in Section 10.1.4.

Quantitative Analysis of Ability to Pay

As described in detail in Appendix C, EPA performed a quantitative analysis of firms' ability to pay for potential regulatory costs using five ability-to-pay rules. Based on this analysis, EPA selected the Beaver ratio test for use in the detailed financial impact analysis presented in Section 10.1.4. The Beaver ratio test assumes that firms can pay for corrective action out of their cash flow up to that amount where their Beaver ratio (ratio of cash flow to total liabilities) equals the critical value of 10 percent, the point at which firms would no longer have sufficient cash flow to assure that bankruptcy will not occur in the future. The selection was based on the following two points:

- Throughout most of the likely range of corrective action costs, firms' ability to pay using the Beaver ratio test did not vary significantly from other potential tests.

- The Beaver ratio test has been validated by previous studies as a predictor of bankruptcy.

Note, however, that while firms that do not pass the Beaver ratio test face an increased risk of bankruptcy, such firms may not actually declare bankruptcy. Firms may fund corrective actions despite falling below the Beaver ratio threshold, although it is unlikely that firms could fund costs in excess of the cash flow ratio measure for more than a few years. Thus, the analysis defines adverse impacts from the rule in terms of increased potential for bankruptcy as measured by the Beaver ratio test, but does not predict actual bankruptcies.

The analysis examines ability to pay of immediate owners of TSDFs only and does not consider the resources of any corporate parent. Although EPA intends to vigorously pursue corporate parents through litigation when immediate owners fail to provide funds for corrective action, the success rate of such activity is difficult to predict. The approach used in this analysis will, however, somewhat underestimate the number of facilities for which ability to pay is demonstrated.

Qualitative Analysis of Ability to Pay

The ultimate incidence of regulatory costs is an important variable in determining the economic impact of those costs on the regulated community. The "incidence" of regulatory costs refers to the point at which the costs are ultimately paid. Specifically, the costs associated with a regulation may be borne directly by firm owners in the form of lower returns on capital, or they may be "passed through" to consumers in the form of higher prices or to workers in the form of lower earnings. The greater the degree to which a firm can pass through regulatory costs to other parties, the greater will be its ability to pay for those costs.

The key determinants of whether a firm will be able to pass through regulatory costs to other parties include the scope of the regulation, the types of costs imposed by the regulation, the elasticities of supply and demand for the output of the industry, and the ease of entry into and exit from the industry.[3] This analysis focuses on the scope of the regulation and the types of costs imposed. The elasticities of supply and demand and the ease of entry and exit depend on the structure of a particular industry; analysis of the hundreds of industries affected by the corrective action rulemaking is beyond the scope of this chapter. However, some important conclusions may be reached by examining the broad effects of the scope of the regulation and the types of costs imposed.

The scope of a regulation, or the degree to which a regulation affects firms in an industry, plays a large role in whether costs may be passed through to other parties. Theoretically, if a regulation affects all firms in an industry, the firms are likely to pass the costs through to purchasers of the products because all firms face increased costs and no firm will be able to undercut increased prices without suffering decreased profit margins. On the other hand, if a regulation affects only a portion of firms in an industry, the costs are unlikely to be passed through because other firms will be able to undercut any attempt to do so. Moreover, new entrants to the industry, if unaffected by the regulation, will prevent the possibility of passing through costs.

The costs of performing corrective action are contingent costs; firms face the costs only in the contingency that a release requiring cleanup occurs. Therefore, the corrective action rulemaking does not entail costs for all firms covered by the rulemaking. Moreover, it is unlikely that all firms in an industry will have an on-site hazardous waste facility (i.e., be subject to the proposed rule). As discussed above, it may thus be difficult for firms required to take corrective action to pass through the costs of the cleanup.

There is, however, a difference between existing costs of corrective action and potential costs of corrective action. Some firms will discover prior releases at the outset of the regulation; those releases were caused by past waste management practices. In general, only a portion of firms in a particular industry will discover prior releases; such firms are unlikely to be able to pass through the costs of the required corrective action. Corrective action liabilities in these cases are likely to result in a reduction of profits for the affected firms.

In contrast, all firms with SWMUs have the potential to face corrective action costs in the future resulting from their future hazardous waste management practices. Consequently, all firms in an industry in which SWMUs are currently part of the production process, including new entrants, will likely behave in one of two ways. First, they may continue to use SWMUs in the production process and view corrective action as a long-term cost of doing business. These firms might purchase insurance or set aside funds according to their estimates of potential costs. Second, they may develop and implement

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[3] See "Principles of Regulatory Cost Incidence," ICF Incorporated, prepared for U.S. EPA, Office of Solid Waste and Emergency Response, January, 1986

an alternative to managing waste in SWMUs. These firms might choose to ship wastes off-site or alter production processes to minimize or cease waste generation. In either case, the firms will likely experience increased costs and a corresponding industry-wide price increase will follow. If all firms in an industry behave in the above manner, then the costs of potential corrective action are likely to be passed through to consumers.

The degree to which large and small firms exist in an industry may further determine the opportunities for passing through costs. If an industry is dominated by large firms due to the capital intensity of the industry or other barriers to entry, those firms are all likely to expect solvency in the future and engage in long-term planning for potential costs. Therefore, firms in these types of industries may pass through expected costs of corrective actions because all firms behave similarly. The commercial waste management industry provides an example of this situation.

If an industry is dominated by small firms whose resources would be entirely exhausted in meeting potential corrective action requirements, some of those firms may decide not to plan for the costs. Instead, they may take the chance that their facility will not experience a release and, if a release occurs, they may have no alternative to declaring bankruptcy. In these cases, the pass-through of regulatory costs may be negligible; sources of funds other than the immediate owners, including public dollars, may be the only resources available to perform the cleanups.

In summary, the degree to which the costs of corrective action may be passed through depends on the specific industries of affected firms. In general, however, it can be assumed that when cleanups occur, their costs will be passed on only if all firms in an industry incur cleanup requirements. Moreover, it is likely that expected future cost outlays will be passed on if all firms in an industry plan for these costs in similar fashion.

Because the corrective action rule will impose significant costs only on firms that actually require cleanup and because the need for corrective action is most directly related to prior waste management practices which vary among firms, the rule is likely to affect firms in the RCRA universe unevenly. Therefore, the stochastic model used to estimate economic impacts does not include a factor for the pass-through of regulatory costs. This approach may overstate the economic impacts of the corrective costs on firms; it is possible firms in some industries may be able to increase prices to reflect the expected value of the future costs of corrective action.

10.1.3 Calculation of Corrective Action Costs

Because firms can smooth the incidence of corrective action costs by borrowing equivalent amounts and repaying them on a yearly basis, the cost information from previous chapters must be allocated evenly over an appropriate number of years, or annualized, before the financial impacts of the costs can be assessed. This analysis uses two steps to annualize cost information: (1) estimating a cost of capital; and (2) discounting the cost flows and annualizing them.

The discount rate (or cost of capital) used in this analysis is the weighted average cost of capital (WACC). The WACC is a common measure used to estimate the cost of capital for firms or industries. A complete description of the methodology used to calculate the WACC is presented in Appendix C. As explained in this Appendix, EPA has estimated the WACC for firms subject to the proposed rule to be 9.49 percent.

Once the proper discount rate has been established, the costs of corrective action developed in previous chapters may be discounted to present value costs and annualized to simulate the financing that a firm may use to pay for the costs. The annualization period used is the period for the corrective action cost flows for each facility, up to a maximum of fifty years. For actions lasting less than ten years, EPA assumed an annualization period of ten years. EPA assumed that cost outlays after the fifty-year time period are beyond a firm's financial planning horizon. Moreover, only those corrective actions that begin in the first 10 years are examined; firms are unlikely to begin planning for later actions at the outset of the regulations.

The assumption that all owners and operators can spread their costs over a given number of years may be somewhat inaccurate. The analysis does not account for the possibility that financial differences between firms exist and can affect the cost flow faced by a firm.

10.1.4 Simulation of Economic Impacts

EPA performed the simulation of economic impacts using a stochastic, or Monte Carlo, computer model (described in detail in Appendix C). The model simulates the variability involved in the number and types of facilities that a firm may own, the range of potential corrective action costs that a particular facility may face, and a firm's ability to cover costs at its facilities. The model accounts for uncertainty by randomly selecting parameter values, such as number of facilities or level of costs, from a range of possible values with each value having a certain probability. By running the simulation numerous times, economic impacts can be estimated within an acceptable margin of error. The model performs this analysis for the baseline scenario and each of the four regulatory alternatives detailed in Chapter 6 and assesses economic impacts in three major areas: firm impacts, facility impacts, and impacts on sources of funding other than immediate facility owners.

The firm impacts and the facility impacts are measured on both an absolute basis and an incremental basis relative to the pre-HSWA baseline scenario. Financial data in the F3DB generally reflect firms' status at some point between 1983 and 1986. EPA believes that very few Subpart F corrective actions were underway during the years for which the data were collected. Thus, the analysis assumes that the financial strength of the regulated community as measured by the F3DB do not reflect the effects of complying with the baseline scenario.

(1) Firm Impacts -- The model estimates the impacts of the corrective action requirements on firms using two measures: percentage of firms with no adverse impacts and percentage of firms with adverse impacts. The results generally are estimated within one percentage point with a 95 percent degree

of confidence. This level of precision was achieved by running the simulation for 5,000 iterations (i.e., for 5,000 simulated firms). The percentage estimates were then multiplied by the total firm population to obtain firm estimates (see Appendix C for more detail).

Firms encountering "adverse impacts" from the corrective action requirements are those that in the course of the simulation are unable to provide funds for corrective action for all facilities owned without falling below the critical threshold defined by the Beaver ratio test. The firms that can pay for all corrective action costs (including financial assurance) at all facilities without significant risk of bankruptcy are considered to have "no impacts." Firms with no corrective action costs are considered to have no impacts, regardless of their current financial state.

(2) Facility Impacts -- The model also has three measures of impacts on a facility basis: percentage of facilities for which neither a RCRA Facility Investigation (RFI) nor corrective action is required, percentage of facilities for which an RFI and/or corrective action are required and the immediate owner covers all costs, and percentage of facilities for which an RFI and/or corrective action are required and the immediate owner fails to cover costs. Again, the results are generally accurate within one percentage point at a confidence level of 95 percent. As with firm impacts, the percentage estimates were then multiplied by the total facility population to obtain facility estimates (see Appendix C for more detail).

The percentage of "facilities for which neither an RFI nor corrective action is required" is calculated because some facilities will not require RFIs and will not undergo corrective action. As described in Chapter 2, about 39 percent of facilities under Options A through D are expected to be in this situation. Although no facilities are required to perform RFIs under the baseline, a release characterization similar to an RFI is required for all land disposal facilities with potential releases. The 74 percent of facilities that are not engaged in land disposal activities will not require release characterizations or corrective action in the baseline scenario.

The remaining facilities are assumed to either require an RFI (or release characterization under the baseline) yet not require corrective actions or to have an RFI and require corrective action. If a firm can fund all costs at all of its facilities, the facilities are counted as "covered." In addition, if a firm can only cover a portion of its facilities, then that percentage of facilities is counted as "covered." The facilities that cannot be covered, either when a firm cannot cover any facilities or when it can only cover a portion of facilities, are counted as "not covered."

The results for facilities not covered should be interpreted with caution. They do not reflect the actual number of facilities at which firms are unable to pay for corrective action; rather, the calculations reflect the facilities at which corrective action cannot be funded without the immediate owner failing the Beaver ratio criterion. Firms may choose to pay the costs of corrective action even if such payments endanger the firm as a going concern (as reflected by an inability to meet the Beaver test) and hope that future income will offset the reduction in cash flow entailed in paying for the regulatory costs. Because the Beaver ratio is a proven bankruptcy predictor, however, it is unlikely that a firm could sustain payments in excess of the calculated amounts for more than a few years.

(3) Impacts on Alternate Sources of Funds -- The model calculates the average cost per facility of facilities not covered in each year analyzed (over a fifty year period). To translate this result into the total costs that are unfunded by immediate owners, the average cost per uncovered facility is multiplied by the number of facilities left uncovered by firms. The results of this calculation provide an estimate of the costs for which sources of funds other than the immediate owner may have to be tapped to perform the corrective action.

One source of such funding may be the CERCLA Hazardous Substance Response Trust Fund (Superfund). Thus, in a general sense, the results of this analysis provide an estimate of the level of costs that may be turned over to Superfund. However, to be eligible for Superfund monies, the corrective action in question must not only go unfunded by the facility owner, but it also must meet a number of other criteria including a score of at least a 28.5 on the Hazard Ranking System. Because it is unlikely that all facilities with unfunded corrective action will achieve this score and meet other criteria, the estimate of facilities at which Superfund monies may be expended will be overestimated. Other sources of funds may include State Remedial action funds, corporate parents of facility owners and operators, or, through price increases, the customers of the firm owning or operating the facility.

The average yearly costs calculated in the model will generally be much higher in the early years of the regulation than in later years; the average corrective action requires the most substantial costs (capital costs) at the outset of the remedial activities. Therefore, although the burden on alternate funding sources may be in the billions of dollars in the early years of the regulation, it should be noted that the costs over time are lower. Moreover, the model estimate of total unfunded costs is the summation of undiscounted costs over all 50 years; discounting the costs to present value would reduce the estimate.

10.2 RESULTS

The following section presents the results of the stochastic simulation of economic impacts for the baseline and each regulatory option, followed by a comparison of the results among the options.

10.2.1 Baseline Scenario

Exhibit 10-1 presents the firm and facility impacts of the baseline scenario. The analysis suggests that 213 firms, or 9 percent of all RCRA firms, are estimated to encounter some adverse impact in meeting the corrective action costs. Conversely, 2,184 firms (91 percent) suffer no adverse impacts.

EXHIBIT 10-1

BASELINE HAS THE LEAST ECONOMIC IMPACT

<u>Firm Results</u>

Adverse Impacts	213 (9%)
No Impacts	2,184 (91%)

<u>Facility Results</u>

Corrective Action and Release Characterization Not Required	3,902 (75%)
Corrective Action and/or Release Characterization Required	1,309 (25%)
Costs Covered	1,040 (20%)
Costs Not Covered	269 (5%)

Total Costs Unfunded by All Firms
(in thousands of dollars)

Range of Years	Total Costs in Range
1 - 5	$64,000
6 - 10	5,000
11 - 15	7,000
16 - 20	5,000
21 - 25	5,000
26 - 30	4,000
31 - 35	2,000
36 - 40	2,000
41 - 45	2,000
46 - 50	2,000
Total	$97,000

On a facility basis, 3,902 facilities, or 75 percent, are estimated not to require release characterizations or corrective action. This number is different from the four regulatory options because only land disposal facilities are subject to the corrective action requirements under the baseline. In addition, 1,040 facilities, or 20 percent, have release characterization and/or corrective action costs that are covered by immediate owners. Only 269 facilities (5 percent) have release characterization and/or corrective action costs that are not covered by immediate owners.

The total cost not covered by immediate owners is about $60 million in the first year of the regulation. After the first year, however, the costs drop significantly to under $1 million per year, resulting in a total cost of $97 million, undiscounted, over the next 50 years.

10.2.2 Option A -- Immediate Cleanup to Background

Exhibit 10-2 presents the estimated economic impacts for Option A, the Immediate Cleanup to Background scenario. Under this alternative, which requires the most expensive remedies and is therefore costlier than any other option, the economic impacts of the corrective action regulations are the greatest. An estimated 696 firms (29 percent) will face adverse impacts under this alternative, as compared to 9 percent under the baseline; this results in an incremental firm effect of 20 percentage points. The facility impacts are also highest; 1,177 facilities (23 percent) are not covered by immediate owners. This compares to 5 percent of facilities under the baseline, resulting in an incremental impact of 18 percentage points.

Not unexpectedly, the total cost at unfunded facilities is highest under this option as well. Because of the high capital expenditures required by Option A in the first year, the total first year cost not covered by facilities is estimated at about $74.0 billion. Again, however, the costs drop sharply after the first year to an average of about $11 million per year, resulting in total costs of $74.3 billion, undiscounted, over the fifty year period analyzed. This compares to a total unfunded cost of $97 million under the baseline, resulting in an incremental impact of $74.2 billion, undiscounted, over 50 years.

10.2.3 Option B -- Immediate Cleanup to Health-Based Standards

Option B (Immediate Cleanup to Health-Based Standards) induces economic impacts that are second in magnitude only to Option A. As shown in Exhibit 10-3, 469 firms (20 percent) encounter adverse impacts. When compared to 9 percent of firms under the baseline, this results in an incremental effect of 11 percentage points. Moreover, 775 facilities (15 percent) are not covered by the firms facing adverse impacts, as compared to 5 percent under the baseline. This results in an incremental facility effect of 10 percentage points.

The total costs not covered by facilities are estimated to be $4.7 billion in the first year, followed by average yearly costs of about $11 million. The total cost unfunded by immediate owners for the 50-year period analyzed is approximately $5.2 billion, undiscounted. Relative to the

EXHIBIT 10-2

OPTION A LEADS TO HIGHEST LEVEL OF ECONOMIC IMPACTS

	Absolute	Relative to the Baseline
Firm Results		
Adverse Impacts	696 (29%)	483 (20%)
No Impacts	1,701 (71%)	
Facility Results		
Corrective Action and RFI Not Required	2,099 (40%)	
Corrective Action and/or RFI Required	3,109 (60%)	
Costs Covered	1,932 (37%)	
Costs Not Covered	1,177 (23%)	908 (18%)

Total Costs Unfunded by All Firms
(in thousands of dollars)

Range of Years	Total Costs in Range: Absolute	Total Costs in Range: Relative to The Baseline
1 - 5	$73,812,000	$73,748,000
6 - 10	91,000	86,000
11 - 15	96,000	89,000
16 - 20	52,000	47,000
21 - 25	39,000	34,000
26 - 30	36,000	33,000
31 - 35	36,000	34,000
36 - 40	36,000	35,000
41 - 45	36,000	35,000
46 - 50	36,000	34,000
Total	$74,271,000	$74,174,000

EXHIBIT 10-3

OPTION B LEADS TO SECOND HIGHEST LEVEL OF IMPACTS

	Absolute	Relative to the Baseline
Firm Results		
Adverse Impacts	469 (20%)	256 (11%)
No Impacts	1,928 (80%)	
Facility Results		
Corrective Action and RFI Not Required	2,099 (40%)	
Corrective Action and/or RFI Required	3,109 (60%)	
Costs Covered	2,334 (45%)	
Costs Not Covered	775 (15%)	506 (10%)

Total Costs Unfunded by All Firms
(in thousands of dollars)

Range of Years	Total Costs in Range: Absolute	Total Costs in Range: Relative to The Baseline
1 - 5	$5,082,000	$5,018,000
6 - 10	30,000	25,000
11 - 15	35,000	28,000
16 - 20	16,000	11,000
21 - 25	16,000	11,000
26 - 30	14,000	11,000
31 - 35	13,000	11,000
36 - 40	12,000	10,000
41 - 45	11,000	9,000
46 - 50	9,000	7,000
Total	$5,238,000	$5,140,000

baseline value of $97 million, then, Option B is associated with $5.1 billion (undiscounted) in unfunded corrective action costs over the next 50 years.

10.2.4 Option C -- Flexible Cleanup to Health-Based Standards

The economic impacts of Option C (Flexible Cleanup to Health-Based Standards), presented in Exhibit 10-4, are less than those of Options A or B. Under Option C, 437 firms, or 18 percent, encounter adverse impacts, as compared to 9 percent under the baseline. Thus, this option creates an incremental effect of 9 percentage points on the firm level. These impacts translate to 614 facilities with costs that may not be funded by immediate owners, or 12 percent of all facilities. With 5 percent of all facilities not covered under the baseline, this option causes an incremental effect of 7 percentage points on the facility level.

The total costs not covered are also less than those of Options A or B. After a first year total of about $200 million, the average annual costs drop to about $7 million, resulting in total costs over the entire 50-year period of about $550 million, undiscounted. Relative to the baseline, a total of $457 million over the baseline level of $97 million may not be covered over the next 50 years.

10.2.5 Option D -- Flexible Cleanup Based on Actual Exposure

Exhibit 10-5 shows the estimates of economic impacts for Option D (Flexible Cleanup Based on Actual Exposure). Under this alternative, 431 firms (18 percent) are estimated to face adverse impacts, or an incremental effect of 9 percentage points from the baseline estimate of 9 percent. This firm impact translates to 608 facilities (12 percent) that are not covered by immediate owners, or an incremental effect of 7 percentage points from the baseline estimate of 5 percent.

Total costs not covered for Option D are less than those in Options B and C. In the first year of the regulation, the total cost is $200 million, followed by average annual costs of about $1 million, resulting in total estimated unfunded costs of $262 million, undiscounted, over the next 50 years. Compared to the baseline level of $97 million, then, an incremental effect of $165 million (undiscounted) in unfunded costs over the next 50 years is associated with this option.

10.2.6 Comparison of Financial Impacts Among Alternatives

Exhibit 10-6 shows a comparison of the key measures of firm and facility impacts for the baseline and each regulatory option discussed above. Below each measure, the relative ranking of alternatives in terms of magnitude of impacts is shown. For both firm and facility level impacts, Option A creates the greatest level of impacts, followed by Option B. Both Options C and D have greater impact than the baseline, but less impact than Options A and B. On both the facility level and the firm level, Option C has virtually identical impact to Option D; thus, no clear conclusions on ranking can be drawn for Options C and D based on these two measures alone. However, Exhibit 10-7, which compares and ranks the baseline and each regulatory option according to the costs estimated to be unfunded by immediate owners, indicates

EXHIBIT 10-4

OPTION C HAS LESS IMPACT THAN OPTION B

	Absolute	Relative to the Baseline
Firm Results		
Adverse Impacts	437 (18%)	224 (9%)
No Impacts	1,960 (82%)	
Facility Results		
Corrective Action and RFI Not Required	2,099 (40%)	
Corrective Action and/or RFI Required	3,109 (60%)	
Costs Covered	2,495 (48%)	
Costs Not Covered	614 (12%)	345 (7%)

Total Costs Unfunded by All Firms
(in thousands of dollars)

Range of Years	Total Costs in Range: Absolute	Total Costs in Range: Relative to The Baseline
1 - 5	$477,000	$413,000
6 - 10	12,000	7,000
11 - 15	18,000	12,000
16 - 20	7,000	2,000
21 - 25	7,000	2,000
26 - 30	7,000	3,000
31 - 35	7,000	5,000
36 - 40	6,000	4,000
41 - 45	6,000	5,000
46 - 50	6,000	5,000
Total	$555,000	$457,000

EXHIBIT 10-5

OPTION D HAS LESS IMPACT THAN B OR C

	Absolute	Relative to the Baseline
Firm Results		
Adverse Impacts	431 (18%)	218 (9%)
No Impacts	1,966 (82%)	
Facility Results		
Corrective Action and RFI Not Required	2,099 (40%)	
Corrective Action and/or RFI Required	3,109 (60%)	
Costs Covered	2,502 (48%)	
Costs Not Covered	608 (12%)	339 (7%)

Total Costs Unfunded by All Firms
(in thousands of dollars)

Range of Years	Total Costs in Range: Absolute	Total Costs in Range: Relative to The Baseline
1 - 5	$211,000	$147,000
6 - 10	8,000	3,000
11 - 15	15,000	8,000
16 - 20	4,000	*
21 - 25	4,000	*
26 - 30	4,000	*
31 - 35	4,000	2,000
36 - 40	4,000	2,000
41 - 45	4,000	2,000
46 - 50	4,000	2,000
Total	$262,000	$165,000

* Relative cost of less than $1,000,000.

EXHIBIT 10-6

OPTIONS ARE SIMILARLY RANKED FOR FIRM AND FACILITY IMPACTS

	Baseline	Immediate Cleanup to Background (Option A)	Immediate Cleanup to Health-Based Standards (Option B)	Flexible Cleanup to Health-Based Standards (Option C)	Flexible Cleanup Based on Actual Exposure (Option D)
Firm Impacts					
Adversely Impacted	9%	29%	20%	18%	18%
Ranking*	1	5	4	3	2
Facility Impacts					
Facilities Not Covered	5%	23%	15%	12%	12%
Ranking*	1	5	4	3	2

* Ranking from 1 through 5: 1 represents lowest level of impacts and 5 represents highest level of impacts.

EXHIBIT 10-7

COSTS NOT COVERED BY FIRMS VARY GREATLY BY ALTERNATIVE

Total Costs in Year	Baseline	Immediate Cleanup to Background (Option A)	Immediate Cleanup to Health-Based Standards (Option B)	Flexible Cleanup to Health-Based Standards (Option C)	Flexible Cleanup Based on Actual Exposure (Option D)
1 - 5	$64,000	$73,812,000	$5,082,000	$477,000	$211,000
6 - 10	5,000	91,000	30,000	12,000	8,000
11 - 15	7,000	96,000	35,000	18,000	15,000
16 - 20	5,000	52,000	16,000	7,000	4,000
21 - 25	5,000	39,000	16,000	7,000	4,000
26 - 30	4,000	36,000	14,000	7,000	4,000
31 - 35	2,000	36,000	13,000	7,000	4,000
36 - 40	2,000	36,000	12,000	6,000	4,000
41 - 45	2,000	36,000	11,000	6,000	4,000
46 - 50	2,000	36,000	9,000	6,000	4,000
50 Year Average	$2,000	$1,485,000	$105,000	$11,000	$5,000
Ranking*	1	5	4	3	2

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* Ranking from 1 through 5: 1 represents the lowest level of impacts and 5 represents the highest level of impacts.

that Option C clearly has greater impact than Option D based on unfunded costs. Therefore, the alternatives can be ranked from greatest to least impact as follows: Options A, B, C, D, and the baseline.

For the impacts shown in Exhibit 10-6 and 10-7, the rankings of regulatory alternatives in order of magnitude of economic impacts are not surprising considering that they reflect the order of alternatives in terms of total costs for non-Federal facilities, as described in Chapter 7. Option C (Flexible Cleanup to Health-Based Standards), as discussed in Chapter 6, represents the lower bound estimate of the proposed rule. The baseline represents the set of regulatory standards that would have been in effect had the post-HSWA regulatory changes not been made. The key points of comparison, therefore, are between the baseline and Option C. The baseline shows lower impacts than Option C because it reflects only the Subpart F regulations and thus requires fewer facilities than any other alternative to undergo corrective actions. As discussed in Chapter 7, 770 non-Federal facilities will require corrective action under the baseline, whereas the other alternatives require from 1,646 to 1,747 facilities to undergo corrective actions.

10.3 CONCLUSIONS AND LIMITATIONS

The results of the stochastic model for estimating economic impacts show that the baseline and four regulatory options vary significantly in terms of the potential impacts on firms, facilities, and alternate sources of funding for corrective action. Option A, the Immediate Cleanup to Background scenario, is by far the most costly of the alternatives with the baseline scenario and all other options are orders of magnitude below Option A. Option C (Flexible Cleanup to Health-Based Standards) entails costs unfunded by immediate owners of over $550 million over the next 50 years, or $460 million more than the baseline regulations produce.

In evaluating the potential impacts of the baseline and four regulatory options on the immediate owners of facilities, several important considerations must be mentioned. First, as discussed in Section 10.1.4, firms may choose to fund RFIs and/or corrective actions despite falling below the Beaver ratio threshold used to assess adverse impacts. The level of costs that other sources of funds may have to cover may therefore be overestimated.

Second, some firms may be able to pass the costs of corrective action on to consumers in the form of higher prices. As discussed in Section 10.1.2, the pass-through of costs was not modeled because of the variety of industries being analyzed and the fact the initial impacts of the corrective action requirements will be on facilities suffering the effects of past waste management practices. However, it is possible that firms in heavily affected industries will be able to pass through costs and reduce the potential burden on alternate sources of funds.

Finally, the timing of costs is important in assessing the impacts of the corrective action program. A significant number of corrective actions are projected to begin in the very near future. To the extent that technical, programmatic, and budgetary constraints delay the implementation of corrective action at a significant number of facilities, the associated financial impacts on firms may be lower.

11. REGULATORY FLEXIBILITY ANALYSIS

The Regulatory Flexibility Act requires Federal agencies to analyze fully the economic effects of their regulations on small entities. To meet the requirements of the Act for the corrective action rulemaking, this chapter provides an analysis of the effects of the rulemaking on small entities It does so by analyzing the regulatory options intended to represent the proposed rule (i.e., Options B and C)

The Act specifically requires the regulatory flexibility analysis to determine whether a regulation has "a significant economic impact on a substantial number of small entities" and to estimate the magnitude of the effects on those entities. This analysis involves the following four steps. define small entities, develop criteria for measuring significant economic impacts; calculate the after-tax present value and annualized costs of corrective action, and simulate the economic effects of corrective action costs on small firms. Using the above steps, the number and percentage of small firms and facilities for which corrective action costs may exceed the firms' ability to pay are estimated. Finally, economic impacts on small entities are compared to the economic impacts on large entities. The general approach for testing economic impacts parallels the approach used to estimate overall economic impacts in Chapter 10. As with the economic impacts chapter, this analysis focuses on financial impacts on the entities affected by the rule rather than economic impacts in general.

The analysis concludes that the proposed rule does not have a significant impact on a substantial number of small entities. Based on EPA guidelines for implementing the Regulatory Flexibility Act, a regulation is defined to affect a substantial number of small entities if more than 20 percent of small entities affected by the regulation suffer significant impacts as a result of the regulation. Only 9 to 11 percent of small firms are estimated to face significant additional impacts from the proposed rule that would not have occurred under the baseline scenario.

11.1. IDENTIFYING SMALL ENTITIES

A three-step process was used to identify the small entities affected by the proposed regulations: (1) determine the industries and firms potentially affected; (2) define a small business for the regulated industries; and (3) identify actual small businesses in these industries based on this definition. Each of these steps is described in more detail below, followed by a discussion of the limitations inherent in the approach.

11.1.1 Determining the Industries and Firms Potentially Affected

The corrective action rulemaking will affect owners or operators of all RCRA facilities that have treated, stored, or disposed of hazardous waste at any point since November 19, 1980. To approximate this universe for the Regulatory Flexibility Analysis, information from ICF's firm/facility/financial data base (F3DB) was used. The methodology and content of the F3DB is explained in detail in Appendix C. In short, the F3DB links active TSDFs identified by EPA's Hazardous Waste Data Management System (HWDMS) with their owners or operators, and maintains financial data on almost all firms owning RCRA facilities. The F3DB has complete financial information on 1,838 firms owning 3,945 facilities; these facilities were the subject of the economic impacts analysis in Chapter 10 and were the starting point for testing the economic impacts of the corrective action rule on small entities. This analysis separates the 1,838 owners or operators of the 3,945 facilities into small and large entities, as discussed below.

11.1.2 Defining a Small Business

The definitions of small entities are based on Regulatory Flexibility Act guidelines prepared by EPA in 1982.[1] These guidelines state that small entities include:

- Small businesses -- any business which is independently owned and operated, and is not dominant in its field as defined by the Small Business Administration (SBA) regulations (13 CFR Part 121).

- Small organizations -- any not-for-profit enterprise that is independently owned and operated and is not dominant in its field.

- Small governmental jurisdictions -- any government of a district with a population of less than 50,000.

The F3DB is dominated by private sector firms, thus the SBA definitions of small businesses are the primary criteria used to define small entities. The economic impacts of the proposed regulations on small non-profit or government entities owning or operating TSDFs were not analyzed. Relevant data on these entities are not available from the F3DB; for example, the F3DB has no information on population of governmental jurisdictions. Moreover, the standard measures of ability to pay for firms are generally inapplicable to government and non-profit entities; for example, a government does not earn net income, making a cash flow figure based on net income impossible to calculate.

The lack of financial information on government and non-profit entities will not significantly affect the accuracy of the ability-to-pay estimates of this section. These entities account for only 8 percent of the facilities in the data base. Moreover, because the Federal government is responsible for 75 percent of these facilities, the potential impact on small non-business entities will be minimal.

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[1] "Guidelines for Implementing the Regulatory Flexibility Act," Memorandum from Allen L. Jennings, U.S. Environmental Protection Agency, February 17, 1982.

SBA regulations define small businesses in terms of either maximum number of employees or maximum revenues by four-digit Standard Industrial Classification (SIC) codes in 13 CFR Part 121. The definitions used for this analysis are current through December 31, 1986; this cutoff date corresponds to the latest employment and sales data available on the F3DB. The F3DB contains sales and employment data on the majority of firms analyzed, which may be compared to the SBA rules to determine the set of small businesses.

For this analysis the definitions of small businesses were applied only to privately-owned firms. The analysis of all publicly-owned firms in the data base indicates that they are far too large to meet the criteria for the definition of a small business. Although some subsidiaries of publicly-owned firms meet the size requirements of a small business, they were also excluded because they are owned by a larger entity that does not qualify as a small business. Therefore, the small business definitions were applied only to the 1,108 privately owned firms in the F3DB.

Every privately-owned firm in the F3DB is linked to information on employment levels; about 150 of those firms were missing sales data. For those firms that were missing sales data and that were in industries for which the SBA definition of small firms is based on sales, sales figures were estimated using Ward's Corporation Reports, 1986 (Ward's). Ward's contains total employment and sales figures for surveyed corporations by three-digit SIC code. To estimate the sales for a particular firm in this analysis, total sales for the closest three-digit SIC code in Ward's were divided by the total number of employees to obtain an average sales per employee figure for that SIC code.[2] The estimated average sales per employee figures for the relevant three-digit SIC codes were then multiplied by the actual number of employees in each firm to arrive at an estimated sales level by firm. As a result of this process, each of the 1,108 privately-owned firms has the data necessary for classifying firms by size.

11.1.3 Identify Small Businesses

Of the 1,108 privately-owned firms analyzed, 869 met the SBA definition of small business. The remaining 239 firms were added to the group of publicly-owned firms and subsidiaries of publicly-owned firms to form a group of "large" firms totalling 969. The economic impacts of the corrective action rulemaking on these two groups of firms are analyzed and compared in Section 11.6.

This analysis focuses only on immediate owners of TSDFs. A corporate parent that owns subsidiaries is not tested unless it directly owns facilities; otherwise, parent firms of immediate owners are not examined. The rationale for this approach parallels the rationale in the economic impact analysis of Chapter 10.

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[2] The F3DB has four-digit SIC codes for each firm. The information from Ward's is presented by three-digit SIC codes, which are broader in scope than four-digit codes. However, the three-digit codes were matched as closely as possible to the relevant four-digit SIC codes; this approximation should not result in significant error.

11.1.4 Limitations

The most significant limitations to the approach for defining small businesses are, in large part, limitations inherent in the use of the F3DB. These limitations, described in detail in Appendix C, center around the fact that owners or operators of only 3,945 facilities are examined, whereas about 5,308 facilities owned by for-profit firms are currently believed to be in existence. This limitation is due to: (1) recent additions to the list of active facilities by EPA that have not been reflected in the F3DB and (2) a lack of available financial information on some firms.

As discussed previously, the limitations inherent in the approach to defining small businesses, namely, the lack of information on government and non-profit entities and the approximations necessary to estimate sales in some instances, are not expected to significantly alter the results of this analysis.

11.2 CRITERIA FOR DETERMINING SIGNIFICANT IMPACTS ON SMALL BUSINESSES

The EPA guidelines for implementing the Regulatory Flexibility Act require a determination of whether a regulation has "a significant economic impact on a substantial number of small entities." The criteria used for measuring both significant impacts and substantial numbers of entities are explained in this section.

11.2.1 Criteria for Determining Significant Impacts

For this analysis, two rules for testing significant impacts are used. These rules were used to establish ability to pay probability distributions for the stochastic computer simulation described in Section 11.4.

In this analysis, a small business is assumed to face a significant impact if its:

- Excess of cash flow over ten percent of its total liabilities (i.e., the Beaver ratio test) is insufficient to meet its corrective action costs; or
- Net income is insufficient to meet its corrective action costs.

These criteria are explained in detail in Appendix C. The discussion below compares and contrasts the criteria used in this analysis with the rules suggested by EPA for regulatory flexibility analyses.

EPA guidance states that significant impacts on small entities occur whenever one or more of the following criteria are met:

- Annual compliance costs (annualized capital, operating, reporting, etc.) increase total costs of production for small entities for the relevant process or product by more than five percent;

- Compliance costs as a percent of sales for small entities are at least 10 percent higher than compliance costs as a percent of sales for large entities;
- Capital costs of compliance represent a significant portion of capital available to small entities, considering internal cash flow plus external financing capabilities; or
- The requirements of the regulation are likely to result in closures of small entities.

Other relevant criteria may be used if appropriate.

The first criterion suggested by EPA compares annual compliance costs to the costs of production and sets a five percent threshold for significance. The corrective action regulations, however, are directed primarily towards cleanup of existing hazardous waste releases rather than current production processes or products. Comparing corrective action costs to current production costs is potentially misleading because hazardous waste releases may be related to a firm's past waste management practices and not to its current levels of production. Therefore, this criterion does not appear to be appropriate for this regulatory flexibility analysis.

The second criterion suggested by EPA compares compliance costs as a percent of sales for small and large entities and sets a 10 percent difference as significant. The sales test is intended to measure the degree to which small firms in a particular industry are disadvantaged in the marketplace relative to large firms. However, for this analysis, corrective action costs as a percentage of sales may not accurately measure the difference in ability to pay between small and large firms. If the returns on sales (income) are sufficient to provide funds for corrective action, then a firm will be able to pay regardless of the percentage of sales that the costs represent. Therefore, the net income ability-to-pay rule is used as a surrogate for the suggested approach.

The third criterion compares the capital costs of compliance with the sum of internally and externally available capital for each firm. The internally available cash is easily measured by net income and adjustments for non-cash items; the externally available cash depends on a firm's relationship with financial institutions and is difficult to predict. However, the net income ability to pay rule used in this analysis parallels this suggested criterion. As discussed in Chapter 10, net income measures internally generated funds. Yet, it also includes the estimated amount of investment required to sustain the current operations of the firm. Because the investment required to sustain the firm is related to the requirements for external financing, the two approaches are comparable.

Moreover, the methodology for estimating annualized costs of corrective action, discussed in Chapter 10, assumes that the firm will smooth the incidence of regulatory costs by borrowing from financial institutions. The discount rate used to annualize the costs is different for small and large firms (see Appendix C) to account for the potential differences in borrowing costs. Therefore, the costs used in this analysis already incorporate an expectation of external financing under terms typical for small firms.

The final EPA criterion for assessing small firm impacts measures the potential for closure of the facility due to the costs of compliance. Both decision rules used in this analysis measure the potential for closure of a facility. The first rule, a modified Beaver ratio, is known as a predictor of firm bankruptcy (see Chapter 10 for more details). If a firm is predicted to have an inordinately high risk of bankruptcy due to corrective action costs, then we assume that the firm would close the facility.[3] The net income rule forecasts an inability to pay for corrective action if total costs exceed available cash flow. If the firm is unable to pay for the obligation, its only option may be to declare bankruptcy, effectively closing the facility.

In summary, the two ability-to-pay rules used for this analysis cover three of the four criteria suggested by EPA to assess small business impacts; as explained above, the other criterion, related to production costs, is inappropriate for this particular analysis. The ability-to-pay rules serve a dual purpose in that they meet requirements for determining the existence of significant impacts and at the same time enable estimation of the magnitude of impacts on small firms using the stochastic computer simulation model described in Appendix C.

11.2.2 Criteria for Determining Substantial Number of Small Entities

EPA guidance for regulatory flexibility analyses establishes a 20 percent rule for defining a substantial number of small entities; that is, a regulation is designated as having significant impacts on small entities if more than 20 percent of small entities affected by the regulation meet the criteria for encountering significant impacts. This rule is used in this analysis to evaluate whether the corrective action regulation creates "significant impacts."

11.3 CALCULATION OF CORRECTIVE ACTION COSTS

Previous sections of this chapter have established the set of small firms to be analyzed and the set of criteria for testing significant impacts. This section explains how the corrective action costs faced by small firms were estimated.

The corrective action cost information provided by the Liner Location Model must be adjusted to accurately represent the flow of costs facing an owner or operator required to perform corrective action. Specifically, because firms can smooth the incidence of costs by borrowing equivalent amounts and repaying them on a yearly basis, the costs must be allocated evenly over an appropriate number of years, or annualized. The cost data,

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[3] In this context, closure of a facility means ceasing the operations of the facility, not necessarily performing closure activities as required by RCRA.

therefore, were converted into annualized amounts for use in the analysis of economic impacts on small businesses.

The methodology for calculating the costs of corrective action is similar to the methodology used in the economic impact analysis. First, for small and large firms, respectively, a weighted average cost of capital (see Appendix C) was established. Second, using the estimated cost of capital, the corrective action cost flows developed in Chapter 8 were discounted to present value figures. Finally, the present value costs were annualized to simulate the financing approaches that firms are likely to use.

11.4 SIMULATION OF ECONOMIC IMPACTS

As in Chapter 10, a stochastic, or Monte Carlo, computer model was used to estimate the economic impacts of the corrective action rulemaking on small entities. The model simulates the variability involved in the number and types of facilities that a firm may own, the range of potential corrective action costs that a particular facility may face, and a firm's ability to cover costs at its facilities. The model accounts for these uncertainties by randomly selecting parameter values, such as number of facilities or level of costs, from a range of possible values with each value having a certain probability. By running the simulation numerous times, the possible error of the results are reduced to an acceptable level.

In the model runs for this analysis, 5,000 iterations are conducted for both small and large firm impacts (i.e., for each run, 5,000 firms and the facilities they own are simulated). The 5,000 iterations reduce the possible error of the results to within one percentage point with a 95 percent degree of confidence. As explained in Chapter 10, the model produces results for the simulated population of firms and facilities. Therefore the results are given in terms of percentages rather than actual numbers. These percentages can then be multiplied by the actual number of small or large firms (or the number of facilities owned by those firms) to obtain approximations of economic impacts on the two groups of firms.

The model used for this analysis is the same as that used for the analysis in Chapter 10. The only differences are the probability distributions associated with parameters such as ability to pay, use of financial test, and number of facilities owned, which are altered based on whether the small or large firm groups are being examined. For example, the ability-to-pay probability distribution for small firms may differ markedly from the distribution for large firms; this difference is likely to make the estimated economic impacts different as well. Therefore, this analysis breaks the population of firms examined into two populations (large and small firms) and uses separate ability-to-pay and facility ownership probability distributions to examine economic impacts for each group.

Because the focus of this chapter is on testing the effects of the proposed rule on small businesses, this analysis, in contrast to Chapter 10, examines the economic impacts of only two regulatory options: Options B and C, which are intended to reflect the bounds of flexibility afforded by the proposed rule. In order to examine the incremental effects of the option beyond the current Subpart F regulations, the baseline scenario is also included in this analysis. (See Chapter 10 for further discussion of the baseline scenario's role in assessing incremental effects.)

The other contrast with Chapter 10 is that because two different ability-to-pay rules are required to comply with Regulatory Flexibility Act requirements, simulations of economic impacts were conducted for each of the two rules, the Beaver ratio criterion and the net income criterion, to create estimates of economic impacts for Option C and the baseline scenario.

11.5 MEASURES OF ECONOMIC IMPACTS

The measures of economic impacts for this analysis concentrate on two areas: firm-level impacts and facility-level impacts. The measures relating to these two areas are the same measures used in Chapter 10 and are described there in detail. The measures are briefly described below.

11.5.1 Firm Results

Firms encountering "adverse impacts" are those that in the course of the simulation are unable to provide funds for corrective action for all facilities owned based on the ability-to-pay rules. Firms encountering "no impacts" are those that can pay for all corrective action costs at all facilities while passing the ability-to-pay rules; this category includes firms with no corrective action costs, regardless of their financial status.

The number of small and large firms encountering adverse impacts is determined by multiplying the percentages of small and large firms adversely affected (estimated by the model) by 1,102 and 1,295, respectively, which are approximations of the number of small and large firms owning RCRA facilities

11.5.2 Facility Results

Facilities for which neither corrective action nor an RFI is required are those where no release sufficient to trigger an investigation or a corrective action exists. Facilities incurring costs of RFIs or corrective actions may either be "covered" or "not covered" based on whether or not each firm can afford all or a portion of costs at facilities that it is simulated to own.

The percentage of facilities in each category is multiplied by the number of facilities owned by small or large firms to obtain the number of facilities in each category. The number of facilities owned by small and large firms, respectively, is 1,323 and 3,885; these numbers are extrapolated from available ownership information (again, see detailed explanation in Chapter 10).

As discussed in Chapter 10, the results for facilities not covered should be interpreted with caution, because firms may choose to pay for facilities to the point where they no longer pass the Beaver ratio or net income criteria. Therefore, the estimate of the number of facilities at which costs may not be covered may be overestimated.

11.6 RESULTS AND CONCLUSIONS

For this analysis, the stochastic simulation model yields estimates of economic impacts of the corrective action requirements on the previously defined groups of small and large firms owning RCRA facilities. Section 11.6.1 presents the results of the analysis for Options B and C and the baseline scenario and compares the impacts on small firms with the impacts on large firms; these results are interpreted for purposes of the Regulatory Flexibility Act in the concluding Section 11.6.2.

11.6.1 Firm and Facility Impacts

This section presents the results of the stochastic simulation of economic impacts for the baseline scenario and the two regulatory options, using both ability-to-pay rules. In each case, the results are interpreted to evaluate the level of economic impact of the corrective action program on small businesses.

Exhibits 11-1 and 11-2 show the firm and facility impacts under the baseline scenario for the Beaver test and net income test respectively. These exhibits show that small firms encounter more severe impacts from the existing corrective action requirements than large firms. On a firm basis, 7 percent of small firms under the net income rule and 10 percent of small firms under the Beaver rule face adverse impacts, whereas only 4 percent of large firms under the net income rule and 8 percent of large firms under the Beaver rule encounter adverse affects. Similarly, 6 to 9 percent of facilities (depending on the ability-to-pay rule) owned by small firms face costs that are not covered by those firms, whereas only 2 to 4 percent of facilities owned by large firms are in a similar situation.

The results of the baseline analyses indicate that the net income rule is less stringent than the Beaver ratio test in evaluating the extent of economic impacts. In fact, this relationship is true among all options tested, thus providing a sensitivity range for the results of the analysis.

Exhibits 11-3 and 11-4 present the economic impact results for Option B, Immediate Cleanup to Health-Based Standards. The total results and the incremental results (relative to the baseline) are presented. Option B results in an additional 10 to 12 percent of small firms being adversely affected relative to the baseline, compared to 6 to 10 percent of large firms, depending on the ability-to-pay test used. On a facility basis, an additional 9 to 13 percent of facilities have corrective action costs that are not covered by small firm owners, while only 6 to 9 percent of facilities have corrective action costs that are not covered by large firm owners. On an absolute basis (i.e., not incremental to the baseline), 17 to 22 percent of small firms face adverse impacts under Option B, depending on the ability-to-pay measure used.

Exhibits 11-5 and 11-6 present the results for Option C, Flexible Cleanup to Health-Based Standards. The results are presented both as total results and as incremental results relative to the baseline. Depending on the ability-to-pay test considered, this option results in an additional 8 to 10 percent of small firms being adversely affected relative to the baseline,

EXHIBIT 11-1

BASELINE -- BEAVER TEST

	Large	Small
Firm Results:		
Adverse Impacts	109 (8%)	105 (10%)
No Impact	1,186 (92%)	997 (90%)
Facility Results:		
Corrective Action and RFI Not Required	2,914 (75%)	988 (75%)
Corrective Action and/or RFI Required and Costs Covered	831 (21%)	209 (16%)
Corrective Action and/or RFI Required and Costs Not Covered	144 (4%)	126 (9%)

EXHIBIT 11-2

BASELINE -- NET INCOME TEST

	Large	Small
Firm Results:		
Adverse Impacts	56 (4%)	77 (7%)
No Impact	1,239 (96%)	1,025 (93%)
Facility Results:		
Corrective Action and RFI Not Required	2,914 (75%)	959 (73%)
Corrective Action and/or RFI Required and Costs Covered	913 (23%)	283 (21%)
Corrective Action and/or RFI Required and Costs Not Covered	58 (2%)	79 (6%)

EXHIBIT 11-3

OPTION B -- BEAVER TEST

INCREMENTAL RESULTS

Firm Results:	Large	Small
Increase in Adverse Impacts Relative to the Baseline	10%	12%
Facility Results:		
Increase in Corrective Action and/or RFI Required and Costs Not Covered Relative to the Baseline	9%	13%

ABSOLUTE RESULTS

Firm Results:	Large	Small
Adverse Impacts	227 (18%)	242 (22%)
No Impact	1,068 (82%)	860 (78%)
Facility Results:		
Corrective Action and RFI Not Required	1,570 (40%)	529 (40%)
Corrective Action and/or RFI Required and Costs Covered	1,830 (47%)	504 (38%)
Corrective Action and/or RFI Required and Costs Not Covered	486 (13%)	290 (22%)

EXHIBIT 11-4

OPTION B -- NET INCOME

INCREMENTAL RESULTS

Firm Results:	Large	Small
Increase in Adverse Impacts Relative to the Baseline	6%	10%
Facility Results:		
Increase in Corrective Action and/or RFI Required and Costs Not Covered Relative to the Baseline	6%	9%

ABSOLUTE RESULTS

Firm Results:	Large	Small
Adverse Impacts	130 (10%)	187 (17%)
No Impact	1,166 (90%)	915 (83%)
Facility Results:		
Corrective Action and RFI Not Required	1,554 (40%)	516 (39%)
Corrective Action and/or RFI Required and Costs Covered	2,020 (52%)	609 (46%)
Corrective Action and/or RFI Required and Costs Not Covered	311 (8%)	198 (15%)

EXHIBIT 11-5

OPTION C -- BEAVER TEST

INCREMENTAL RESULTS

Firm Results:	Large	Small
Increase in Adverse Impacts Relative to the Baseline	8%	10%
Facility Results:		
Increase in Corrective Action and/or RFI Required and Costs Not Covered Relative to the Baseline	5%	11%

ABSOLUTE RESULTS

Firm Results:	Large	Small
Adverse Impacts	212 (16%)	225 (20%)
No Impact	1,083 (84%)	877 (80%)
Facility Results:		
Corrective Action and RFI Not Required	1,570 (40%)	529 (40%)
Corrective Action and/or RFI Required and Costs Covered	1,970 (51%)	525 (40%)
Corrective Action and/or RFI Required and Costs Not Covered	346 (9%)	269 (20%)

EXHIBIT 11-6

OPTION C -- NET INCOME TEST

INCREMENTAL RESULTS

Firm Results:	Large	Small
Increase in Adverse Impacts Relative to the Baseline	4%	8%
Facility Results:		
Increase in Corrective Action and/or RFI Required and Costs Not Covered Relative to the Baseline	3%	8%

ABSOLUTE RESULTS

Firm Results:	Large	Small
Adverse Impacts	109 (8%)	170 (15%)
No Impact	1,186 (92%)	932 (85%)
Facility Results:		
Corrective Action and RFI Not Required	1,570 (40%)	519 (39%)
Corrective Action and/or RFI Required and Costs Covered	2,133 (55%)	622 (47%)
Corrective Action and/or RFI Required and Costs Not Covered	179 (5%)	183 (14%)

compared to 4 to 8 percent of large firms. This proportion is significantly below the threshold of 20 percent used to define a substantial number of small entities under EPA's Regulatory Flexibility Act guidelines. Moreover, an additional 8 to 11 percent of facilities have corrective action costs that are not covered by small firm owners, whereas only 3 to 5 percent of facilities have corrective action costs that are not covered by large firm owners. Of note is that in absolute terms, 15 to 20 percent of small firms face adverse impacts under Option C.

11.6.2 Conclusions

Following the EPA guidelines for regulatory flexibility analyses, the proposed corrective action rule options analyzed did not meet the criteria for imposing significant impacts on small entities. Using ability-to-pay measures as tests of significant impacts, an incremental increase of over 20 percent of small firms (i.e., a "substantial number") were not adversely affected. Regardless of the ability-to-pay rule used, no more than 12 percent of small firms suffer adverse impacts under the proposed rule options, relative to the baseline scenario. Given that the baseline scenario represents the financial effects of the existing corrective action regulations (as described in Chapter 10), this analysis demonstrates that the proposed corrective action program is unlikely to significantly affect a substantial number of small businesses using EPA-mandated definitions of significant impact.

If, however, the impacts on small businesses are assessed on an absolute basis, then Options B and C are sufficiently costly to meet the 20 percent rule for creating significant impacts. The absolute impacts to small firms under the options range from 15 to 22 percent. Absolute economic impacts to small firms are significant only when using the Beaver test. In all other cases, the proposed rule options do not result in a significant impact on a substantial number of small entities (i.e., on more than 20 percent of all small firms) when evaluated without the effects of the baseline scenario

12. FEDERAL FACILITIES

In earlier chapters of this report, the population of RCRA Subtitle C facilities was discussed, and the number of facilities likely to require corrective action was estimated. In that discussion, the population of Subtitle C facilities was divided into two groups: privately-owned or operated facilities (including municipal and non-profit facilities) and Federally-owned or operated facilities. Federal facilities are of special concern and are examined in this chapter in more detail for several reasons:

(1) While constituting only six percent of the total population of RCRA facilities affected by corrective action requirements, Federal facilities typically contain more SWMUs per facility than non-Federal facilities and may incur higher corrective action costs;

(2) Ownership by the Federal government implies that corrective action will be funded from public money and is subject to overall Federal funding priorities.

In this chapter, the population of Federal facilities is analyzed in terms of the following: the size of the population of Federal facilities; the composition of Federal facilities; and the number of SWMUs per Federal facility. Also, this chapter estimates the number of Federal facilities that will undergo RFIs, the number of Federal facilities that will need to take corrective action, and the cost of corrective action for the Federal facility population.

12.1 OVERALL POPULATION OF FEDERAL FACILITIES

A complete characterization of Federal facilities is not currently available; however, this analysis is based on verified data in EPA's Hazardous Waste Data Management System (HWDMS). Exhibit 12-1 summarizes the distribution of Federal facilities listed in HWDMS across the agencies that own or operate the facilities. This exhibit also shows the distribution of different types of facilities (i.e., land disposal, treatment and storage, and incineration) among these agencies.

As of August 1987, HWDMS indicates that there are 352 Federally-owned or operated facilities. Of this total, 277 facilities (79 percent) belong to the Department of Defense (DOD). The remaining facilities are split among various civilian agencies: 34 facilities (10 percent) for the Department of Energy (DOE); 6 facilities for the National Aeronautics and Space Administration, and 7 facilities for EPA (about 2 percent each); and fewer facilities distributed among other civilian agencies. Within the DOD, there is a roughly even apportionment of facilities among the US Army (34 percent of the DOD total), the US Air Force (31 percent of the DOD total), and the US Navy (29 percent of the DOD total). Six percent of the total DOD facilities could not be categorized into one of these three branches.

EXHIBIT 12-1

DISTRIBUTION OF FEDERAL FACILITIES ACROSS AGENCIES

	All Facilities	Treatment Storage and Disposal Facilities	Land Disposal Facilities	Incineration Facilities
DEPARTMENT OF DEFENSE (DOD):				
US Army	93 (26%)	59 (24%)	25 (21%)	9 (43%)
US Air Force	87 (25%)	70 (28%)	16 (20%)	1 (5%)
US Navy	81 (23%)	67 (27%)	11 (14%)	3 (14%)
Unspecified DOD	16 (5%)	11 (4%)	3 (4%)	2 (10%)
DOD TOTAL	277 (79%)	207 (82%)	55 (69%)	15 (71%)
CIVILIAN AGENCIES:				
Dept. of Energy	34 (10%)	17 (7%)	15 (19%)	2 (10%)
Environmental Protection Agency	7 (2%)	4 (2%)	0 (0%)	3 (12%)
National Aeronautics and Space Administration	6 (2%)	2 (1%)	4 (5%)	0 (0%)
Dept. of Transportation	4 (1%)	1 (0%)	3 (4%)	0 (0%)
Dept. of Agriculture	2 (1%)	1 (0%)	1 (2%)	0 (0%)
Unspecified Civilian	22 (6%)	19 (8%)	2 (3%)	1 (5%)
CIVILIAN TOTAL	75 (21%)	44 (18%)	25 (31%)	6 (29%)
TOTAL FEDERAL FACILITIES:	352 (100%)	251 (100%)	80 (100%)	21 (100%)

Source: HWDMS, August 1987.

Exhibit 12-2 presents the number of land disposal, treatment and storage, and incineration facilities for both the DOD population and the civilian agency population. The relative distribution of facility types is consistent between the total DOD and civilian agency populations; that is, for both populations, there are more treatment and storage facilities than land disposal facilities, and even fewer incineration facilities. However, the DOD population has a greater proportion of treatment and storage facilities than the civilian agency population. Seventy-five percent of DOD facilities are treatment and storage facilities compared with 59 percent of the civilian agency population. Also, 20 percent of DOD facilities are land disposal facilities compared with 33 percent of civilian facilities, and 5 percent of DOD facilities are incineration facilities compared with 8 percent of civilian agency facilities.

12.2 CHARACTERIZATION OF RCRA FEDERAL FACILITIES

While it is important to know how many Federal facilities will be subject to the corrective action program, it is equally important to understand the potential environmental problems these facilities pose. Section 12.2.1 below suggests that Federal facilities are larger (i.e., comprise more SWMUs per facility) than privately-owned or operated facilities, and in Section 12.2.2, estimates suggest that a higher proportion of Federal facilities may require corrective action as compared with private-sector facilities.

12.2.1 Average Number of SWMUs per Facility

At present, there are relatively little data available on the actual number of SWMUs at each Federal facility. Without such information, estimates of the average number of SWMUs per facility must be based on the limited information available.

In creating the facility data base for this RIA, 65 RCRA facility RFAs were examined in detail. Six of these 65 RFAs were for DOD facilities. While the sample was selected to be as representative as possible for RCRA facilities, the fact that RFAs are not yet available for all RCRA facilities limits the sample in certain ways. (See Appendix A for a full explanation of the development of the facility data base.) One should not assume that the six Federal facility RFAs represent all Federal facilities; however, they do constitute nine percent of the total RFA sample. As stated above, the Federal facility population is approximately six percent of the total RCRA facility population. Thus, Federal facilities are represented in the hypothetical data base in approximate proportion to their distribution among all RCRA facilities. ?

An examination of the six Federal facility RFAs produced an average of 29 SWMUs per Federal facility. However, no DOE facilities were represented in the Federal facility sample. EPA's experience with DOE facilities suggests that they are much larger than facilities owned by other Federal agencies;

EXHIBIT 12-2

DISTRIBUTION OF FEDERAL FACILITIES BY FACILITY TYPE

TYPE OF FACILITY:	All Federal Facilities	All DOD Federal Facilities	All Civilian Federal Facilities
Treatment and Storage	251 (71%)	207 (75%)	44 (59%)
Land Disposal	80 (23%)	55 (20%)	25 (33%)
Incineration	21 (6%)	15 (5%)	6 (8%)
TOTAL FEDERAL FACILITIES:	352 (100%)	277 (100%)	75 (100%)

Source: HWDMS, August 1987.

however, there are no data to accurately calculate the difference in size between large DOE and non-DOE Federal facilities. There is some anecdotal information about the number of SWMUs located in DOE facilities: the DOE Hanford Site, located in Richland, Washington, has 1,200 identified SWMUs; the Idaho National Energy Laboratory has 352 SWMUs; the Savannah River Plant in Aiken, South Carolina, and the Oak Ridge National Laboratory have approximately 350 SWMUs each; and the Lawrence Livermore National Laboratories have over 180 SWMUs. Thus, the calculated average of 29 SWMUs per facility grossly underestimates the condition of DOE facilities.

To estimate the number of SWMUs per Federal facility, it is assumed that non-DOE facilities average 29 SWMUs (based on the RFA data base), and DOE facilities average 290 SWMUs; that is, DOE facilities are, typically, ten times the size of other Federal facilities. This estimate is clearly speculative, but it represents a reasonable assumption given the available data. Exhibit 12-1 shows that DOE facilities constitute 10 percent of the total Federal facility population; thus, for an overall average of SWMUs per Federal facility, we estimate the number to be 55 (i.e., 90 percent have 29 SWMUs and 10 percent have 290 SWMUs).

12.2.2 Estimate of RCRA Federal Facilities that will Require Ground-Water Corrective Action

The Federal facility population is not as completely described as the non-Federal population. Because limited information is available, an exact estimate of the number of Federal facilities requiring corrective action cannot be provided; to do so would presume a greater accuracy than the sample data allow. However, a range for the number of Federal facilities requiring corrective action, based on various assumptions, can be estimated. These assumptions are presented as the following five cases:

Case I -- (Worst-Case Estimate): Assumes all Federal facilities (i.e., 352) would require an RFI and would then be found to require some degree of corrective action for contaminated ground water.

Case II -- (Upper Estimate): Using information from 625 completed RFAs (used to create the facility data base as described in Appendix A) it was found that 22 were for Federal facilities. Nineteen of these Federal facility RFAs (86 percent) indicate the need for an RFI. Therefore, it is assumed that 86 percent (303) of all Federal facilities will require RFIs, and all of these facilities would require corrective action for ground water.

Case III -- (Mixed Estimate): As in Case II, 86 percent will require an RFI and approximately 50 percent (depending on the option selected)[1] of all facilities requiring an RFI may need to take corrective action, regardless of whether the facility is Federal or not. Therefore, it is assumed that 139 to 161 Federal Facilities would require corrective action.

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[1] The variation is slight: 53 percent for Option A; 50 percent for Option B; 47 percent for Option C; and 46 percent for Option D.

Case IV -- (Lower Estimate): This case assumes that the likelihood of an RFI and of a corrective action as estimated in Chapter 2 for the overall RCRA population are applicable to Federal facilities as well. This suggests that 62 percent of the 352 Federal facilities, or 218 facilities, would require an RFI, and approximately 50 percent (again, depending on the option selected) of these facilities, or 100 to 116 facilities, would further require corrective action for ground-water contamination.

Case V -- (Midpoint Estimate): It may be more reasonable to assume the actual number of Federal facilities requiring corrective action lies somewhere between the worst-case and lower estimates, stated above in Cases I and IV. Although it seems unlikely that every Federal facility will require corrective action, it is also unlikely that Federal facilities will require the same proportion of RFIs and corrective actions as non-Federal facilities. Therefore the analysis assumes that the probability of triggering an RFI lies midway between the estimates given above (i.e., between 0.62 and 1.0), that is, 0.81,[2] and that the probability of a Federal facility moving from an RFI to corrective action is midway between 0.50 and 1.00, or 0.75. Thus, for Case V, 80 percent of the 352 Federal facilities (285) require an RFI, and approximately 75 percent of these facilities (208 to 217) would further require corrective action.

Exhibit 12-3 summarizes the five cases analyzed in this chapter. Taken together, these cases imply that somewhere between 100 and 352 Federal facilities will require corrective action. Given the lack of complete information, it is estimated that 211 (i.e., Option C for Case V above) represents the most likely number. It is important to remember that the above discussion is based on ground-water corrective action only. As with non-Federal facilities, when releases to other media are considered, the numbers of both RFIs and corrective action are likely to be higher.

12.3 ESTIMATE OF CORRECTIVE ACTION COSTS AT FEDERAL FACILITIES

Corrective action costs can be considered in two ways: (1) the cost of cleanup at individual Federal facilities; and (2) the total cost to the Federal government for cleaning up all Federal facilities. The following sections estimate these two costs for Federal facilities.

12.3.1 Per-Facility Cost of Corrective Action at Federal Facilities

The per-facility cost results developed in Chapter 8 of this RIA were not directly applied to Federal facility cleanups. While the cleanup technologies are the same, and the regulatory alternatives are the same, the per-facility costs of Federal and non-Federal facilities may differ because of differences in the number of SWMUs per facility.

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[2] Note that this is not very different from the result obtained from the 22 Federal facility RFAs.

EXHIBIT 12-3

ESTIMATED NUMBER OF FEDERAL FACILITIES REQUIRING GROUND-WATER CORRECTIVE ACTION

Case I (Worst-Case Estimate):

Number of Facilities (N = 352)	100%	Number Requiring RFI (N = 352)	100%	Number Requiring* Corrective Action (N = 352)

Case II (Upper Estimate):

Number of Facilities (N = 352)	86%	Number Requiring RFI (N = 303)	100%	Number Requiring* Corrective Action (N = 303)

Case III (Mixed Estimate):

Number of Facilities (N = 352)	86%	Number Requiring RFI (N = 303)	50%	Number Requiring* Corrective Action (N = 142)**

Case IV (Lower Estimate):

Number of Facilities (N = 352)	62%	Number Requiring RFI (N = 218)	50%	Number Requiring* Corrective Action (N = 102)**

Case V (Mid-Point Estimate):

Number of Facilities (N = 352)	81%	Number Requiring RFI (N = 285)	75%	Number Requiring* Corrective Action (N = 211)**

* Estimated number of facilities requiring corrective action based on ground-water cleanup only.

** These numbers represent Option C; numbers for other options for Cases III, IV, and V vary slightly (see text).

The cost estimates developed in Chapter 8 were pro-rated to account for the fact that Federal facilities average about 4.6 times the number of SWMUs (i e., 55 divided by 12) as non-Federal facilities, with the understanding that this is a rough approximation.

The estimated per-facility cost at Federal facilities varies with the regulatory option chosen. For example, the per-facility cost (i.e., net present value cost) of the baseline, or pre-HSWA scenario, is $17 million. Similarly, for Options A through D, the Federal per-facility costs are approximately: $1.3 billion; $123 million; $29 million; and $22 million.[3] It may be useful, especially when considering agency or facility budgets, to convert these costs into annualized costs.[4] Options A through D correspond to the following approximated annualized costs per Federal facility: $87 million; $8 million; $2 million; and $1.5 million. The annualized baseline or Pre-HSWA cost is approximately $1 million.

12.3.2 Total Cost of Corrective Action at Federal Facilities

The total cost of taking corrective action at Federal facilities depends on two factors: the number of facilities requiring corrective action and the cost for each cleanup. While the analysis above has estimated a single per-facility cost (for each of the four regulatory options), the analysis estimates a range of facilities requiring corrective action, in Section 12.2.2 above. Consequently, the total cost will also be a range. The range has been narrowed by emphasizing two of the five cases presented above; in particular, cost estimates are derived for Cases III and V. Exhibit 12-4 shows the total Federal facility cleanup costs, for each of the four regulatory options, associated with these two cases (i.e., "Mixed Estimate" and "Midpoint Estimate").[5]

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[3] These cost estimates have been discounted at three percent to 1987 and are based on the same financial assumptions (e.g., timing of cost, use of institutional controls) as are non-Federal facilities. See Chapter 8 for more detail. More important, these costs do not include RFIs or CMSs. The above estimates are rough, and these investigative costs are overshadowed by calculation error and rounding.

[4] Annualized costs throughout this chapter are calculated at 3 percent for 20 years.

[5] These figures only represent ground-water cleanup costs; they do not include costs for cleaning up other contaminated media or associated investigative or administrative costs.

EXHIBIT 12-4

COST OF CORRECTIVE ACTION AT FEDERAL FACILITIES*

		COST FOR REGULATORY OPTION:**			
		A	B	C	D
	Baseline*** Scenario (billions)	Immediate Cleanup to Back-ground (billions)	Immediate Cleanup to Health-Based Standards (billions)	Flexible Cleanup to Health-Based Standards (billions)	Flexible Cleanup Based on Actual Exposure (billions)
Case III (Mixed Estimate)					
Total Cost	1.2	209.3	18.7	4.1	3.0
Incremental Total Cost	--	208.1	17.5	2.9	1.8
Annualized Cost	0.08	14.1	1.2	0.3	0.2
Incremental Annualized Cost	--	14.0	1.1	0.2	0.1
Case V (Midpoint Estimate)					
Total Cost	1.0	282.1	26.3	6.1	4.6
Incremental Total Cost	--	281.1	25.3	5.1	3.6
Annualized Cost	0.07	19.0	1.8	0.4	0.3
Incremental Annualized Cost	--	18.9	1.7	0.3	0.2

* These figures only represent ground-water cleanup costs; they do not include costs for cleaning up other contaminated media or associated administrative costs.

** In billions of dollars; discounted at 3 percent to 1987 and annualized for 20 years.

*** Based on 80 Federal land disposal facilities.

Excluding the baseline estimate, total ground-water cleanup costs range from approximately 3 to 209 billion dollars for the "Mixed Estimate" Case III, and approximately 5 to 282 billion dollars for the "Midpoint Estimate" Case V. These ranges are broad and reflect the divergent environmental strategies incorporated into Options A through D. Using the "Midpoint Estimate" Case V, for example, the upper limit of 282 billion dollars assumes an immediate cleanup to background at all affected facilities. Option C, however, which represents flexible cleanup to health-based levels, would cost approximately 6 billion dollars. These figures are based on total discounted costs.

Using the lower bound estimate of the proposed rule (i.e., Option C), total Federal facility costs can be narrowed to 4 to 6 billion dollars for Case III and Case V, respectively. This represents an annualized cost incremental to the baseline of approximately 200 to 300 million dollars per year. Compared with the cost estimates presented in Chapter 8, Federal facility cleanups will constitute approximately 39.5 percent of the total cost of this rule.

PART 4

SUMMARY

13. CONCLUSIONS AND LIMITATIONS

This regulatory impact analysis was performed to characterize the costs, benefits, and other impacts of EPA's proposed corrective action rule. The general approach taken was to establish alternative regulatory options with varying cleanup targets, types of remedies, and timing. These regulatory options were then compared and contrasted both qualitatively, using hazardous constituent release scenarios and case studies, and quantitatively, using data compiled through a sample of 65 RCRA RFAs in order to yield representative costs and benefits. Based on this analysis, the following conclusions were reached:

- The qualitative analysis suggests that the regulatory strategy upon which the proposed rule is based offers a high degree of protection of human health and the environment while not placing unnecessary burdens on facility owners and operators.

- Based on the quantitative analysis, under the regulatory options most similar to the proposed rule, over 50 percent of the facilities undertaking corrective action for ground-water contamination were simulated to reach cleanup targets within 75 years.

- Costs for ground-water corrective action under the proposed rule were simulated to have a lower bound mean present value cost per facility of $6.3 million and an annualized per- facility cost of $0.4 million. Moreover, under this same option, national costs were simulated to be about $7.4 billion, or $0.5 billion on an annualized basis, more than the costs that would have been incurred for corrective action prior to the enactment of HWSA.

- Based on the economic impacts analysis for Option C, an additional 7 percent of all facilities and 9 percent of all firms will face adverse impacts from the corrective action requirements of the proposed rule, leaving a total of $97 million (undiscounted) in corrective action costs left unfunded due to insolvency.

- Based on the regulatory flexibility analysis, the regulatory options most similar to the proposed rule does not impose significant impacts on a substantial number of small entities (i e., only 9 to 11 percent of entities are adversely affected) when considered relative to the impacts of corrective action requirements prior to the enactment of HSWA.

In reviewing the results presented by this analysis, a number of key limitations to the analysis and assumptions made in the quantitative analysis and supporting analysis should be considered. These limitations and assumptions, which are discussed more thoroughly where appropriate throughout the RIA, are summarized below. In general, these limitations fall into three categories: effectiveness, costs, and supporting analyses.

Effectiveness

- Effectiveness measures the degree to which a particular option achieves the cleanup target. It should not be viewed as a measure of potential ground-water protection benefits.

- Because the RIA simulated releases to ground water only, the effectiveness of the regulatory options in addressing releases to other environmental media is likely to vary somewhat from the estimates presented in the RIA.

- Due to modeling constraints, the performance of simulated remedies may diverge somewhat from the actual performance and effectiveness of such remedies. For instance, in the model, caps are simulated to fail in 35 years and recovery wells are assumed to be 95 percent effective in removing ground-water contamination. In practice, the life of caps and the efficiency of recovery wells will vary from site to site, depending on local factors, such as hydrogeologic conditions.

- Because only four remedies were simulated, the model may not accurately reflect the broader range of remedies available in practice. Moreover, the model uses simplified remedy selection rules in selecting among the range of remedies. In contrast, under the proposed rule, detailed studies would be used as the basis for selecting among corrective measure remedies.

- In all cases, it was assumed for modeling purposes that background contaminant concentrations are zero. It is likely that, at some RCRA facilities, background concentrations are not equal to zero. Because concentrations must reach the detection limit before corrective action can be triggered, it will take longer to detect a release if background concentrations are zero than it would if ground-water supplies were already contaminated to a level higher than the detection level. As a result, the RIA may underestimate the likelihood of triggering corrective action for all options.

Costs

- Because the RIA models the entire corrective action program (i.e., by including RCRA Section 3008(h) and a revised Subpart F program in addition to the Subpart S rule authorized by Section 3004(u)), the costs of the Subpart S rule itself are overestimated.

- The quantitative analysis assumes that the target cleanup level is equal to the trigger level. Because the proposed rule actually allows the target cleanup level to be set at a point higher than the level at which action is first initiated, the analysis may have over estimated costs.

- The remedy selection rules used for the model only approximate the proposed rule and are not as flexible as the rule, thus potentially overestimating costs.

- Because the quantitative analysis modeled releases to ground water only, this analysis underestimates the costs of corrective action.

- For modeling purposes, remedies were simulated only once for a given release scenario (i.e., not for additional future releases), thus potentially underestimating costs.

- Because of modeling limitations, the RIA does not simulate the use of Alternate Concentration Limits (i.e., site-specific cleanup standards set under Subpart F). Thus, the RIA may overestimate the cost of the baseline scenario and underestimate the incremental cost of other options.

- The RIA simulates off-site land disposal of excavated wastes. However, the additional costs of treating land-disposal wastes to the Land Disposal Restrictions (40 CFR Part 268) were not included in the cost estimates. Moreover, incineration of excavated wastes was not simulated. As a result, the RIA may significantly underestimate costs for the options that select excavation remedies.

- The model did not estimate the costs of institutional controls where they were selected. As a result, the RIA may underestimate costs for the options that select institutional controls.

- The RIA derives the costs of RFIs and CMSs from lower-bound estimates of similar Superfund investigation steps. If, in practice, the investigative costs for RCRA corrective actions diverge from these lower-bound estimates, then the accuracy of the cost estimates would be reduced.

- Using Superfund remedial action program data, total national costs for the proposed corrective action rule were estimated to be $12.9 billion (non-incremental to baseline), compared to $10.6 billion to $45 billion in total national costs (non-incremental) for the proposed rule in this analysis.

Supporting Analyses

- Because the economic impact analysis does not simulate the availability of alternate funding sources, such as payouts from financial assurance mechanisms, corporate parents, price increases, Superfund, or State cleanup funds, the RIA may overestimate the economic impacts of the proposed rule.

- In the economic impacts and regulatory flexibility analyses, corrective action costs are not simulated to vary with the financial size of the firm required to take corrective action. Therefore, the RIA may underestimate the economic impacts of the proposed rule on small firms.

- Federal facility costs are estimated using a very imprecise methodology that involves extrapolating from smaller private facilities to very large Federal facilities. Actual costs observed at Federal facilities may differ significantly from those estimated in the RIA.

APPENDICES

Appendix A: Development of Facility Data Base

Appendix B: Corrective Action Triggers

Appendix C: Methodology for Economic Impact Analysis

Appendix D: CERCLA Corrective Action Activities

APPENDIX A

DEVELOPMENT OF FACILITY DATA BASE

This appendix describes the development of the facility data base used in the RIA to estimate the costs and risks associated with various regulatory approaches to corrective action. The data base reflects, in part, information collected on each of 65 actual RCRA facilities. We supplemented the data collected on the 65 facilities using best professional judgement to make assumptions where there were data gaps. As a result, we developed a partially hypothetical facility data base for this analysis. While not statistically representative of the actual universe of facilities, we selected the sample of facilities to be as representative as possible of the facilities subject to the SWMU corrective action proposal.

This appendix is divided into three primary sections. The first section describes the survey of actual facilities, the second provides an overview of the hydrogeologic mapping of the facilities, and the third explains how we supplemented the data to complete the database.

A.1 FACILITY SURVEY

We developed the facility data base used for the RIA from a survey of actual RCRA facilities. This section explains how we developed the sampling approach and executed the survey. It is divided into the following sections:

- Section A.1.1 discusses the general characteristics of facilities subject to the proposed corrective action regulations;
- Section A.1.2 briefly discusses the availability of data on facilities and SWMUs and discusses the data sources used in this analysis;
- Section A.1.3 describes the universe of facilities represented by the survey sample;
- Section A.1.4 discusses the methodology used to make the survey sample as representative of the overall population of facilities and SWMUs as possible;
- Section A.1.5 discusses the general approach used for analyzing each individual facility; and
- Section A.1.6 presents the primary characteristics of the survey sample.

A.1.1 Facilities Subject to RCRA Corrective Action Regulations

As explained in Chapters 2 and 4, the RCRA corrective action program as amended by HSWA applies to all RCRA Subtitle C land disposal, incineration, and treatment/storage facilities that are either currently operating, in the process of closing, or already closed. The corrective action program extends to all units at these facilities that have been used for management of solid wastes from which hazardous wastes or constituents may be released. Areas where wastes have routinely and systematically been released, wastewater treatment units, and waste recycling units are also regulated by the RCRA corrective action program.

EPA has estimated the national population of Subtitle C facilities subject to the RCRA corrective action regulations to be 5,661 facilities.[1] According to the Hazardous Waste Data Management System (HWDMS), approximately 26 percent of the Subtitle C facilities (1,487 facilities) are classified as land disposal facilities, 3.5 percent (196 facilities) as incineration facilities, and 70 percent (3,978 facilities) as treatment/storage facilities.[2] The majority of these facilities are currently interim status facilities with either permit status or closure status pending approval by the appropriate authorities. Approximately 21 percent of the facilities have submitted a closure plan that has either been approved or is currently under review.

A.1.2 Data on Facilities Subject to RCRA Corrective Action Regulations

For the RIA, the primary data sources on SWMUs were RCRA Facility Assessments (RFAs). RFAs are prepared as the first of three phases in the RCRA corrective action program. The purpose of an RFA is to: (1) identify and gather information on releases at a Subtitle C facility, (2) evaluate SWMUs and other areas of concern for the potential for releases to the environment, (3) make preliminary determinations regarding releases of concern and the need for further actions and interim measures at the facility, and (4) screen from further investigation all those SWMUs which do not pose a significant threat to human health or the environment.[3]

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[1] U.S. EPA, "Summary Report on RCRA Permit Activities for March 1987." Prepared by State Programs Branch and Information Management Staff, Office of Solid Waste, April 13, 1987, based on OSW tracking data.

[2] Land disposal facilities are defined as any hazardous waste management facility with a landfill, surface impoundment, waste pile, or land treatment unit. Any facility that has an incinerator but no land disposal units is considered an incineration facility. All other hazardous waste management facilities are defined as treatment/storage facilities.

[3] U.S. EPA, "RCRA Facility Assessment Guidance." Prepared by the Offi of Solid Waste, October 1986.

RFAs generally consist of brief descriptions of the industrial processes at the facility, the location of the facility and its surrounding environment, the design of each SWMU, the types of wastes handled by each SWMU, and the release history or potential for releases at each SWMU and the facility in general All units potentially subject to Sections 3004(u), 3004(v), and 3008(h) are evaluated in the RFA. The units evaluated include spill areas, recycling units, wastewater treatment units, and units that were closed prior to the enactment of RCRA or HSWA. Depending upon the size of each facility and the number of SWMUs at the facility, RFAs may range from a few pages to several hundred pages per facility.

RFAs represent a compilation of several data sources on individual facilities. In preparing RFAs, several sources are consulted including RCRA Part A and Part B permit applications, responses to Regional requests for information on SWMUs, RCRA inspection reports, RCRA exposure information reports, and other sources (e.g., correspondence, waste manifests, notices to local authorities, reports of releases, and so forth) as appropriate. In addition, other sources such as CERCLA Remedial Investigation/Feasibility Study and CERCLA Preliminary Assessment/Site Investigation reports, if they exist, are also consulted. Many RFAs also include actual site visits to verify information and gather visual evidence on each SWMU. Because RFAs represent a single concise document that attempts to synthesize a wide range of data on a particular facility, we used RFAs for the purposes of developing a facility database for the RIA.

EPA has been conducting RFAs over the past two years and ultimately intends to prepare an RFA for each facility subject to the RCRA Subtitle C program. Exhibit A-1 shows the number of RFAs that had been completed as of April 16, 1987. The exhibit shows that EPA has completed RFAs for approximately eleven percent (624 of 5,661 facilities) of all Subtitle C facilities. More than 74 percent of these facilities (464 facilities) are land disposal facilities, five percent (33 facilities) are incineration facilities, and 20 percent (127 facilities) are treatment/storage facilities.

Because HSWA greatly expanded the scope of the RCRA corrective action program, the data on facilities and SWMUs subject to the corrective action requirements are often sketchy and unverified. The quality of data contained in each RFA varies greatly according to the amount of data available on a facility and the surrounding environment. Some RFAs contain a large amount of useful information on each unit and are very detailed. Others contain more limited information. Our approach to addressing the data limitations is presented in Section A.3 of this appendix.

A.1.3 Universe of Subtitle C Facilities Represented

A detailed analysis of the RCRA corrective action program at each f the 5,661 Subtitle C facilities was infeasible given the complexity of the program, the difficulty in determining when actions are necessary, and the limited availability of data. Thus, only a sample of facilities was investigated.

EXHIBIT A-1

COMPLETED RFAS BY REGION AND FACILITY TYPE
(As of April 16, 1987)

Region	Land Disposal	Incinerator	Treatment and Storage	Total
1	42	1	16	59
2	44	2	25	71
3	50	6	22	78
4	86	4	23	113
5	114	9	19	142
6	73	8	9	90
7	11	0	4	15
8	15	0	4	19
9	19	3	0	22
10	10	0	5	15
Total	464	33	127	624

Source: U.S. EPA, Hazardous Waste Data Management Retrieval System, Retrieval Number F87043, April 16, 1987.

Two factors limited the universe of facilities represented in this analysis. First, given that RFAs were the best source of information, the universe was limited to the 624 facilities with completed RFAs. Second, because corrective action regulations affect primarily facilities requiring corrective action (i.e., they have only a limited effect on facilities where corrective action is unnecessary), the universe of facilities from which we drew the sample did not include facilities for which the RFA indicated that there is no need for corrective action. If the evidence uncovered during the RFA supports continued investigation of the facility, the RFA recommends the preparation of a RCRA Facility Investigation (RFI). An RFI is a detailed characterization of a facility and the extent of its releases to determine if corrective measures are necessary.

We assumed that corrective measures were not needed at those facilities for which the RFA did not recommend an RFI. Therefore, we limited the sample universe to facilities for which an RFA had been completed and for which the RFA recommended an RFI.[4] Exhibit A-2 shows, for different types of facilities, the number and proportion of RFAs that recommend RFIs. The exhibit indicates that nearly seventy percent (437 facilities) of all completed RFAs recommend RFIs. The majority of facilities for which RFIs are recommended are land disposal facilities (342 facilities), followed by 72 treatment/storage facilities and 23 incineration facilities, all requiring an RFI.[5]

A.1.4 Methodology Used to Select Representative Survey Sample

In most circumstances, a representative survey sample can be selected by taking a random sample from the sample universe. In this instance, however, selection of the survey sample was complicated by the fact that the sample universe was not entirely representative of the total population of facilities that might require corrective action. Because the sample universe was limited to those facilities for which RFAs had been completed and for which the RFA recommended an RFI, we had to develop a more sophisticated methodology for selecting the survey sample to ensure that our sample would be

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[4] As explained below these facilities are believed to represent about 62 percent of all facilities. At the remaining 38 percent, environmental damages and corrective action costs are assumed to be negligible. Analytic results presented in the RIA, thus, include an adjustment for the fact that, in addition to the effect observed at facilities represented in the sample, there will be no effects at facilities not represented in the sample (i.e., facilities where an RFI is not required).

[5] Because of the HSWA permitting deadlines for land disposal facilities, most regional EPA offices have focused priorities toward land disposal facilities. The impact of the deadline is demonstrated by the fact that 31 percent of all land disposal facilities have had an RFA completed, compared with only three percent of all treatment/storage facilities.

EXHIBIT A-2

SEVENTY PERCENT OF ALL COMPLETED RFAs RECOMMENDED RFIs
(As of April 16, 1987)

Facility Type	RFA Completed	RFI Recommended	Percent RFI Recommended
Land Disposal	464	342	74%
Incineration	33	23	70%
Treatment and Storage	127	72	57%
Total	624	437	70%

Source: U.S. EPA, Hazardous Waste Data Management Retrieval System, Retrieval Number F87043, April 16, 1987.

as representative as possible of the overall population of Subtitle C facilities.

The methodology that we developed for selecting the survey sample consisted of three steps. First, because we expected the characteristics of SWMUs at each facility to differ across the types of facilities (e.g., land disposal versus treatment/storage facilities), it was important that the distribution of facilities within the sample accurately reflect the distribution of facility types in the actual universe of facilities. Second, the survey sample also had to reflect the fact that the probability of an RFA recommending an RFI may differ by facility type (e.g., land disposal facilities may be more likely to require corrective measures than treatment/storage facilities). Third, we combined the results of the first two steps to form a distribution of facility types for selection from the actual universe of facilities. We then adjusted the distribution to reflect the fact that our sample was chosen only from those facilities with RFAs calling for RFIs. These three steps are discussed below.

STEP 1: ADJUSTMENT FOR DISTRIBUTION OF FACILITY TYPES

Exhibit A-3 compares the distribution of RCRA Subtitle C facilities for which an RFA had been completed, by type of facility, with the actual distribution of facilities. The exhibit shows that the distribution of types of facilities for which RFAs were completed is not the same as the distribution of types of all facilities. The sample universe contained a disproportionately large number of land disposal and incineration facilities relative to treatment/storage facilities. For example, more than 70 percent of all Subtitle C facilities are treatment/storage facilities, but only 15 percent of the facilities in the sample universe are treatment/storage facilities. Therefore, a simple random sample from the subset of facilities with RFAs may have included too few treatment/storage facilities relative to land disposal and incineration facilities.

To adjust for this problem, we stratified the survey sample according to the three broad categories of facilities (i.e., land disposal, incineration, and treatment/storage facilities). The ultimate goal of the stratification process was to generate the appropriate number of facilities that should be sampled from each stratum of the survey sample in order to reflect the actual distribution of facility types. Therefore, based on the data presented in Exhibit A-3, we adjusted the sample to reflect the fact that 26 percent of the facilities are land disposal facilities, 4 percent are incineration facilities, and 70 percent are treatment/storage facilities.

STEP 2: ADJUSTMENT FOR DIFFERING PROBABILITIES THAT AN RFA WILL RECOMMEND AN RFI ACROSS FACILITY TYPES

The second adjustment was necessary to reflect the varying probabilities of an RFA calling for an RFI (i.e., the likelihood that there is a potential for a corrective action) across different types of facilities. For example,

EXHIBIT A-3

COMPARISON OF ACTUAL DISTRIBUTION OF FACILITIES WITH DISTRIBUTION OF FACILITIES HAVING COMPLETED RFAS (As of April 16, 1987)

Type of Facility	Number of Facilities 1/	Percent	Facilities with Completed RFAs 2/	Percent
Land Disposal	1,487	26%	464	75%
Incineration	196	4%	33	5%
Treatment and Storage	3,978	70%	127	20%
Totals	5,661	100%	624	100%

1/ U.S. EPA, "Summary Report on RCRA Permit Activities for March 1987." Prepared by State Programs Branch and Information Management Staff, Office of Solid Waste, April 13, 1987.

2/ U.S. EPA, Hazardous Waste Data Management System, Retrieval Number F87043, April 16, 1987.

because many land disposal facilities dispose of wastes directly in or on land, land disposal facilities may be more likely to have an RFA recommend an RFI than a treatment/storage facility that may typically store wastes in above-ground containers for shorter periods of time. To reflect such differences, we assumed that the percentages of RFAs calling for an RFI presented in Exhibit A-2 for the first 624 RFAs can be used to predict the likelihood of an RFA calling for an RFI for all facilities. According to these figures, about 73.7i percent of the RFAs done at land disposal facilities can be expected to call for an RFI, while at incineration and treatment/storage facilities the percentages are 69.70 percent and 56 69 percent, respectively. Statistical tests for differences of proportions suggest that the type of facility is a statistically significant factor in determining the likelihood that an RFA will call for an RFI.[6] Therefore, we adjusted the sample to reflect the probability of an RFA recommending an RFI for each facility type.

STEP 3: CALCULATION OF STRATUM WEIGHTS

We made the adjustments described above by multiplying the distribution of RFAs recommending RFIs for each facility type by the actual distribution of facility types. For example, as shown in Exhibit A-2, approximately 73.71 percent of all Subtitle C land disposal facilities will need to conduct an RFI. And, as shown in the second column of Exhibit A-3, approximately 26.27 percent of all Subtitle C facilities are land disposal facilities. By multiplying 73.71 percent by 26.27 percent, we determined that the unadjusted "stratum weight" for land disposal facilities in this case was 0.1936. As shown in Exhibit A-4, we completed this procedure for the other two facility types, by computing unadjusted stratum weights of 0.0241 and 0.3984 for incineration and treatment/storage facilities, respectively.

The unadjusted stratum weights represent, by type of facility, the fraction of facilities in the total population that will have RFAs recommending RFIs. As Exhibit A-4 reveals, 62 percent of all facilities (i.e., the sum of the unadjusted weights) may require an RFI once all of the RFAs are completed. Because we drew our sample only from those facilities with RFAs calling for RFIs, and not from the entire population of facilities, we adjusted the weights by scaling them to add to one (e.g., we calculated the adjusted weight for land disposal as 0.1936/0.6161, or 0.3143 out of 1). Exhibit A-4 shows the adjusted weights for each type of facility. Based on these weights, we selected a sample with 31 percent land disposal facilities, 4 percent incineration facilities, and 65 percent treatment/storage facilities.

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6 Using a standard difference of proportions test, we determined that the difference between the proportion of RFAs calling for an RFI at land disposal facilities and at treatment/storage facilities was significant at the 0 05 level. The differences between land disposal facilities and incineration facilities and between incineration facilities and treatment/storage facilities were not statistically significant at the 0.05 level.

EXHIBIT A-4

CALCULATION OF STRATUM WEIGHTS

Type of Facility	Percentage	Probability that RFA will Recommend RFI	Unadjusted Weight	Adjusted Weight
Land Disposal	26.27%	73.71%	0.1936	0.3143
Incineration	3.46%	69.70%	0.0241	0.0391
Treatment and Storage	70.27%	56.69%	0.3984	0.6466
Totals	100.00%		0.6161	1.0000

SELECTION OF ACTUAL SURVEY SAMPLE

The number of available RFAs for each facility type limited the size of the survey sample. In general, with a sample size of 29 or more observations, statistical confidence intervals can be constructed that are about as precise as those based on a larger sample.[7] Because the survey sample for this analysis essentially represented three separate survey samples (i.e., land disposal, incinerator, and treatment/storage facilities), the ideal survey sample would contain at least 29 observations in each of the three sub-samples. However, as noted previously, the three facility type groups must exist in the survey sample in fixed proportions to reflect the actual national distribution of facility types. Because the smallest of the three sub-samples, incineration facilities, represented only 3.9 percent of the sample, the requirement that there be fixed proportions among the three facility type groups meant that the size of an "ideal" sample would have been at least 736 (i.e., 29 divided by 3.91 percent). However, a sample of this size does not exist since only 624 RFAs have been completed.

The number of available RFAs for treatment/storage facilities further limited the sample size. Because 65 percent of the sample had to be treatment/storage facilities and only 72 RFAs recommending RFIs had been completed for these facilities, the sample size could be no larger than 111 facilities. We sought a total of 123 facilities for the sample, including all available RFAs calling for RFIs at treatment/storage facilities. With a sample of this size, inferences about the total population of facilities can be made with reasonable confidence; only conclusions based on small subsamples are potentially limited.[8]

We randomly selected the sample of land disposal and incineration facilities from a list of RCRA Subtitle C facilities with completed RFAs that recommended an RFI. The procedure for random selection involved assigning

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[7] A confidence interval for the mean value of a particular variable in a large sample can be constructed using the normal distribution. With the normal distribution, a 95 percent confidence interval is developed by multiplying the standard error of the estimate by 1.96. For samples of less than 120 observations, the t-distribution (which reflects the greater imprecision associated with small samples) is used instead of the normal distribution. When estimating a 95 percent confidence interval using the t-distribution, the standard error of the estimate is multiplied by a coefficient that depends on the sample size. For a sample size of 29 (i.e., with 28 degrees of freedom), the appropriate coefficient is 2.048. At two significant digits, this is essentially the equivalent to the normal coefficient (i.e., both 1.96 and 2.048 round off to 2.0).

[8] Because of the small size of the incineration subsample, we drew no conclusions about incinerators but grouped them with treatment/storage facilities for our analysis.

each facility a random number using a random number table. We then selected the appropriate number of facilities within each strata based on the random number assigned to each facility. This procedure avoided statistical preference for facility size, location, or ownership status (e.g., private versus public). In some instances, however, we eliminated facilities because certain data (such as geographic coordinates necessary for hydrogeologic mapping) were unavailable.

We attempted to obtain the RFAs for each facility selected for the sample by either contacting or visiting the EPA Regional offices. In some instances, RFAs were either unavailable or insufficient for use in the survey. Of the 77 useable RFAs that we received, only 41 were for treatment/storage facilities. In order to preserve the fixed proportions among the facility groups we included only 21 of the 30 available land disposal facilities and three of the four available incineration facilities in the sample. For the treatment/storage stratum, however, we included all 41 treatment/storage facilities in the final survey sample. We dropped two facilities (one land disposal and one treatment/storage facility) at a later stage due to insufficient data. Thus our final sample consisted of 21 RFAs for land disposal facilities, three for incineration facilities, and 41 for treatment/storage facilities.

A.1.5 General Approach Used for Analyzing Each Facility

We analyzed each of the facilities in the final survey sample using a series of standardized questionnaires. We used the first questionnaire, shown in Exhibit A-5, to assimilate data at an aggregate facility level. We completed these forms for each facility in the final survey sample. We completed the second questionnaire, shown in Exhibit A-6, for each SWMU at each facility in the survey sample. We developed these forms using actual RFAs as a guide. We designed the forms to provide as much information as possible in a format that would facilitate subsequent analysis.

A.1.6 Overview of Collected Data

This section provides an overview of the data collected in our survey of RFAs for the sample of 65 facilities. A variety of aggregate statistics on both the facilities and the 893 individual SWMUs at the facilities are discussed below. Note that, in many cases, data were not available to fully characterize all units. Section A.3 describes how we supplemented this information before we modeled the costs and risks associated with corrective action.

OPERATING STATUS OF THE FACILITIES

The RFAs provided data on the operating status of 58 of the 65 facilities in the database. Of these 58 facilities, 52 facilities (90 percent) are still in operation and 6 facilities (10 percent) have been closed. Of those facilities that have closed, all were reported to have been closed between 1982 and 1986. Note, however, that several of the facilities that were

EXHIBIT A-5

SWMU CORRECTIVE ACTION SURVEY QUESTIONNAIRE FOR FACILITY INFORMATION

Answer all questions below for each RFA reviewed. Where data are either insufficient, unavailable, ambiguous, or inapplicable, enter "-99" in the appropriate space.

1 ICF Staff Person completing questionnaire (initials) ________
2 RFA Contractor: ________
3 Date of RFA (mo/day/year) ___/___/___
4 ICF Staff Person entering data to PC (initials) ________
5 Date Questionnaire Entered (mo/day/year) ___/___/___

6 EPA Facility Identification Number ________________

7 Facility Name. ________________

8 Facility City and State ________________

9 SIC Code (Use 4 digits even if only 2 or 3 digits are available)
   9a Primary - _____ 9b. Secondary - ______
   9c If SIC Code is unavailable, describe activities of facility. ________________

10. Year industrial activity (i.e., not necessarily waste management) began at facility: _____

11 Year industrial activity ceased at facility (enter "0" if still open) _____

12 Distance to nearest drinking water well from facility boundary: ____ meters

13 Is well downgradient? ___ Yes (1) ___ No (0) ___ Unknown (-99)

14 Approximate number of individuals using drinking water well: ______

15. Distance to nearest surface water (e.g., lake, stream, or river) from facility boundary: ______ meters

16. Is surface water downgradient? ___ **Yes (1)** ___ **No (0)** ___ **Unknown (-99)**

17. Distance to nearest population potentially exposed to air releases (distance from facility boundary): ______ meters

18. Size of population potentially subject to air exposure: ______

19. Number of SWMUs identified at facility:
   19a. Unregulated SWMUs whose existence is confirmed by RFA. _____
   19b Regulated Subtitle C SWMUs (e.g., all SWMUs that have managed hazardous wastes since November 19, 1980). _____

   19c Total number of confirmed SWMUs (equal to 19a plus 19b) _____

   19d. SWMUs whose existence is speculated about but not confirmed by RFA: _____

EXHIBIT A-5 (CONTINUED)

20 Are there upgradient monitoring wells which show ground-water contamination? ___ Yes (1) ___ No (0) (skip Q21) ___ Unknown (-99) (skip Q21)

21. If yes, list constituents and concentrations:

	#1	#2	#3	#4	#5	#6
21a Constituent.	____	____	____	____	____	____
21b Concentration	____	____	____	____	____	____

*** (At this point, complete one SWMU questionnaire for each SWMU at the facility The number of SWMU questionnaires completed should be equal to the number entered for question 19c on the previous page (i.e., do not complete a questionnaire for SWMUs whose existence is unconfirmed). Following completion of all SWMU questionnaires for this facility, decide whether you have obtained definitive release information for all SWMUs. If you have, do not complete questions 22 through 24 below. Otherwise, if definitive release information has not been obtained for one or more SWMUs, proceed to questions 22 to 24)

22. Have there been any noted releases from facility: __ Yes (1) __ No (0) __ Unknown (-99)

23 Facility-wide Release Information* (fill in as appropriate)

	#1	#2	#3	#4	#5
23a. Waste/constituent released	____	____	____	____	____
23b. EPA waste code, if available	____	____	____	____	____
23c. Quantity of waste released	____	____	____	____	____
23d. Release to (check all that apply):					
(1) Soil	____	____	____	____	____
(2) Groundwater	____	____	____	____	____
(3) Surface Water	____	____	____	____	____
(4) Air	____	____	____	____	____
(5) Other	____	____	____	____	____
(-99) Unknown	____	____	____	____	____
23e. Is release confirmed ("C") or suspected ("S")?	____	____	____	____	____

24. If soil at facility is contaminated, how much soil (throughout facility) is currently contaminated? _______(cubic yards)

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* This question refers to wastes/constituents which have escaped from the facility into the environment.

EXHIBIT A-6

SWMU CORRECTIVE ACTION SURVEY QUESTIONNAIRE FOR UNIT INFORMATION

(Answer all questions below for each unit at each facility reviewed. Where data are either insufficient, unavailable, ambiguous, or inapplicable, enter "-99" in the appropriate space if no alternative is provided)

1. ICF Staff Person completing questionnaire (initials) ____ 2. ICF Staff Person entering data to PC (initials) ________

3. EPA facility identification number: ________________ 4. Facility name. ____________________________

5. Sequential SWMU number (start w/ 001 for each fac.) ______ 6. SWMU name (if specified in RFA) ______________________

7. SWMU Status (Check one).

____ (1) Unregulated SWMU whose existence is confirmed by RFA
____ (2) Regulated Subtitle C land disposal SWMU (i e , landfill, surface impoundment, waste pile, or land treatment unit that managed hazardous waste after 7/26/82)
____ (3) Other regulated Subtitle C SWMU (i e., a unit used to manage hazardous waste at some time after November 19, 1980 which is not included in (2) above)

8. Year SWMU was first used. ____ 9 When did use of SWMU stop (enter "0" if still in use) ______

10 If no longer in use, how was unit closed?

____ (1) Unit dismantled and removed ____ (2) Excavation and decontamination ____ (3) Containment system installed
____ (4) Unit capped ____ (5) No closure measures taken ____ (6) Impoundment closed w/ waste in place
____ (7) Other - Describe ______________________________ ______ (-99) Unknown or unavailable

11. SWMU Unit Type and Design Type

11a. 3-digit code from unit/design type coding sheet ________

11b If Q11a is 065, 066, 067, or 068 (i e , miscellaneous unit), describe ______________________________

12. SWMU Capacity Information (Provide as many size pa[illegible] as possible based upon unit/design type coding sheet)

12a. Size Variable 1. ________________

12b. Size Variable 2: ________________

12c Size Variable 3 ________________

EXHIBIT A-6 (CONTINUED)

13. Types and Quantities of Wastes/Constituents Contained in or Handled by Unit.
    Note for Q13: Unlike the size questions in Q12, which refer to SWMU capacity, Q13 refers to wastes actually handled or contained in the unit. Also, use supplementary form if there are more than five waste types

	Waste Type 1	Waste Type 2	Waste Type 3	Waste Type 4	Waste Type 5
13a. Type of Waste/Constituent	___	___	___	___	___
13b. EPA Waste code, if available	___	___	___	___	___
13c Quantity of waste contained in unit (metric tons) or handled by unit (metric tons/year)	___	___	___	___	___
13d. Is 13c in terms of Mt (enter "1") or Mt/yr (enter "2")?	___	___	___	___	___
13e Year waste removed from unit (enter "0" if still in unit; "-99" if unknown; "1" if inapplicable, e.g., incinerator)	___	___	___	___	___

14. SWMU Release Information

14a. Has the SWMU released any wastes/constituents to the environment? ___ Yes (1) ___ Suspected (2) ___ No (0) ___ Unknown(-99)

14b. Were corrective actions taken for these releases? ___ Yes (1) ___ No (0) ___ Unknown (-99)

14c. If so, for what medium? (check all that apply) _ Soil ___ Groundwater ___ Surface water ___ Air ___ Other ___ Unknown

14d. Are there still wastes/constituents that are currently a threat to the environment? ___ Yes (1) ___ Suspected (2) ___ No (0) ___ Unknown(-99)

If so, answer questions 14e. through 14h. Use supplementary form if more than five waste consitutents have been released

	Constituent 1	Constituent 2	Constituent 3	Constituent 4	Constituent 5
14e. Type of waste/constituent released	___	___	___	___	___
14f. EPA waste code, if available	___	___	___	___	___
14g. Quantity of waste released	___	___	___	___	___
14h Release to (check all that apply):					
(1) Soil	___	___	___	___	___
(2) Groundwater	___	___	___	___	___
(3) Surface Water	___	___	___	___	___
(4) Air	___	___	___	___	___
(5) Other	___	___	___	___	___
(-99) Unknown	___	___	___	___	___

15 If soil around SWMU is contaminated, how much soil? (cubic yards) ___

16 Briefly describe the activities suggested by the RFA for this unit

___ (1) No further action ___ (2) Additional investigation to determine appropriate action
___ (3) Specific remedial action

EXHIBIT A-6 (CONTINUED)

Unit/Design Type Coding Sheet

Unit/Design Type (Q11)	Size Variable #1 (Q12A)	Size Variable #2 (Q12B)	Size Variable #3 (Q12C)
001 Lined Landfill	Surface area (sq mtrs)	Depth (meters)	Total disposed (MT)
002 Unlined Landfill	Surface area (sq mtrs)	Depth (meters)	Total disposed (MT)
003 Unspecified Landfill	Surface area (sq mtrs)	Depth (meters)	Total disposed (MT)
004 Land Treatment	Surface area (sq mtrs)	Depth (meters)	Metric tons/year
005 Waste Pile - Impermeable pad	Surface area (sq mtrs)	Cubic meters disposed	Metric tons disposed
006 Waste Pile - Other Pad	Surface area (sq mtrs)	Cubic meters disposed	Metric tons disposed
007 Waste Pile - No Pad	Surface area (sq mtrs)	Cubic meters disposed	Metric tons disposed
008 Waste Pile - Indoor	Surface area (sq mtrs)	Cubic meters disposed	Metric tons disposed
009 Waste Pile - Unspecified	Surface area (sq mtrs)	Cubic meters disposed	Metric tons disposed
Treatment Surface Impoundments			
010 Lined Treatment Impoundment	Surface area (sq mtrs)	Depth (meters)	Gallons/year
011 Unlined Treatment Impoundment	Surface area (sq mtrs)	Depth (meters)	Gallons/year
012 Unspecified Treatment Impoundment	Surface area (sq mtrs)	Depth (meters)	Gallons/year
Storage Surface Impoundments			
013 Lined Storage Impoundment	Surface area (sq mtrs)	Depth (meters)	Gallons
014 Unlined Storage Impoundment	Surface area (sq mtrs)	Depth (meters)	Gallons
015 Unspecified Storage Impoundment	Surface area (sq mtrs)	Depth (meters)	Gallons
Unspecified Surface Impoundments			
016 Lined Impoundment - Treatment or Storage not specified	Surface area (sq mtrs)	Depth (meters)	Gallons
017 Unlined Impoundment - Treatment or Storage not specified	Surface area (sq mtrs)	Depth (meters)	Gallons
018 Unspecified Impoundment - Treatment or Storage not specified	Surface area (sq meters)	Depth (meters)	Gallons
019 Cont. Storage - Impermeable Pad	Surface area (sq mtrs)	# Dumpsters	# 55 gallon drums
020 Cont. Storage - Other Pad	Surface area (sq mtrs)	# Dumpsters	# 55 gallon drums
021 Cont. Storage - No Pad	Surface area (sq mtrs)	# Dumpsters	# 55 gallon drums
022 Cont. Storage - Indoor	Surface area (sq mtrs)	# Dumpsters	# 55 gallon drums
023 Cont. Storage - Unspecified	Surface area (sq mtrs)	# Dumpsters	# 55 gallon drums
Treatment Tanks			
024 Above ground tanks - Carbon	# tanks	Total combined capacity of all tanks in SWMU (gallons)	
025 Above ground tanks - Steel	# tanks	Total combined capacity of all tanks in SWMU (gallons)	
026 Above ground tanks - Conc.	# tanks	Total combined capacity of all tanks in SWMU (gallons)	
027 Above ground tanks - Unspec	# tanks	Total combined capacity of all tanks in SWMU (gallons)	
028 Surface tanks - Carbon	# tanks	Total combined capacity of all tanks in SWMU (gallons)	
029 Surface tanks - Steel	# tanks	Total combined capacity of all tanks in SWMU (gallons)	
030 Surface tanks - Concrete	# tanks	Total combined capacity of all tanks in SWMU (gallons)	
031 Surface tanks - Unspec	# tanks	Total combined capacity of all tanks in SWMU (gallons)	
032 Underground tanks - Carbon	# tanks	Total combined capacity of all tanks in SWMU (gallons)	
033 Underground tanks - Steel	# tanks	Total combined capacity of all tanks in SWMU (gallons)	
034 Underground tanks - Concrete	# tanks	Total combined capacity of all tanks in SWMU (gallons)	
035 Underground tanks - Unspec	# tanks	Total combined capacity of all tanks in SWMU (gallons)	
036 Unspecified treatment tank	# tanks	Total combined capacity of all tanks in SWMU (gallons)	

EXHIBIT A-6 (CONTINUED)

Unit/Design Type Coding Sheet (continued)

Unit/Design Type (Q12)	Size Variable #1 (Q12A)	Size Variable #2 (Q12B)
Storage Tanks		
037 Above ground tanks - Carbon	# tanks	Total combined capacity of all tanks in SWMU (gallons)
038 Above ground tanks - Steel	# tanks	Total combined capacity of all tanks in SWMU (gallons)
039 Above ground tanks - Conc.	# tanks	Total combined capacity of all tanks in SWMU (gallons)
040 Above ground tanks - Unspec.	# tanks	Total combined capacity of all tanks in SWMU (gallons)
041 Surface tanks - Carbon	# tanks	Total combined capacity of all tanks in SWMU (gallons)
042 Surface tanks - Steel	# tanks	Total combined capacity of all tanks in SWMU (gallons)
043 Surface tanks - Concrete	# tanks	Total combined capacity of all tanks in SWMU (gallons)
044 Surface tanks - Unspec.	# tanks	Total combined capacity of all tanks in SWMU (gallons)
045 Underground tanks - Carbon	# tanks	Total combined capacity of all tanks in SWMU (gallons)
046 Underground tanks - Steel	# tanks	Total combined capacity of all tanks in SWMU (gallons)
047 Underground tanks - Concrete	# tanks	Total combined capacity of all tanks in SWMU (gallons)
048 Underground tanks - Unspec.	# tanks	Total combined capacity of all tanks in SWMU (gallons)
049 Unspecified storage tank	# tanks	Total combined capacity of all tanks in SWMU (gallons)
Unspecified Tanks		
050 Above ground tanks - Carbon	# tanks	Total combined capacity of all tanks in SWMU (gallons)
051 Above ground tanks - Steel	# tanks	Total combined capacity of all tanks in SWMU (gallons)
052 Above ground tanks - Conc.	# tanks	Total combined capacity of all tanks in SWMU (gallons)
053 Above ground tanks - Unspec.	# tanks	Total combined capacity of all tanks in SWMU (gallons)
054 Surface tanks - Carbon	# tanks	Total combined capacity of all tanks in SWMU (gallons)
055 Surface tanks - Steel	# tanks	Total combined capacity of all tanks in SWMU (gallons)
056 Surface tanks - Concrete	# tanks	Total combined capacity of all tanks in SWMU (gallons)
057 Surface tanks - Unspec.	# tanks	Total combined capacity of all tanks in SWMU (gallons)
058 Underground tanks - Carbon	# tanks	Total combined capacity of all tanks in SWMU (gallons)
059 Underground tanks - Steel	# tanks	Total combined capacity of all tanks in SWMU (gallons)
060 Underground tanks - Concrete	# tanks	Total combined capacity of all tanks in SWMU (gallons)
061 Underground tanks - Unspec.	# tanks	Total combined capacity of all tanks in SWMU (gallons)
062 Unspecified storage tank	# tanks	Total combined capacity of all tanks in SWMU (gallons)
063 Incinerator	Throughput capacity (MT/hour)	
064 Injection Well	Depth (meters)	Below confining layer? (If no, enter "0"; if yes, enter "1")
065 Waste Transfer Station	Describe in Q11b	
066 Waste Recycling Operation	Describe in Q11b	
067 Spill area	Describe in Q11b	
068 Other	Describe in Q11b	

recorded as still in operation have submitted closure plans but have not yet closed.

The average first year of operation among the 37 facilities with opening dates is 1948. The average age of these 37 facilities is approximately 39 years, while the 6 facilities that have closed had an average operating life of 32 years. The oldest facility began operation in 1854, while the newest facility began operation in 1980. Note that the periods of operation refer only to the period during which the facility was used for the current production purposes; years during which facilities were used for other purposes (e g., when owned by other companies or used for making different products) are not included in the operating age statistic. Also note that the period of operation does not necessarily reflect the period during which the facility handled hazardous wastes or constituents.

NUMBER OF SWMUS LOCATED AT FACILITIES

The results of the survey suggest that there are an average of 14 SWMUs per facility. We classified the SWMUs into three types of units based on their regulatory status: (1) newly regulated SWMUs, (2) regulated Subtitle C land disposal SWMUs, and (3) other regulated Subtitle C SWMUs. Newly regulated SWMUs are regulated under RCRA only by virtue of the HSWA corrective action requirements (i.e., RCRA Sections 3004 (u) and 3008 (h)). Subtitle C land disposal SWMUs are landfills, surface impoundments, waste piles, and land treatment units that managed hazardous waste after July 26, 1982. We classified any other Subtitle C units that managed hazardous waste after November 19, 1980 as other regulated Subtitle C SWMUs. Exhibit A-7 shows the average and median number of SWMUs by type of facility and type of unit. On average, of the 14 SWMUs per facility, approximately half are newly regulated by HSWA corrective action provisions. Approximately six SWMUs per facility are regulated Subtitle C units: one land disposal unit and five other Subtitle C units, including treatment and storage units. Note that the number of SWMUs at each federal facility (an average of 29 per facility) is higher than the average number of SWMUs at all other types of facilities.

Exhibit A-8 shows the frequency distribution of the total number of SWMUs located at all facilities surveyed. The exhibit suggests that there are three broad types of facilities: facilities with approximately six or fewer SWMUs, facilities with approximately 9 to 15 SWMUs, and facilities with twenty or greater SWMUs. The total number of SWMUs per facility range from one to 42 SWMUs.

PROXIMITY OF FACILITIES TO DRINKING WATERS, SURFACE WATERS, AND POPULATIONS AT RISK OF AIR EXPOSURE

Where available, we collected information on the proximity of the facility to drinking water wells, surface waters, and populations potentially at risk of exposure to air releases. We also collected some information regarding the approximate numbers of individuals using these water supplies and the sizes of populations at risk of releases to the air.

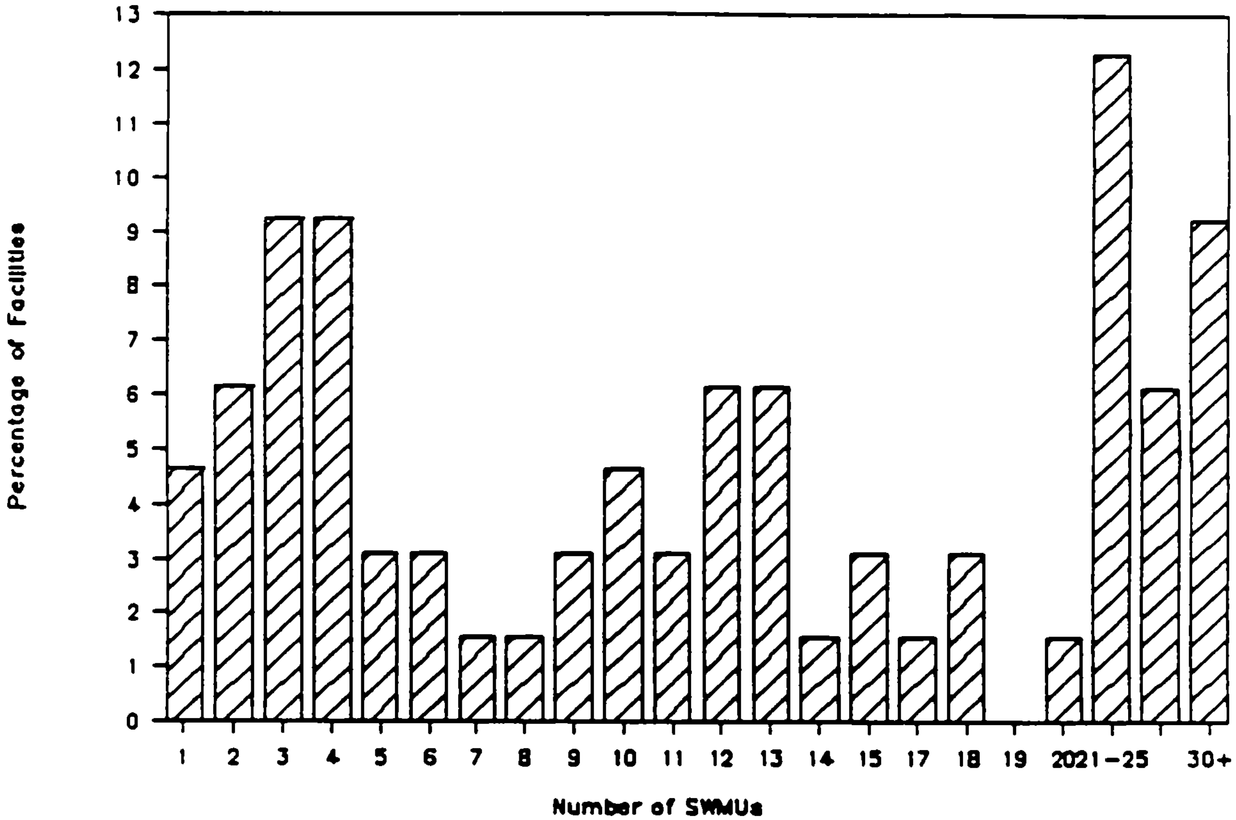
EXHIBIT A-7

DISTRIBUTION OF SWMUS BY FACILITY TYPE

	Number of Facs.	All Types of Units		Newly Regulated Units		Subtitle C Land Disposal Units		Other Subtitle C Units	
		Avg. No. Per Fac.	Median No. Per Fac.	Avg. No. Per Fac.	Median No. Per Fac.	Avg. No. Per Fac.	Median No. Per Fac.	Avg. No. Per Fac.	Median No. Per Fac.
All Facilities	65	14	12	7	5	1	0	5	4
Land Disposal Facs.	21	16	13	10	8	2	1	3	2
Incinerator Facs.	3	17	22	10	10	0	0	7	4
T&S Facilities	41	12	11	6	2	0	0	7	4
Federal Facilities	6	29	28	17	16	0	0	12	11

EXHIBIT A-8

THERE ARE THREE BROAD CLASSES OF FACILITIES BASED ON FREQUENCY OF SWMUs



Drinking Water

The RFAs provided data on the distance from the facilities surveyed to nearby drinking water wells for 17 facilities. The data suggest that the mean distance to drinking water well systems located both up- and down-gradient from the facility boundaries is approximately 13,000 meters. One facility is located as far as 100,000 meters from the nearest drinking water well, while two facilities are located directly above aquifers used by drinking water wells.

Data on the approximate number of individuals using drinking water wells located near the facilities surveyed were available for twelve facilities The data suggest that there are an average of 18,383 individuals using wells near the facilities surveyed. The largest number of people served by a drinking water well near a facility is 70,000 individuals.

Nine of eleven facilities for which data on gradient were available were located upgradient of drinking water wells. For these nine facilities, the average distance from the facility boundary to the drinking water well system is approximately 1,400 meters. The mean population using these wells is estimated to be approximately 30,600 people based on information that was available for five facilities.

Surface Waters

The survey provided data on the distance from the facility to the nearest surface water for 38 facilities. The data suggest that the average distance to the nearest surface water from the facility boundary is 550 meters. The distance varies from a low value of zero (where surface waters run through a facility) to a high of 6,400 meters. Of the 27 facilities for which data on hydraulic gradient were available, 26 facilities were located upgradient of surface waters.

Air Exposure

Finally, we obtained information on the distances to populations potentially affected by releases of hazardous wastes or constituents to the air for 25 facilities. The data suggest that the mean distance to populations is approximately 1,400 meters. The sizes of the populations potentially affected by air releases at two facilities are 70 people and 30,000 people. No data were available on sizes of the populations at the other facilities. In many instances, the RFAs described small populations in close proximity to the facility that were potentially at risk of exposure to air borne pollutants, but did not provide adequate information on the precise locations and sizes of these populations for inclusion in the survey results

FACILITY INTER-UNIT AREA FACTORS

The Liner Location Model (LLM)[9] was used in the RIA to estimate costs and risks associated with each regulatory alternative under consideration. The LLM aggregates all of the surface areas of the units at a particular facility in order to estimate releases. In reality, of course, the units are not aggregated together as a single unit but are spread across the facility To correct for this, we developed a correction factor called the inter-unit area factor to measure the area between the units at the facility

To determine the appropriate inter-unit area factor for each facility, we consulted any available facility maps in the RFAs that were properly scaled and legible. We used the 13 available maps to determine the ratio of the total facility area to the total unit area, which is the inter-unit area factor. We found inter-unit area factors ranging from a low of 1 to a high of 21.7. The median inter-unit area factor is about 5.0.

REGULATORY STATUS OF SWMUS

Data on the regulatory status of the 893 SWMUs in the database were available for 889 units. Of these units, 486 units (55 percent) are regulated under RCRA only by virtue of the HSWA corrective action requirements, 76 units (9 percent) are regulated Subtitle C hazardous waste land disposal units, and 327 units (37 percent) are other regulated Subtitle C treatment or storage hazardous waste management units.

OPERATING STATUS OF SWMUS

Data on the operating status of SWMUs were available for 746 SWMUs. The data suggest that 53 percent of all units (471 SWMUs) were still in operation at the time of completion of the RFA. Of the 275 units (31 percent) that are no longer in use, 25 percent were closed within the past three years. Fifty percent have been closed since 1980. The average date of first use was 1970, with the oldest unit first used in 1900 and the newest unit yet to begin operation. For the 190 units with opening dates that had closed by the time of completion of the RFA, the average operating life was 12 years, ranging from 1 year to 73 years of operation.

PROCEDURES USED TO CLOSE UNITS

Data on the procedures used to close SWMUs no longer in use were available for 258 units (29 percent). These data suggest that the most common procedure used to close units was a cap, which was used to close 34 percent of the units for which data were available. Dismantling and removing the unit was the second most common closure method used; this method was employed at 16

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[9] U.S. EPA, "Liner Location Risk and Cost Analysis Model Phase II Report." Prepared by ICF Incorporated for Economic Analysis Branch, Office of Solid Waste, March 14, 1986.

percent of the units for which data were available. The third most common closure procedure was excavation of wastes and decontamination of remaining equipment, which was used to close 14 percent of the SWMUs for which data were available. The degree to which these closure procedures were done in compliance with RCRA closure standards is unknown. Finally, no closure measures were taken at 21 percent of the units that are no longer in use and for which data on closure were available.

SWMU TYPES AND DESIGNS

The distribution of design types among all 893 SWMUs is presented in Exhibit A-9. These statistics suggest that the most prevalent type of SWMUs in the survey population is unlined landfills (12 percent of all units), followed by above ground storage tanks (10 percent), underground storage tanks (8 percent), and container storage areas with pads (8 percent). Other more prevalent types and designs of SWMUs include unspecified container storage areas (7 percent), above ground treatment tanks (7 percent), unlined storage surface impoundments (5 percent), and waste transfer stations (4 percent). Types of units in the miscellaneous category include units ranging from drainage pipes and drum crushing operations to trash compactors. Taken as a group, however, tanks dominate the population of SWMUs, with tanks constituting more than a third (36 percent) of all units.

Exhibit A-9 also presents the distributions of design types by regulator status. These data indicate that unlined landfills are the most common type of previously unregulated unit (12 percent of all previously unregulated units), followed by unlined storage surface impoundments and above ground tanks. Only 2 percent of all regulated Subtitle C units, however, are unlined landfills. Among the regulated Subtitle C units, container storage areas with pads are most prevalent (6 percent), followed closely by above ground storage tanks (5 percent) and unspecified container storage areas (4 percent). In general, Subtitle C SWMUs seem less likely to be landfills or surface impoundments than do the newly regulated SWMUs.

SWMU CAPACITY INFORMATION

Data on the sizes and capacities of individual SWMUs were available for several units. We gathered different information for different types of units. For example, we gathered throughput capacity data for incinerators and volume data for landfills. In some instances, we obtained both size and capacity information for a given unit type. The actual parameters that we sought for each unit type are listed on the unit and design type coding sheet from the unit questionnaire in Exhibit A-6. Exhibit A-10 provides a summary of the data obtained on the sizes of various types of SWMUs.

TYPES AND QUANTITIES OF HAZARDOUS WASTES OR CONSTITUENTS CONTAINED IN OR HANDLED BY SWMUS

Where available, we gathered data for each SWMU on: (1) the types of wastes and constituents contained in or handled by the unit; (2) the relevant

EXHIBIT A-9

SWMU TYPES AND DESIGNS

SWMU Type and Design	All Units Frequency	All Units Percentage	Newly Regulated Units Frequency	Newly Regulated Units Percentage	Regulated Subtitle C Units Frequency	Regulated Subtitle C Units Percentage
Landfills						
Lined	12	1.3%	5	0.6%	7	0.8%
Unlined	111	12.4%	98	11.0%	13	1.5%
Unspecified	21	2.4%	16	1.8%	5	0.6%
Treatment Surface Impoundments						
Lined	10	1.1%	5	0.6%	5	0.6%
Unlined	16	1.8%	7	0.8%	9	1.0%
Unspecified	19	2.1%	13	1.5%	6	0.7%
Storage Surface Impoundments						
Lined	15	1.7%	6	0.7%	9	1.0%
Unlined	43	4.8%	39	4.4%	4	0.4%
Unspecified	5	0.6%	3	0.3%	2	0.2%
Unspecified Surface Impoundments						
Lined	10	1.1%	10	1.1%	0	0.0%
Unlined	14	1.6%	11	1.2%	3	0.3%
Unspecified	4	0.4%	1	0.1%	3	0.3%
Container Storage Area						
Pad	72	8.1%	17	1.9%	55	6.2%
No pad	11	1.2%	4	0.4%	7	0.8%
Unspecified	60	6.7%	22	2.5%	38	4.3%
Treatment Tanks						
Above Ground	60	6.7%	28	3.1%	32	3.6%
Surface	20	2.2%	8	0.9%	12	1.3%
Underground	10	1.1%	6	0.7%	4	0.4%
Unspecified	14	1.6%	4	0.4%	10	1.1%
Storage Tanks						
Above Ground	87	9.7%	39	4.4%	48	5.4%
Surface	23	2.6%	3	0.3%	20	2.2%
Underground	73	8.2%	36	4.0%	37	4.1%
Unspecified	16	1.8%	6	0.7%	10	1.1%
Unspecified Tanks						
Above Ground	8	0.9%	2	0.2%	6	0.7%
Surface	1	0.1%	0	0.0%	1	0.1%
Underground	4	0.4%	1	0.1%	3	0.3%
Unspecified	9	1.0%	6	0.7%	3	0.3%
Land Treatment Units	10	1.1%	6	0.7%	4	0.4%
Waste Piles	29	3.2%	21	2.4%	8	0.9%
Incinerators	21	2.4%	12	1.3%	9	1.0%
Injection Wells	11	1.2%	8	0.9%	3	0.3%
Waste Transfer Stations	34	3.8%	20	2.2%	14	1.6%
Waste Recycling Operations	14	1.6%	4	0.4%	10	1.1%
Spill Area	14	1.6%	11	1.2%	3	0.3%
Other Units	12	1.3%	10	1.1%	2	0.2%
Totals:	893	100.0%	488	54.6%	405	45.4%

EXHIBIT A-10

LANDFILLS REPRESENT THE LARGEST AND MOST OBSERVED SWMU TYPE

SWMU Type and Design	Number of Observations	Capacity
Landfills	60	82,047 square meters (surface area)
Treatment Surface Impoundments	17	23,624 square meters (surface area)
Storage Surface Impoundments	32	16,648 square meters (surface area)
Container Storage Areas	42	463 55-gallon drums
Land Treatment	3	76,387 square meters (surface area)
Waste Piles	7	3,750 metric tons (total disposed)
Injection Wells	4	529 meters deep

EPA waste codes; (3) the quantity of wastes handled by or contained in the unit; and (4) the year the wastes were removed from the unit (if applicable) Some data on the types of wastes and constituents contained in or handled by the unit were available for 661 SWMUs (74 percent of the units surveyed), although the quality of the data was frequently poor. Approximately 16 percent of the units had wastes described with EPA waste codes and, for a significant fraction of the units, only vague waste descriptions (such as "wastewater" or "rinsewater") were available. Because of these data limitations, we used professional judgement based on the available data to assign waste streams to each unit for the modeling of costs and risks associated with the corrective action rule. The imputation of waste streams and summaries of waste streams assigned to each unit are presented in Section A.3.

Data on the quantities of hazardous wastes or constituents handled by or contained in the unit were available for 67 SWMUs (8 percent). Finally, the years in which wastes were removed from units that have been closed were available for 70 SWMUs. The years of waste removal ranged from 1965 to 1986; over 77 percent of the units with waste removal dates had their waste removed after 1980.

SWMU RELEASE INFORMATION

The survey data suggest that of the 658 SWMUs for which data were available, 183 units (28 percent) have had confirmed releases of hazardous wastes or constituents to the environment. An additional 139 units (21 percent) were also suspected to have had a release. Corrective measures were taken for approximately 18 percent of the releases (58 corrective measures at the 322 SWMUs with confirmed or suspected releases).

The data also suggest that 71 percent of the units with confirmed or suspected releases (230 SWMUs of the 322 units with confirmed or suspected releases) may be considered a threat to the environment because they are currently releasing hazardous wastes or constituents. Of these units, 51 percent are a confirmed threat to the environment, while 49 percent are suspected of being a threat to the environment. Of the SWMUs that may represent a threat to the environment, the majority were releasing to soil and ground water, with releases to surface waters and air somewhat less common. The most common release was to ground water (115 of the 230 SWMUs that may be a threat to the environment, or 50 percent). Releases to soil were the second most common (47 percent), followed by releases to surface waters and air (20 and 6 percent, respectively). Note that many units released to more than one media. At five SWMUs, the RFAs noted contaminated soil around the unit, ranging from 1 cubic yard of contaminated soil to 2,700 cubic yards of contaminated soil.

In general, data on types and quantities of wastes released were quite limited. For this reason, we performed no further analysis on types and quantities of wastes released. The modeling of costs and risks associated with the corrective action rule includes modeling of quantities of waste released. Section A.3 discusses the waste stream assigned to each unit for the modeling effort, which determines the types of wastes released.

FURTHER ACTIVITIES SUGGESTED FOR INDIVIDUAL SWMUS

Finally, each RFA typically made a recommendation regarding further actions needed at each SWMU. In general, these recommendations varied from no further action required, to specific remedial actions, to additional investigation (such as ground-water monitoring or soil testing) to determine appropriate action. According to the data available for 883 SWMUs, at 424 SWMUs (48 percent) the RFAs recommended additional investigations to determine appropriate remedial action. At 376 units (43 percent) no further action was recommended and at 83 units (9 percent) the RFAs recommended specific types of corrective measures.

A.2 OVERVIEW OF HYDROGEOLOGIC MAPPING

To characterize the hydrogeology of the 65 facilities in the survey, we identified the most appropriate DRASTIC[10] hydrogeologic setting for each facility using topographical maps and other geologic sources, including soil surveys and rock maps. The DRASTIC system provides generally recognized values for Depth to ground water, net Recharge, Aquifer media, Soil media, Topography (slope), Impact of the vadose zone, and hydraulic Conductivity of the aquifer for each hydrogeologic setting.

Once we had chosen the appropriate DRASTIC setting for each facility, we mapped the characteristics of the setting to the key hydrogeologic parameters required for modeling the fate and transport of contaminants at the facilities using several assumptions. First, we approximated the actual depth to ground water with the midpoint of the range of water table depths provided for each DRASTIC setting. Similarly, we estimated the aquifer permeability (conductivity) at each facility as the midpoint of the range of hydraulic conductivities provided for the chosen DRASTIC setting. We converted the range provided for each DRASTIC setting's net recharge to the nearest LLM infiltration setting of 0.5 inches per year, 1 inch per year, 10 inches per year, or 20 inches per year.

In addition, we used field experience and engineering judgement to develop a consistent methodology for determining the appropriate vadose zone permeability associated with each DRASTIC setting. We first matched DRASTIC's description of the setting and impact of the vadose zone to the appropriate

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[10] U.S. EPA, "DRASTIC: A Standardized System for Evaluating Ground Water Pollution Potential Using Hydrogeologic Settings." Prepared by Robert S. Kerr Environmental Research Laboratory, Office of Research and Developmen February, 1985.

type of rock or unconsolidated deposit in Freeze and Cherry's Groundwater [11] Exhibit A-11 summarizes the rationale that we then used to derive a vadose zone permeability from Freeze and Cherry for each setting. Finally, using engineering judgement based on the description of the setting, we associated each DRASTIC setting with up to six of the eleven generic LLM flow field scenarios depicted in Exhibit A-12. Note that each flow field defines an aquifer configuration and a set of ground-water velocities. Exhibit A-13 summarizes all of the hydrogeologic parameters associated with each of the 31 DRASTIC settings assigned to facilities, along with the distribution of facilities across each setting.

A.3 DEVELOPMENT OF HYPOTHETICAL FACILITY CHARACTERIZATION

Because many RFAs contained limited information on facilities and SWMUs subject to the corrective action requirements, we found that many facilities in the sample were missing information that would be needed for modeling releases at the facilities. Because of these data gaps, we could not accurately model the actual facilities found in the sample. Consequently, we could either develop completely hypothetical facilities based on the data that we had found or we could fill in the data gaps at the actual facilities with information from other SWMUs in the sample or outside sources. Because the development of a reasonable number of completely hypothetical facilities would require numerous simplifications and assumptions, we decided to supplement the survey findings at each of the 893 SWMUs with representative data from other SWMUs or other data sources.

Section A.3.1 describes the SWMU characteristics that were required for the modeling effort and provides an overview of the gaps in the survey data. Sections A.3.2 through A.3.7 describe the methodologies that we used to fill in the missing information.

A.3.1 Overview of Missing Data

In order to estimate the costs and risks associated with the regulatory options, we needed the following information for each of the 65 facilities:

- Hydrogeologic characteristics;
- Annual rainfall (infiltration);
- Distance to the nearest downgradient drinking water well, and
- Inter-unit area factor.

The hydrogeologic mapping described in Section A.2 provided the hydrogeologic characteristics and annual rainfall for all facilities. The RFA survey

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[11] R. Allen Freeze and John A. Cherry, Groundwater, (New Jersey Prentice-Hall, Inc., 1979) p. 19.

EXHIBIT A-11

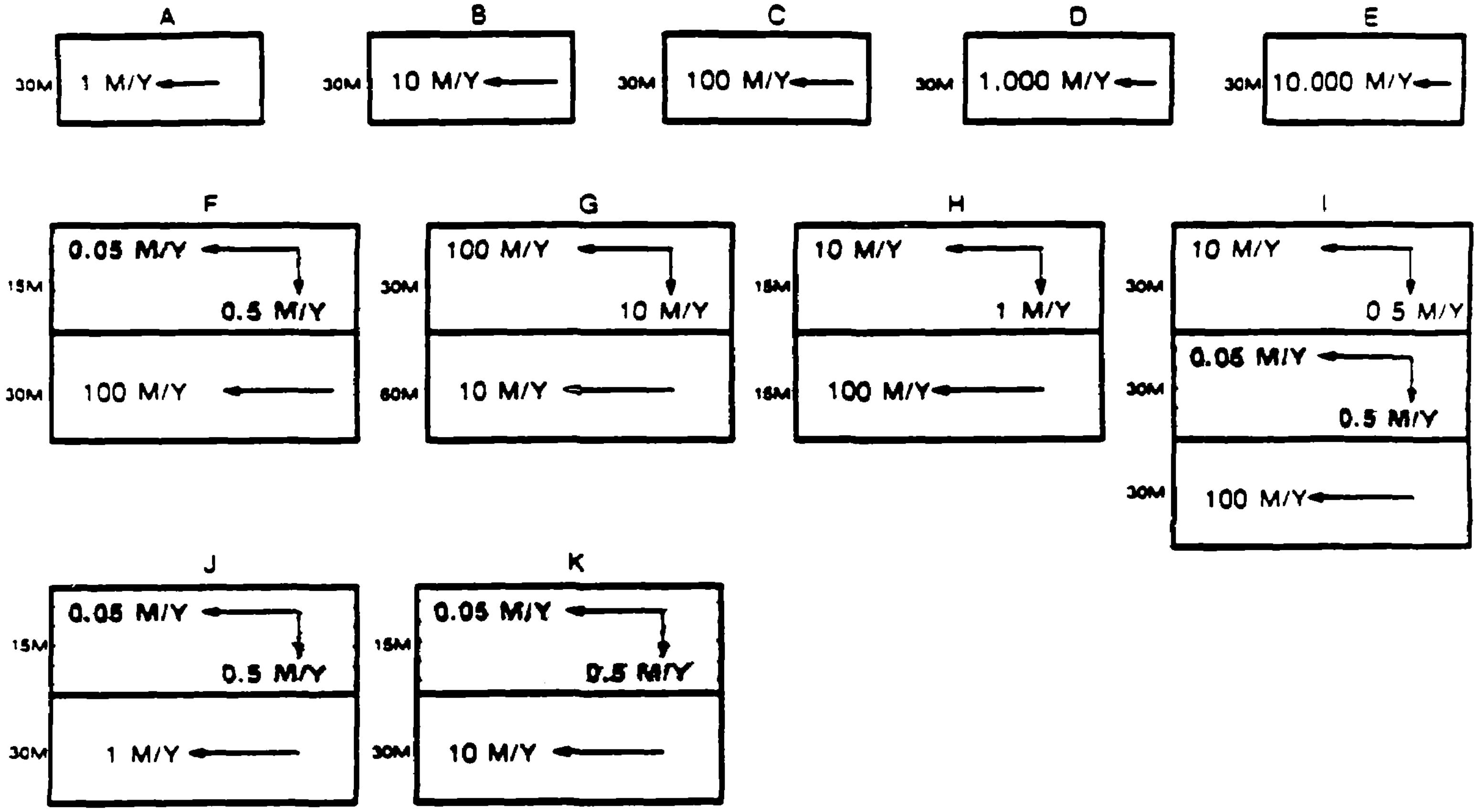
ASSIGNMENT OF VADOSE ZONE PERMEABILITIES

DRASTIC Code	Description of Code	Impact of Vadose Zone	Vadose Zone Permeability (Cm/Second)	Rationale for Choice of Vadose Zone Permeability Within Range Provided by Freeze and Cherry *
1Eb	West Wide Alluvial Valleys	Sand & gravel	4.7160E 01	Midpoint of range for clean sand
2B	Alluvial Mountain Valleys	Sand & gravel	4.7160E 01	Midpoint of range for clean sand
2E	Playa Lakes	Sand & gravel with significant silt and clay	4.7160E 05	Low end of silty sand range
6B	Alluvial Mountain Valleys	Sand & gravel with significant silt and clay	4.7160E 05	Low end of silty sand range
6C	Mountain Flanks	Bedded limestone, sandstone, & shale	4.7160E-05	Midpoint of fractured limestone & sandstone range
6Da	Alternating SS, LS, & SH - Thin Soil	Bedded limestone, sandstone, & shale	9.4320E 07	Low end of limestone & sandstone range
6Db	Alternating SS, LS, & SH - Deep Regolith	Bedded limestone, sandstone, & shale	4.7160E 05	Midpoint of fractured limestone & sandstone range
6Fa	River Alluvium with Overbank	Silt/clay	4.7160E-03	Midpoint of silty sand range
6Fb	River Alluvium without Overbank	Sand & gravel	4.7160E 01	Midpoint of range for clean sand
7Aa	Glacial Till Over Bedded Sedimentary Rock	Silt/clay	9.4320E-07	Midpoint of glacial till range
7Ab	Glacial Till Over Outwash	Silt/clay	9.4320E 07	Midpoint of glacial till range
7Ac	Glacial Till Over Solution Limestone	Silt/clay	9.4320E 07	Midpoint of glacial till range
7Bb	Outwash Over Bedded Sedimentary	Sand & gravel	4.7160E 01	Midpoint of range for clean sand
7C	Moraine	Silt/clay	4.7160E-04	High end of glacial till range
7Ea	River Alluvium with Overbank Deposit	Silt/clay	4.7160E 03	Midpoint of silty sand range
7Eb	River Alluvium without Overbank Deposit	Sand & gravel	4.7160E 01	Midpoint of range for clean sand
7F	Glacial Lake Deposits	Sand & gravel with significant silt and clay	4.7160E-05	Low end of silty sand range
7G	Thin Till Over Bedded Sedimentary	Silt/clay	9.4320E 07	Midpoint of glacial till range
8D	Thick Regolith	Silt/clay	4.7160E 05	Midpoint of range for silt
8F	Mountain Crests	Metamorphic/igneous	4.7160E-04	Midpoint of fractured igneous & metamorphic rock
9C	Mountain Flanks	Bedded limestone, sandstone, & shale	4.7160E 05	Midpoint of fractured limestone & sandstone range
9Da	Glacial Till Over Crystalline Bedrock	Silt/clay	9.4320E-07	Midpoint of glacial till range
9Db	Glacial Till Over Outwash	Silt/clay	9.4320E-07	Midpoint of glacial till range
9Ga	River Alluvium with Overbank Deposit	Silt/clay	4.7160E 03	Midpoint of silty sand range
9Gb	River Alluvium Without Overbank Deposit	Sand & gravel	4.7160E 01	Midpoint of range for clean sand
10Ab	Unconsol. & Semi-consol. Shallow Surf. Aq.	Sand & gravel	4.7160E-01	Midpoint of range for clean sand
10Ba	River Alluvium with Overbank Deposit	Silt/clay	4.7160E-03	Midpoint of silty sand range
10C	Swamp	Sand & gravel	4.7160E-01	Midpoint of range for clean sand
11A	Solution Limestone	Karst limestone	4.7160E-02	Midpoint of karst limestone range
11C	Swamp	Karst limestone	4.7160E 02	Midpoint of karst limestone range
11D	Beaches and Bars	Sand & gravel	4.7160E-01	Midpoint of range for clean sand

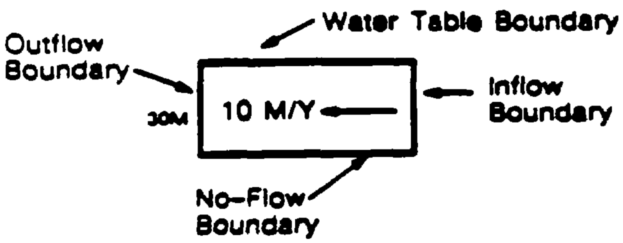
* R. Allen Freeze and John A. Cherry, Groundwater, (New Jersey: Prentice-Hall, Inc., 1979), p. 19.

EXHIBIT A-12

ELEVEN GENERIC GROUND-WATER FLOW FIELDS USED IN SATURATED ZONE MODELING



EXPLANATION



Average Linear Groundwater Velocity Vectors (Meters/Year) Through Each Layer of Saturated Material with Constant Thickness (Meters).

Cross-Hatch Lines Indicate Layer is Non-Aquifer

EXHIBIT A-13

HYDROGEOLOGIC SETTINGS

DRASTIC Code	Description of Code	Depth to Groundwater (Meters)	Net Infiltration (In/Yr)	Saturated Zone Permeability (Cm/Second)	Vadose Zone Permeability (Cm/Second)	Flow Fields	Number of Facilities	Percent of All Facilities
1Eb	West Wide Alluvial Valleys	3.0	10	4.0086E-02	4.7160E-01	C D F	2	3.1%
2B	Alluvial Mountain Valleys	12.2	1	2.3580E-02	4.7160E-01	A B C	1	1.5%
2E	Playa Lakes	26.7	1	4.0086E-02	4.7160E-05	F	1	1.5%
6B	Alluvial Mountain Valleys	6.9	10	2.3580E-02	4.7160E-05	B C D F	1	1.5%
6C	Mountain Flanks	12.2	1	2.3816E-03	4.7160E-05	B C D	1	1.5%
6Da	Alternating SS, LS, & SH - Thin Soil	6.9	10	2.3816E-03	9.4320E-07	B C D	1	1.5%
6Db	Alternating SS, LS, & SH - Deep Regolith	6.9	10	2.3816E-03	4.7160E-05	B C D	2	3.1%
6Fa	River Alluvium with Overbank	6.9	10	7.0740E-02	4.7160E-03	B C F	2	3.1%
6Fb	River Alluvium without Overbank	3.0	10	7.0740E-02	4.7160E-01	B C	2	3.1%
7Aa	Glacial Till Over Bedded Sedimentary Rock	12.2	10	9.4319E-03	9.4320E-07	A B C K	3	4.6%
7Ab	Glacial Till Over Outwash	6.9	10	7.0740E-02	9.4320E-07	F K	3	4.6%
7Ac	Glacial Till Over Solution Limestone	12.2	10	9.4319E-02	9.4320E-07	E F	1	1.5%
7Bb	Outwash Over Bedded Sedimentary	6.9	20	9.4319E-03	4.7160E-01	A C D	1	1.5%
7C	Moraine	6.9	10	2.3580E-02	4.7160E-04	C D F	1	1.5%
7Ea	River Alluvium with Overbank Deposit	6.9	10	4.0086E-02	4.7160E-03	B C F	3	4.6%
7Eb	River Alluvium without Overbank Deposit	3.0	20	4.0086E-02	4.7160E-01	B C	5	7.7%
7F	Glacial Lake Deposits	6.9	10	9.4319E-03	4.7160E-05	C F	4	6.2%
7G	Thin Till Over Bedded Sedimentary	6.9	10	9.4319E-03	9.4320E-07	A B C K	2	3.1%
8D	Thick Regolith	3.0	10	2.3816E-03	4.7160E-05	A B C F J K	2	3.1%
8F	Mountain Crests	30.5	1	2.3186E-03	4.7160E-04	B C	1	1.5%
9C	Mountain Flanks	12.2	10	9.4319E-03	4.7160E-05	B C D E	1	1.5%
9Da	Glacial Till Over Crystalline Bedrock	6.9	10	2.3816E-03	9.4320E-07	A B C	1	1.5%
9Db	Glacial Till Over Outwash	12.2	10	7.0740E-02	9.4320E-07	F K	3	4.6%
9Ga	River Alluvium with Overbank Deposit	6.9	10	7.0740E-02	4.7160E-03	B C F	1	1.5%
9Gb	River Alluvium Without Overbank Deposit	3.0	20	7.0740E-02	4.7160E-01	B C	5	7.7%
10Ab	Unconsol. & Semi-consol. Shallow Surf. Aq.	3.0	20	4.0086E-02	4.7160E-01	C D	4	6.2%
10Ba	River Alluvium with Overbank Deposit	6.9	10	4.0086E-02	4.7160E-03	B C F	6	9.2%
10C	Swamp	0.8	20	7.0740E-02	4.7160E-01	C F	1	1.5%
11A	Solution Limestone	3.0	20	9.4319E-02	4.7160E-02	E	1	1.5%
11C	Swamp	0.8	20	9.4319E-02	4.7160E-02	E	1	1.5%
11D	Beaches and Bars	3.0	20	4.0086E-02	4.7160E-01	C D	2	3.1%
						Totals:	65	100.1%

provided inter-unit area factors for 13 facilities and downgradient drinking water well distances for 17 facilities. Section A.3.2 describes our methodology for completing the facility data for the remaining facilities

In addition to the facility-specific information, we also needed the following characteristics for each unit at any given facility:

- Type of waste managed by the unit (i.e., the unit's waste stream);
- Years of operation;
- Type of unit;
- Year of waste removal;
- Regulatory status; and
- Size of unit and quantity of waste managed by the unit.

For three types of units, we could not adequately determine all of the characteristics required for modeling: waste transfer stations (34 SWMUs), spill areas (14 SWMUs), and "other" units (12 SWMUs). From the RFAs we could not adequately determine quantities of wastes handled by waste transfer stations nor could we find other sources with average waste transfer quantities. In many cases we could not determine whether a particular station was transferring waste into the facility or out of the facility. Because spill areas and "other" units had extremely diverse characteristics, we also could not adequately model these units. For example, one spill area was a truck washing area, while another was an old spill of unknown origin. "Other" units ranged from a paper and packing operation to a centrifugal pump. For these reasons, spill areas, waste transfer stations, and "other" units were not modeled and their characteristics were not completed. Our methodologies for completing the missing information for all other units are described below.

Based on all of the information given in the RFA, we assigned a waste stream[12] to each of the units using the methodology described in Section A.3.3. Approximately 48 percent of the units had valid opening dates from the RFA Survey, while 31 percent of the SWMUs had valid closing dates and 53 percent of the units were still open at the time of the RFA. Section A.3 4 discusses our methodology for determining opening and closing dates for the remaining units. From the RFAs we classified all SWMUs into the 68 unit types listed in Exhibit A-6. In many cases, these unit types were not identical to the types of units that could be modeled by the Liner Location Model (LLM) and

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12 Waste streams characterize the types of waste managed by a unit Each waste stream contains up to six hazardous constituents at different concentrations.

the RCRA Risk-Cost Analysis (WET)[13] model; Section A.3.5 discusses our assumptions for converting these unit types into LLM and WET unit types.

The RFA survey provided actual dates of waste removal for 8 percent of the units. Approximately 22 percent of the SWMUs still contained waste when the RFA was conducted. For some types of units (e.g., deep well injection), waste removal is not possible. Section A.3.6 describes our methodology for determining dates of waste removal based on these facts. From the survey we knew the regulatory status of over 99 percent of the units. We assumed that any units with unknown regulatory status would be older units that were unregulated prior to HSWA. Finally, each type of unit required different size and waste quantity information. Section A.3.7 discusses the information available from the RFA survey for each type of unit, as well as our methodology for determining sizes of units and quantities of wastes managed by SWMUs.

A.3.2 Methodology for Completing Facility Information

The RFA survey and the hydrogeologic mapping provided some information on all of the required facility characteristics, but inter-unit area and downgradient drinking water well data were missing for some facilities. We assigned the median inter-unit area factor, 5.0, to the 52 facilities with missing inter-unit area factors. At the 48 facilities with missing downgradient drinking water well distances, we assumed a well at 400 meters. This distance reflected a conservative assumption that is generally consistent with available summary data on the distance from facilities to nearby wells. Because the LLM does not model wells at distances greater than 1,500 meters, we also assigned the 8 facilities with well distances greater than 1,500 meters, a well distance of 1,500 meters.

A.3.3 Inference of Waste Characteristics

To characterize the wastes managed at the modeled SWMUs, we assigned a waste stream to each unit from the WET model waste stream data base. The WET model estimates costs and risks associated with different technologies, wastes, and environments. Each of the 265 waste streams in the model represents wastes generated by an average plant or facility within an industry. In order to model costs and risks associated with corrective action, we assigned waste streams to each SWMU using the following four steps:

1) Determining the physical characteristics of the SWMU waste (i.e., whether the stream is a solid, a liquid, or a sludge);

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13 U.S. EPA, "The RCRA Risk-Cost Analysis Model Phase III Report" Prepared by ICF Incorporated for Economic Analysis Branch, Office of Solid Waste, March 1, 1984.

2) Determining the chemical characteristics of the waste (i.e, whether the waste is organic or inorganic),

3) Determining the hazardous constituents in the waste; and

4) Assigning a waste steam characterization from the WET model waste stream data base to each SWMU stream for which Steps 1, 2, and 3 had been completed.

In reviewing the RFAs to obtain information on waste stream characteristics, we found that information was often incomplete or too general for completing all of the above steps. Therefore, we developed a consistent set of assumptions for completing the waste stream characteristics. These assumptions are described below.

To determine the physical characteristics of the waste stream, we reviewed RFA information describing the waste and the SWMU. When adequate information was not available for determining the physical characteristics of the waste, we made the following assumptions: (1) all wastes managed in tanks, surface impoundments, and land treatment units are liquids; and (2) all wastes managed in landfills, waste piles, and containers are solids.

When adequate information was not available for determining the chemical characteristics of a waste stream, we made the following assumptions: (1) all wastes managed in surface impoundments and land treatment units are dilute aqueous organic wastes; (2) all wastes managed in tanks are aqueous inorganic wastes; and (3) all wastes managed in landfills and waste piles are inorganic solids. Finally, when enough information was not available to determine the hazardous constituents in the waste, we assigned the SWMU the most prevalent hazardous constituent among all other SWMUs at the same facility.

Once the physical and chemical characteristics and hazardous constituents for a stream were determined, we assigned a waste stream to each unit using best professional judgement. For 124 SWMUs, however, we assigned no waste stream because the unit contained non-hazardous waste or, in a few cases, we could not adequately determine an appropriate waste stream. We did not model the costs and risks associated with corrective action at these units. Exhibit A-14 shows the 10 most common waste streams assigned to the units, including the hazardous constituents contained in each stream. Exhibit A-15 provides the distribution of all units across waste streams aggregated by waste stream category.[14]

In general, there is no simple way to verify the accuracy of the assumptions used in the process of characterizing SWMU waste streams. The

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[14] The first four digits of the six digit waste stream code provide the general category of the waste.

EXHIBIT A-14

MOST PREVALENT WASTE STREAMS ASSIGNED TO UNITS

Waste Stream Number	Description of Waste Stream #	Hazardous Constituents	Number of Units	Percent All Unit
None *	Waste stream contains no hazardous constituents	None	124	13.
03.01.02	1,1,1-Trichloroethane spent solvents and sludges from degreasing	1,1,1-Trichloroethane	46	5.
01.01.16	Wastewater treatment sludges from electroplating operations	Nickel, Copper, Chromium (VI), Lead, Cadmium	33	3.
03.03.01	Paint application sludges	Toluene, Methyl Ethyl Ketone, Chromium (VI), Lead, Mercury	33	3.
03.01.10	Methyl Ethyl Ketone spent solvents from manufacture of paint and allied products	Methyl Ethyl Ketone	29	3.
04.01.01	Dissolved air flotation (DAF) float from the petroleum refining industry	Chromium, Lead	25	2.
01.02.06	Waste leaching solution from acid leaching of emission control dust/sludge from secondary lead smelting	Cadmium, Lead, Chromium (VI)	24	2.
03.01.01	Trichloroethene spent solvents and sludges from degreasing	Trichloroethene	21	2
01.01.12	Sludge from tin plating mill operations	Lead, Chromium (VI)	18	2.
03.01.06	Dichloromethane spent solvent	Dichloromethane	18	2
		Totals:	371	41

* Note that units with no waste stream number contained non-hazardous waste or, in a few cases, the data were inadequate for waste identification.

EXHIBIT A-15

SUMMARY OF ALL WASTE STREAMS

Waste Stream Category	Description of Category	Number of Units	Percent of All Units
None *	Waste stream contains no hazardous constituents	124	13.9%
01.01	Metal sludges	109	12.2%
01.02	Solutions containing heavy metals	77	8.6%
01.03	Cyanide sludge	6	0.7%
01.04	Biosludges containing heavy metals	14	1.6%
01.05	Metal sludges with organics	19	2.1%
02.01	Phenols	6	0.7%
02.02	Wastewater from organic chemical production	104	11.7%
02.03	Wastewater treatment sludge from pesticide production	4	0.5%
02.04	Other aqeous organics	3	0.3%
03.01	Spent solvents	188	21.1%
03.02	Still bottoms from solvent recovery	25	2.8%
03.03	Organic/metal sludges	36	4.0%
03.04	Liquid residues from organic chemical production	13	1.5%
03.05	Solid residues from organic chemical production	18	2.0%
03.06	Other concentrated organics	9	1.0%
04.01	Oily wastes from petroleum refining	80	9.0%
04.02	Other oily wastes	21	2.4%
05.01	Residues from metal smelting and refining	6	0.7%
05.03	Other inorganic solid residues	6	0.7%
06.01	Inorganic solids	7	0.8%
06.03	Organic solids	5	0.6%
06.04	Organic liquids	12	1.3%
06.05	Gases	1	0.1%
	Totals:	893	100.0%

* Note that units with no waste stream category contained non-hazardous wastes or, in some cases, the data were inadequate for waste identification.

characterizations were, however, completed using best professional judgement and are based on what we believe to be reasonable assumptions.

A.3.4 Estimation of Unit Operating Life

Based on the information that was available from the RFA survey, we developed an algorithm for completing the operating lives of the 703 SWMUs that were missing either an opening date or a closing date. We applied the following steps for each unit consecutively until both the opening and closing dates were determined:

1) If the SWMU was missing an opening date, we substituted the earliest opening date of all other SWMUs at the same facility.

2) If the SWMU was still missing an opening date, we substituted the facility opening date.

3) If the SWMU was a newly regulated unit and was missing a closing date, we assumed that the more stringent regulatory environment created by HSWA would have forced the unit to close by 1987. As a conservative assumption, we assumed that all such units closed in 1987 so that the waste would remain in the unit as long as possible.

4) If the SWMU was still missing a closing date, we substituted the facility closing date (if the facility had already closed when the RFA was conducted).

5) If the opening date was still missing and the unit may have closed prior to the completion of the RFA, we calculated the opening date by subtracting the average operating life[15] from the closing date.

6) If the closing date was still missing and the unit may have closed prior to the completion of the RFA, we calculated the closing date by adding the average operating life to the opening date.

7) If both the opening and the closing dates were missing, we substituted the latest closing date of all other units at the same facility. In a few cases, no other units at the facility had closing dates. From the RFAs, though, we knew that these units were all closed. As a conservative estimate, we assumed that they closed

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[15] To determine average operating lives for this and all subsequent steps, we first calculated the average operating lives of all similar types of units (e.g., we calculated the average operating life of all landfills). If this estimation of average operating life was statistically valid (i.e., the standard error was less than one), then we applied the estimate to all units of that particular type. Only the estimate for container storage units was statistically valid. For the other types of units, we used the average operating life of all units in the survey, 12 years.

in 1986. We then calculated the opening date by subtracting the average operating life from the new closing date.

8) If the opening date was still missing but we knew that the SWMU was still open, we calculated the opening date by subtracting half the average operating life from 1987. We then calculated the closing date by adding half the average operating life to 1987.

9) In many cases we knew when the SWMU opened and that it was still open, but we had to estimate when the unit would close in the future. Because many units had already been open for longer than the average operating life, we could not simply add the average operating life to the opening date to determine the closing date. Instead, we found the average operating life of all units that had operating lives longer than the current operating life of the unit in 1987. If, for example, the unit opened in 1950 and was still operating in 1987, we calculated the average operating life of all units that were open for more than 37 years. We then added that average operating life to the opening year to determine the closing year. If no other units were operating for longer than the current operating life of the unit, we assumed that the unit would close in 1988.

10) If the SWMU was a regulated Subtitle C unit, its year of closure could be no earlier than 1980 (the year in which RCRA was enacted) or the unit would not have been regulated. If the above steps assigned a closure date prior to 1980, we changed the date to 1983, as a more realistic assumption.

The above procedure resulted in an average opening year of 1963; the units' opening years ranged from 1900 to 1987. The assigned closing years ranged from 1920 to 2011, with a mean of 1991. The average operating life of the SWMUs was 28 years; the median operating life was 24 years. Note that the average operating life after the above calculations was greater than the average operating life in the original data (which was 12 years) because many of the 110 units that are still open began operation many years ago; the operating lives of these units are not included in the survey estimate of operating life.

A.3.5 Assumptions About Unit Types

In order to model the costs and risks associated with corrective action, we mapped the 68 types of units in the RFA survey to the 13 unit types in Exhibit A-16. It was necessary to describe each unit in terms of one of these unit types because the modeling tools used for the RIA simulate releases for only a limited set of specific design types. We based the assignment of these unit types on several assumptions. First, release profiles for landfills and surface impoundments were only available for two liner designs: double composite and unlined. Because double composite liners were not widely used and were not required before HSWA was enacted in 1984, we assumed that only

EXHIBIT A-16

SIMULATED MODEL UNIT TYPES

- Lined Landfill
- Unlined Landfill
- Lined Treatment Surface Impoundment
- Lined Storage Surface Impoundment
- Lined Disposal Surface Impoundment
- Unlined Treatment Surface Impoundment
- Unlined Storage Surface Impoundment
- Unlined Disposal Surface Impoundment
- Tank
- Deep Well Injection
- Waste Pile
- Land Treatment
- Spill Area

the most recently lined landfills and surface impoundments that were opened after 1980 and not closed before 1985 could be modeled accurately as double composite lined units. We modeled all other landfills and surface impoundments as unlined units. Under these criteria, we found that two of the 12 lined landfills and one of the 35 lined surface impoundments in the survey could be considered double composite lined. We modeled the remaining lined landfills and surface impoundments as unlined.

Second, we assumed that all units with no design description (e.g., unspecified landfills and unspecified treatment impoundments) were older units with no liners or pads. We also modeled surface impoundments that were not specified as treatment or storage as disposal impoundments. Waste piles required an additional classification based on waste pile design types. Exhibit A-17 lists the WET model design types that we assigned to each of the survey waste pile types. In addition, we modeled incinerators, waste recycling operations, and container storage areas as spill areas. Finally, tanks required specific tank design types from the Hazardous Waste Tank Failure (HWTF) model.[16] Because these design types included sizes, we discuss the assumptions required for the assignment of tank design types in Section A.3.7.

A.3.6 Methodology for Determining Dates of Waste Removal

The RFA survey provided actual dates of waste removal for 8 percent of the 893 units. In addition, the model did not require dates of waste removal for incinerators, injection wells, or waste recycling operations. We assumed that releases at these units are a function of throughput, and that the waste is removed at the end of the operating life. The methodology that we developed for determining the dates of waste removal for the remaining units is described below.

For the 451 previously unregulated SWMUs with no date of waste removal, we assumed the waste remained in the unit at closure. However, if the SWMU was a regulated Subtitle C treatment and storage unit, then the regulations require clean closure. For the 305 such units, we assumed that the waste would be removed during the year of closure. Regulated land disposal units are not required to remove the waste at closure; we assumed that the waste would remain in the 67 land disposal units with no removal date after closure

A.3.7 Estimation of SWMU Sizes and Quantities of Wastes Managed by SWMUs

As Exhibit A-18 reveals, each type of unit required several size and waste quantity parameters. In reviewing the RFAs to obtain the necessary information, we found several data gaps. Because little reliable information was available on quantities of wastes managed by the units, we estimated waste quantities from unit sizes. The methodologies that we developed for

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[16] U.S. EPA, "Hazardous Waste Tanks Risk Analysis." Prepared by ICF Incorporated and Pope-Reid Associates for Office of Solid Waste, June 1986

EXHIBIT A-17

MAPPING OF SURVEY WASTE PILE TYPES TO WET MODEL WASTE PILE TYPES

Survey Design	WET Model Design
▪ Impermeable Pad	▪ Impermeable Liner with Periodic Inspections
▪ Other Pad	▪ Synthetic with Clay Liner
▪ No Pad	▪ No Liner
▪ Indoor	▪ Indoor
▪ Unspecified	▪ No Liner

EXHIBIT A-18

REQUIRED SIZE PARAMETERS BY UNIT TYPE

Simulated Unit Type	Surface Area	Depth	Throughput
Lined Landfill	X	X	X
Unlined Landfills	X	X	X
Line Surface Impoundments	X	X	X
Unlined Surface Impoundments	X	X	X
Tanks	X	X	X
Deep Well Injection	NA	L	X
Waste Piles	W	X	X
Land Treatment Units	W	X	X
Spill Area	S	S	X

X - Derived from the RFA data base.

W - Calculated by the WET model based on selected WET model unit design

S - Calculated based on size of release by the spill area algorithm

L - Calculated by the LLM based on the depth to ground water

NA - Not Applicable

completing the missing size information and estimating waste quantities are described below for each unit type.

LANDFILLS

We applied the following methodology to assign sizes and waste quantities to the 144 landfills in the sample:

1) For the 27 units with surface area and depth information available:

- Size = Volume = Surface area x Depth; and

- Throughput = Size x Specific gravity / Operating life.

The specific gravity depends on the type of waste managed in the unit; the WET model waste stream data base provided the specific gravities used in this and all subsequent specific gravity calculations.

2) For the 33 units with surface area information only:

- Size = Volume = Surface area x LLM default depth; and

- Throughput = Size x Specific gravity / Operating life.

3) For the 84 units with no surface area information:

- Size = Median surface area x LLM default depth; and

- Throughput = Size x Specific gravity / Operating life.

The LLM default depths depend on the surface area of the unit; the depths ranged from 3 to 7 meters. We calculated the median surface areas used in Step 3 from the original data as 4,226 square meters.

The mean surface area for the completed data was 47,382 square meters, although the median surface area was only 4,226 square meters. The mean depth was 3.6 meters and the mean throughput was 25,416 metric tons per year.

LAND TREATMENT UNITS

Ten SWMUs in the RFA sample were land treatment units. In order to assign sizes to these units and to determine the quantity of waste that they manage, we applied the following methodology:

1) For the 3 units with surface area information:

- Size = Surface area; and

- Throughput - Land treatment waste application rate from the WET model (i.e., 206 MT/acre/year) x Size.

2) For the 7 units with no surface area information:

- Size - Median land treatment unit size from Pope Reid Associates (PRA) data, 17 acres;[17] and

- Throughput - Land treatment waste application rate from the WET model (i.e., 206 MT/acre/year) x Size.

Because land treatment units can be no deeper than 5 feet,[18] we conservatively assigned all land treatment units a depth of 5 feet. The completed units handled a mean quantity of 6,213 metric tons per year.

WASTE PILES

There are 29 waste piles included in this analysis. The WET model creates several waste piles from each waste pile unit. The new piles are either small (60 cubic meters) or large (2,830 cubic meters), and the sum of all the waste contained in the piles is the quantity specified for the original waste pile unit. We used the following methodology to determine the waste pile sizes and to determine the quantity of waste in the original units:

1) For the 14 units with surface area information:

- Size - Large waste pile size modeled in the WET model (2,830 cubic meters); and

- Throughput - Surface Area x Estimated height of each pile x Specific gravity / Residence time.

We estimated the height of each pile to be 3.75 meters, based on the WET model default value for the height of the 2,830 cubic meter waste pile size.

2) For the 15 units with no surface area information:

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17 U.S. EPA, "Draft Document, Engineering Cost Documentation for Baseline and Proposed Double Liner Rule, Leak Detection System, and CQA Programs. Cost For Landfills, Surface Impoundments and Waste Piles." Prepared for Economic Analysis Branch, Office of Solid Waste, March 20, 1987 by Pope-Reid Associates.

18 40 CFR 264.271(c)(1)

- Size - Small waste pile size modeled in the WET model (60 cubic meters); and
- Throughput - Median waste quantity from PRA data (140 cubic meters) x Specific gravity / Residence time.

For both steps we used the WET model estimate for residence time of 22.5 days. Because waste piles are found on the surface, we assumed that waste pile depths below the surface would be 0 meters for all units.

After the above calculations, the mean quantity of waste managed at each unit was about 45,000 metric tons per year.

SURFACE IMPOUNDMENTS

There are a total of 136 surface impoundments in this analysis (including storage, treatment, and disposal impoundments). We used the following methodology to determine sizes and waste quantities for these units:

1) For the 41 units with surface area and depth information:

   - Size - Volume - Surface area x Depth; and
   - Throughput - Size x Specific gravity / Residence time.

   We assumed disposal impoundments would hold waste for the entire life of the unit (i.e. residence time is equal to the operating life of the unit). Waste at treatment and storage impoundments, though, would remain in the unit for five and ten days, respectively.

2) For the 14 units with surface area information only:

   - Size - Surface area x LLM default depth; and
   - Throughput - Size x Specific gravity / Residence time.

3) For the 81 units with no surface area information:

   - Size - Median surface area x LLM default depth; and
   - Throughput - Size x Specific gravity / Residence time.

We calculated the median surface area for Step 3 from the original data as 2,000 square meters. The default LLM depth for surface impoundments is 2.5 meters.

The mean surface area after completion of the data was 8,124 square meters. The mean depth was 2.6 meters and the mean quantity was 650,000 metric tons per year.

TANKS

The RFA sample included 280 SWMUs that consisted of one or more tanks We modeled the releases from these tanks using release profiles from the HWTF model. Because the number and types of tanks within these SWMUs are quite variable and the HWTF model contains only seventeen tank design types (see Exhibit A-19), we developed the following methodology for determining the number of tanks within a SWMU and for matching each tank to the appropriate HWTF model design type:

1) We divided the tank SWMUs into two categories:

   - Units handling organic waste only; and

   - Units handling aqueous wastes only.

2) We further divided each of these categories into two subcategories:

   - SWMUs with treatment tanks; and

   - SWMUs with storage or accumulation tanks

3) Based on the survey design type, any RFA size information, and the tank subcategory from Step 2, we assigned the most appropriate HWTF model tank design type from Exhibit A-19 to each tank SWMU, adjusting the number of tanks in the SWMU to compensate for any size differences. For tanks with unspecified survey designs, we selected the most prevalent design type among all similar units. In some cases, the number of tanks in the SWMU was unknown. We assumed that such SWMUS would each contain one tank, and selected the design type accordingly.

Exhibit A-19 presents the number of tanks that we assigned to each HWTF model design type. Note that the 31 tanks which contained non-hazardous waste are not included in this exhibit because they were not included in the modeling effort. The surface area and depth of the tank units are inherent in the chosen design. Because the modeling of costs and risks associated with corrective action assumes that releases from a tank are to the ground area directly beneath the horizontal tank area, we used the following calculation to obtain this surface area:

$$\text{Surface area} = \text{Length} \times \text{Diameter}.$$

Based on the volume given for each type of tank (see Exhibit A-19), we calculated the length and diameter of the tank for use in the above equation. To calculate the diameter we assumed an aspect ratio (ratio of length to diameter) of 3, and that the tank was in the shape of a cylinder. Based on these assumptions, we derived the following equation for the diameter of the tank:

EXHIBIT A-19

HWTF MODEL TANK TYPES

HWTFM Code	Design Description	Number of Tank Units	Percentage of All Tank Units
16	5500 gallon, above ground, cradled, carbon steel storage or accumulation tank	75	25.5
2	Open 2300 gallon, above ground, cradled, carbon steel treatment tank	40	13 6
20	4000 gallon, underground, carbon steel storage or accumulation tank	37	12.6
23	4000 gallon, underground, stainless steel storage or accumulation tank	30	10.2
3	Closed 2300 gallon, above ground, cradled, carbon steel treatment tank	26	8.8
15	5500 gallon, above ground, cradled, carbon steel storage or accumulation tank	25	8.5
18	210,000 gallon, above-ground, ongrade carbon steel storage or accumulation tank	15	5.1
25	2100 gallon, in-ground, concrete storage or accumulation tank	15	5.1
9	3700 gallon, in-ground, concrete steel treatment tank	12	4.1
7	60,000 gallon, above ground, ongrade, carbon steel treatment tank	8	2.7
24	4000 gallon, underground, stainless steel storage or accumulation tank	5	1.7
27	2100 gallon, in-ground, carbon steel storage or accumulation tank	4	1 4
17	210,000 gallon, above-ground, ongrade carbon steel storage or accumulation tank	2	0 7

$$\text{Diameter} = (4/3 \times \text{Volume})^{1/3}$$

For above ground tanks, we assigned a depth below the surface of zero (i e , the tank was at ground level). For in-ground tanks, we assumed that the depth would be half the height (i.e., half of the tank was in the ground). Finally, for underground tanks, we assigned a depth equal to the diameter (height) plus 1.52 meters (i.e., we assumed the top of the tank was five feet underground).

CONTAINER STORAGE AREAS

The RFA survey included 143 container storage areas. At 21 units, the survey provided the number of dumpsters in the container storage area, and at 42 units the survey included the number of 55-gallon drums. Using these data and the assumption that each dumpster held 7,640 liters (based on field experience), we calculated the total storage capacity of the unit. We used the median capacity among all units with data for units with no volume information.

To calculate the quantity of waste managed in the container storage areas (throughput) from these capacities, we used an assumed residence time for the containers of either 90 days or one year. Prior to the enactment of RCRA in 1980 there were no restrictions on the time during which a container could remain in the storage area, but after 1980 restrictions existed on the storage time. Therefore, we assumed a 90 day residence time for units that opened during or after 1980, and a one year residence time for units that opened before 1980 to calculate the quantity of waste managed as follows:

$$\text{Quantity} = \text{Total storage capacity} / \text{Residence time.}$$

If the facility opened before 1980 but operated after that date, we assumed that the quantity of waste handled each day would be unchanged after the effective date of the regulations were implemented. However, we included the effect of the decreased residence time in the calculation of quantities spilled.

INCINERATORS

The RFA survey provided little information on quantities handled by the 21 incinerators included in the survey. Four incinerators had capacity information, but extrapolating capacity to all other incinerators from only four values would not be statistically valid. For this reason, we assigned all incinerators with no capacity information the average throughput of 7,000 metric tons per year for incinerators during 1981 from the Westat Survey[19].

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19 U.S. EPA, "National Survey of Hazardous Waste Generators and Treatment, Storage and Disposal Facilities Regulated Under RCRA in 1981." Prepared by Westat, Inc., for Office of Solid Waste, April 1984.

WASTE RECYCLING UNITS

We found 14 waste recycling operations at the 65 facilities in the survey. Five of these units contained non-hazardous waste and, thus, did not require quantity information for modeling. Of the 9 waste recycling operations handling hazardous waste, information was available on quantities of waste handled by 5 units. We used engineering judgement based on qualitative descriptions in the RFAs to provide quantity estimates for the remaining four units. The quantities handled by the 9 waste recycling units with hazardous waste ranged from 55 gallons per day to 20,000 gallons per day.

INJECTION WELLS

The RFA survey included 11 injection wells, but no information was available on quantities of wastes managed by these units. We assigned all injection wells the WET model default throughput value of 138,000 cubic meters per year. We converted this value to metric tons per year using the specific gravity for each type of waste; the final quantities managed by the wells ranged from 344,000 to 1,361,000 metric tons per year, with a mean of 662,000 metric tons per year.

APPENDIX B

CORRECTIVE ACTION TRIGGERS

This appendix identifies the constituent-specific concentrations that trigger corrective actions for the baseline scenario and four regulatory options analyzed in the RIA. In addition, the appendix explains how corrective action triggers were developed. The use of different corrective action triggers is a significant factor in determining the health risk and costs associated with the baseline scenario and four regulatory options.

Appendix B is comprised of four sections. The first section discusses the guidelines used in selecting the constituents modeled in the RIA. Section B.2 then discusses technical detection limits used in the RIA. Section B.3 describes the various possible health-based corrective action triggers used in the analysis (Maximum Contaminant Levels, Risk Specific-Doses, Reference Doses, and Liner Location Model calculated 10^{-4} and 10^{-6} risk level concentrations) for each of the 120 constituents modeled. Finally, Section B.4 discusses the process used to select the appropriate health-based concentration level for each constituent and identifies the health-based corrective action concentration used for each regulatory option.

B.1 CONSTITUENT SELECTION

In this RIA, the human health risk and corrective action costs associated with ground-water contamination were analyzed using EPA's Liner Location Model (LLM). In the LLM, 120 hazardous constituents are modeled. These constituents are listed in Exhibit B-1. These constituents were selected during the development of the LLM in 1984 by using Agency background documents on waste streams and information obtained from RCRA facility site questionnaires.[1] In addition, occasional updates have occurred in conjunction with various applications of the model.

EPA narrowed its focus to 120 constituents, despite the fact that waste streams frequently contain a large number of constituents, because "there are usually one or two constituents that produce much higher (orders of magnitude) risk projections than the other waste stream constituents. Thus, a few constituents of concern can be selected and used as indicators of the overall risk of a multi-chemical waste stream."[2] One-hundred eighteen of these "constituents of concern" were chosen from a list of chemicals that were either priority pollutants or included in Appendix VIII of 40 CFR 261. Constituent selection was based upon relative concentration in industry waste

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[1] U.S. EPA, "Appendix H to EPA's Liner Location Risk and Cost Analysis Model," 1987.

[2] Ibid, H-4.

EXHIBIT B-1

MODELED CONSTITUENTS

1 ACENAPTHENE
2 ACENAPHTHYLENE
3 ACETALDEHYDE
4 ACETONE
5 ACETONITRILE
6 ACROLEIN
7 ACRYLONITRILE
8 ALDICARB
9 ALLYL ALCOHOL
10 ANILINE
11 ANTIMONY
12 ARSENIC
13 BARIUM
14 BENZENE
15 BENZO(A)ANTHRACENE
16 BENZO(A)PYRENE
17 BENZO(B)FLUORANTHENE
18 BENZOTRICHLORIDE
19 BENZYL CHLORIDE
20 BIS(CHLOROMETHYL)ETHER
21 BIS(2)ETHYLEXYL PHTHALATE
22 CADMIUM
23 CARBON DISULFIDE
24 CARBON TETRACHLORIDE
25 CHLORDANE
26 CHLOROACETALDEHYDE
27 CHLOROBENZENE
28 CHLOROFORM
29 2-CHLOROPHENOL
30 CHROMIUM (VI)
31 CHRYSENE
32 COPPER
33 CYANIDES
34 CYCLOHEXANE
35 DIBENZO (A,H) ANTHRACENE
36 1,2 DICHLOROBENZENE
37 1,4 DICHLOROBENZENE
38 1,2 DICHLOROETHANE
39 1,1 DICHLOROETHENE
40 1,2 DICHLOROETHENE
41 DICHLOROMETHANE
42 1,2 DICHLOROPROPANE
43 DICHLOROPROPANOLS
44 1,3 DICHLOROPROPENE
45 2,4 DICHLOROPHENOL
46 2,6 DICHLOROPHENOL
47 DIMETHOATE
48 DIMETHYL ALKYLAMINE
49 2,4 DIMETHYLPHENOL
50 1,3 DINITROBENZENE
51 2,4 DINITROTOLUENE
52 DINOSEB
53 ENDOSULFAN
54 EPICHLOROHYDRIN
55 ETHYLBENZENE
56 ETHYLENE OXIDE
57 FLUORANTHENE
58 FLUORIDES
59 FORMALDEHYDE
60 HEPTACHLOR
61 HEXACHLOROBENZENE
62 HEXACHLOROBUTADIENE
63 HEXACHLOROETHANE
64 HEXACHLOROCYCLOPENTADIENE
65 HEXANE
66 HYDROQUINONE
67 INDENO(123-CD)PYRENE
68 LEAD
69 LINDANE
70 MALEIC ANHYDRIDE
71 MERCURY
72 METHANOL
73 METHOMYL
74 METHYL CHLORIDE
75 METHYL ETHYL KETONE
76 METHYL ISOBUTYL KETONE
77 METHYL ISOCYANATE
78 METHYL METHACRYLATE
79 MOLYBDENUM
80 NAPHTHALENE
81 NAPHTHOQUINONE
82 NICKEL
83 NITROBENZENE
84 4-NITROPHENOL
85 PARALDEHYDE
86 PARATHION
87 PCB-1254
88 PENTACHLORONITROBENZENE
89 PENTACHLOROPHENOL
90 PHENOL
91 PHORATE
92 PHTHALIC ANHYDRIDE
93 2-PROPANOL
94 PYRIDINE
95 TCDD
96 1,1,1,2 TETRACHLROETHAN
97 1,1,2,2 TETRACHLOROETHA
98 TETRACHLOROETHENE
99 THALLIUM
100 TOLUENE
101 TOLUENE DIAMINE
102 TOLUENE DIISOCYANATE
103 TOXAPHENE
104 1,2,4 TRICHLOROBENZENE
105 1,1,1 TRICHLOROETHANE
106 1,1,2 TRICHLOROETHANE
107 TRICHLOROETHENE
108 2,4,6 TRICHLOROPHENOL
109 2,4,6 TRINITROTOLUENE
110 VANADIUM
111 VINYL CHLORIDE
112 XYLENE
113 ZINC
114 ETHYLENE DIBROMIDE
115 TETRAETHYL LEAD
116 NITRATE
117 CHLORIDE
118 SODIUM
119 BERYLLIUM
120 IRON

streams, toxicity (type of effect and potency), and overall environmental persistence. The remaining two constituents, iron and chloride, are not considered hazardous and, consequently, were not modeled to assess health effects. They were left in the data base for completeness of available constituent information.

B.2 DETECTION LIMITS

Due to the limits of analytic chemistry, not all concentrations of a particular constituent can be detected with certainty. For each constituent, the LLM includes a detection limit. The model user can decide whether or not to override the corrective action triggers developed for the different regulatory options with the detection limits. If this model option is used, modeled concentrations below constituent detection limits do not trigger corrective action. In some cases, detection limits are used as corrective action triggers for all constituents (as discussed in Section B.4). These detection limits are identified in Exhibit B-2. In this exhibit, the column labeled "detectable concentration" displays the original detection concentrations assigned to each constituent for use in the LLM by EPA in 1985, and the column labeled "PQLs" contains EPA's recently developed Practical Quantification Limits for each constituent where available. These values were obtained on the basis of one of two sources, as described below.

B.2.1 Practical Quantification Limits

Practical Quantification Limits (PQLs) were developed by EPA and generally represent the lowest concentration of analytes in ground waters that can be determined reliably within specified limits of precisions and accuracy by specified methods under routine laboratory operating conditions.[3] PQLs were used as constituent-specific detection limits, where available (i.e., for 85 constituents). The Agency has developed PQLs for constituents for which it is feasible to analyze in ground-water samples and for 17 chemicals routinely monitored in the Superfund program. PQLs have been developed for guidance purposes and do not constitute regulatory requirements.

B.2.2 LLM Detection Limits

Where PQLs were unavailable, detectable concentration levels established during development of the LLM were used as detection limits. LLM detectable concentration levels were used for 33 organic and inorganic constituents.[4] For the most part, the detectable concentration values for organics represent the minimum analytic detection limits specified for Superfund contractor laboratories. However, the detectable concentration developed for inorganics

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[3] 40 CFR Parts 264 and 270, as amended by 52 FR 25942 (July 9, 1987).

[4] Two additional constituents modeled (iron and chloride) were not assigned detection limits because they were not modeled to assess health effects.

EXHIBIT B-2

DETECTION LIMITS

Constituents	Detection Limits (mg/l)	
1 ACENAPTHENE	1E-02	
2 ACENAPHTHYLENE	1E-02	
3 ACETALDEHYDE	5E-03	**
4 ACETONE	1E-01	
5 ACETONITRILE	1E-01	
6 ACROLEIN	5E-03	
7 ACRYLONITRILE	5E-03	
8 ALDICARB	5E-03	**
9 ALLYL ALCOHOL	5E-03	**
10 ANILINE	1E-02	
11 ANTIMONY	3E-02	
12 ARSENIC	1E-02	
13 BARIUM	2E-02	
14 BENZENE	2E-03	
15 BENZO(A)ANTHRACENE	1E-02	
16 BENZO(A)PYRENE	1E-02	
17 BENZO(B)FLUORANTHENE	1E-02	
18 BENZOTRICHLORIDE	5E-03	**
19 BENZYL CHLORIDE	5E-03	**
20 BIS(CHLOROMETHYL)ETHER	5E-03	**
21 BIS(2)ETHYLEXYL PHTHALATE	1E-02	
22 CADMIUM	1E-03	
23 CARBON DISULFIDE	5E-03	
24 CARBON TETRACHLORIDE	1E-03	
25 CHLORDANE	1E-04	
26 CHLOROACETALDEHYDE	5E-05	*
27 CHLOROBENZENE	2E-03	
28 CHLOROFORM	5E-04	
29 2-CHLOROPHENOL	5E-03	
30 CHROMIUM	1E-02	
31 CHRYSENE	1E-02	
32 COPPER	6E-02	
33 CYANIDES	4E-02	
34 CYCLOHEXANE	5E-03	**
35 DIBENZO (A,H) ANTHRACENE	1E-02	
36 1,2 DICHLOROBENZENE	2E-03	
37 1,4 DICHLOROBENZENE	2E-03	
38 1,2 DICHLOROETHANE	5E-04	
39 1,1 DICHLOROETHENE	1E-03	
40 1,2 DICHLOROETHENE	1E-03	
41 DICHLOROMETHANE	5E-03	*
42 1,2 DICHLOROPROPANE	5E-04	
43 DICHLOROPROPANOLS	5E-03	**
44 1,3 DICHLOROPROPENE	5E-03	
45 2,4 DICHLOROPHENOL	5E-03	

EXHIBIT B-2 (Continued)

DETECTION LIMITS

Constituents	Detection Limits (mg/l)	
46 2,6 DICHLOROPHENOL	1E-02	
47 DIMETHOATE	1E-02	
48 DIMETHYL ALKYLAMINE	5E-03	**
49 2,4 DIMETHYLPHENOL	5E-03	
50 1,3-DINITROBENZENE	1E-02	
51 2,4 DINITROTOLUENE	2E-04	
52 DINOSEB	1E-03	
53 ENDOSULFAN	5E-05	
54 EPICHLOROHYDRIN	5E-03	**
55 ETHYLBENZENE	2E-03	
56 ETHYLENE OXIDE	5E-03	**
57 FLUORANTHENE	1E-02	
58 FLUORIDES	2E-02	*
59 FORMALDEHYDE	5E-03	**
60 HEPTACHLOR	5E-05	
61 HEXACHLOROBENZENE	5E-04	
62 HEXACHLOROBUTADIENE	5E-03	
63 HEXACHLOROETHANE	5E-04	
64 HEXACHLOROCYCLOPENTADIENE	5E-03	
65 HEXANE	5E-03	**
66 HYDROQUINONE	5E-03	**
67 INDENO(123-CD)PYRENE	1E-02	
68 LEAD	1E-02	
69 LINDANE	5E-06	*
70 MALEIC ANHYDRIDE	5E-03	**
71 MERCURY	2E-03	
72 METHANOL	5E-03	**
73 METHOMYL	5E-03	**
74 METHYL CHLORIDE	1E-03	
75 METHYL ETHYL KETONE	1E-02	
76 METHYL ISOBUTYL KETONE	5E-03	**
77 METHYL ISOCYANATE	5E-03	**
78 METHYL METHACRYLATE	2E-03	
79 MOLYBDENUM	2E-02	*
80 NAPHTHALENE	1E-02	
81 NAPHTHOQUINONE	1E-02	
82 NICKEL	5E-02	
83 NITROBENZENE	1E-02	
84 4-NITROPHENOL	1E-02	
85 PARALDEHYDE	5E-03	**
86 PARATHION	1E-02	
87 PCB-1254	5E-02	
88 PENTACHLORONITROBENZENE	1E-02	
89 PENTACHLOROPHENOL	5E-03	
90 PHENOL	1E-03	
91 PHORATE	2E-03	
92 PHTHALIC ANHYDRIDE	5E-03	**

EXHIBIT B-2 (Continued)

DETECTION LIMITS

	Constituents	Detection Limits (mg/l)	
93	2-PROPANOL	5E-03	**
94	PYRIDINE	5E-03	
95	TCDD	5E-06	
96	1,1,1,2 TETRACHLOROETHANE	5E-03	
97	1,1,2,2 TETRACHLOROETHANE	5E-04	
98	TETRACHLOROETHENE	5E-04	
99	THALLIUM	1E-02	
100	TOLUENE	2E-03	
101	TOLUENE DIAMINE	5E-03	*
102	TOLUENE DIISOCYANATE	5E-03	**
103	TOXAPHENE	2E-03	
104	1,2,4 TRICHLOROBENZENE	1E-02	
105	1,1,1 TRICHLOROETHANE	5E-03	
106	1,1,2-TRICHLOROETHANE	2E-04	
107	TRICHLOROETHENE	1E-03	
108	2,4,6 TRICHLOROPHENOL	5E-03	
109	246-TRINITROTOLUENE	5E-03	**
110	VANADIUM	4E-02	
111	VINYL CHLORIDE	2E-03	
112	XYLENE	5E-03	
113	ZINC	2E-02	
114	ETHYLENE DIBROMIDE	5E-03	**
115	TETRAETHYL LEAD	5E-03	**
116	NITRATE	2E-02	**
117	CHLORIDE	NA	
118	SODIUM	5E+00	*
119	BERYLLIUM	5E-03	*
120	IRON	NA	

* LLM detection limit.

** Detectable concentration for this constituent is unknown. Concentration set to default values of 0.005 mg/l for organics and 0.02 mg/l for inorganics.

NA These constituents have not been modeled to assess human health effects.

are recorded directly from the Post-Closure Liability Trust Fund Model data base.[5] A detectable concentration of 0.02 mg/l was assigned to all inorganics listed in this data base. However, not all LLM inorganic "constituents of concern" were listed in the Post-Closure Liability Trust Fund Model data base. To those inorganics not contained in the data base, a default value of 0 02 mg/l was assigned. These assignments resulted in all modeled inorganic constituents having a detectable concentration of 0.02 mg/l. In addition, a default value of 0.005 mg/l was used for organic constituents.[6]

B.3 HEALTH-BASED CORRECTIVE ACTION TRIGGERS

The RIA identifies Agency-developed health-based standards for use as corrective action triggers for certain regulatory options. (A discussion of the specific corrective action triggers used under the baseline scenario and each regulatory option is provided in Section B.4.) These triggers were determined based on a combination of three sets of EPA concentration values including: Maximum Contaminant Levels, Risk-Specific Doses, and Reference Doses. In addition, for those constituents lacking an Agency approved health-based standard, the LLM was used to calculate constituent concentrations that would result in risk levels for use as corrective action triggers. Each of these health-based standards is described in more detail in the preamble to the Proposed Corrective Action Rule.

Maximum Contaminant Levels (MCLs) for 18 hazardous constituents used in the RIA are listed in Exhibit B-3. Drinking water standards under the Safe Drinking Water Act are promulgated as MCLs. Generally, MCLs represent the allowable lifetime exposure to the contaminant for a 70-kilogram adult who is assumed to ingest two liters of water per day. However, an MCL is also required by law to reflect available technology and the economic feasibility associated with removing a given contaminant from the water supply.

Risk-Specific Doses (RSDs) that were used in the RIA are listed in Exhibit B-4. An RSD is an exposure level that corresponds to a specified cancer risk level. An RSD is calculated using chemical-specific potency factors developed by the Agency's Carcinogen Assessment Group and an assumed water consumption rate of two liters per 70-kilogram adult per day over a 70-year lifetime. RSDs used in the RIA analysis would result in an approximate risk of 10^{-4}.

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[5] U.S. EPA, "Appendix H to EPA's Liner Location Risk and Cost analysis Model, 1986."

[6] This concentration falls within the middle range of the Contract Required Quantitation Limits for the Target Compound List of Superfund. The list for Superfund sample analysis can be found in "Appendix H of USEPA Contract Laboratory Program" (Revised 8/87).

EXHIBIT B-3

MAXIMUM CONTAMINANT LEVELS

Constituent	MCL (mg/l) (1)
12 ARSENIC	5E-02
13 BARIUM	1E+00
14 BENZENE	5E-03
22 CADMIUM	1E-02
24 CARBON TETRACHLORIDE	5E-03
30 CHROMIUM VI	5E-02
37 1,4 DICHLOROBENZENE	7E-02
38 1,2 DICHLOROETHANE	5E-03
39 1,1 DICHLOROETHYLENE	7E-03
58 FLUORIDES	4E+00
68 LEAD	5E-02
69 LINDANE	4E-03
71 MERCURY	2E-03
103 TOXAPHENE	5E-03
105 1,1,1 TRICHLOROETHANE	2E-01
107 TRICHLOROETHELYNE	5E-03
111 VINYL CHLORIDE	2E-03
116 NITRATE	1E+01

(1) Concentration values for Appendix IX constituents obtained from EPA memorandum dated April 13, 1987 from Marcia Williams, Director, Office of Solid Waste to David Wagoner, Director, Waste Management Division, Region VII. Memorandum listed Agency established MCLs, RfDs, and RSDs based on the Integrated Risk Information System (IRIS). Concentration values for non-Appendix IX constituents obtained from recent EPA rulemaking. Only constituents modeled for this analysis are shown here; MCLs do exist for other constituents. (MCLs have been established for 24 constituents.)

EXHIBIT B-4

RISK-SPECIFIC DOSE BASED CONCENTRATIONS IN WATER

Constituent	RSD (mg/l) *
7 ACRYLONITRILE	7E-03
10 ANILINE	1E-01
12 ARSENIC	2E-04
14 BENZENE	1E-01
15 BENZO(A)ANTHRACENE	1E-03
16 BENZO(A)PYRENE	3E-04
22 CADMIUM	2E-05
24 CARBON TETRACHLORIDE	3E-02
25 CHLORDANE	2E-03
28 CHLOROFORM	4E-02
35 DIBENZO (A,H) ANTHRACENE	7E-05
38 1,2 DICHLOROETHANE	4E-02
39 1,1 DICHLOROETHYLENE	6E-02
41 DICHLOROMETHANE	3E-01
51 2,4 DINITROTOLUENE	1E-02
54 EPICHLOROHYDRIN	4E-01
56 ETHYLENE OXIDE	1E-02
61 HEXACHLOROBENZENE	2E-03
62 HEXACHLOROBUTADIENE	5E-02
63 HEXACHLOROETHANE	3E-01
88 PENTACHLORONITROBENZENE	1E-02
97 1,1,2,2 TETRACHLOROETHANE	2E-02
106 1,1,2 TRICHLOROETHANE	6E-02
107 TRICHLOROETHELYNE	3E-01
108 2,4,6 TRICHLOROPHENOL	2E-01
111 VINYL CHLORIDE	2E-01

* RSDs were calculated using scores developed by the Cancer Assessment Group to result in a 10E-4 lifetime risk.

Source: RSDs derived from data presented in EPA memorandum dated April 13, 1987 from Marcia Williams, Director, Office of Solid Waste, to David Wagoner, Director, Waste Management Division, Region VII. Memorandum listed Agency-established MCLs, RfDs, and RSDs based on the Integrated Risk Information System (IRIS).

Reference Dose (RfD) based concentrations used in the analysis are listed in Exhibit B-5. Reference Doses (RfDs) are "acceptable" exposure levels that have been established and verified by EPA for many noncarcinogens (analogous in concept to the Acceptable Daily Intake, or ADI). An RfD represents the level of exposure which is not likely to result in any adverse effects to human health. An RfD is calculated by using an uncertainty factor to adjust a "no observed adverse effect level" (NOAEL). RfDs are reported in mg/kg/day. However, we have converted appropriate RfDs to concentration levels (mg/l for use in this analysis) assuming a water consumption rate of 2 liters per day for a 70-kilogram adult over a 70-year lifetime.

Risk-based Concentration Levels were also calculated for use as triggers for constituents for which there were no MCLs, RfDs, or RSDs. For carcinogens, the concentration levels are based on a 10^{-4} risk (as calculated by the LLM). For noncarcinogens without an Agency-approved potency factor, we approximated an effects threshold by calculating the dose associated with a 10^{-6} risk level, which provides a better approximation of the NOAEL than a 10^{-4} risk level. The approximation is done using a continuous dose-response function for non-carcinogens incorporated in the Liner Location Model.[7] These concentration values are listed in Exhibits B-6 and B-7.

The RIA employed corrective action triggers, similar to the action levels included in the proposed rule, to determine the year in which corrective action begins, if at all at a specific facility. In general, the health-based concentrations used to trigger corrective action under Options B, C and D in the RIA are the same concentrations used as action levels under the proposed rule. Differences in the RIA corrective action triggers and the proposed rule action levels are due to several reasons:

- For carcinogens without MCLs or Agency-approved potency factors, the risk-based concentration level is based on a 10^{-4} risk level as calculated by the LLM rather than the 10^{-6} risk level used for the proposed rule action levels.

- Constituent-specific health data are constantly updated, and the corrective action triggers used for the RIA were developed using available data in August 1987.

- For constituents where the detection limit is greater than the health-based concentration level, the detection limit is used in the RIA to trigger corrective action.

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[7] See U.S. EPA Draft Report, "Appendix D to EPA's Liner Location Risk and Cost Analysis Model, January 1985."

EXHIBIT B-5

REFERENCE-DOSE BASED CONCENTRATIONS IN WATER

Constituent	RfD Based Concentration Levels (mg/l)(1)
4 ACETONE	4E+00
8 ALDICARB	5E-02
9 ALLYL ALCOHOL	2E-01
11 ANTIMONY	1E-02
13 BARIUM	2E+00
21 BIS(2EHP)	7E-01
23 CARBON DISULFIDE	4E+00
24 CARBON TETRACHLORIDE	3E-02
25 CHLORDANE	2E-03
27 CHLOROBENZENE	1E+00
28 CHLOROFORM	3E-01
30 CHROMIUM	4E+01
33 CYANIDES	7E-01
39 1,1 DICHLOROETHYLENE	3E-01
41 DICHLOROMETHANE	2E+00
45 2,4 DICHLOROPHENOL	1E-01
47 DIMETHOATE	7E-01
52 DINOSEB	4E-02
54 EPICHLOROHYDRIN	7E-02
55 ETHYLBENZENE	4E+00
58 FLUORIDES	2E+00
62 HEXACHLOROBUTADIENE	7E-02
64 HEXACHLOROCYCLOPENTADIENE	2E-01
69 LINDANE	1E-02
72 METHANOL	2E+01
73 METHOMYL	9E-01
75 METHYL ETHYL KETONE	2E+00
76 METHYL ISOBUTYL KETONE	2E+00
83 NITROBENZENE	2E-02
88 PENTACHLORONITROBENZENE	3E-01
89 PENTACHLOROPHENOL	1E+00
90 PHENOL	1E+00
94 PYRIDINE	7E-02
98 TETRACHLOROETHENE	7E-01
100 TOLUENE	1E+01
104 1,2,4 TRICHLOROBENZENE	7E-01
105 1,1,1 TRICHLOROETHANE	3E+00
106 1,1,2 TRICHLOROETHANE	2E-01
110 VANADIUM	7E-01
115 TTE-LEAD	3E-06
116 NITRATE	4E+01
119 BERYLLIUM	2E-01

(1) Concentration values for Appendix IX constituents obtained from EPA memorandum dated April 13, 1987 from Marcia Williams, Director, Office of Solid Waste to David Wagoner, Director, Waste Management Division, Region VII. Memorandum listed Agency established MCLs, RfDs, and RSDs based on the Integrated Risk Information System (IRIS). Concentration values for non-Appendix IX constituents obtained from the IRIS data base. Only constituents modeled for this analysis are shown here; RfDs do exist for other constituents.

EXHIBIT B-6

LLM CALCULATED 10E-4 RISK CONCENTRATIONS IN WATER FOR CARCINOGENS

Constituent	Concentration Resulting in 10E-4 Risk Level (mg/l)
1 ACENAPHTHENE	3E-04
2 ACENAPHTHYLENE	3E-04
17 BENZO(B)FLUORANTHENE	3E-04
20 BIS(CHLOROMETHYL)ETHER	4E-07
31 CHRYSENE	3E-04
42 1,2 DICHLOROPROPANE	9E-02
43 DICHLOROPROPANOLS	9E-02
57 FLUORANTHENE	3E-04
60 HEPTACHLOR	1E-03
67 INDENO(123-CD)PYRENE	3E-04
87 PCB-1254	8E-04
95 TCDD	2E-08
101 TOLUENE DIAMINE	1E-02
102 TOLUENE DIISOCYANATE	8E-01
114 EDB	9E-05

Source: U.S. EPA, "Appendix H to EPA's Liner Location Risk and Cost Analysis Model," 1987.

EXHIBIT B-7

LLM CALCULATED 10E-6 RISK CONCENTRATIONS IN WATER FOR NONCARCINOGENS*

Constituent	Concentration Resulting in 10E-6 Risk Level (mg/l)
3 ACETALDEHYDE	4E+00
5 ACETONITRILE	8E-01
6 ACROLEIN	4E-02
18 BENZOTRICHLORIDE	2E-02
19 BENZYL CHLORIDE	8E-01
26 CHLOROACETALDEHYDE	9E-03
29 2-CHLOROPHENOL	6E-01
32 COPPER	1E+00
34 CYCLOHEXANE	7E+00
36 1,2 DICHLOROBENZENE	3E+00
40 1,2 DICHLOROETHENE	1E+00
44 1,3 DICHLOROPROPENE	2E-02
46 2,6 DICHLOROPHENOL	1E+00
48 DIMETHYL ALKYLAMINE	2E-01
49 2,4 DIMETHYLPHENOL	7E-02
50 1,3-DINITROBENZENE	2E-01
53 ENDOSULFAN	8E-01
59 FORMALDEHYDE	7E-02
65 HEXANE	7E+00
66 HYDROQUINONE	1E-01
70 MALEIC ANHYDRIDE	4E+01
74 METHYL CHLORIDE	9E-01
77 METHYL ISOCYANATE	2E-02
78 METHYL METHACRYLATE	1E+01
79 MOLYBDENUM	3E-03
80 NAPHTHALENE	1E+01
81 NAPHTHOQUINONE	1E-01
82 NICKEL	4E-02
84 4-NITROPHENOL	4E-01
85 PARALDEHYDE	4E+00
86 PARATHION	7E-05
91 PHORATE	3E-04
92 PHTHALIC ANHYDRIDE	4E+01
93 2-PROPANOL	1E-01
96 1,1,1,2 TETRACHLROET	5E+00
99 THALLIUM	1E-02
109 246-TRINITROTOLUENE	8E-02
112 XYLENE	2E+00
113 ZINC	3E+00
118 SODIUM	7E+01

* Used to approximate "No observed adverse effect level."

B.4 TRIGGERS FOR BASELINE SCENARIO AND REGULATORY OPTIONS

Different corrective action triggers are employed under the baseline scenario and four regulatory options analyzed in the RIA. Chapter 6 of the RIA details the four regulatory options considered in the analysis. Below we discuss the triggers used for the baseline scenario and regulatory options.

Baseline Scenario employs MCLs as well as detection limits as corrective action triggers. These values are displayed in Exhibit B-8. Prior to the establishment of HSWA, facilities were required to clean up to either background levels or MCLs. This alternative used MCLs as triggers when available. Otherwise, detection limits were used. (All MCL concentrations exceed the respective detection limits.) Implicit in the use of detection limits is an assumption that there are no background contaminant concentrations. A facility must release sufficient quantities of waste to cause contaminant concentrations in ground water to exceed detection limits and thereby trigger corrective action.

Option A (Cleanup to Background) used detection limits as corrective action triggers. A list of these detection limits are provided in Exhibit B-8. (PQLs were used when they existed.)

Options B, C, and D (Immediate Cleanup to Health-Based Standards, Deferred Cleanup to Health-Based Standards, and Exposure-Based Approach) used Agency-approved detection levels to trigger corrective action. Exhibit B-8 identifies the constituent concentrations used as corrective action triggers for these options. The Agency considered MCLs to be the controlling health-based standards. Under Options B, C, and D, these MCLs are used as corrective action triggers.

Of the remaining 100 constituents (two constituents were not modeled), 40 constituents used RSDs or RfD-based concentration levels as corrective action triggers. Specifically, corrective actions were triggered by RSDs for 14 constituents, and 26 constituents used RfDs as triggers. Some of the constituents are carcinogens as well as systemic toxicants and have associated RfDs, as well as RSDs. In those cases, we decided to use RSDs as corrective action triggers. This decision was based upon Agency policy. For carcinogenic constituents without Agency-approved levels, triggers were set at risk levels of 10^{-4} using LLM potency factors. For noncarcinogenic constituents without Agency-approved levels, triggers were set at 10^{-6} risk levels to approximate the no observed adverse effects level.[8] We assigned these concentration values as triggers for 40 constituents. Detection limits were used as corrective action triggers for 20 constituents. This resulted from the detection limit being higher than the appropriate RSD, RfD, or calculated LLM 10^{-6} or 10^{-4} risk level.

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[8] U.S. EPA Draft Report "Appendix D to EPA's Liner Location Risk and Cost Analysis Model, January 1985."

EXHIBIT B-8

BASELINE SCENARIO AND FOUR REGULATORY OPTIONS

Constituents	Baseline CA Triggers (mg/l)(1)	Baseline Source For Trigger	Option A CA Triggers (mg/l)(2)	Option A Source For Trigger	Options B,C,D CA Triggers (mg/l)(3)	Options B,C,D Source For Trigger
1 ACENAPTHENE	1E-02	PQL	1E-02	PQL	1E-02	PQL
2 ACENAPHTHYLENE	1E-02	PQL	1E-02	PQL	1E-02	PQL
3 ACETALDEHYDE	5E-03	LLM	5E-03	LLM	4E+00	NOAEL Approx. (4)
4 ACETONE	1E-01	PQL	1E-01	PQL	4E+00	RfD
5 ACETONITRILE	1E-01	PQL	1E-01	PQL	8E-01	NOAEL Approx.
6 ACROLEIN	5E-03	PQL	5E-03	PQL	4E-02	NOAEL Approx.
7 ACRYLONITRILE	5E-03	PQL	5E-03	PQL	7E-03	RSD
8 ALDICARB	5E-03	LLM	5E-03	LLM	5E-02	RfD
9 ALLYL ALCOHOL	5E-03	LLM	5E-03	LLM	2E-01	RfD
10 ANILINE	1E-02	PQL	1E-02	PQL	1E-01	RSD
11 ANTIMONY	3E-02	PQL	3E-02	PQL	3E-02	PQL
12 ARSENIC	5E-02	MCL	1E-02	PQL	5E-02	MCL
13 BARIUM	1E+00	MCL	2E-02	PQL	1E+00	MCL
14 BENZENE	5E-03	MCL	2E-03	PQL	5E-03	MCL
15 BENZO(A)ANTHRACENE	1E-02	PQL	1E-02	PQL	1E-02	PQL
16 BENZO(A)PYRENE	1E-02	PQL	1E-02	PQL	1E-02	PQL
17 BENZO(B)FLUORANTHENE	1E-02	PQL	1E-02	PQL	1E-02	PQL
18 BENZOTRICHLORIDE	5E-03	LLM	5E-03	LLM	2E-02	NOAEL Approx.
19 BENZYL CHLORIDE	5E-03	LLM	5E-03	LLM	8E-01	NOAEL Approx.
20 BIS(CHLOROMETHYL)ETHER	5E-03	LLM	5E-03	LLM	5E-03	LLM DET
21 BIS(2)ETHYLEXYL PHTHALATE	1E-02	PQL	1E-02	PQL	7E-01	RfD
22 CADMIUM	1E-02	MCL	1E-03	PQL	1E-02	MCL
23 CARBON DISULFIDE	5E-03	PQL	5E-03	PQL	4E+00	RfD
24 CARBON TETRACHLORIDE	5E-03	MCL	1E-03	PQL	5E-03	MCL
25 CHLORDANE	1E-04	PQL	1E-04	PQL	2E-03	RSD
26 CHLOROACETALDEHYDE	5E-05	LLM	5E-05	LLM	9E-03	NOAEL Approx.
27 CHLOROBENZENE	2E-03	PQL	2E-03	PQL	1E+00	RfD
28 CHLOROFORM	5E-04	PQL	5E-04	PQL	4E-02	RSD
29 2-CHLOROPHENOL	5E-03	PQL	5E-03	PQL	6E-01	NOAEL Approx.
30 CHROMIUM VI	5E-02	MCL	1E-02	PQL	5E-02	MCL
31 CHRYSENE	1E-02	PQL	1E-02	PQL	1E-02	PQL
32 COPPER	6E-02	PQL	6E-02	PQL	1E+00	NOAEL Approx.
33 CYANIDES	4E-02	PQL	4E-02	PQL	7E-01	RfD
34 CYCLOHEXANE	5E-03	LLM	5E-03	LLM	7E+00	NOAEL Approx.
35 DIBENZO (A,H) ANTHRACENE	1E-02	PQL	1E-02	PQL	1E-02	PQL
36 1,2 DICHLOROBENZENE	2E-03	PQL	2E-03	PQL	3E+00	NOAEL Approx.
37 1,4 DICHLOROBENZENE	7E-02	MCL	2E-03	PQL	7E-02	MCL
38 1,2 DICHLOROETHANE	5E-03	MCL	5E-04	PQL	5E-03	MCL
39 1,1 DICHLOROETHENE	7E-03	MCL	1E-03	PQL	7E-03	MCL
40 1,2 DICHLOROETHENE	1E-03	PQL	1E-03	PQL	1E+00	NOAEL Approx.
41 DICHLOROMETHANE	5E-03	LLM	5E-03	LLM	3E-01	RSD
42 1,2 DICHLOROPROPANE	5E-04	PQL	5E-04	PQL	9E-02	LLM 10E-4
43 DICHLOROPROPANOLS	5E-03	LLM	5E-03	LLM	9E-02	LLM 10E-4
44 1,3 DICHLOROPROPENE	5E-03	PQL	5E-03	PQL	2E-02	NOAEL Approx.
45 2,4 DICHLOROPHENOL	5E-03	PQL	5E-03	PQL	1E-01	RfD

EXHIBIT B-8 (Continued)

BASELINE SCENARIO AND FOUR REGULATORY OPTIONS

	Baseline		Option A		Options B,C,D	
Constituents	CA Triggers (mg/l)(1)	Source For Trigger	CA Triggers (mg/l)(2)	Source For Trigger	CA Triggers (mg/l)(3)	Source For Trigger
46 2,6 DICHLOROPHENOL	1E-02	PQL	1E-02	PQL	1E+00	NOAEL Approx.
47 DIMETHOATE	1E-02	PQL	1E-02	PQL	7E-01	RfD
48 DIMETHYL ALKYLAMINE	5E-03	LLM	5E-03	LLM	2E-01	NOAEL Approx.
49 2,4 DIMETHYLPHENOL	5E-03	PQL	5E-03	PQL	7E-02	NOAEL Approx.
50 1,3-DINITROBENZENE	1E-02	PQL	1E-02	PQL	2E-01	NOAEL Approx.
51 2,4 DINITROTOLUENE	2E-04	PQL	2E-04	PQL	1E-02	RSD
52 DINOSEB	1E-03	PQL	1E-03	PQL	4E-02	RfD
53 ENDOSULFAN	5E-05	PQL	5E-05	PQL	8E-01	NOAEL Approx.
54 EPICHLOROHYDRIN	5E-03	LLM	5E-03	LLM	4E-01	RSD
55 ETHYLBENZENE	2E-03	PQL	2E-03	PQL	4E+00	RfD
56 ETHYLENE OXIDE	5E-03	LLM	5E-03	LLM	1E-02	RSD
57 FLUORANTHENE	1E-02	PQL	1E-02	PQL	1E-02	PQL
58 FLUORIDES	4E+00	MCL	2E-02	LLM	4E+00	MCL
59 FORMALDEHYDE	5E-03	LLM	5E-03	LLM	7E-02	NOAEL Approx.
60 HEPTACHLOR	5E-05	PQL	5E-05	PQL	1E-03	LLM 10E-4
61 HEXACHLOROBENZENE	5E-04	PQL	5E-04	PQL	2E-03	RSD
62 HEXACHLOROBUTADIENE	5E-03	PQL	5E-03	PQL	5E-02	RSD
63 HEXACHLOROETHANE	5E-04	PQL	5E-04	PQL	3E-01	RSD
64 HEXACHLOROCYCLOPENTADIENE	5E-03	PQL	5E-03	PQL	2E-01	RfD
65 HEXANE	5E-03	LLM	5E-03	LLM	7E+00	NOAEL Approx.
66 HYDROQUINONE	5E-03	LLM	5E-03	LLM	1E-01	NOAEL Approx.
67 INDENO(123-CD)PYRENE	1E-02	PQL	1E-02	PQL	1E-02	PQL
68 LEAD	5E-02	MCL	1E-02	PQL	5E-02	MCL
69 LINDANE	4E-03	MCL	5E-06	LLM	4E-03	MCL
70 MALEIC ANHYDRIDE	5E-03	LLM	5E-03	LLM	4E+01	NOAEL Approx.
71 MERCURY	2E-03	MCL	2E-03	PQL	2E-03	MCL
72 METHANOL	5E-03	LLM	5E-03	LLM	2E+01	RfD
73 METHOMYL	5E-03	LLM	5E-03	LLM	9E-01	RfD
74 METHYL CHLORIDE	1E-03	PQL	1E-03	PQL	9E-01	NOAEL Approx.
75 METHYL ETHYL KETONE	1E-02	PQL	1E-02	PQL	2E+00	RfD
76 METHYL ISOBUTYL KETONE	5E-03	LLM	5E-03	LLM	2E+00	RfD
77 METHYL ISOCYANATE	5E-03	LLM	5E-03	LLM	2E-02	NOAEL Approx.
78 METHYL METHACRYLATE	2E-03	PQL	2E-03	PQL	1E+01	NOAEL Approx.
79 MOLYBDENUM	2E-02	LLM	2E-02	LLM	2E-02	LLM DET
80 NAPHTHALENE	1E-02	PQL	1E-02	PQL	1E+01	NOAEL Approx.
81 NAPHTHOQUINONE	1E-02	PQL	1E-02	PQL	1E-01	NOAEL Approx.
82 NICKEL	5E-02	PQL	5E-02	PQL	5E-02	LLM DET
83 NITROBENZENE	1E-02	PQL	1E-02	PQL	2E-02	RfD
84 4-NITROPHENOL	1E-02	PQL	1E-02	PQL	4E-01	NOAEL Approx.
85 PARALDEHYDE	5E-03	LLM	5E-03	LLM	4E+00	NOAEL Approx.
86 PARATHION	1E-02	PQL	1E-02	PQL	1E-02	LLM DET
87 PCB-1254	5E-02	PQL	5E-02	PQL	5E-02	PQL
88 PENTACHLORONITROBENZENE	1E-02	PQL	1E-02	PQL	1E-02	RSD
89 PENTACHLOROPHENOL	5E-03	PQL	5E-03	PQL	1E+00	RfD
90 PHENOL	1E-03	PQL	1E-03	PQL	1E+00	RfD
91 PHORATE	2E-03	PQL	2E-03	PQL	2E-03	PQL
92 PHTHALIC ANHYDRIDE	5E-03	LLM	5E-03	LLM	4E+01	NOAEL Approx.

EXHIBIT B-8 (Continued)

BASELINE SCENARIO AND FOUR REGULATORY OPTIONS

	Baseline		Option A		Options B,C,D	
Constituents	CA Triggers (mg/l)(1)	Source For Trigger	CA Triggers (mg/l)(2)	Source For Trigger	CA Triggers (mg/l)(3)	Source For Trigger
93 2-PROPANOL	5E-03	LLM	5E-03	LLM	1E-01	NOAEL Approx.
94 PYRIDINE	5E-03	PQL	5E-03	PQL	7E-02	RfD
95 TCDD	5E-06	PQL	5E-06	PQL	5E-06	PQL
96 1,1,1,2 TETRACHLROETHANE	5E-03	PQL	5E-03	PQL	5E+00	NOAEL Approx.
97 1,1,2,2 TETRACHLOROETHANE	5E-04	PQL	5E-04	PQL	2E-02	RSD
98 TETRACHLOROETHENE	5E-04	PQL	5E-04	PQL	7E-01	RfD
99 THALLIUM	1E-02	PQL	1E-02	PQL	1E-02	PQL
100 TOLUENE	2E-03	PQL	2E-03	PQL	1E+01	RfD
101 TOLUENE DIAMINE	5E-03	LLM	5E-03	LLM	1E-02	LLM 10E-4
102 TOLUENE DIISOCYANATE	5E-03	LLM	5E-03	LLM	8E-01	LLM 10E-4
103 TOXAPHENE	5E-03	MCL	2E-03	PQL	5E-03	MCL
104 1,2,4 TRICHLOROBENZENE	1E-02	PQL	1E-02	PQL	7E-01	RfD
105 1,1,1 TRICHLOROETHANE	2E-01	MCL	5E-03	PQL	2E-01	MCL
106 1,1,2-TRICHLOROETHANE	2E-04	PQL	2E-04	PQL	6E-02	RSD
107 TRICHLOROETHELYNE	5E-03	MCL	1E-03	PQL	5E-03	MCL
108 2,4,6 TRICHLOROPHENOL	5E-03	PQL	5E-03	PQL	2E-01	RSD
109 246-TRINITROTOLUENE	5E-03	LLM	5E-03	LLM	8E-02	NOAEL Approx.
110 VANADIUM	4E-02	PQL	4E-02	PQL	7E-01	RfD
111 VINYL CHLORIDE	2E-03	MCL	2E-03	PQL	2E-03	MCL
112 XYLENE	5E-03	PQL	5E-03	PQL	2E+00	NOAEL Approx.
113 ZINC	2E-02	PQL	2E-02	PQL	3E+00	NOAEL Approx.
114 ETHYLENE DIBROMIDE	5E-03	LLM	5E-03	LLM	5E-03	LLM DET
115 TETRAETHYL LEAD	5E-03	LLM	5E-03	LLM	5E-03	LLM DET
116 NITRATE	1E+01	MCL	2E-02	LLM	1E+01	MCL
117 CHLORIDE	NA	NA	NA	NA	NA	NA
118 SODIUM	5E+00	LLM	5E+00	LLM	7E+01	NOAEL Approx.
119 BERYLLIUM	5E-03	LLM	5E-03	LLM	2E-01	RfD
120 IRON	NA	NA	NA	NA	NA	NA

1 Corrective action triggers are MCLs where available. Otherwise, technical detection levels are used as trigger concentrations.

2 Corrective action triggers are Practical Quantification Limits where available. Otherwise, LLM detection limits are used as triggers.

3 The trigger concentration for each constituent is the MCL if one exists; the RSD if the constituent is a carcinogen for which no MCL has been derived; the RfD if the constituent is a noncarcinogen for which no MCL has been derived; an LLM calculated concentration resulting in a 10E-6 risk in the absence of the MCL, and RfD for noncarcinogens; and an LLM calculated concentration resulting in a 10E-4 risk in the absence of the MCL and RSD for carcinogens. If the appropriate health-based concentration is lower than the respective detection limit, the detection limit is used as the trigger.

4 No observed adverse effect level. LLM approximated based on a 10E-6 risk level.

NA These constituents were not modeled for health purposes.

Recently, the Agency revised several constituent health-based action levels and presented these new levels in the preamble to the proposed Corrective Action Rule. Their constituent action levels from the preamble were compared to the trigger levels for options B, C, and D of the RIA, and, in general, these levels were found to be consistent. The discrepancies that were found can in large part be explained by the RIA's use of detection limits when the health-based triggers are below the detection limit, and the RIA's use of a carcinogenic risk level of 10^{-4} versus the proposed rule's use of 10^{-5} or 10^{-6} risk levels. In addition, a few differences arose because some of the constituent RSDs and RfDs obtained from the April 13, 1987 EPA Memorandum from Marcia Williams, Director, Office of Solid Waste to David Wagoner, Director, Waste Management Division, Region VII have been revised. The Agency has also issued entirely new RSDs and RfDs for several constituents. These updates and additions, however, lead to a difference of more than one order of magnitude in the trigger level for three of the 120 constituents modeled: endosulfan, heptachlor and xylene.

APPENDIX C

METHODOLOGY FOR ECONOMIC IMPACT ANALYSIS

This appendix presents the methodology developed for the economic impact analysis portion of the corrective action RIA. The appendix is divided into four sections. Sections C.1, C.2, and C.3 present the preliminary analyses used in the Monte Carlo simulation. First, Section C.1 describes ICF's firm/facility/financial data base (F3DB), which provides extensive information on owners of hazardous waste treatment, storage, and disposal facilities. Next, Section C.2 outlines the methodology developed to determine the weighted average cost of capital (WACC) used in our financial analysis. Section C.3 provides a summary of the ability-to-pay analysis used in the Monte Carlo simulation. Finally, Section C.4 details the steps performed in the actual Monte Carlo model.

C.1 FIRM/FACILITY/FINANCIAL DATA BASE (F3DB)

The firm/facility/financial data base (F3DB), a computerized data system, provides easy access to financial and ownership data concerning owners of active treatment, storage, and disposal facilities (TSDFs). This system links data on active TSDFs obtained from EPA's Hazardous Waste Data Management System (HWDMS) with data on the owners of the TSDFs. The F3DB identifies TSDF owners based on data from the HWDMS that has been verified using public and private financial services. The data base also provides information, obtained from various financial sources, on the finances and ownership of firms that own TSDFs. For many firms, complete financial data were not available; we imputed financial variables for these firms.

The purpose of this section is to provide detailed documentation of the sources used to develop the firm/facility/financial data base and the methodology used to impute financial variables where data were unavailable. This section is divided into five main subsections: C.1.1 briefly describes the data base, C.1.2 presents an overview of the data sources used, C.1.3 outlines the imputations methodology, C.1.4 lists and describes the F3DB data elements, and C.1.5 discusses the limitations of the F3DB.

C.1.1 Overview

This subsection identifies the types of facility, facility ownership, firm ownership, and firm financial data contained in the F3DB. The subsection also presents a breakdown of the current ownership and financial status of the firms in the data base.

C.1.1.1 Facility Data

The firm/facility/financial data base includes the 4,958 facilities defined as active TSDFs on EPA's Hazardous Waste Data Management System

(HWDMS) in October 1986. For most of the facilities in the data base, the following data are included:

- Facility name;
- EPA facility ID number;
- Facility address;
- Facility latitude and longitude; and
- Facility process codes (i.e., storage or treatment tank; container; waste pile; landfill; land treatment; treatment, storage or disposal surface impoundment; incinerator; ocean disposal; underground injection well; other treatment).

C.1.1.2 Ownership and Financial Data

For most facility owners, the data base contains:

- The name and owner type (i.e., publicly- or privately-owned firm; federal, state, or municipal government; non-profit; bankrupt; discontinued operations) of the immediate owner;
- The name and owner type of the ultimate owner (i.e., corporate parent), if applicable. Consistent with the definition of corporate parent used for the 40 CFR Part 264 Subpart H financial assurance regulations, an ultimate owner must own 50 percent or more of the immediate owner's voting stock.[1] If a corporate parent is foreign based, we have indicated that the facility has a foreign ultimate owner but have included financial information for the top domestic corporate parent.
- Selected financial variables for the latest year that data are available:
  - -- Net income;
  - -- Net worth;
  - -- Current assets;
  - -- Current liabilities;

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[1] 40 CFR Sections 264.141(d) and 265.141(d) define parent corporation a "a corporation which directly owns 50 percent of the voting stock of the facility which is the facility owner or operator."

- -- Total assets;
- -- Total liabilities;
- -- Depreciation, depletion and amortization;
- -- Tangible net worth;
- -- Cash flow;
- -- Net working capital;
- -- Common equity, ticker symbol, and auditors opinion for publicly-held firms only;

- The date of the financial information;
- The company's fiscal year end date;
- The company's Standard Industrial Classification (SIC) Code;
- The number of TSDFs owned by each firm;
- The year in which the company was founded; and
- The number of employees.

C.1.1.3 Status of TSDFs in the Data Base

Ownership Status. The data base currently includes 4,958 facilities identified as active TSDFs on the October 1986 HWDMS, classified as follows:

- 1,928 are owned directly by publicly-held firms;
- 2,340 are owned directly by privately-held firms;
- 139 are owned directly by bankrupt firms;
- 133 are owned directly by firms with discontinued operations;
- 7 are owned directly by non-profit firms;
- 291 are owned directly by the Federal government;
- 53 are owned directly by State governments; and
- 67 are owned directly by municipalities.

For the 4,540 facilities owned by the private sector (i.e., all TSDFs excluding those owned by Federal, State, or municipal governments, or non-profit firms), we have identified 2,305 immediate owners. We have also identified 484 corporate parents or ultimate owners of immediate owners which do not directly own any active TSDFs on the data base. Approximately one-third of all immediate owners (i.e., 735 of the 2,305 firms) are subsidiaries of private sector parent companies. The ownership status of the 2,789 firms currently included on the F3DB may be broken down as follows:

- 535 firms are publicly held;
- 2,027 firms are privately held;
- 8 firms are non-profit;
- 96 firms are bankrupt; and
- 123 firms have discontinued operations.

Financial Status. The F3DB contains financial data on 2,222 of the 2,562 solvent public or privately held firms. Financial information is not included on the data base for 227 firms which have been identified as either bankrupt, discontinued operations, or non-profit, as well as an additional 340 firms for which we have not obtained financial data. Of these 340 firms, 27 are publicly held and 313 are privately held.[2]

C.1.2 Data Sources

This subsection describes the various data sources used to compile the F3DB. The ownership and financial data gathered from these sources have been entered directly into the data base. Where the required data were missing from these sources, the available data have been used to assist in the imputation of missing values.

C.1.2.1 Ownership Characteristics

Ownership information, obtained from HWDMS for each of the TSDFs, has been checked and verified using Standard & Poor's Compustat financial services, Business Information Reports (BIRs) from Dun & Bradstreet, the Directory of Corporate Affiliations, the Wall Street Journal, Mergers and Acquisitions, Corporate Action, and other financial newspapers and magazines. Ownership information not available on HWDMS has been researched and collected. For example, for facilities whose immediate owners are subsidiaries of other firms, ownership information has been provided on their direct corporate parents and, if the parents are also subsidiaries, ownership information has been provided for the highest domestic-based corporate entities associated with the immediate subsidiary owners.

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[2] Dun & Bradstreet is unable to provide financial data on 123 privately held firms. For the remaining privately held firms, we are currently imputing financial data where firm-specific data are not included in the BIRs.

C.1.2.2 Financial Characteristics

We obtained financial data for all publicly-held firms from Compustat Data were based on fiscal year-end financial statements filed with the SEC Financial information for privately-held firms was obtained from BIRs where available. Where data were not available, we have imputed financial variables. BIRs do not supply a figure for "depreciation, depletion and amortization"; therefore, this figure has been imputed in all instances for facilities owned by private firms.

C.1.2.3 Data Sources Used for Imputations

Where financial variables were not available from the BIRs, the information for private firms has been imputed using three sources: Dun & Bradstreet Industry Norms (D&B Norms), Robert Morris Associates Annual Statement Studies (RMA), and Ward's Directory of 49,000 Private U.S. Companies (Ward's). Each of these sources is briefly described below:

- Robert Morris Associates Annual Statement Studies (RMA) is published by Robert Morris Associates, a national association of bank loan and credit officers. It contains composite financial data for manufacturing, wholesaling, retailing, services, and contracting industries. RMA collects a large sample of firms' financial statements for various SIC codes. The data are averaged and grouped into four asset-size categories ($0-1 million, $1-10 million, $10-50 million, and $50-100 million). Not all SIC codes are represented in RMA.

- Dun & Bradstreet Industry Norms (D&B Norms) have been used to supplement RMA when the appropriate SIC code was not available. Like RMA, D&B Norms consist of industry averages presented by SIC code by asset size. However, D&B Norms contains fewer size categories than RMA.

- Ward's Directory of 49,000 Private U.S. Companies (Ward's) includes sales information for a large group of small privately-held companies of approximately $1-10 million in annual sales in 21 manufacturing and 37 non-manufacturing SIC industry categories. Sales information for parent companies of subsidiaries, divisions, groups, joint ventures and affiliates are provided, regardless of size. The directory provides data on the latest sales figures, address and phone number of the firm, name of the chief executive officer, and number of employees by sales size within their respective SIC codes. Aggregate data on total assets and total number of employees are provided by SIC code. Ward's generally does not supply information on small firms with fewer than 100 employees.

C.1.3 Imputations Methodology

Where complete financial data were not available for private firms, we have imputed financial variables using industry-average data from RMA and D&B Norms. This subsection first discusses our approach for imputing financial variables and then presents the formulae used for most imputations.

C.1.3.1 Approach

Our overall objective in imputing financial values was to derive a value as close to the actual firm's financial conditions as possible within the data constraints. Therefore, we have derived missing variables from the application of accounting and mathematical identities to the available firm-specific data wherever possible. The following are some of the accounting and mathematical identities included on balance sheets that have been used to impute missing financial variables:

1. Total Assets = Total Liabilities + Net Worth;

2. Total Assets = Current Assets + Fixed Assets + Other Assets;

3. Total Liabilities = Current Liabilities + Long Term Liabilities; and

4. Net Worth = Capital Stock + Paid-In Capital + Retained Earnings.

For example, using identities 1 and 3 above, we have derived total assets as the sum of current liabilities, long term liabilities, and net worth, if all three financial variables were known. As will be discussed next, these accounting identities were also used in our imputations formulae.

For variables that could not be derived from accounting or mathematical identities due to limited firm-specific data, we have imputed values by applying industry-average ratios of financial variables to the data that were available. In order to impute values that reflect as closely as possible the firm's actual financial conditions, we have used industry-average data from RMA or D&B Norms that corresponded to the industry SIC code where the firm had a large percentage of its business (i.e., the primary or secondary SIC code), and to the firm's asset size. The firm-specific SIC codes were available from the BIR. If it was not possible to determine the appropriate asset size category, we have used average data for all asset sizes for the SIC code that corresponded to the one in which the company had a large percentage of its business.

Exhibit C-1 illustrates a sample page of industry-average data from RMA for firms with $1-10 million in assets in SIC #8541 (machine tools and metal working equipment). As shown in the exhibit, for this group of firms, total current assets are 62.4 percent of total assets. Therefore, where firm-specific data for total assets were available for a firm in SIC #8541 with $1-10 million in assets, we were able to impute current assets using RMA industry-average ratios.

Finally, for firms for which no firm-specific data were available, we have imputed financial variables from the industry-average sales figure for that company's largest business sector.

C.1.3.2 Imputations Formulae

The following presents seven cases in which formulae have been used to impute financial variables in the firm/facility/financial data base. The formula used for a particular imputation depends on the amount of firm-specific financial data that was available from the BIRs. The seven cases are presented by decreasing availability of financial data. For example, in Case I, all but one of the financial variables are available from the BIR; Case VII describes the steps we have used to impute data when no firm-specific financial information is available from the BIR. The seven cases are described below.[3]

Case I -- The BIR provided all of the financial data -- i.e., net income, net worth, current assets, current liabilities, total assets, and total liabilities -- except for depreciation, depletion, and amortization (DD&A). DD&A has been imputed by multiplying the company's sales figure by the ratio of DD&A to sales (see (7) in Exhibit C-1 for an example of this ratio). BIRs never include DD&A figures. Therefore, this imputation method has been used for all imputations in addition to any others that were required.

Case II -- Either (a) the BIR contained all of the financial information except total assets, or (b) the BIR contained all financial data except net income, but included two years of complete data for all other variables including net worth. In the first case, total assets have been derived by adding current assets, fixed assets, and other assets. In the second case, the company's net income has been derived by subtracting the net worth of the previous year from the current year's net worth. This method has been used only where data from the BIR suggested that a change in retained earnings was the primary cause for a change in net worth. We have also examined trends of the firm and other firm-specific data for this imputation.

Case III -- The BIR contained the following financial data: current assets, current liabilities, fixed assets, other assets, and net worth. Net

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[3] The following cases assume that the imputations are based on industry-average data from RMA. The formulae used for imputing with D&B Norms are slightly different.

EXHIBIT C-1

SAMPLE DATA FROM RMA FOR SIC CODE #8541 (42, 45) MACHINE TOOLS AND METAL WORKING EQUIPMENT*

1-10 Million Asset Size Column	Pct.	Ratios	
Assets:			
Cash	8.2		
Accounts Receivable	23.4	Percent Profit Before Taxes/ Tangible Net Worth (5)	7.9
Inventory	28.4		
Other Current	2.5		
Total Current (1)	62.4		
Fixed Assets	29.7	Sales/Total Assets (6)	1.5
Intangibles	1.0		
Other Non-Current	6.9		
Total Assets	100.0		
Liabilities:		Percent Depr., Depl., Amort./Sales (7)	3.4
Notes Payable	8.7		
Cur. Mat L/T/D	3.7		
Accounts Payable	11.7		
Accrued Expenses	7.2		
Other Current	5.2		
Total Current (2)	36.5		
Long Term Debt	15.7		
Other Non-Current	1.8		
Net Worth/(Tot. Liab. + N.W.)(3)	46.1		
Total Liabilities and Net Worth	100.0		
Income Data:			
Net Sales	100.0		
Cost of Sales	72.7		
Gross Profit	27.3		
Operating Expenses	26.5		
Operating Profit	0.8		
Other Expenses	1.2		
Profit Before Taxes (4)	-0.4		

* Numbers in parentheses refer to text.

worth has been used to impute net income and the other missing financial variables. Net income has been imputed by multiplying net worth by the ratio of profit before taxes to tangible net worth (see (5) on Exhibit C-1). The product is equal to imputed profit before taxes. We have applied a 46 percent tax rate to derive after-tax profit -- i.e., net income. We have derived total assets by adding fixed assets, current assets and other assets from the BIR. Where fixed assets, current assets, and other assets were not available, we have imputed total assets by dividing current assets by the ratio of current assets to total assets (see (1) on Exhibit C-1). Where current assets were not available, total assets have been imputed from net worth by dividing net worth by the ratio of net worth to total liabilities plus net worth (see (3) on Exhibit C-1). Where current assets were not available, current assets have been imputed by multiplying imputed or derived total assets by the ratio of current assets to total assets (see (1) on Exhibit C-1).

Current liabilities have been imputed using the following formula:[4]

$$\text{Current Liabilities} = \text{Total Liabilities} \times \frac{[\text{Current Liabilities}/(\text{Total Liabilities} + \text{Net Worth})]}{1 - [\text{Net Worth}/(\text{Total Liabilities} + \text{Net Worth})]}$$

Ratios enclosed in brackets have been taken directly from RMA (see (2) and (3) on Exhibit C-1).

Case IV -- The BIR included only sales data. In this case, sales data have been used to impute missing financial variables. To impute net income, sales has been multiplied by the percentage ratio of profit before taxes to sales (see (4) on Exhibit C-1). The result is imputed profit before taxes. To adjust to an after-tax basis, we have applied a 46 percent tax rate to derive imputed net income.

Net worth has been derived from imputed net income. First, the percentage ratio of profit before taxes to tangible net worth (see (5) on Exhibit C-1) was multiplied by 54 percent to adjust to an after-tax basis. Imputed net income was then divided by this ratio to produce imputed net worth.

Because current assets and net worth were not available, total assets have been imputed by dividing sales by the ratio of sales to total assets (see (6) on Exhibit C-1). Total liabilities have been derived by subtracting imputed net worth from imputed total assets. Current assets, current liabilities, and DD&A have been imputed in the same manner as in Case III.

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[4] $$CL = TL \times \frac{(CL(TL+NW))}{1 - \frac{NW}{(TL+NW)}} = \frac{TL \times (CL/TA)}{\frac{TA}{TA} - \frac{NW}{TA}} = TL \times \frac{CL/TA}{TL/TA} = TL \times \frac{CL}{TL} = CL$$

Case V -- The BIR contained at least three months of interim data and the fiscal year end date was known. Interim balance sheet variables have been incorporated into the data base directly from the BIR without modification Balance sheet variables (i.e., net worth, total assets, total liabilities, current assets, and current liabilities) report the financial position of a company at a particular point in time; therefore, their validity is the same whether the data pertain to an interim period or the fiscal year end. Annual sales, net income, and DD&A figures have been extrapolated to the fiscal year and based on the interim figure. Where sales, net income or DD&A were not available from the BIR, they have been imputed using the same methods described in Cases III and IV.

Case VI -- The BIR contained no firm-specific financial information but provided the number of employees and SIC code. Financial variables have been imputed from the firm's sales figure if it was available from Ward's. If sales data were not available from Ward's, the average value of sales per employee figure for the applicable SIC code included in Ward's has been used. This figure has been multiplied by the number of employees to obtain an estimate of sales for that company. For the remainder of the variables, the approach described in Case IV has been used.

Case VII -- The BIR reports only the company's SIC code. In these cases, a sales figure has been assigned by obtaining the average sales figure for that SIC code from RMA. Average sales has been obtained by dividing net sales for all companies by the number of firms within the SIC code. This produces an industry average sales per firm figure, which has been used to impute the other variables as described in Case IV.

C.1.4 Data Elements

This subsection lists and describes the elements of the F3DB as found on a display or printout of the database.

C.1.4.1 TSDF Ownership and Financial Data on the Firm/Facility/Financial Data Base

The following data elements are included on the firm/facility/financial data base:

- TICK is the ticker symbol for the owner firm. Tickers for publicly-held firms are provided by Securities & Exchange Commission filing lists. Tickers for privately held firms are assigned sequentially.

- SEQNO is the sequence number of the ticker symbol for the immediate owner firm, used to identify multiple subsidiaries of a parent firm. Each subsidiary of a firm will have a unique SEQNO; the TICK for the subsidiary will be that of the parent. A SEQNO with a zero value indicates a firm with no corporate parent. Such a firm may or may not have subsidiary firms.

- INTERSEQ is the sequence number of the ticker symbol for the direct parent of the immediate owner.

- IMMEDNAM is the immediate owner name. An immediate owner name accompanied by a blank ultimate owner name identifies a firm that has no corporate parent.

- INTERNAM is the direct parent owner name. A facility with a parent is always accompanied by an immediate owner and an ultimate owner name. The ultimate owner is the highest domestic-based corporate entity associated with the immediate and the parent owners. Tickers and sequence numbers are derived from the ultimate owner.

- ULTNAM is the ultimate owner name. If there is no direct parent between an immediate owner and an ultimate owner, then the ultimate owner is the direct parent of the immediate owner. An ultimate owner can own facilities directly (i.e., in some cases it will be an immediate owner), or indirectly through its subsidiaries.

- OWNTYP is the owner type of the firm (1 = Federal, 2 = State, 3 = municipal, 4 = public firm, 5 = private firm, 6 = nonprofit firm, 7 = bankrupt firm, 8 = discontinued operations).

- JOINTOWN flags subsidiaries with joint owners (i.e., two parents that each own 50 percent of the subsidiary). If a subsidiary has joint owners, then JOINTOWN = "Y".

- FCID is EPA's 12-digit facility identification number. The first two digits are the abbreviation for the State in which the facility is located.

- FOROWN flags firms which have foreign parents. If a firm has a foreign parent, then FOROWN = "Y".

- FORNAM is the name of the foreign owner identified by the FOROWN flag. Financial data for foreign owners are not included.

- FACNAM is the name of the facility associated with a specific FCID.

- FIRMDATE is the year the firm came into existence. (Available for private firms only.) A missing value is represented by a zero.

- LOWFAC is the number of facilities owned immediately by a firm.

- INFODATE is the date of the financial data. A missing value is represented by a zero.

- FYREND is the month ending the fiscal year for the firm. A missing value is represented by a zero.

- EMPLOYE is the number of employees at the firm. (Available for private firms only.) A missing value is represented by a <u>negative</u> zero.

- SIC identifies the firm's primary Standard Industrial Classification Code taken directly from the <u>BIR</u> or from Compustat.

- NETWRT is the net worth value. Net worth is often referred to as stockholders' equity or owners' equity, and represents the sum of paid-in capital, or the stated value of the capital, including both common and preferred stock, retained earnings, and appropriated surplus. A missing value is represented by a <u>negative</u> zero.

- NWFOOT is the footnote indicating method of imputation for the net worth value, if the net worth value has been imputed. If net worth has not been imputed, NWFOOT is blank.

- TOTASS is the total assets of the firm, representing total liabilities plus net worth. A missing value is represented by a <u>negative</u> zero.

- TAFOOT is the footnote indicating method of imputation for total assets, if total assets have been imputed. Otherwise, TAFOOT is blank.

- TOTLIB is the total liabilities of the firm. TOTLIB is set equal to TOTASS minus NETWRT.

- CURASS is the current assets of the firm. Current assets include those tangible assets that can be readily turned into money (e.g., cash on hand). A missing value is represented by a <u>negative</u> zero.

- CAFOOT is the footnote indicating method of imputation for the current assets value, if current assets have been imputed. Otherwise, CAFOOT is blank.

- CURLIB is the current liabilities of the firm. Current liabilities are short-term liabilities to be paid within one year or less, such as salaries, taxes due, accrued interest, or accounts payable.

- CLFOOT is the footnote indicating method of imputation for the current liabilities value, if current liabilities have been imputed.

- NETINC is the net income value for the firm. Net income, also referred to as net earnings, represents the difference between total sales and total costs of goods sold plus expenses over a given period. A missing value is represented by a <u>negative</u> zero.

- NIFOOT is the footnote indicating method of imputation for the net income value, if net income has been imputed. Otherwise, NIFOOT is blank.

- DDANDA is the depreciation, depletion, and amortization value for the firm. Depreciation reflects the decline in the value of a physical ass resulting from normal usage and wear; depletion refers to the allowance made for the shrinkage or exhaustion of a product, nearly always a natural resource; amortization of assets is a method of gradually reducing the book value of a fixed asset by spreading its depreciation over a period of time, and amortization of debt refers to gradually retiring an obligation by making regular payments of both principal and interest over a period of time. A missing value is represented by a negative zero

- DDFOOT is the footnote indicating method of imputation for the depreciation, depletion and amortization, if DDANDA has been imputed. Otherwise DDFOOT is blank.

- TANNWRT is the tangible net worth value for the firm. If tangible net worth is missing, then it is set equal to net worth.

- CSHFLOW is the cash flow value for the firm. Cash flow, or a firm's net profits plus allowance for depreciation, is set equal to DDANDA plus NETINC.

- NWCAP is the net working capital value for the firm. Net working capital is set equal to CURASS minus CURLIB.

- TOTDBT is the total debt value of the firm. (Available only for public firms.) A missing value is represented by a negative zero.

- COMEQTY is the common equity value for the firm. (Available only for public firms.) A missing value is represented by a negative zero.

- USAASS represents assets in the U.S. for the firm. (Available only for public firms.) A missing value is represented by a negative zero.

- OPNION is the auditor's opinion of the firm. (Available only for public firms.) A missing value is represented by a negative zero.

C.1.4.2 Other Data Items On The Firm/Facility/Financial Data Base

The following data elements are also included on the firm/facility/financial data base:

Locational data items:

- Facility Street
- Facility City
- Facility Zip Code
- Facility County Code
- Facility Owner Street Address

- Facility Owner City
- Facility Owner State
- Facility Owner Zip Code
- Facility Operator Name
- Facility Operator Street Address
- Facility Operator City
- Facility Operator State
- Facility Operator Zip Code
- Owner/Operator Zip Code

Permit status date items:

- RCRA Permit Application or Permit Status
- Part B Flag
- Loss of Interim Status Flag

Process code data items:

- Permit/Closure Process Indicator
- Permit/Closure Process Code
- Interim Status Capacity Process Code

C.1.5 F3DB Limitations

The major limitation of the F3DB is that the data base has complete financial information on owners or operators of only 3,945 facilities, whereas the total number of facilities is currently estimated to be 5,661. This limitation arises for several reasons:

- The F3DB does not contain information on about 700 facilities. These facilities were not considered active facilities subject to RCRA at the time of the last F3DB update; in the intervening months, EPA has added this group of facilities to its list of regulated facilities as tracked by HWDMS. The F3DB has yet to reflect this change.

- Although government-owned facilities are not excluded from the corrective action rulemaking, financial information on government owners or operators is not available from the F3DB. The standard measures of ability to pay for firms are generally inapplicable to government financial information; for example, a government does not earn net income, making a cash flow figure based on net income impossible to calculate. The impact of the regulation on municipalities is, however, discussed in general terms in the Regulatory Flexibility Analysis presented in Chapter 11.

- Of the 4,540 facilities in the F3DB owned by private sector firms, the owners or operators of only 3,945 facilities are actually examined. As discussed earlier, 272 of these facilities are owned by bankrupt firms or are discontinued operations of solvent firms; thus, there is no current financial information available on the owners or operators of these facilities. The other 323 facilities are excluded mainly because recent changes in facility ownership have made existing financial information obsolete. These facilities are owned or operated by a diverse array of firms, including small firms with multiple name changes that HWDMS has been unable to track, as well as very large firms that have become privately owned through buyouts and do not publicly disclose financial details. Therefore, it is not expected that the group of firms excluded have any particularly unusual financial characteristics.

Another limitation is that some or all of the financial information for a portion of the firms examined was not available from data sources that were consulted; rather, financial information for some privately-held firms were imputed from industry average data according to SIC code and firm size.[5] These imputations represent the best available estimate of financial data for these firms, but the actual data may vary from the imputed data.

Finally, although the F3DB contains only one year of financial data, a firm's performance may vary from year to year. Predicting the future impacts of corrective action costs based on one year of data may affect the accuracy of our results.

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[5] Imputations were done for at least one variable for about 79 percent of firms owning facilities in the data base.

C.2 METHODOLOGY FOR CALCULATING WEIGHTED AVERAGE COST OF CAPITAL

This section presents our methodology for estimating the weighted average cost of capital (WACC) used in our analyses. The first part, subsection C.2.1, describes the procedure we used to estimate the WAAC for the total economic impact analysis. The second part, subsection C.2.2, provides a summary of the methodology used to determine the WAAC for the assessment of small business impacts in the regulatory flexibility analysis.

C.2.1 Weighted Average Cost of Capital -- Total Analysis

This analysis uses a two-step procedure to determine the discount rate, or real cost of capital, for obtaining present value amounts for corrective action costs. The first step is to derive the nominal cost of capital for 20 industries representing a substantial percentage of firms in the F3DB using the standard weighted average cost of capital (WACC) formula. The second step is to derive a real cost of capital by dividing the estimated nominal cost of capital by the expected inflation rate.

The 20 industries used to determine a weighted average cost of capital were chosen based on their relative importance in the F3DB; they represent over 50 percent of the facilities in the data base. These industries were identified by their three-digit SIC codes. Firms in over 100 other industries own the rest of the facilities; these industries were excluded to simplify the analysis.

The WACC has been used to estimate the cost of capital for many years.[6] As typically derived at the firm level:

$$WACC = \frac{V_D}{V_E + V_D} K_D (1-t) + \frac{V_E}{V_E + V_D} K_E$$

where:

V_D = Value of long-term debt in the firm's capital structure;

V_E = Value of equity (or net worth) in the firm's capital structure;

K_D = Expected cost of debt (this is the same as the bondholders' expected rate of return);

t = Corporate income tax rate (assumed to equal 34 percent -- the maximum federal income tax rate for corporations); and

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[6] See Richard Brealey, Stewart Myers, Principles of Corporate Finance (New York: McGraw-Hill, Inc., 1981) pp. 411-415.

K_E - Expected cost of equity (the same as the shareholders expected rate of return).

While cost of capital calculations are typically made at the firm level, this analysis is conducted at the industry level. An industry cost of capital is merely the aggregation of its component firms' cost of capital. The estimated industry cost of capital is derived here by finding each variable in the WACC equation for each firm in an industry and averaging each variable for input into the equation.

Firm-specific data for the firms within each industry are drawn primarily from the F3DB and from the Value Line Investment Survey.[7] Information from the F3DB is used to calculate the debt and equity weights in the industry capital structure. For each firm in the F3DB in the SIC codes examined, the debt and equity weights, or $[V_D/(V_D + V_E)]$ and $[V_E/(V_E + V_D)]$, are weighted by that firm's proportion of total assets in the group of F3DB firms; these weighted debt and equity weights for the component firms are then added to obtain the industry debt and equity weights, presented in Exhibit C-2.

These debt and equity weights from data in the F3DB are in book value terms rather than market values, which financial theorists suggest using. However, financial managers, lenders, and credit rating agencies typically characterize a firm's capital structure in terms of book value weights, it is believed that the use of book values has little impact on the results.[8]

Having estimated the relative weights for debt and equity, we next estimated the cost of equity using the capital asset pricing model (CAPM).[9] As typically derived at the firm level:

$$KE = Rf + ß\ (Rm - Rf)$$

where:

K_E - Expected cost of equity;

R_f - Expected risk-free rate of return;

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[7] Value Line, Inc., The Value Line Investment Survey (New York: Value Line, Inc., 1987).

[8] J.K. Butters, W.E. Fruhan, Jr., D.W. Mullins, T.R. Piper, Case Problems in Finance, (Illinois: Richard D. Irwin, Inc., 1981), pp. 106.

[9] Brealy and Myers, p. 131.

EXHIBIT C-2

INDUSTRY DEBT AND EQUITY WEIGHTS

3-digit SIC	Industry Name	VE/(VE+VD)	VD/(VD+VE)
249	Miscellaneous Wood Products	0.536	0.464
281	Industrial Organic Chemicals	0.448	0.552
282	Plastics Materials and Synthetic Resins, Synthetic Rubber, Synthetic and Other Man-made Floors, Except Glass	0.373	0.627
283	Drugs	0.576	0.424
284	Soap, Detergents, and Cleaning Preparations, Perfumes, Cosmetics, and Other Toilet Preparations	0.436	0.564
285	Paints, Varnishes, Lacquers, Enamels, and Allied Products	0.460	0.540
286	Industrial Organic Chemicals	0.519	0.481
287	Agricultural Chemicals	0.464	0.536
289	Miscellaneous Chemical Products	0.513	0.487
291	Petroleum Refining	0.390	0.610
307	Miscellaneous Plastics Products	0.402	0.598
331	Blast Furnaces, Steel Units, and Rolling and Finishing Mills	0.309	0.691
347	Coating, Engraving, and Allied Services	0.446	0.554
349	Miscellaneous Fabricated Metal Products	0.476	0.524
367	Electronic Components and Accessories	0.487	0.513
371	Motor Vehicles and Motor Vehicle Equipment	0.425	0.575
372	Aircraft and Parts	0.426	0.574
495	Sanitary Services	0.514	0.486
516	Wholesale Trade Chemicals and Allied Products	0.313	0.687
739	Miscellaneous Business Services	0.421	0.579

Source: F3DB

β - A measure of the volatility of the expected return on the firm's stock relative to the market's volatility; and

R_m - Expected return on the market portfolio.

We are interested in aggregating an industry's cost of equity rather than determining that of an individual firm in the industry. Therefore, we developed an estimate of an industry's beta by aggregating over all component firms in an industry. Betas for firms listed in the F3DB were obtained from Value Line.

Betas are only meaningful and available for firms whose stock is publicly traded. Further, betas are not readily available for all publicly traded firms. For most industries, therefore, only a very small number of betas could be obtained for firms in the F3DB. If these betas were used to calculate industry averages, the results would be subject to substantial error due to the small sample size.

To alleviate this problem, SIC code-defined industries were matched to industry groupings in Value Line. The firms in Value Line industries that were close to the SIC industries were used for obtaining betas for the industries. The SIC code industries are matched with Value Line industries in Exhibit C-3. Value Line has many more betas for each industry grouping than were available for F3DB firms, therefore, the average betas should be more reliable indicators of the true average among the F3DB firms.

The betas for each firm in the Value Line groupings had to be adjusted before using them in the weighted average cost of capital formula. Because each firm is financed with a combination of debt and equity, a stock's beta in Value Line measures both the financial risk of the firm (the risk of having to meet interest payments on debt) and the business risk of the firm (the risk that the business will generate a satisfactory rate of return). However, the debt/equity structure of the Value Line firms may be very different from the debt/equity structure of the F3DB firms for which we are estimating a cost of capital. When averaging betas for Value Line firms to estimate an expected rate of return, the main concern is the business risk of the industry; the financing risk depends on the level of debt firms decide to use and is unrelated to the business risk. Therefore, we adjust the Value Line betas for financial risk, then readjust according to the average financial risk of the F3DB firms.

EXHIBIT C-3

SIC CODE/VALUE LINE INDUSTRY COMPARISON

3-digit SIC	SIC Industry Name	Value Line Industry Name
249	Miscellaneous Wood Products	Furniture/ Home Furnishing
281	Industrial Organic Chemicals	Chemicals * (specialty)
282	Plastics Materials and Synthetic Resins, Synthetic Rubber, Synthetic and Other Man-made Floors, Except Glass	Chemicals * (specialty)
283	Drugs	Drugs
284	Soap, Detergents, and Cleaning Preparations, Perfumes, Cosmetics, and Other Toilet Preparations	Household Products
285	Paints, Varnishes, Lacquers, Enamels, and Allied Products	Chemicals * (specialty)
286	Industrial Organic Chemicals	Chemicals (diversified)
287	Agricultural Chemicals	Chemicals (basic)
289	Miscellaneous Chemical Products	Chemicals * (specialty)
291	Petroleum Refining	Petroleum (Integrated)
307	Miscellaneous Plastics Products	Furniture/Home Furnishings
331	Blast Furnaces, Steel Units, and Rolling and Finishing Mills	Steel (integrated)
347	Coating, Engraving, and Allied Services	Metal Fabricating
349	Miscellaneous Fabricated Metal Products	Metal Fabricating
367	Electronic Components and Accessories	Electronics
371	Motor Vehicles and Motor Vehicle Equipment	Auto & Trucks; Auto Parts
372	Aircraft and Parts	Aerospace and Defense (selected)
495	Sanitary Services	Ind. Servcs.
516	Wholesale Trade Chemicals and Allied Products	Chemicals (diversified)
739	Miscellaneous Business Services	Industrial Services

* Firms within the Chemicals-Specialty Value Line grouping were selected according to relevant SIC codes.

To adjust betas for business risk (by "removing" financial risk), each beta must be multiplied by the ratio of [VE/(VE + VD)].[10] The betas are then averaged for each industry. The average betas for business risk of a given industry must then be readjusted for the average debt/equity mix of all of the F3DB industries, thus adjusting the average beta for the average debt/equity mix in any given industry.

We used each industry beta together with the expected excess return on the market (R_m - R_f) to determine the total industry risk premium. In other words, the industry premium is measured as the degree to which the overall market return exceeds the risk-free return, adjusted for the risk of the industry. The long-term (1926-1976) average excess return on the market of 8.8 percent as measured by Ibbotson and Sinquefield is an estimate of this expected excess return.[11] By use of this value, we assumed that the excess return is fairly constant over time.

We estimated the expected risk-free rate using a government bond rate. U.S. Treasury debt is considered to be the most risk-free investment available on the market. An examination of the Wall Street Journal revealed that long-term government bonds currently provide a yield of about 8.5%.[12]

The last rate needed to calculate the WACC is the expected return on debt. We used a typical return on a long-term medium grade industrial bond. An analysis of rates of industrial bonds rated BB by Standard and Poor's suggests this rate is now approximately 11 percent.[13]

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[10] The beta for a firm is a weighted average of the debt and equity betas: ß firm = ß debt * $[V_D/(V_D + V_E)]$ + ß equity * $[V_E/(V_E + V_D)]$. The beta for debt, however, is usually assumed to be zero (the returns are guaranteed barring bankruptcy). Therefore, the equation narrows to ß firm = ß equity * $[V_E/(V_E + V_D)]$. The beta from Value Line is the beta of the stock, or ß equity. The beta of the firm, or the beta that reveals the risk of the business, is therefore equal to the beta of equity from Value Line multiplied by the proportion of equity in the value of the firm. See Brealy and Myers, p. 175.

[11] R.G. Ibbotson, R.A. Sinquefield, Stocks, Bonds, Bills, and Inflation: Historical Returns (1926-1978), (Virginia: Financial Analysis Research Foundation, 1979), p. 23.

[12] This is the average of five 30-year Treasury bonds as found in the Wall Street Journal, June 22, 1987.

[13] From Standard and Poor's Monthly Bond Book, June, 1987.

The final step in estimating a real cost of capital is dividing the above derived nominal cost of capital by an expected inflation rate.[14] Value Line forecasts an average 4 percent annual inflation rate, as measured by the GNP deflator, over the next three to five years.[15] Correspondingly, a 3.5-4.0 percent inflation rate is forecast by the 1987 Economic Report of the President.[16] Thus, we used an inflation rate of 4 percent for this analysis.

Exhibit C-4 presents estimates of the current real cost of capital for the 20 selected industries. As shown in the exhibit, the average real cost of capital among all of these industries is 9.49 percent. This is the discount rate assumed to be used by the universe of firms in analyzing corrective action costs.

C.2.2 Weighted Average Cost of Capital -- Regulatory Flexibility Analysis

(1) Methodology for calculating weighted average costs of capital

The regulatory flexibility analysis uses the same two-step procedure as in Section C.2.1 to determine the cost of capital for discounting corrective action costs. First, we derive a nominal cost of capital using the standard weighted average cost of capital formula; second, we derive a real cost of capital by adjusting the nominal rate by the expected rate of inflation.

The weighted average costs of capital derived separately for small and large firms are different from the rate derived for all firms in the economic impact analysis. Small and large firms may have different discount rates because the financial risks of the firms may be different; specifically, small firms may have a higher percentage of debt than large firms because investors perceive more risk of bankruptcy and, therefore, may be less willing to invest equity capital in small firms. This difference is reflected in the calculation of the weighted average cost of capital for small and large firms. Exhibits C-5 and C-6 show the difference in these calculations.

As in Section C.2.1, the weighted average cost of capital was calculated using the standard formula by averaging data from key industries. To develop the costs of capital as shown in the Exhibits C-5 and C-6, we established the 10 most prevalent SIC codes for the large and small groups, and calculated debt to equity ratios weighted by asset size for industry. Note that the industries used for small firms were all represented in the calculation of

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[14] The equation is:

$$\frac{[1 + (\text{Nominal cost of capital}/100)]}{[1 + (\text{Expected Inflation Rate}/100]}$$

[15] Value Line, March 6, 1987, p. 1.

[16] Council of Economic Advisors, Economic Report of the President, (Washington, D.C.: U.S. GPO, 1987), p. 58.

EXHIBIT C-4

WEIGHTED AVERAGE COST OF CAPITAL

WACC = [Vd/(Vd+Ve)]Kd(1-t) + [Ve/(Vd+Ve)]Ke

Ke = Rf + B(Rm - Rf) Rf=8.5% Rm-Rf=8.8% Kd=11% t=34% Inflation=4.0%

SIC CODE	Ve/(Vd+Ve)	Vd/(Ve+Vd)	INDUSTRY AVG BETA (VALUE LINE)	INDUSTRY AVG BETA ADJ FOR DEBT	B(Rm-Rf)	Ke = Rf+B(Rm-Rf)	Kd(1-t)	NOMINAL WACC	REAL WACC
249	0.536	0.464	0.79	1.47	12.936	21.436	7.26	14.858	10.441
281	0.448	0.552	0.73	1.63	14.344	22.844	7.26	14.242	9.848
282	0.373	0.627	0.73	1.96	17.248	25.748	7.26	14.156	9.765
283	0.576	0.424	0.85	1.48	13.024	21.524	7.26	15.476	11.035
284	0.436	0.564	0.63	1.44	12.672	21.172	7.26	13.326	8.967
285	0.460	0.540	0.58	1.26	11.088	19.588	7.26	12.931	8.587
286	0.519	0.481	0.71	1.37	12.056	20.556	7.26	14.161	9.770
287	0.464	0.536	0.72	1.55	13.640	22.140	7.26	14.164	9.773
289	0.513	0.487	0.73	1.42	12.496	20.996	7.26	14.307	9.910
291	0.390	0.610	0.56	1.44	12.672	21.172	7.26	12.686	8.352
307	0.402	0.598	0.63	1.57	13.816	22.316	7.26	13.313	8.954
331	0.309	0.691	0.38	1.23	10.824	19.324	7.26	10.988	6.719
347	0.446	0.554	0.59	1.32	11.616	20.116	7.26	12.994	8.648
349	0.476	0.524	0.59	1.24	10.912	19.412	7.26	13.044	8.696
367	0.487	0.513	0.86	1.77	15.576	24.076	7.26	15.449	11.009
371	0.425	0.575	0.69	1.62	14.256	22.756	7.26	13.846	9.467
372	0.426	0.574	0.78	1.83	16.104	24.604	7.26	14.649	10.239
495	0.514	0.486	0.76	1.48	13.024	21.524	7.26	14.592	10.184
516	0.313	0.687	0.71	2.27	19.976	28.476	7.26	13.901	9.520
739	0.421	0.579	0.76	1.81	15.928	24.428	7.26	14.488	10.084
WEIGHTED AVERAGE BY NUMBER OF FIRMS IN SIC CODE								13.873	9.493

EXHIBIT C-5

WEIGHTED AVERAGE COST OF CAPITAL FOR SMALL FIRMS

WACC = [Vd/(Vd+Ve)]Kd(1-t) + [Ve/(Vd+Ve)]Ke

Ke = Rf + B(Rm - Rf) Rf=8.5% Rm-Rf=8.8% Kd=12% t=34% Inflation=4.0%

SIC CODE	Ve/(Vd+Ve)	Vd/(Ve+Vd)	INDUSTRY AVG BETA (VALUE LINE)	INDUSTRY AVG BETA ADJ FOR DEBT	B(Rm-Rf)	Ke = Rf+B(Rm-Rf)	Kd(1-t)	NOMINAL WACC	REAL WACC
249	0.536	0.464	0.79	1.47	12.936	21.436	7.92	15.165	10.735
281	0.448	0.552	0.73	1.63	14.344	22.844	7.92	14.606	10.198
286	0.519	0.481	0.71	1.37	12.056	20.556	7.92	14.478	10.075
289	0.513	0.487	0.73	1.42	12.496	20.996	7.92	14.628	10.219
331	0.309	0.691	0.38	1.23	10.824	19.324	7.92	11.444	7.158
347	0.446	0.554	0.59	1.32	11.616	20.116	7.92	13.359	8.999
367	0.487	0.513	0.86	1.77	15.576	24.076	7.92	15.788	11.33[illegible]
495	0.514	0.486	0.76	1.48	13.024	21.524	7.92	14.912	10.493
516	0.313	0.687	0.71	2.27	19.976	28.476	7.92	14.354	9.956
739	0.421	0.579	0.76	1.81	15.928	24.428	7.92	14.870	10.452
WEIGHTED AVERAGE BY NUMBER OF FIRMS IN SIC CODE								14.329	9.932

EXHIBIT C-6

WEIGHTED AVERAGE COST OF CAPITAL FOR LARGE FIRMS

WACC = [Vd/(Vd+Ve)]Kd(1-t) + [Ve/(Vd+Ve)]Ke

Ke = Rf + B(Rm - Rf)   Rf=8.5%   Rm-Rf=8.8%   Kd=11%   t=34%   Inflation=4.0%

SIC CODE	Ve/(Vd+Ve)	Vd/(Ve+Vd)	INDUSTRY AVG BETA (VALUE LINE)	INDUSTRY AVG BETA ADJ FOR DEBT	B(Rm-Rf)	Ke = Rf+B(Rm-Rf)	Kd(1-t)	NOMINAL WACC	REAL WACC
283	0.576	0.424	0.85	1.48	13.024	21.524	7.26	15.476	11.035
289	0.513	0.487	0.73	1.42	12.496	20.996	7.26	14.307	9.910
291	0.390	0.610	0.56	1.44	12.672	21.172	7.26	12.686	8.352
331	0.309	0.691	0.38	1.23	10.824	19.324	7.26	10.988	6.719
367	0.487	0.513	0.86	1.77	15.576	24.076	7.26	15.449	11.009
371	0.425	0.575	0.69	1.62	14.256	22.756	7.26	13.846	9.467
372	0.426	0.574	0.78	1.83	16.104	24.604	7.26	14.649	10.239
495	0.514	0.486	0.76	1.48	13.024	21.524	7.26	14.592	10.184
366	0.462	0.538	0.87	1.88	16.571	25.071	7.26	15.489	11.047
491	0.403	0.597	0.28	0.69	6.114	14.614	7.26	10.224	5.984
WEIGHTED AVERAGE BY NUMBER OF FIRMS IN SIC CODE								13.835	9.456

cost of capital in Section C.2.1; moreover, only two industries in the large firm group were not in the Section C.2.1 calculation, SIC codes 366 (Communications Equipment) and 491 (Electric Utilities).

The only other difference from the Section C.2.1 cost of capital calculation is the estimated cost of debt. Because small firms have more risk of bankruptcy, they tend to have higher costs of debt. To accommodate thisassumption, the cost of debt for small firms was increased by one percentage point to 12 percent.[17]

The betas for firms in an industry, as in C.2.1, were adjusted for the debt/equity ratio of that firm, then averaged for the industry.[18] Next, the average industry betas were readjusted for the average debt/equity ratio for firms in the industry. The betas were then multiplied by the market premium and used in the weighted average cost of capital formula.

Exhibits C-5 and C-6 present the calculations. We calculated a cost of capital of 9.932 for small firms and a cost of capital of 9.456 for large firms. As would be expected, the cost of capital used in Chapter 10 (9.49) is between the costs of capital developed for small and large firms; the cost of capital in Section C.2.1 is an average of these two groups.

(2) Methodology for obtaining present value of costs and annualizing

Once the proper discount rates have been established, the costs of corrective action developed in the analysis may be discounted and annualized for both small and large firms. We used the annualization period equal to the period for the corrective action cost flows for each facility, up to a maximum of fifty years. This is the same approach that was used in Section C.2.1.

C.3 ABILITY TO PAY ANALYSIS

This section is divided into four parts, starting with a discussion of the types of owners and operators evaluated. Next, we discuss the general concept of ability to pay, followed by a description of the five ability to pay rules considered for use in this analysis. In the fourth section, the five rules are used to test ability of RCRA firms to pay for regulatory costs, along with a breakdown of the results by important SIC codes. Based on these results, we specify an ability to pay test for the financial analysis.

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17 It is difficult to estimate the cost of debt for small firms because it often depends on a firm's relationship with a bank; small firms rarely use the debt markets. The 12 percent level was deemed appropriate because it is currently about 3 1/2 points above the prime lending rate, a typical spread for commercial lenders.

18 As in C.2.1, the betas were not available for actual firms in the F3DB, therefore betas were obtained from firms in similar industries providec by Value Line.

C.3.1. Corporate Structure -- Types of Owners or Operators Examined

Because many firms that directly own TSDFs are in turn owned by parent corporations, a key aspect of this analysis is determining which entity will fund potential corrective action costs when there are multiple layers of ownership. For example, parent firms may allocate their funds only to facilities owned directly or they may spread their resources to facilities owned by their subsidiaries as well. This subsection discusses the assumptions made in this analysis regarding the resources available from parent and subsidiary owners of TSDFs.

The F3DB identifies both immediate and ultimate owners of TSDFs. A facility's immediate owner is defined as the firm that is the direct owner of the facility. The ultimate owner, if one exists, is defined as the corporate parent of the firm that owns the facility, or, if the chain of ownership involves more than one firm, as the firm that is the most senior of the corporate parents. This analysis tests the ability to pay of immediate owners only and does not consider the resources of any corporate parent.

Although EPA intends to vigorously pursue corporate parents through litigation when immediate owners fail to provide funds for corrective action, the success rate of such activity is difficult to predict. "Piercing the corporate veil" provided by the legal structure of the parent-subsidiary relationship and forcing ultimate owners to pay may be a complex and resource-intensive task. Therefore, our analysis addresses only the ability to pay of immediate owners.

This approach will, however, somewhat underestimate the number of facilities for which ability to pay is demonstrated. Some parent firms will most likely provide financial resources for corrective action at facilities owned by their subsidiaries.

C.3.2 The Concept of Ability to Pay

A firm's ability to pay for regulatory costs is best defined as the availability of financial resources to cover those costs. This definition reveals the approximation inherent in measuring a firm's ability to pay because the financial resources available to meet regulatory costs may be evaluated in a number of different ways.

The first step in an ability-to-pay analysis is determining the appropriate threshold for separating firms that are able to pay from those that are not. For example, a firm could be considered to have sufficient reserves up to the point at which it becomes insolvent, i.e., the point at which it is unable to meet its other cash obligations such as interest payments and accounts payable. This threshold considers the firm able to pay only until the obligation induces bankruptcy. In contrast, a firm could be considered to have sufficient reserves up to the point at which it has sufficient cash to reinvest to maintain current plant and equipment. This threshold considers the firm able to pay only until it can no longer sustain-its ongoing operations; it is thus likely to be less stringent than the first measure. Either measure could potentially be a valid indicator of a firm's ability to pay, depending on how one wants to assess the burden on the firm.

Five ability-to-pay rules were examined for potential use in this analysis. These rules, described in the next subsection, are varied according to the different possible thresholds of ability to pay. There is no single "correct" measure of ability to pay; therefore, in the following discussion, we present the pros and cons of each type of measure and the ability-to-pay threshold it involves. Then, after analyzing preliminary ability to pay results for each rule, we specify one rule to be used in the analysis of impacts of corrective action costs.

C.3.3 Ability-to-Pay Rules

This subsection describes the five ability-to-pay rules that we considered using for the economic impact analysis. The following subsection discusses how we selected one rule from this group for use in the analysis.

Rule 1: Ability to pay is equal to cash flow minus ten percent of total liabilities: This formula is derived from the "Beaver ratio," which is a ratio of cash flow to total liabilities greater than or equal to 0.1.[19] The Beaver ratio tests a firm's ability to pay based on a bankruptcy threshold; it has been found in at least two studies to be among the best single predictors of firm bankruptcy.[20] Cash flow is measured as net income plus depreciation, depletion, and amortization, or NIDDA.

A Beaver ratio greater than 0.1 assures a substantial margin of safety in a firm's cash flow position, and indicates that the firm currently has sufficient excess cash flow to meet both the normal investment needs of a business and the possibility of deterioration in future cash flows. The implicit assumption in this rule is that firms can pay for corrective action out of their cash flow up to that amount where their Beaver ratio equals the critical value of 10 percent, the point at which they would no longer have sufficient cash flow to assure that bankruptcy will not occur in the future.

Rule 2: Ability to pay is equal to net income: Using net income as a measure of ability to pay is a modification of the Superfund Financial

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[19] Named for its developer, William Beaver, "Financial Ratios as Predictors of Failure," Empirical Research in Accounting: Selected Studies, 1966.

[20] Ibid., Table 3. See also Background Document for the Financial Test and Municipal Revenue Test: Financial Assurance for Closure and Post-Closure Care, Appendix A, U.S. EPA, November 30, 1981, where the Beaver ratio was found to be one of the most effective single ratio tests among bankruptcy pre tc

Assessment System (SFAS).[21] Under SFAS, a firm's ability to pay is considered to be equal to its predicted future residual cash flow, which is measured as a weighted average of cash flow (net income plus depreciation) for the past three to five years, minus the amount of investment required to sustain the firm at its current earnings. By assuming that the amount of required sustaining investment is equal to the firm's annual depreciation, the SFAS measure of future residual cash flow becomes equivalent to the weighted average of net income for the past three to five years. The threshold for this ability-to-pay test is the level of resources above that required to sustain a firm's current operations, as opposed to the bankruptcy threshold of the previous test.

Because the financial data base used to perform this analysis only contains one year of data for firms, time series data were not available to predict net income. Therefore, the amount firms are considered to be able to pay under Rule 2 is assumed to be equal to the firms' latest year of net income.

Rule 3: Ability to pay is equal to 50 percent of net income: This rule is based on the same assumptions as the second ability-to-pay rule, differing only in that a portion of net income is assumed to be available for corrective action costs. This test is intended to test the sensitivity of the second ability to pay rule. Moreover, it is possible that net income does not accurately represent the cash flow available to pay for regulatory costs. For example, if a company used straight-line depreciation of its fixed assets, the assumption that depreciation represents the required sustaining investment of the firm may be inaccurate (i.e., the replacement cost of assets may be much more substantial). An ability-to-pay rule of only 50 percent of net income may offset the potential for inaccuracies in the net income figure.

Rule 4: Ability to pay is equal to three percent of total assets: This measure reflects the assumption that over the long term, firms' net income will average a given return on assets. Therefore, the measure is similar to a measure of net income. Under this ability-to-pay rule, it is assumed that an average return on assets is six percent and that half this return, or three percent, is available for corrective action costs.[22] The threshold level for ability to pay is that necessary to sustain current operations; the average return on assets is not set at a level to test for bankruptcy.

Rule 5: Ability to pay is equal to five percent of total assets: This rule is based on the same assumptions as the fourth ability-to-pay rule,

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21 See Superfund Financial Assessment System. Technical Support Document, Industrial Economics, Inc., prepared for U.S. EPA Office of Policy and Resource Management, May 25, 1982.

22 See "Flexible Regulatory Enforcement Policies for Corrective Action," prepared by ICF Inc. for U.S. EPA, Office of Policy, Planning and Evaluation, September 12, 1985. The six percent figure represents an average return on assets for all manufacturing firms over the period 1970 to 1983.

differing only with respect to the percentage return on assets that is available to firms for corrective action costs. It was designed to test the sensitivity of ability to pay Rule 4.

Each of the ability-to-pay rules reflects different aspects of a firm's financial situation. The two rules (Rules 4 and 5) that are based only on total assets characterize ability to pay in terms of a stock of resources, which reflect resources built up over past years, rather than in terms of its flow variables (e.g., net income, cash flow) which represent a current period's performance. Ability-to-pay Rules 1 through 3, by contrast, focus on the flow variables of a single year to determine ability to pay. Thus, one unprofitable year for a firm resulting in negative cash flow (Rule 1) or negative net income (Rules 2 and 3) would result in the firm being considered unable to meet its corrective action obligations. Although stock variables reflect the pool of resources available to the firm at a particular time, flow variables may better reflect the ability of the firm to generate resources in the future.

C.3.4 Estimated Ability to Pay

This section examines the ability of F3DB firms to pay for regulatory costs in general using the different ability to pay rules presented in Section C.3.3. This preliminary analysis enables us to choose an appropriate ability-to-pay rule for use in the computer simulation model (described in Section C.4) that generates our final results. As a supplement to our analysis of F3DB firms, we also present a breakdown of firms by selected industries (SIC codes) to demonstrate the widely different potential effects of the corrective action rulemaking on different industries.

(1) Examining the set of ability-to-pay rules

A stochastic computer simulation model, described in Section 13.4, is used in this analysis to test the degree to which firms affected by the corrective action rule may be able to pay for the costs of the regulation. To choose the appropriate ability-to-pay rule for use in the model, we preliminarily tested the firms described in Section 10.1 for their ability to pay for a range of generic costs without regard for the probability of those costs being incurred. We repeated this analysis for each of the five ability-to-pay rules described in Section C.3.3 to determine how different rules affected the results. As discussed in Section C.3.1, we tested only immediate owners of TSDFs.

In order to determine the amount of funds available for a specific facility, some assumptions must be made about the manner in which the resources of the immediate owner of the facility are allocated. For this portion of the analysis, two scenarios were developed which represent different assumptions about the allocation of funds from firms to facilities: either all funds are divided equally among facilities (equal allocation) or available funds are applied to successive facilities until exhausted (successive allocation).

The results of this analysis are shown in Exhibits C-7 through C-10. In Exhibits C-7 and C-8, the firms are tested by the five ability-to-pay rules assuming that they allocate resources equally among facilities. Exhibit C-7 shows the number of facilities for which regulatory costs are fully funded for costs ranging from $0 to $10 million; Exhibit C-8 provides a close-up view of the low end of the cost range. Because many firms own more than one facility, the percentage of firms passing an ability-to-pay test for a given cost level is translated into the percentage of facilities for which regulatory costs can be met by immediate owners. Exhibits C-9 and C-10 reveal the number of facilities at which compliance costs can be paid given the successive resource allocation assumption for the same cost range.

The results are very similar between the two allocation principles. In each case, the percentage of facilities covered decreases steadily as the costs increase, with sharper declines in the lower cost intervals (see Exhibits C-8 and C-10). The declines in the lower cost intervals may be attributed to the fact that some firms have very low or negative incomes; they will fail the tests measuring net income for almost any compliance costs.

The different ability-to-pay tests behave similarly under both the equal and successive resource allocation approaches. The Beaver ratio test is the most stringent in the lower cost intervals (less than $100,000), but it is soon overtaken by the 50 percent of net income test. The 5 percent of total assets test is the least stringent; it projects about 20 percent more facilities to be covered than the most stringent test.

Of the five ability-to-pay tests examined, the Beaver ratio test is the most attractive test to single out for the economic impact analysis. There are two major reasons for this choice:

1. Throughout most of the cost range, under both allocation principles, the Beaver ratio test results are within 5 percent of the net income test and the 3-percent of total assets test, and within 10 percent of the other two "sensitivity" tests. Therefore, results for the Beaver ratio test are unlikely to vary significantly from other potential tests.

2. The Beaver ratio test has been validated by previous studies as a predictor of bankruptcy. Firms with a Beaver ratio less than the critical value face a significantly higher chance of bankruptcy than firms that have cash flow in excess of 10 percent of total liabilities.

The Beaver ratio test, as discussed earlier, assures a margin of safety in a firm's cash flow position for meeting its obligations. A firm could be expected to pay for corrective action costs up to the point at which its Beaver ratio equals the critical value of 10 percent. At that point, the firm could commit more funds to corrective action costs (either by using any

EXHIBIT C-7

FACILITIES FOR WHICH CORRECTIVE ACTION COSTS ARE FUNDED

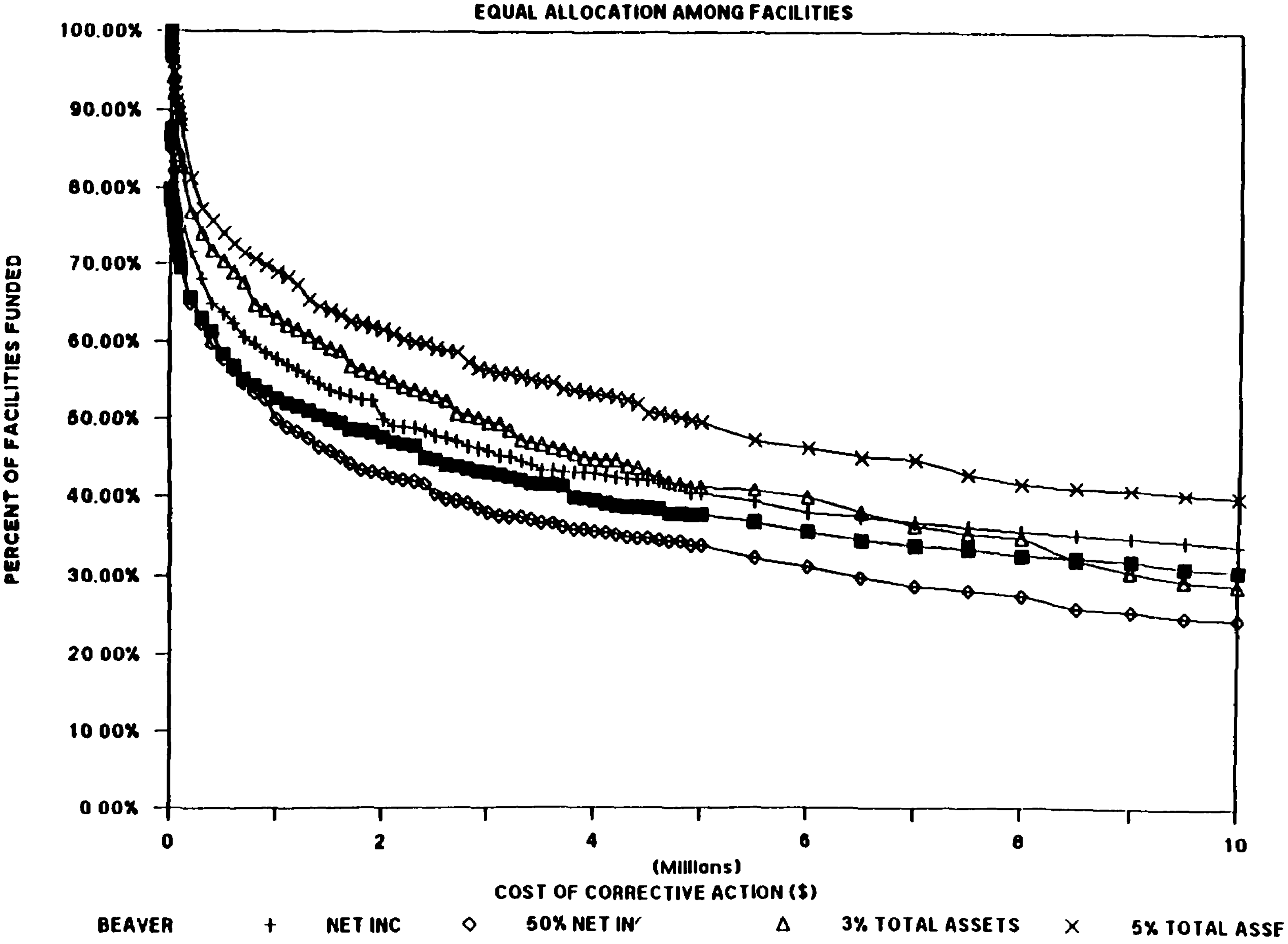


EXHIBIT C-8

FACILITIES FOR WHICH CORRECTIVE ACTION COSTS ARE FUNDED
(For First $100,000 of Costs)

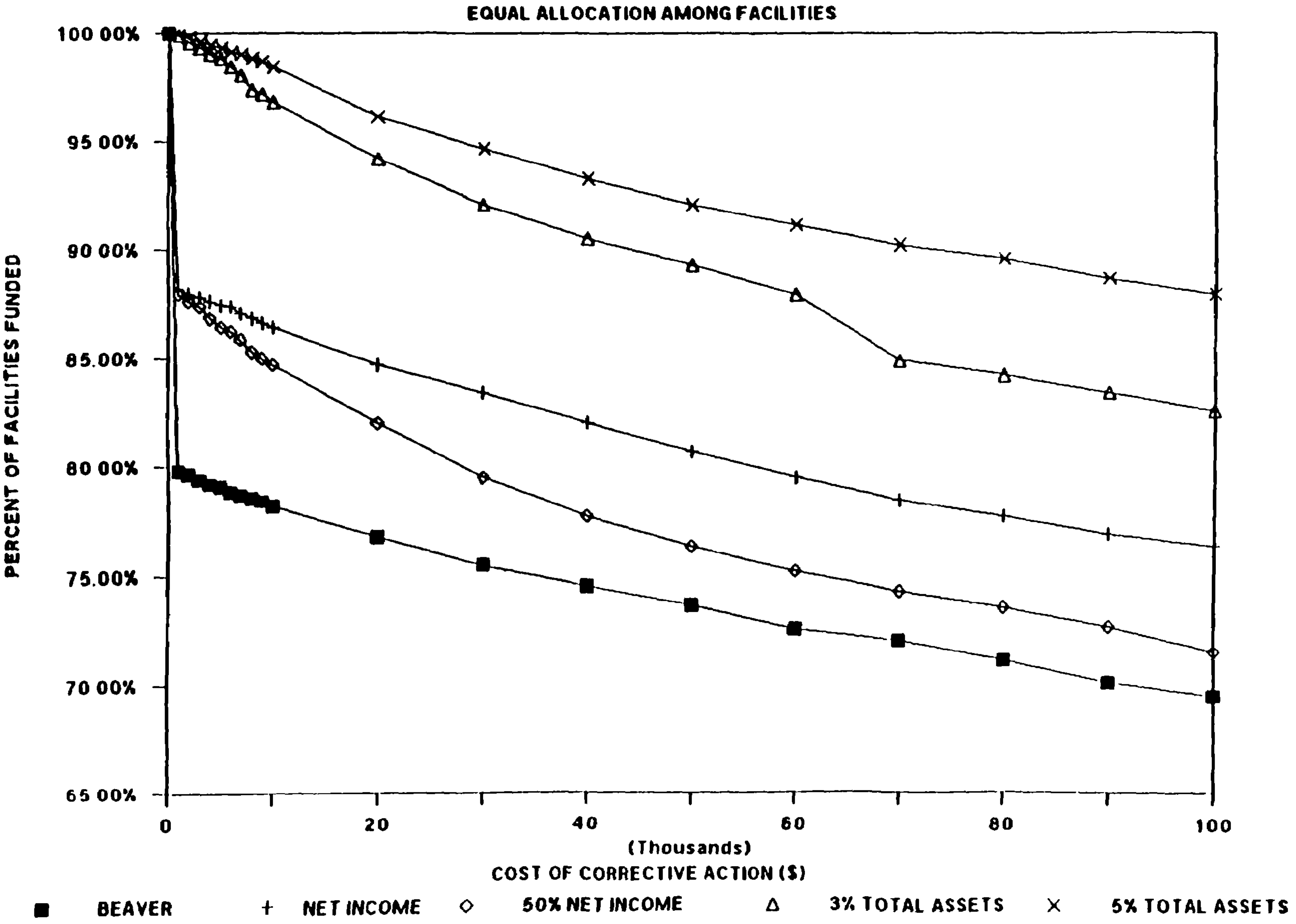


EXHIBIT C-9

FACILITIES FOR WHICH CORRECTIVE ACTION COSTS ARE FUNDED

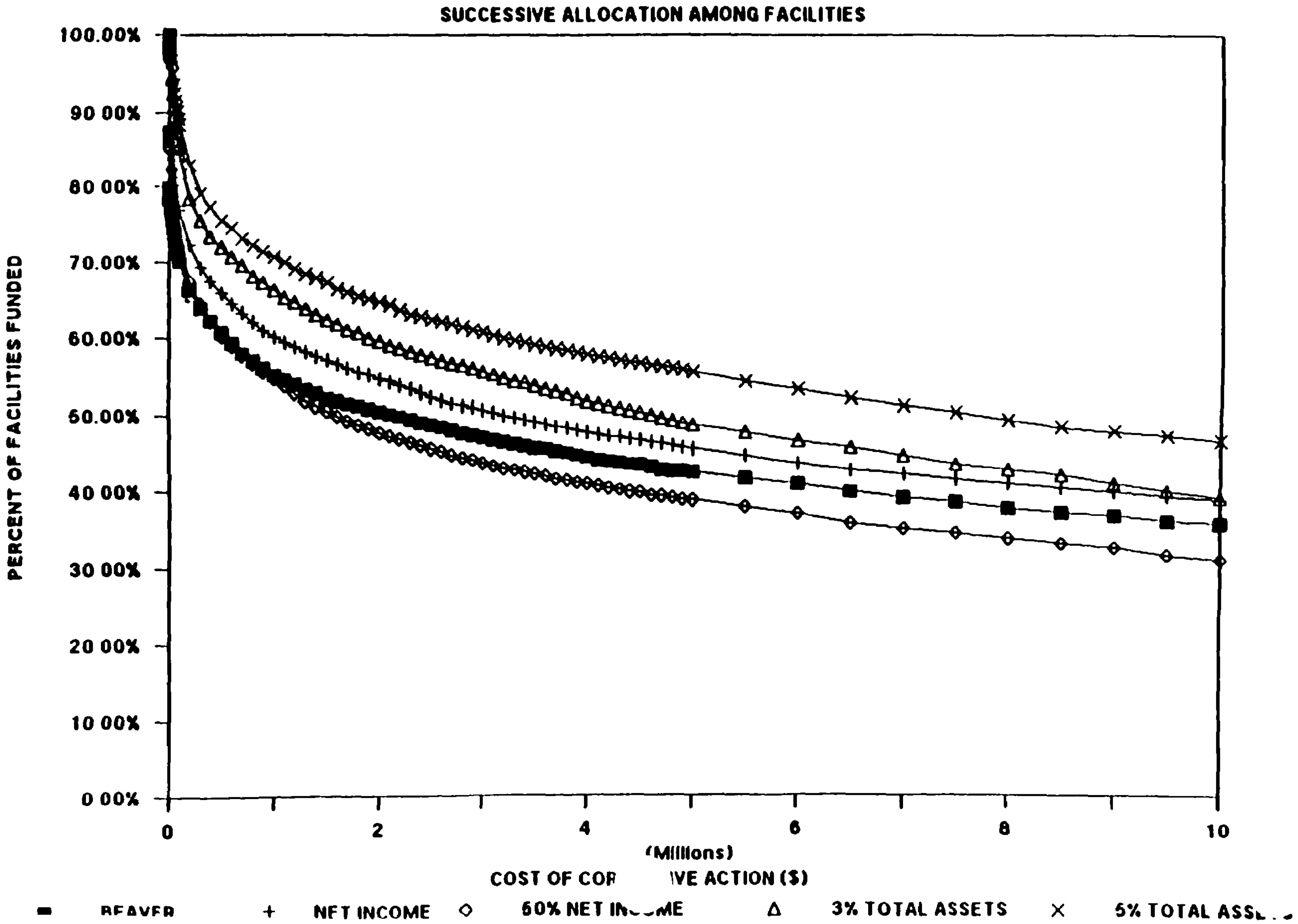
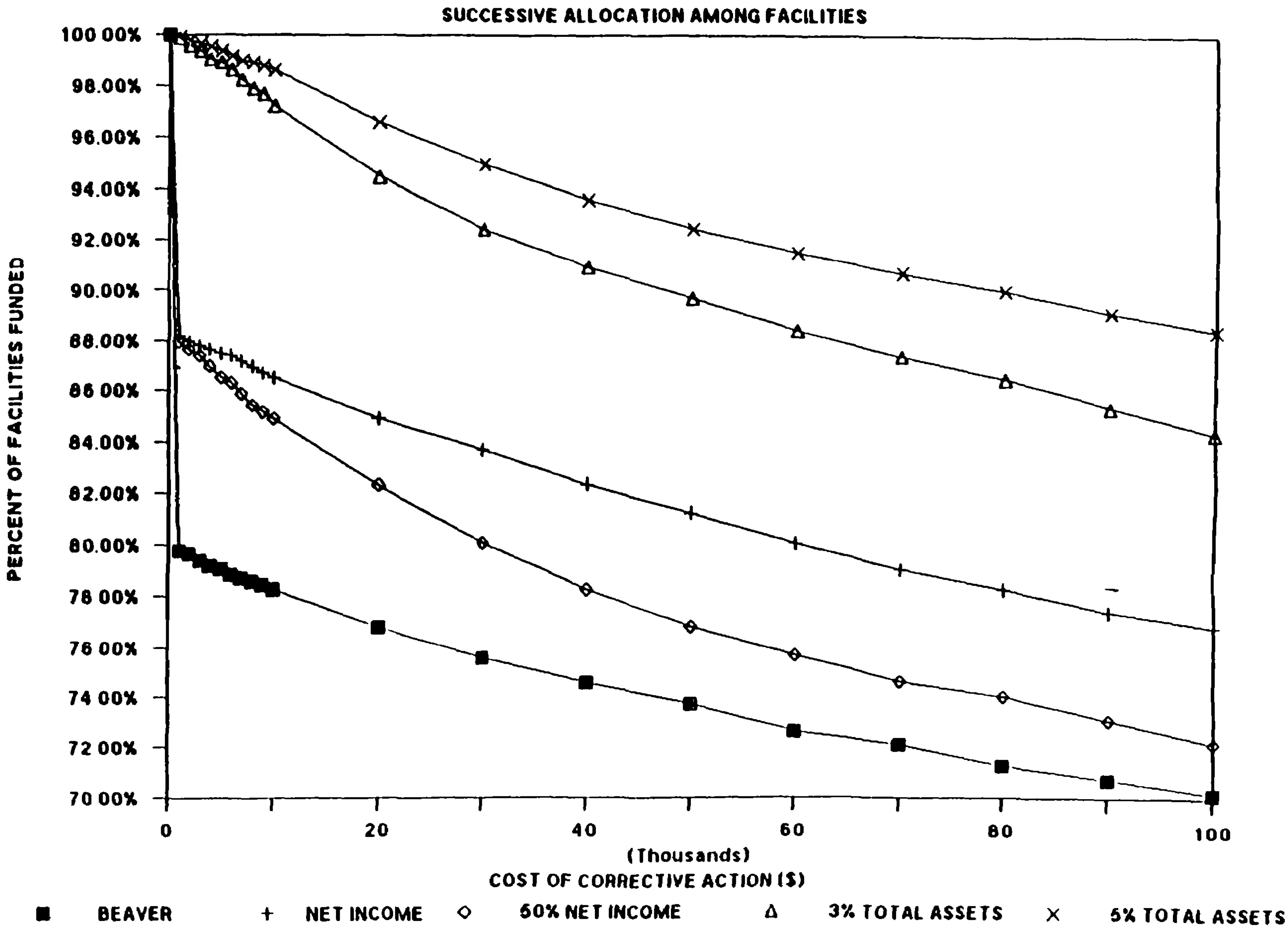


EXHIBIT C-10

FACILITIES FOR WHICH CORRECTIVE ACTION COSTS ARE FUNDED
(For first $100,000 of Costs)



positive income or by liquidating assets), but it would likely be in danger of eventually going bankrupt. Therefore, in the computer simulation model the Beaver ratio test is used to measure the funds available to pay for corrective action costs. If a simulated firm is unable to provide funds for corrective action for all facilities owned without failing the Beaver ratio test, it is counted as facing an "adverse impact." A firm facing an adverse impact may be able to pay for costs by allowing its Beaver ratio to fall below the 10 percent threshold, but such a firm would face an increased risk of bankruptcy. Thus, our analysis does not make predictions of bankruptcy per se; rather, it assumes that firms suffer significant impacts if the costs of corrective action threaten to reduce their Beaver ratio past the critical point.

(2) Ability to Pay in Selected Industries

To assess how the corrective action regulations may affect different types of industries, we analyzed the performance of firms for several common SIC codes. Although this analysis does provide an indication of how some types of industries may be able to cover the corrective action costs more easily than others, it does not assess the actual impacts of the regulations on these industries. To perform the analysis, we used two of the ability-to-pay tests, the Beaver ratio test and the net income test. The Beaver test, as discussed above, is the test selected for the simulation of economic impacts; the net income test is added to test the sensitivity of the results of the industry-specific analysis.

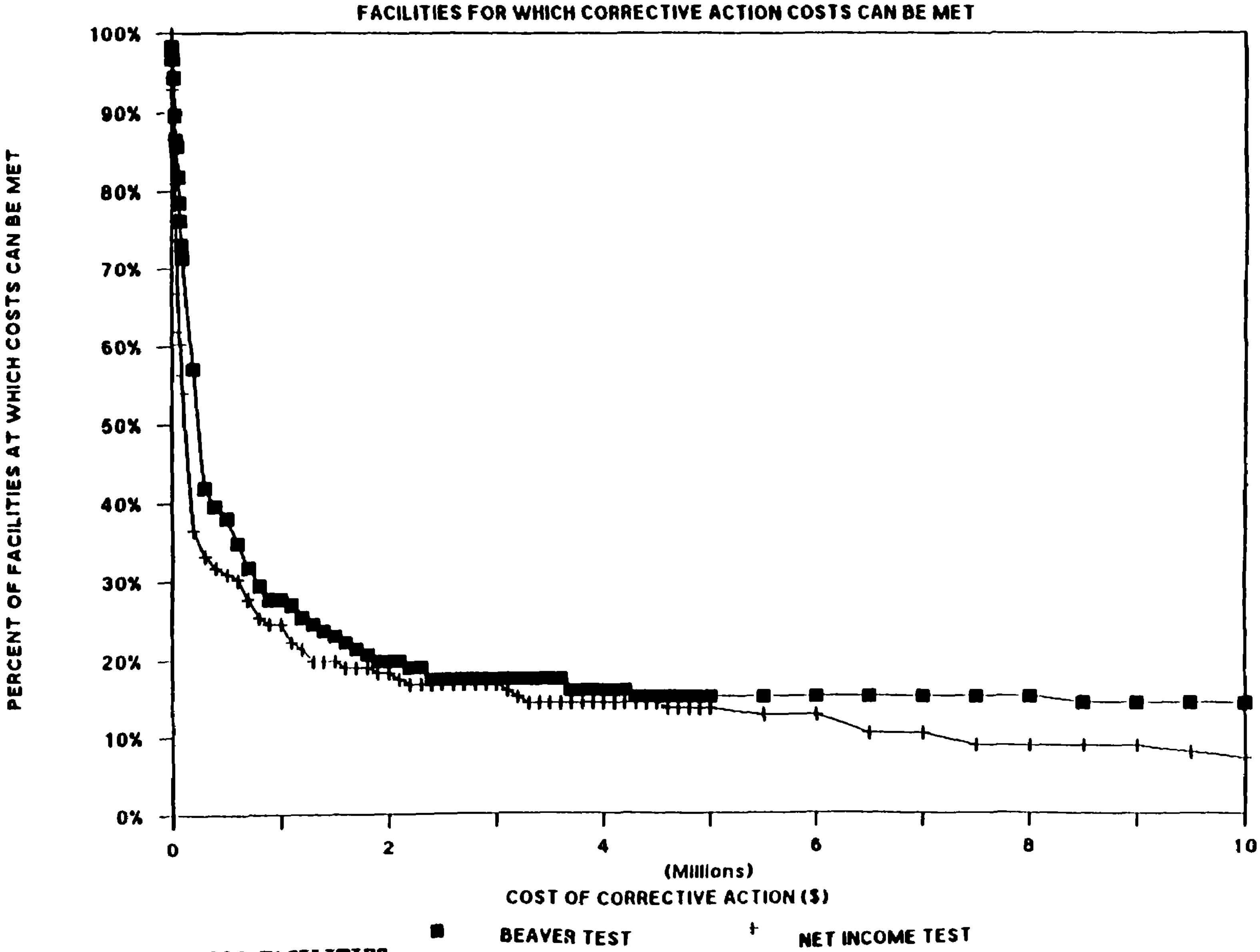
The results of our analysis are depicted in Exhibits C-11 through C-16. Each exhibit depicts the percentage of facilities with costs covered by firms in an SIC code group. Note that in some industries, not all firms are able to pass the tests even with no corrective action costs. For example, over 20 percent of facilities in the petroleum refining industry (Exhibit C-14) cannot pass the Beaver test with zero corrective action costs.

Exhibits C-11 through C-13 show industries that have a relatively low ability to pay. For these industries, the number of facilities with adequate funding by immediate owners drops severely in the lower cost range, indicating that net income levels are low. For example, for the sanitary services industry, the percentage of facilities at which costs can be funded drops from close to 100 percent at $1,000 to 25 percent at $1 million. A similar pattern occurs for both the coating and engraving industry and the miscellaneous wood products industry. The fact that net income levels are low may mean that firms in these industries are relatively small or it may mean that industry returns are relatively poor.

Exhibits C-14 through C-16 show industries that have a higher ability to pay; these industries maintain a higher percentage of facilities covered than the entire universe of firms for a given level of costs. For example, the petroleum refining industry is estimated to be able to fund costs at 70 to 80 percent of its facilities even at cost levels above $5 million. Firms in the motor vehicle industry and the aircraft industry are estimated to be able to pay for compliance costs up to $10 million for about 80 percent of facilities. In comparison, the entire sample of firms owning TSDFs is able to fund costs

EXHIBIT C-11

INDUSTRIES WITH RELATIVELY LOW ABILITY TO PAY:
SIC 495 -- SANITARY SERVICES



TESTED 89 FIRMS OWNING 126 FACILITIES

EXHIBIT C-12

INDUSTRIES WITH RELATIVELY LOW ABILITY TO PAY:
SIC 347 -- COATING, ENGRAVING, AND ALLIED SERVICES

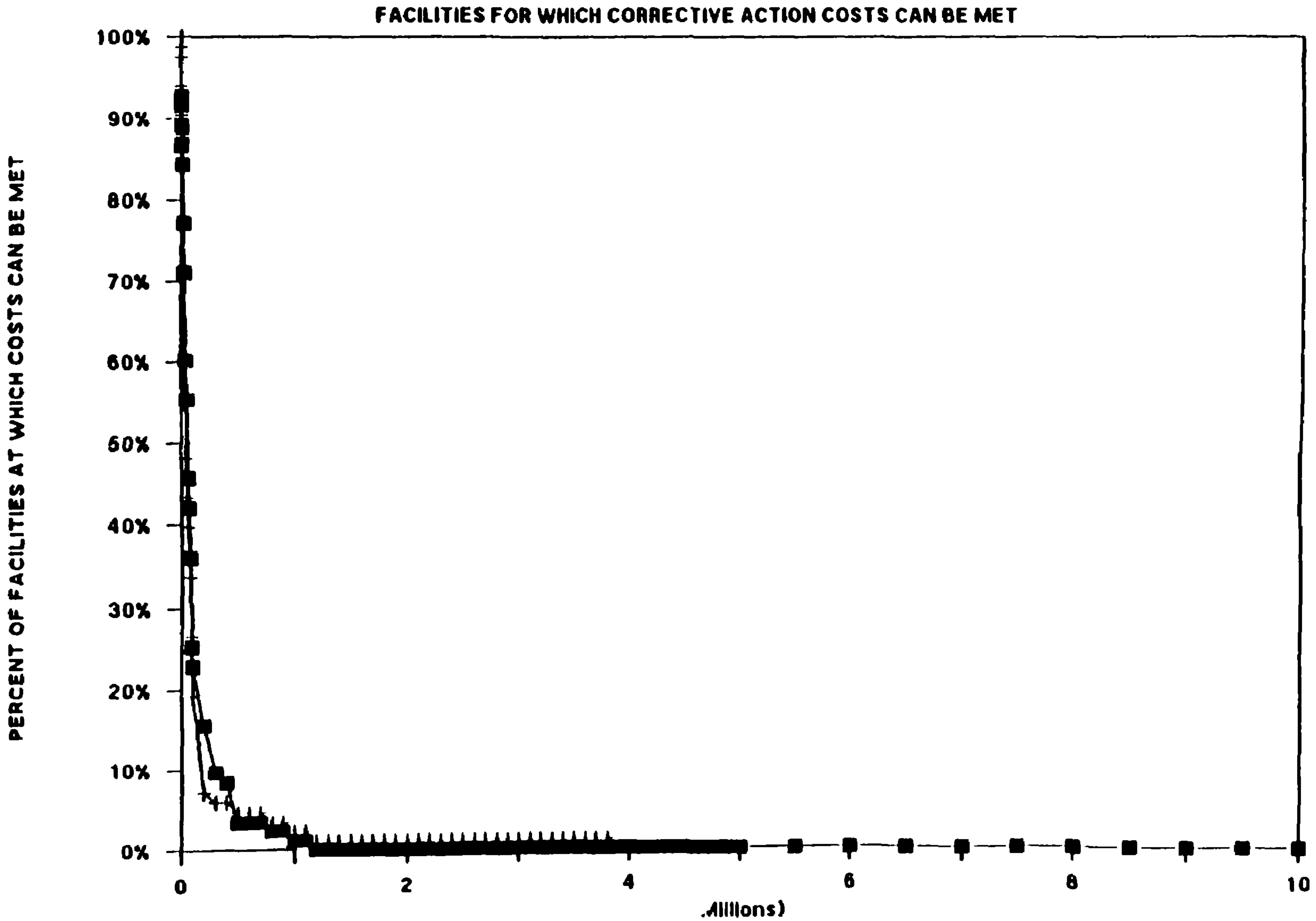
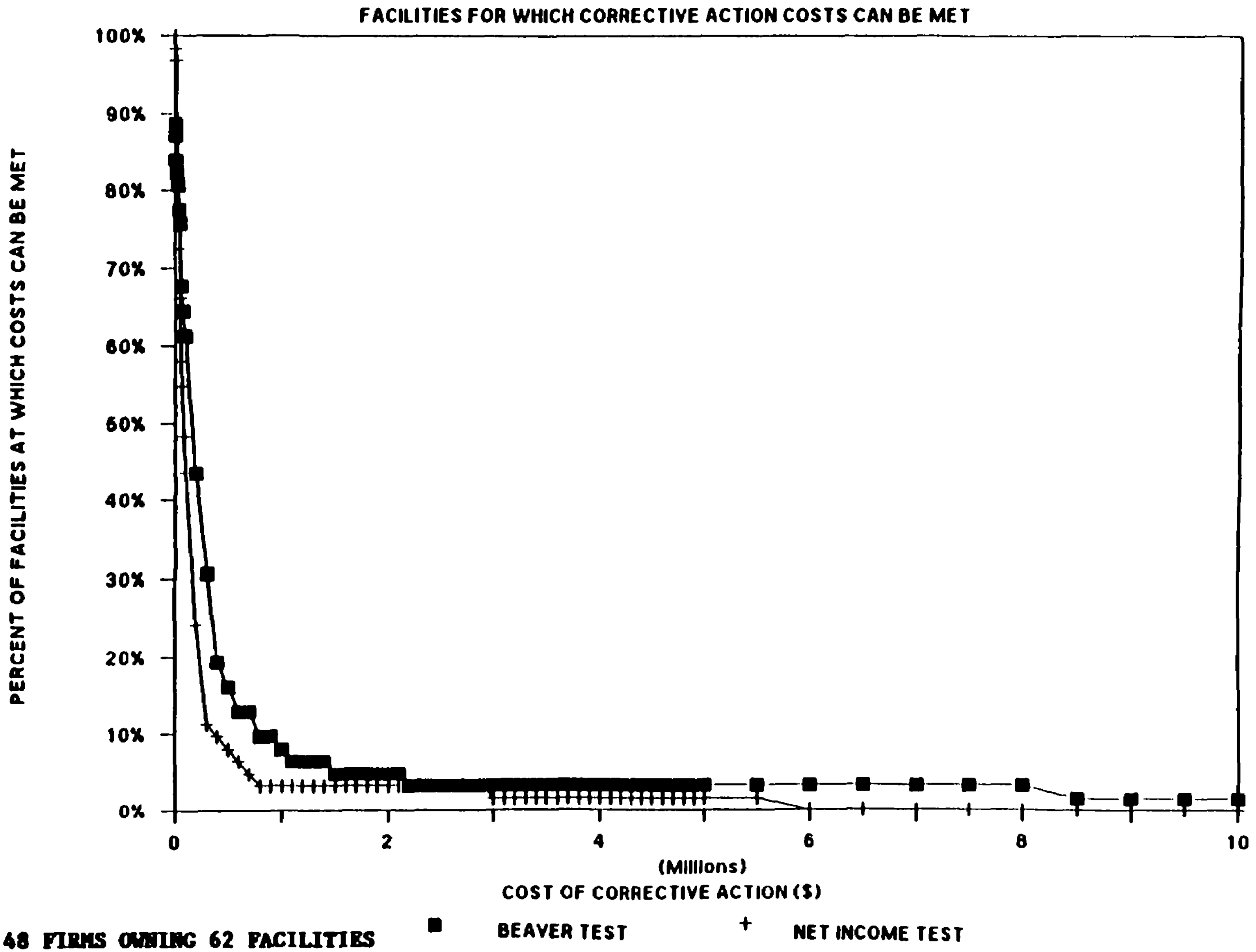


EXHIBIT C-13

INDUSTRIES WITH RELATIVELY LOW ABILITY TO PAY: SIC 249 -- MISCELLANEOUS WOOD PRODUCTS



TESTED 48 FIRMS OWNING 62 FACILITIES

EXHIBIT C-14

INDUSTRIES WITH RELATIVELY HIGH ABILITY TO PAY: SIC 291 -- PETROLEUM REFINING

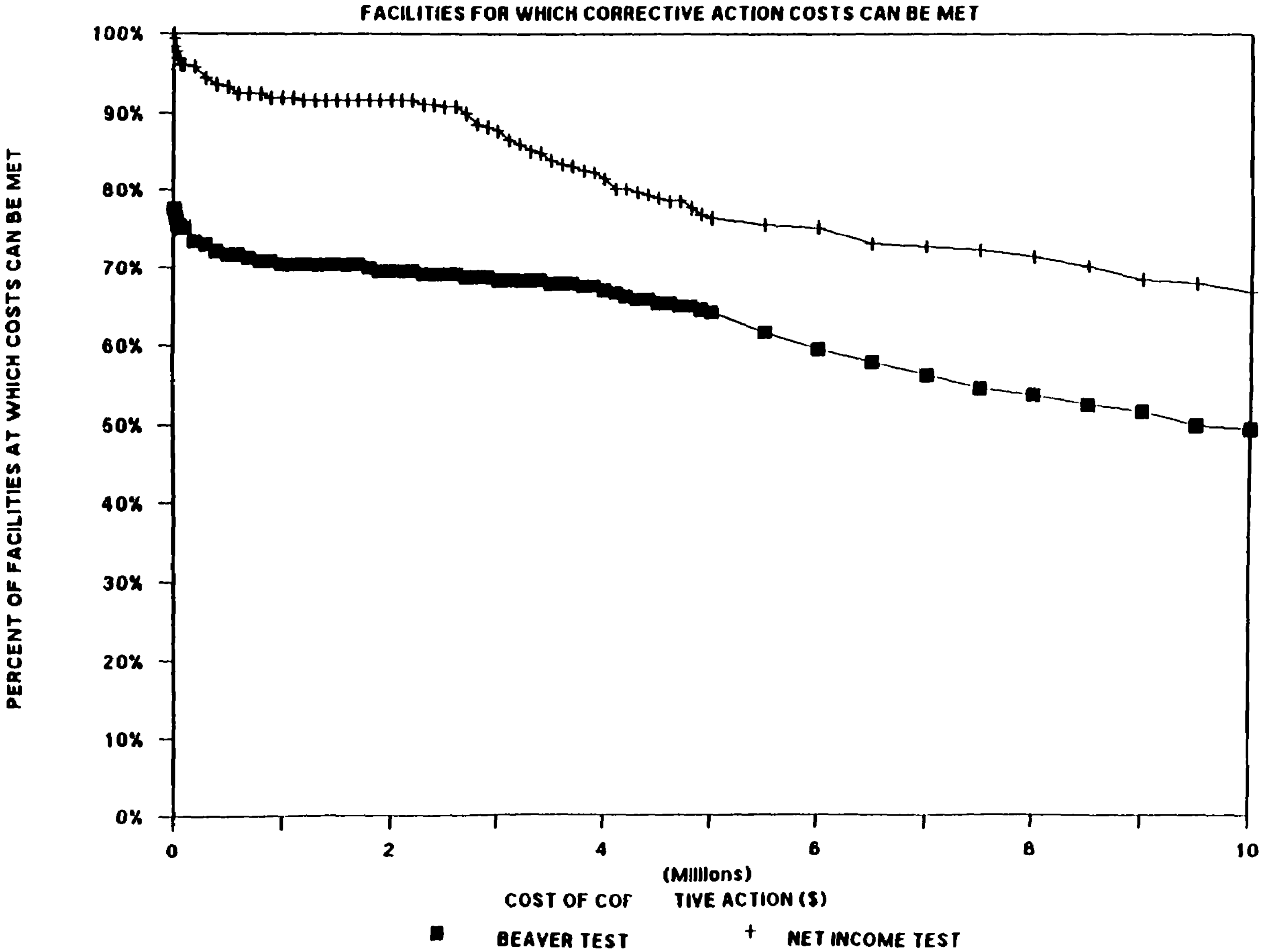
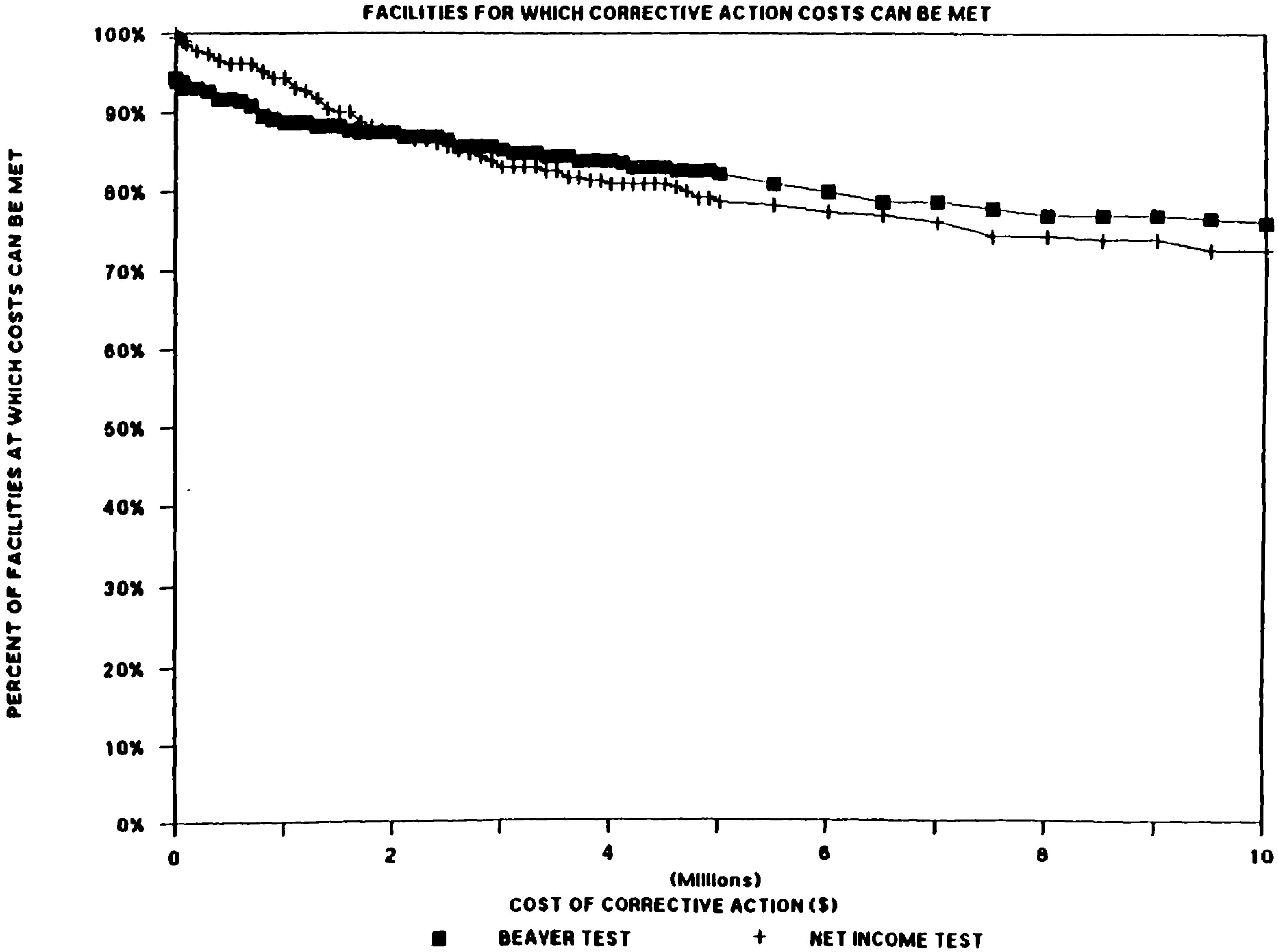


EXHIBIT C-15

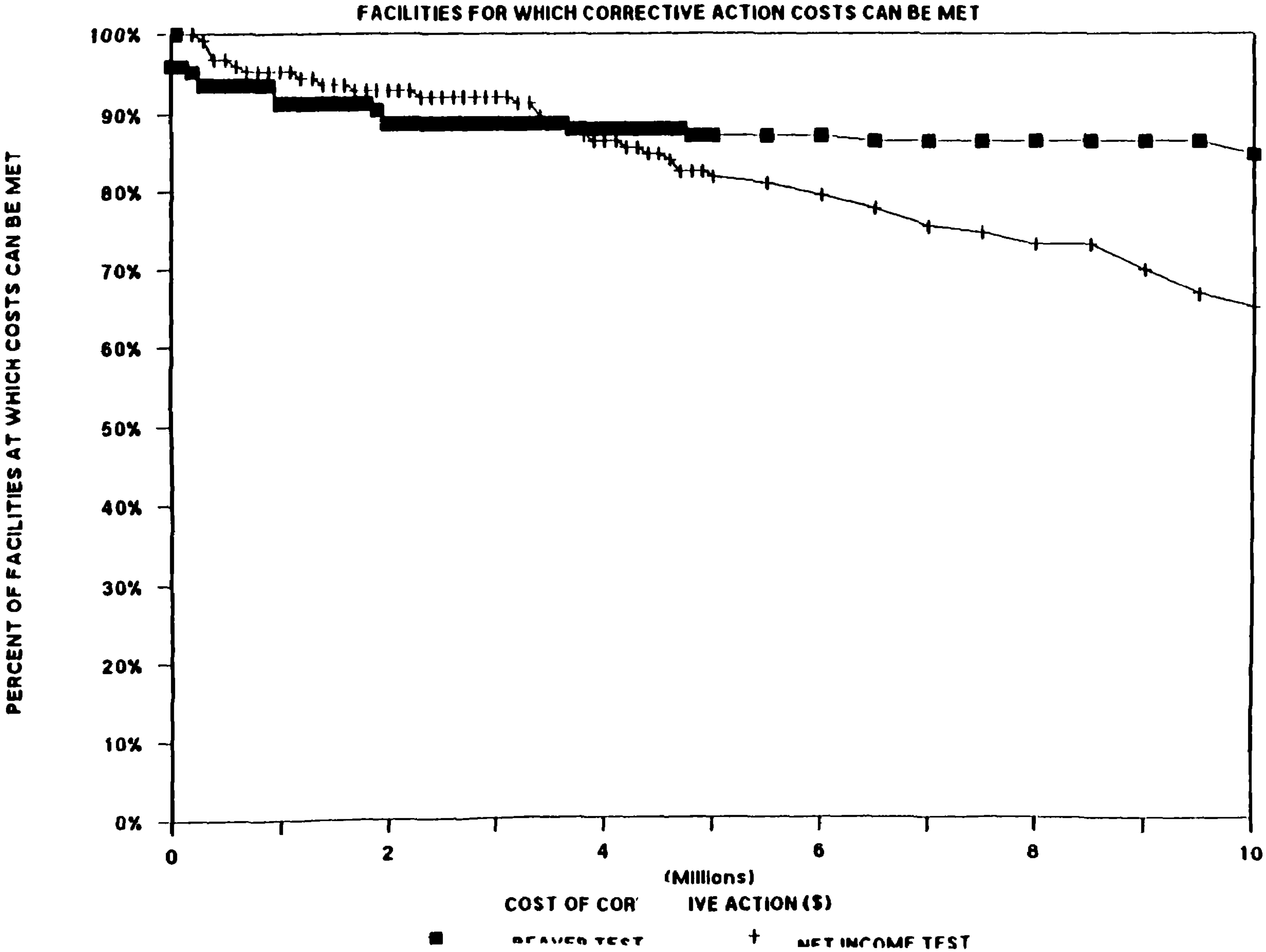
INDUSTRIES WITH RELATIVELY HIGH ABILITY TO PAY:
SIC 371 -- MOTOR VEHICLES AND MOTOR VEHICLE EQUIPMENT



TESTED 39 FIRMS OWNING 229 FACILITIES

EXHIBIT C-16

INDUSTRIES WITH RELATIVELY HIGH ABILITY TO PAY: SIC 372 -- AIRCRAFT AND PARTS



of $5 million to $10 million for only about 30 to 50 percent of its facilities (see Exhibits C-7 through C-10).

C.4 MONTE CARLO MODEL

Based on the previous analyses (Sections C.1 through C.3), we developed a Monte Carlo model to simulate the economic impacts of the corrective action regulations. The major steps in the stochastic approach are detailed below. The corresponding steps are depicted in a flow diagram in Exhibit C-17.

(1) Simulate a Firm -- The program begins by simulating a firm with a certain level of ability to pay (using the Beaver ratio test) and a certain number of facilities owned. These parameters are simulated for each firm by drawing from probability distributions based on the data in the F3DB. The probability distributions for ability to pay and number of facilities, therefore, are set up using actual data, ensuring that the random values chosen will be realistic. Exhibits C-18 and C-19, respectively, present these distributions. Note that the ability to pay distribution is actually presented as an "inability to pay" distribution, with all firms (i.e., 100 percent) being unable to pay at the highest cost.

(2) Simulate Facilities -- Once the firm's ability to pay and its number of facilities have been selected, we simulate each facility owned by the firm. Using a probability distribution based on the corrective action cost data from the LLM, a facility is randomly assigned a flow of corrective action costs, called a cost stream. Only the first fifty years of costs are used because the planning horizon for a firm is highly unlikely to exceed fifty years. Moreover, only those corrective actions that begin in the first ten years are examined; firms are unlikely to begin planning for later actions at the outset of the regulations.

The model keeps track of the costs for each simulated facility so that it can test the firm's ability to pay against the costs of all facilities owned by the simulated firm. Some facilities will not have to face corrective action costs; the probability of a facility having no corrective action costs is incorporated into the probability distribution from which facility costs are randomly selected. The cost distributions for simulated facilities will vary depending on which regulatory alternative is analyzed.

(3) Simulate Financial Assurance Costs for Firm X -- If a facility seeks a permit under RCRA Section 3004(u), it will be required to provide financial assurance in the event of a corrective action, representing an additional cost of the rulemaking that must be estimated.[23] In addition, if a facility does

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[23] 40 CFR 264.101 currently requires owners or operators of TSDFs to provide financial assurance for corrective action. The October 24, 1986 proposed rule (51 FR 37854) gives details on the financial assurance requirements, including the amount of coverage required for a facility and the types of mechanisms allowed for providing coverage.

EXHIBIT C-17

FLOW CHART FOR SIMULATION OF ECONOMIC IMPACTS

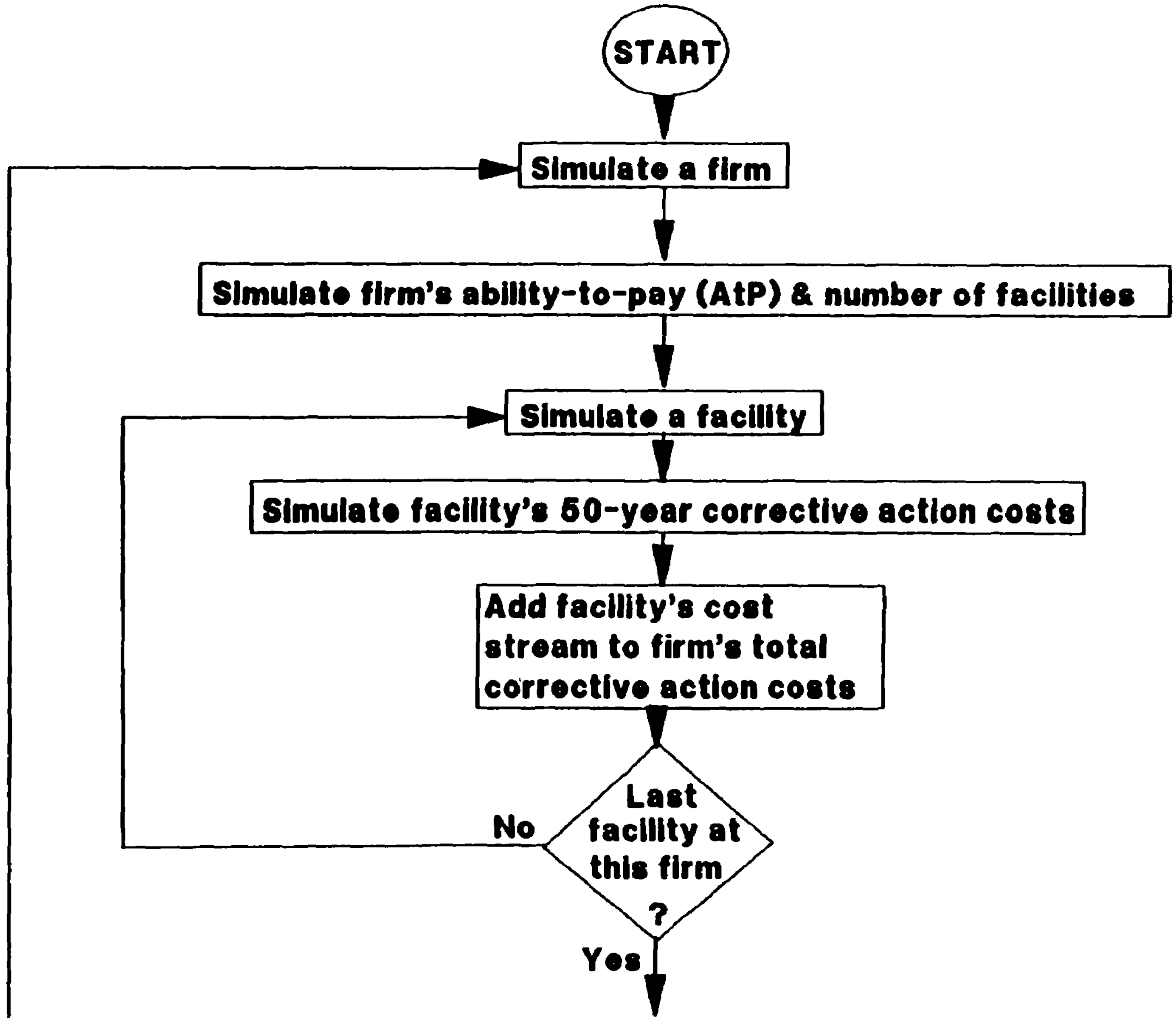


EXHIBIT C-17 (Continued)

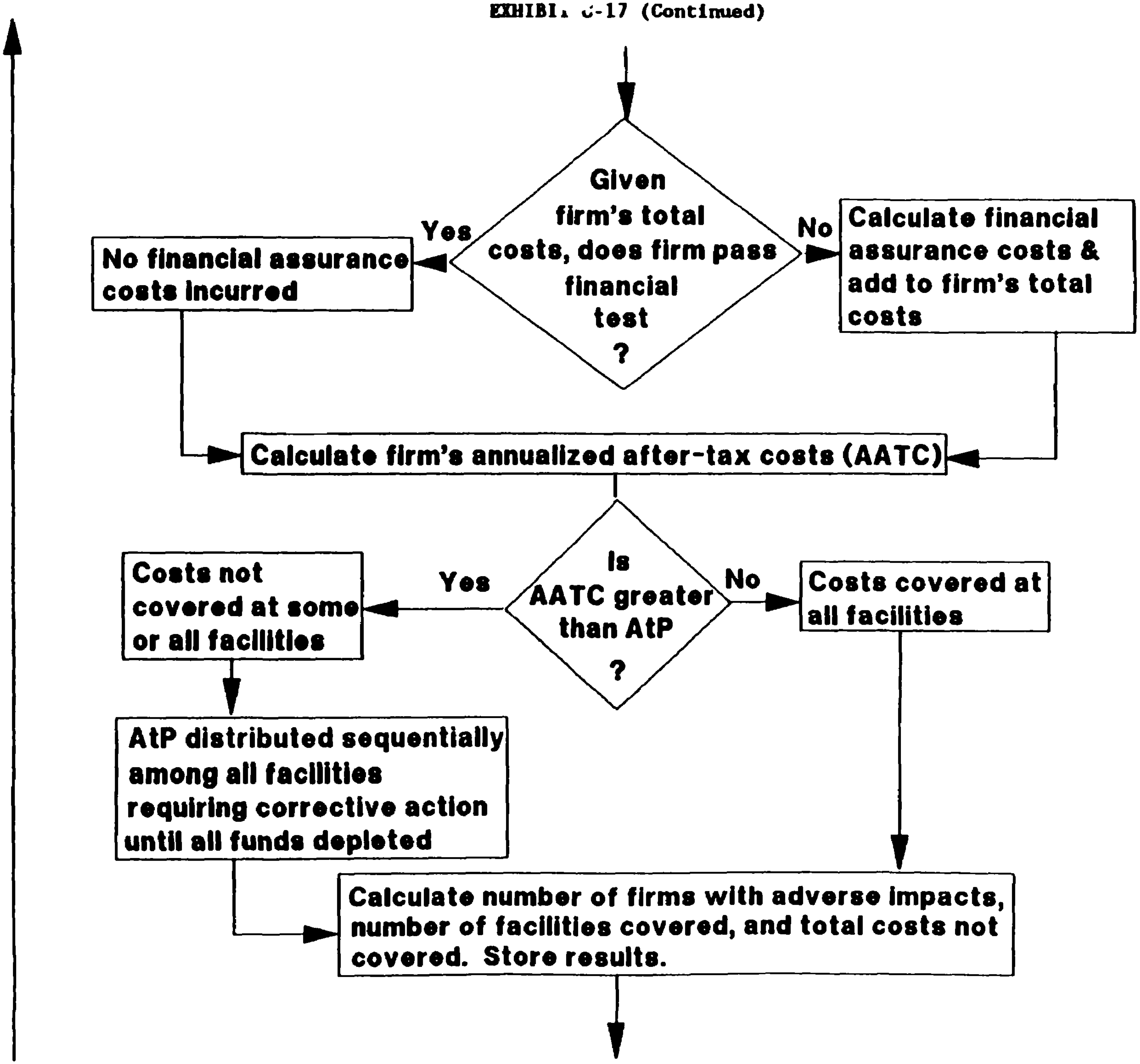


EXHIBIT C-17 (Continued)

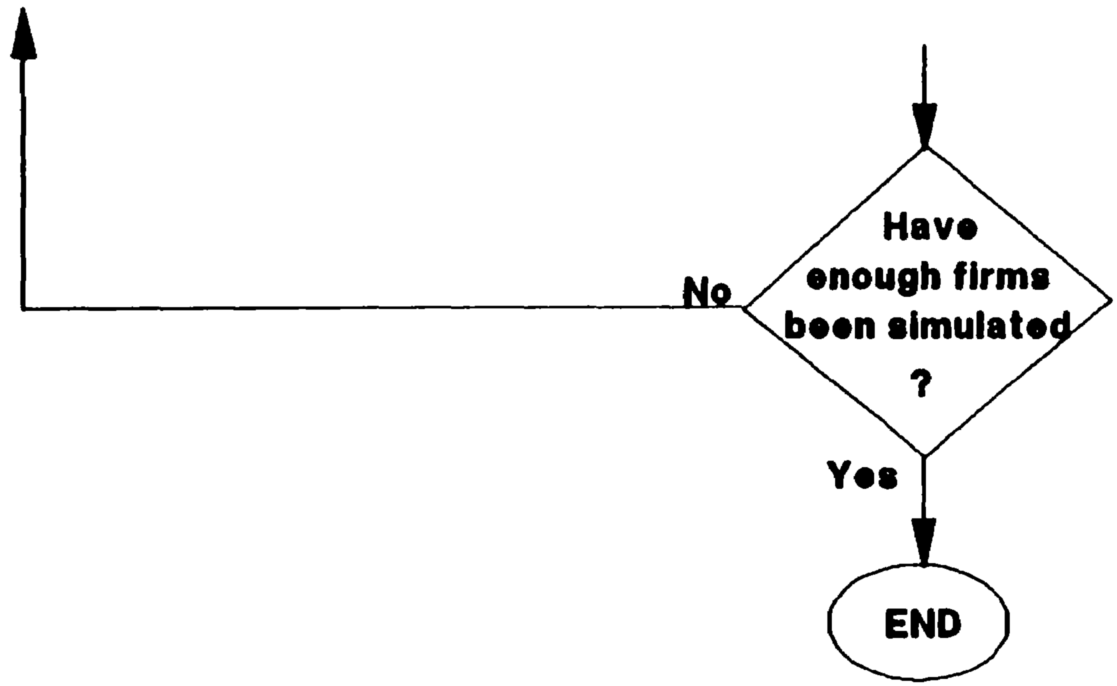


EXHIBIT C-18

DISTRIBUTION OF INABILITY TO PAY FOR CORRECTIVE ACTION

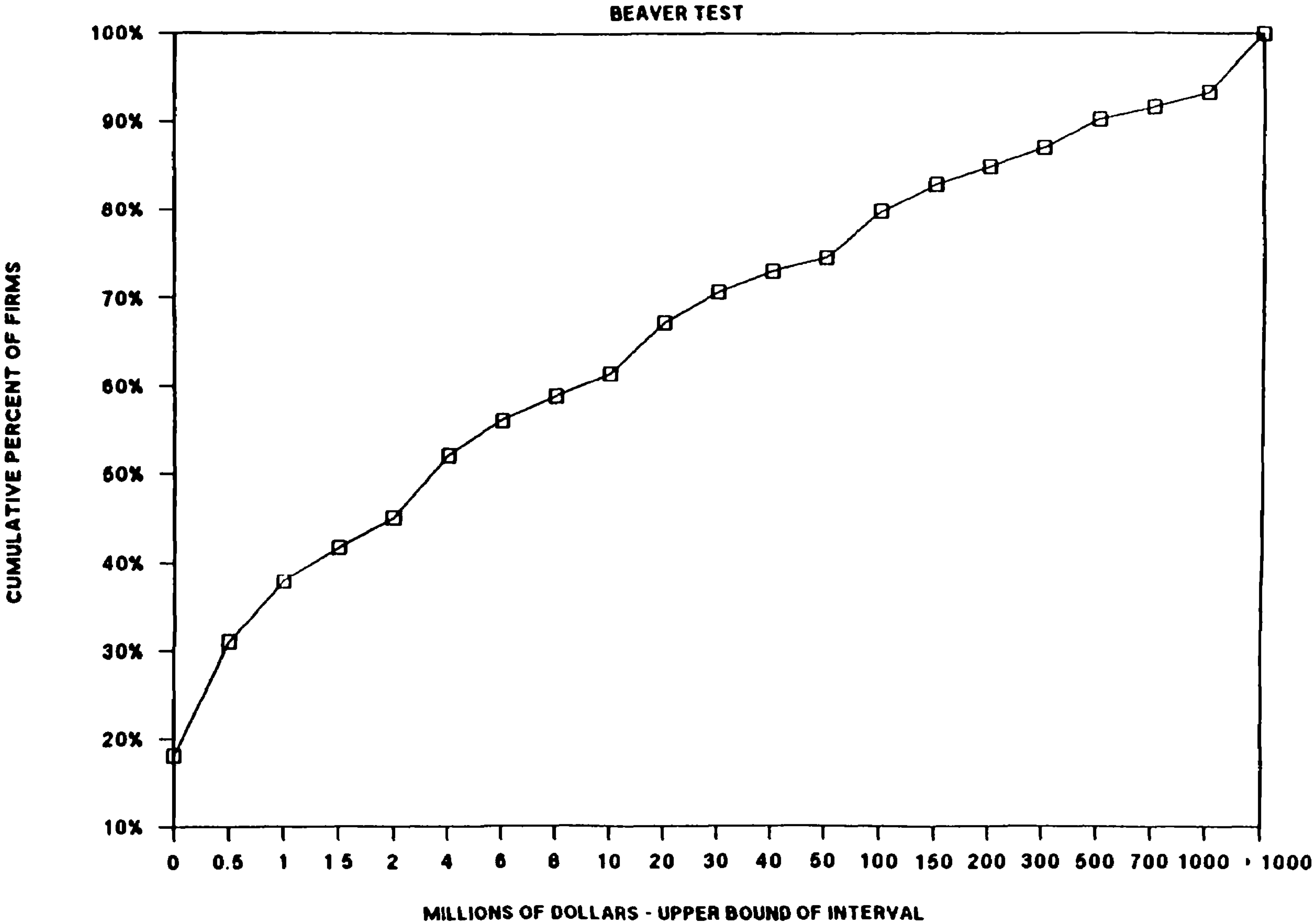
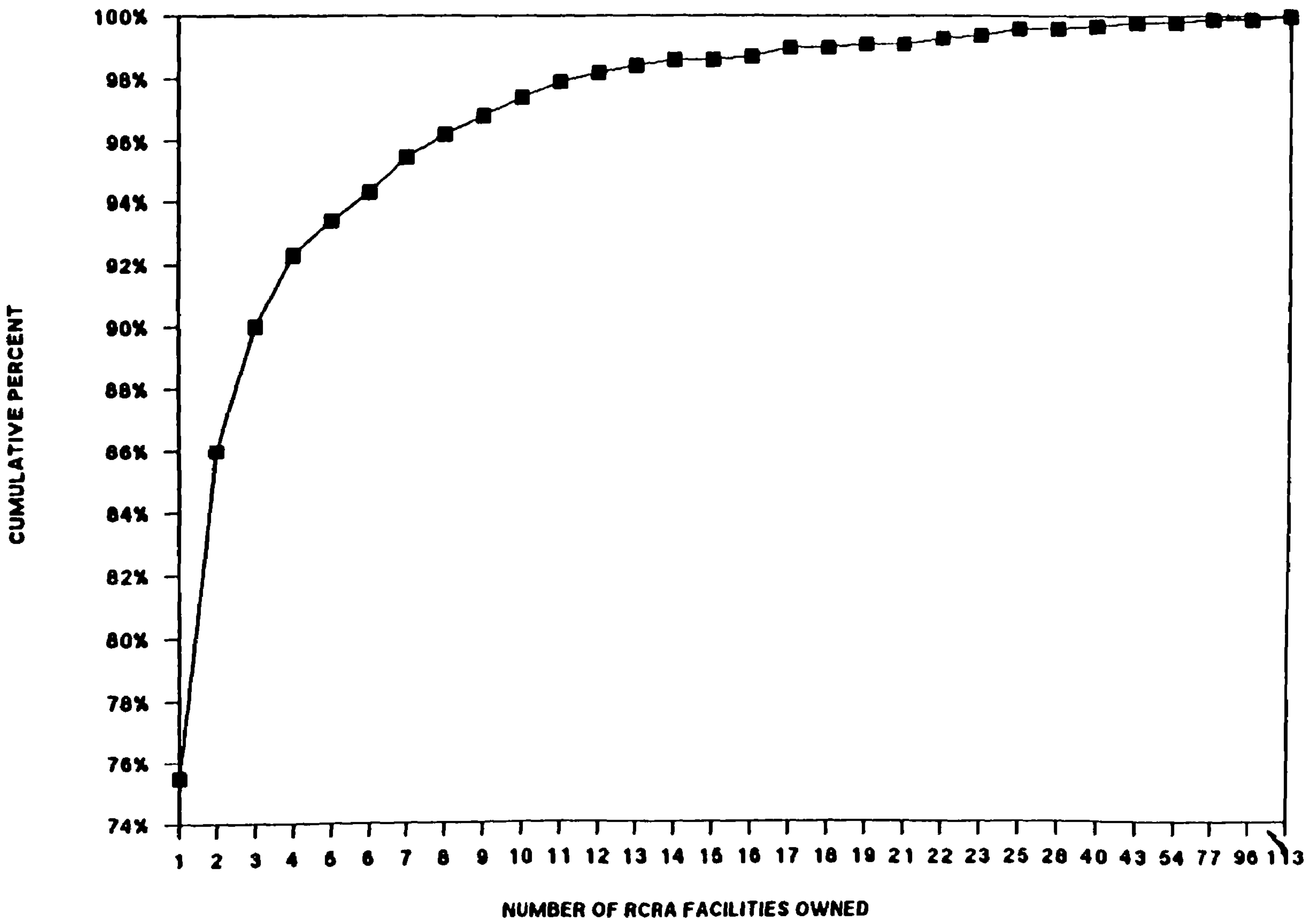


EXHIBIT C-19

DISTRIBUTION OF RCRA FACILITIES OWNED



not seek a permit under RCRA Section 3004(u), it may be required to undertake corrective action under RCRA Section 3008(h). Although EPA has proposed but not finalized the specific details of its financial assurance for corrective action program, the Agency intends to pursue financial assurance for all corrective actions regardless of the authority used to required the action. This simulation assumes that the financial assurance rules, although only proposed, are applicable to ensure that all economic impacts of the corrective action rulemaking are evaluated. Therefore, to estimate the impacts of the financial assurance rules, the model assumes that all facilities, and thus all firms, will require financial assurance.

The financial assurance requirements allow several different mechanisms to be used to provide coverage, including a financial test, letter of credit, trust fund, and surety bond (as explained below, our analysis only addresses the use of the financial test and the trust fund). These mechanisms must be used to provide coverage for the amount of a corrective action cost estimate at a facility. The mechanisms each have different costs; therefore, the use of the mechanisms must be estimated to properly gauge the total costs of providing assurance.

The financial test, a set of criteria through which a firm may demonstrate that it has the financial resources necessary to fund its obligation, is virtually costless.[24] We thus assume that firms eligible to use the financial test will always do so. If a firm passes the test, then it does not have to purchase an assurance mechanism; if a corrective action is incurred, the firm is expected to make arrangements necessary to pay for those costs. The first step in estimating financial assurance costs is, therefore, to estimate whether a firm is able to use the financial test.

The model determines whether or not the firm will pass the financial test and incur no financial assurance costs. The frequency distribution for firms passing the financial test is determined through an analysis of the firms in the F3DB. Because the corrective action rule requires owners or operators using the financial test to pass the test for <u>all</u> Subtitle C financial assurance requirements, we analyzed the F3DB firms for their ability to pass the test to cover the summation of potential closure/post-closure care costs, liability coverage, and corrective action costs. We estimated closure/post-closure costs and liability coverage amounts for each firm based on the type

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[24] <u>Background Document for the Financial Test and Municipal Revenue Test: Financial Test for Closure and Post-Closure Care</u>, Appendix B, U.S. EPA, Office of Solid Waste, November 30, 1981, p. II-14.

of facilities owned by each firm.[25] The results of the F3DB analysis determine the likelihood that a simulated firm will be able to use the test.

If the firm does not pass the financial test, it is assumed by the model to use a trust fund that is funded over a specified pay-in period. This approach, while conservative in that a firm may actually be able to obtain a less expensive mechanism such as a letter of credit, ensures that the firm sets aside funds for corrective action financial assurance. In addition, there is no centralized source of information regarding the degree to which TSDFs use financial assurance mechanisms such as letters of credit.

The model may understate the use of the financial test because it assumes that a firm will either use the financial test for all obligations or none of them. In reality, firms may use the financial test for one type of cost (e.g., liability coverage) and obtain other assurance mechanisms for the other types of coverage. However, modeling the firm's decision rules for using the financial test for a portion of costs would require use of currently unavailable firm-specific information on the costs and availability of mechanisms and the combinations of mechanisms to be used. Moreover, if the financial test is used for corrective action and other mechanisms for the other costs, the costs of the other mechanisms may outweigh the cost savings of using the financial test for corrective action.

Under the terms of the October 24, 1986 proposed rule, a firm is required to fund the trust fund only for the amount of corrective action costs that are estimated to occur in years after the pay-in period. In other words, the trust fund requirements assure that funds for future costs are available by shifting the costs from the time they would have been incurred to the pay-in period of the trust fund. To simulate this regulation in the model, all corrective action costs that are expected after the pay-in period are shifted to the pay-in period. In each year of the pay-in period the trust fund deposit is the total of the costs shifted divided by the pay-in period. These costs are added to the corrective action costs that are already expected to be incurred during the pay-in period.

(5) Determine Annualized Costs for Firm X -- After the corrective action cost flows are adjusted for financial assurance requirements, the costs of corrective action for all facilities owned by a simulated firm are added for each year in the fifty-year period analyzed. Although the firm's corrective action costs may vary widely from year to year, financing allows the firm to smooth costs over time and lessen the impact of higher costs in any particular year. To simulate this effect, the model first discounts the firm's cost flow to present value using the discount rates determined in Section C.2 and

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[25] Data on estimated costs of closure and post-closure care were obtained from estimates by Pope-Reid and Associates, in a memorandum to U.S. EPA, Office of Solid Waste, September 13, 1985. The amounts for liability coverage, under Subtitle C requirements, are $8 million for firms owning or operating at least one land disposal facility and $2 million for firms owning or operating any other Subtitle C facility.

adjusted for taxes. Next, the present value amount is annualized using the formula presented in Section C.2. The annualization period reflects the period over which corrective costs are incurred, subject to a maximum of 50 years and a minimum of 10 years (50 years is the modeling period and 10 years is the assumed minimum period over which debt can be financed).

The regulation specifies the financial assurance trust fund pay-in period for a facility as either one-half of the corrective action period, or 20 years, whichever is shorter. The model, however, does not address the corrective action period on a facility basis. Instead, the corrective action period is modelled on a firm basis. In the analysis, the various corrective action periods for all the facilities owned by each firm are combined and an average duration for corrective action is determined for each regulatory alternative. Then, the model compares one-half of the corrective action period to 20 years and chooses the appropriate pay-in period for each regulatory alternative. Exhibit C-20 displays the pay-in periods for each regulatory alternative.

(6) Test Simulated Firm for Ability to Pay -- When the annualized costs of corrective action are determined, the model compares the results to the ability to pay figure chosen in Step 1. If the firm is able to pay for the sum of the corrective action costs for all of its facilities, then all of the facilities are considered to be covered. If a firm faces no costs at any of its facilities, then it is assumed to not face any adverse impacts regardless of its ability to pay. If the firm is unable to pay all of the costs, then the model estimates the number and percentage of facilities that can be covered and the number and percentage that cannot be covered using a modification of the successive allocation approach.

The successive allocation approach assumes that a firm will fund corrective action costs at each facility successively until funds are exhausted or all costs are covered. Under this approach, the facilities must be ordered in some manner before costs can be allocated. For example, a firm may attempt to cover costs at as many facilities as possible by paying for the least expensive actions first. Alternatively, a firm may fund the most expensive actions first, or may not follow any pattern at all. The model makes the simplifying assumption that the funds are divided equally but successively among all of a firm's facilities requiring corrective action. For example, if a firm has only half of the funds required to cover corrective action costs at all of its facilities, then we assume that half of its facilities will receive sufficient funds to cover their costs and half will not be funded.

The model keeps a running total of the number and percentage of firms and facilities for which corrective action costs may go unfunded, and the amount of those unfunded costs. This information is adjusted after each simulation of a firm and its facilities.

(7) Continue Simulations Until Margin of Error is Reduced to Satisfactory Levels -- The model calculates the degree of error in the estimated percentage of facilities for which corrective action may be funded based on the number of

EXHIBIT C-20

DETERMINATION OF TRUST FUND PAY-IN PERIOD

Regulatory Alternative	Average Corrective Action Period (years)	Trust Fund Pay-in Period (years)
Baseline	More than 40 years	20
Option A	26	13
Option B	More than 40 years	20
Option C	27	13
Option D	26	13

iterations performed. The model continues to simulate firms until the error is reduced to a satisfactory level.

For this analysis, 5,000 iterations were conducted for each model run. Separate runs were conducted for small and large firms as defined by criteria established under the Regulatory Flexibility Act for the baseline and each regulatory option. The estimates of economic impacts on the entire population of firms was determined using a weighted average of the results for small and large firms. We used this approach because the probability distributions for ability to pay and facility ownership are significantly different for small and large firms. Combining data on these firms into a single probability distribution would entail such wide ranges that the results would be subject to a great deal of error. Moreover, the firms had to be separated into small and large populations to examine the effects of the corrective action program on small businesses as required by the Regulatory Flexibility Act. Economic impacts on small and large firms as distinct groups are discussed in Chapter 11.

Given the nature of the model, results are produced for the simulated population of firms and facilities rather than the actual members of the regulated community. The results of the analysis are in percentage terms that relate to the simulated set of firms and facilities. To extrapolate the results to the regulated community, these percentages must be multiplied by the actual number of small or large firms (or facilities owned by those firms) known to exist in order to obtain approximations of the impacts on the actual RCRA universe of firms and facilities.

The total number of firms encountering adverse impacts is determined by a summation of the small and large firm results. The percentage of large firms estimated by the model to encounter adverse impacts is multiplied by 1,295 to estimate the number of large firms adversely impacted; the percentage of small firms estimated to encounter adverse impacts is multiplied by 1,102 to estimate the number of small firms adversely impacted.[26]

The total number of facilities in each category is again determined by adding the results for the large and small firm groups. The model generates the percentage of facilities owned by each group that are in each category;

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26 These numbers are approximations based on the following logic. We know that there are 5,661 total RCRA facilities (see Section 10.1), and we know that firms own 92 percent of facilities for which ownership information exists (4,540 of 4,958). Therefore, multiplying 5,661 by 92 percent, we estimated that 5,208 facilities are owned by firms. Next, we know that large firms own about 75 percent of facilities at a rate of 3 facilities per firm, compared to 25 percent owned by small firms at a rate of 1.2 facilities per firm. Applying these weights of small and large to the 5,208 facilities gives a result of 1,295 large firms and 1,102 small firms.

these percentages are multiplied by 3,885 for large firms and 1,323 for small firms.[27]

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[27] We established in footnote 26 that approximately 5,208 facilities are owned by firms. We know that of facilities for which ownership information exists, 75 percent are owned by large firms and 25 percent are owned by small firms. We therefore extrapolate this percentage to the estimated number of facilities and obtain results of 3,885 facilities owned by large firms and 1,323 facilities owned by small firms.

APPENDIX D

This Appendix presents a summary of 46 Superfund Records of Decision (RODs) taken from EPA's fiscal year 1987 ROD annual report. These RODs were chosen as representative sites requiring corrective action for hazardous waste releases to ground water, soil, surface water, and air, and are presented to support the media-specific discussions in Chapter 4.

Each ROD was summarized to present the area of contamination, the state in which the site is located, the corrective action activities taken at the site, an indication of the principal media of concern, and the annualized cost for the total corrective action effort. As this Appendix illustrates, corrective action activities often must be taken to address releases to two or more media at a single site.

REPRESENTATIVE CERCLA CORRECTIVE ACTION ACTIVITIES FOR RELEASES TO ALL MEDIA *

FACILITY (ACREAGE)	STATE	CORRECTIVE ACTIONS	CONTAMINATED MEDIA ** GW	SOIL	SW	AIR	ANNUALIZED *** COSTS
1 (245)	MA	- Site gradation and installation of permeable soil cap over 1,000 c.y. of contaminated sludge and soils - GW pumping and treatment (odor control) - Waste pile stabilization and cap installation with gas collection layer - Treatment of gaseous emissions, WQ & AQ monitoring	X	X		X	$2,400,000
2 (115)	NJ	- Installation of 65-acre cap with gas collection system - Pumping and treatment of shallow GW - Construction of surface runoff controls - Provision of alternate drinking water supply, fencing, and GW monitoring	X	X	X	X	$8,200,000
3 (26)	NJ	- Construction of landfill cap - GW and leachate extraction and pretreatment - GW monitoring and perimeter fencing	X	X		X	$2,500,000
4 (44)	DE	- Backfilling and capping of landfill including gas venting system - Installation of SW drainage ditches - GW monitoring to determine remedial action	X	X	X	X	$2,300,000
5 (13.6)	PA	- Installation of RCRA cover on landfill with gas venting system - Diversion of SW and extension of public water supply to 12 houses - Excavation of buried waste and drums for offsite disposal - Sampling, pumping, and treatment of GW, sampling of SW	X	X	X	X	$2,700,000
6 (2 houses)	PA	- Dismantling of 2 houses - Packaging, sealage, and disposal of radioactive materials - Excavation and disposal of local contaminated soils - Sewer removal and replacement of 200 ft of sewer line		X		X	$670,000
7 (N/A)	KY	- Drum removal and disposal - Soil capping with gas venting system - Riverbank erosion protection and SW treatment - GW, gas, & air monitoring, and evacuation of 7 families	X	X	X	X	$350,000
8 (40)	IN	- Consolidation of 2,500 c.y. contaminated soils and sediments - Installation of soil cover over landfill with drainage blanket - Extension of public water supply - Establishment of GW, SW and sediments monitoring	X	X	X	X	$710,000
9 (4.5 miles of streets)	CO	- (No action alternative) - Evaluation of problem and design of institutional controls		X		X	$319,000

			GW	SOIL	SW	AIR	ANN. COSTS
10 (60)	NJ	- Capping of 29-acre landfill with gas collection system - Removal and offsite disposal of lagoon sediments and liquids - Construction of slurry wall,GW and SW interceptor systems - Leachate treatment and offsite disposal	X	X	X	X	$1,500,000
11 (N/A)	NY	- Hydraulic dredging & offsite disposal of 23,000 c.m. sediment - SW treatment and disposal - Marsh restoration & longterm monitoring		X	X		$6,300,000
12 (N/A)	DE	- Excavation and removal of 25,000 c.y. sludge,soils, & SW - Installation of synthetic liner, cover and cap for storage area - Installation of GW recovery wells & monitoring system	X	X	X		$355,000
13 (N/A)	KY	- SW diversion and onsite pond drainage - Consolidation of pond sediments, sludge and materials - Installation of clay cap and monitoring system			X		$130,000
14 (5)	TN	- Excavation of 1,600 c.y. of pond sediments - Dilution of pondwater from three onsite ponds - GW monitoring and pond sediment consolidation	X	X	X		$220,000
15 (3)	AL	- Excavation, removal, & disposal of UST's and swamp waste oils - Diversion of surface runoff - Gradation and revegetation of swamp area - Soil excavation and incineration		X	X		$740,000
16 (11)	FL	- RCRA landfill closure - Leachate collection, treatment, & onsite disposal - SW treatment and cover system for sludge pond waste		X	X		$120,000
17 (10)	MI	- Drainage of wetlands - Removal and treatment of 250 c.y. sludge for offsite disposal - Purging and treatment of GW for three years	X	X	X		$330,000
18 (3.5 mile channel)	OH	- Excavation of 52,000 c.y. brook sediments (36,000 solidified & stored onsite, 16,000 thermally treated) - Treatment of wastewater from sediment dewatering		X	X		$5,800,000
19 (185)	TX	- Onsite incineration of 150,000 c.y. sludges and soils - Backfilling of excavated areas with residue ash - Treatment and discharge of contaminated SW		X	X		$16,800
20 (4,400)	CA	- Capping of 2.5 acres with soil/cement mixture - Major SW diversions and dam enlargements - Hydrogeologic studies and perimenter controls		X	X		$15,300,000
21 (320)	WA	- Excavation and processing of 22,000 c.y. of sludge and waste from onsite ponds - Capping of waste ponds - SW diversion and monitoring system		X	X		$550,000

			GW	SOIL	SW	AIR	ANN. COSTS
22 (20)	MA	- Removal and incineration of 190,000 c.y. soil - GW extraction and treatment - Wetland restoration,levee construction,brook relocation - GW and Air monitoring	X	X	X	X	$11,400,000
23 (375)	NH	- Excavation and treatment of 10,800 c.y. soils and sediments - Restoration, regrading, and revegetation of excavated wetlands - GW extraction and offsite treatment	X	X	X		$1,200,000
24 (12.2)	NJ	- Excavation, treatment,& backfilling of 28,000 c.y. of soils and sediments - Construction of secure landfill - Treatment of local wells via air stripping - Extension of public drinking water to local residents	X	X	X		$950,000
25 (103)	NJ	- Gradation, compaction, and capping of 65-acre landfill - Installation of SW drainage system with perimeter ditches - Installation of methane ventilation system and perimeter fencing - Initiation of GW monitoring	X	X	X	X	$1,900,000
26 (40)	NJ	- Excavation and offsite disposal of 6,500 c.y. soil - Filling and gradation of extracted area - Extraction and onsite treatment of GW - Perimeter fencing and monitoring	X	X			$990,000
27 (N/A)	NJ	- Excavation and onsite treatment of 10,000 c.y. soils - Offsite disposal of 4,000 c.y. soils in RCRA landfill - Evaluation of extent of GW contamination - Provision of alternate water supply for local residents	X	X			$2,100,000
28 (15)	NJ	- Removal and offsite disposal of storage tank & contents - Excavation of 2,700 c.y. surface soils, lagoon sediments, and liquids - Site cover installation - GW extraction and treatment	X	X	X		$1,100,000
29 (N/A)	PA	- Excavation and removal of 3,900 c.y. soils - Drainage and removal of 192,000 gallons of lagoon liquid and sediments - Removal of all tanks, buildings, and contaminated debris		X	X		$515,000
30 (N/A)	WV	- Excavation and consolidation of 3,600 c.y. soils - Biodegradation of soils in onsite treatment bed - Construction of SW diversion dikes and sedimentation channels		X	X		$180,000
31 (84.5)	PA	- Capping of excavated & consolidated contaminated soils and sediments - Site grading, and revegetation of soil cover and cap - Construction of flood retention & SW management basins and ditches - Pumping, treatment, and monitoring of GW	X	X	X		$2,500,000

			GW	SOIL	SW	AIR	ANN. COSTS
32 (11)	FL	- Excavation,onsite incineration, and backfilling of 9,000 c.y. soils - GW recovery and treatment	X	X			$620,000
33 (3)	KY	- Excavation and offsite disposal 8,000 c.y. soils - Extraction, offsite treatment, & reinjection of GW - Backfilling of excavated areas	X	X			$2,800,000
34 (3.5)	FL	- Excavation, aeration, & treatment of contaminated soils - Recovery, treatment, and reinjection of GW	X	X			$471,000
35 (30)	FL	- Collection and disposal of free oil - Excavation, stabilization & solidification, and onsite placement of 57,000 c.y. of soils - Implementation of institutional land use controls and GW monitoring	X	X			$900,000
36 (45)	FL	- Excavation, fixation,& onsite disposal of 94,000 c.y. of soil and 20,000 c.y. of pond sediments - Treatment and discharge of SW and GW aquifers	X	X	X		$2,400,000
37 (4.5)	OH	- Removal of 20,000 c.y. onsite soil for offsite disposal - Removal of offsite soils & sediments to background concentrations - Removal of 3,800 c.y. of battery casings - Improvement of site drainage & cleaning of contaminated facilities		X			$1,700,000
38 (10)	MN	- SW diversion - Excavation of 4,600 c.y. sludge and 20,500 c.y. soils and sediments for onsite incineration - GW pumping and treatment - Extension of public water supply	X	X	X		$3,800,000
39 (N/A)	MN	- Excavation, onsite treatment and storage of soils and sludges - Installation of irrigation and leachate collection systems - Removal of contaminated standing waters - Backfilling and capping of excavated areas		X	X		$130,000
40 (112)	MN	- Excavation, treatment, and offsite disposal of 4,000 c.y. of sludges, sediments, and soils - Removal, treatment, and disposal of 110,000 gallons of aqueous lagoon wastes		X	X		$210,000
41 (N/A)	IL	- Excavation and onsite incineration of 25,530 c.y. soils - Replacement of excavated soils with clean fill - Conventional industrial cleaning of the site		X			$4,300,000

			GW	SOIL	SW	AIR	ANN COSTS
42 (N/A)	MI	- Excavation, seperation, and offsite disposal of 15,000 c.y. of waste materials and soils		X			$2,600,000
43 (13.5)	TX	- Removal and disposal of surface structures in offsite fill - Excavation and disposal offsite of 22,500 c.y. soils - Construction of multi-layer site cap and 30 ft deep slurry wall - GW treatment and monitoring at depth	X	X			$3,000,000
44 (N/A)	MO	- Excavation, containerization, and offsite incineration of 20,000 c.y. of soils - Excavation, sampling,overpacking, and offsite disposal of buried drums		X			$3,300,000
45 (110)	CO	- Excavation and onsite disposal of contaminated soils - Provision of alternate water supply to 5-7 residences - Install RCRA multilayer cap - Conduct supplemental RI/FS, mine reclamation, and 5 years of GW monitoring	X	X			$330,000
46 (N/A)	OR	- Limited excavation and offsite disposal of 350 tons of contaminated soils - Installation of 15 shallow GW extraction wells - Extraction and onsite treatment of GW	X	X			$520,000

* = Figures taken from EPA FY 87 ROD annual report.

** = Columns marked "X" denote principal media(s) of concern during corrective action activities. A marked column does not mean that contamination of that media necessarily exceeded health based standards.

*** = Annualized corrective action costs include the capital cost discounted over ten years and the first year operation and maintenance costs (all estimates rounded to two significant figures).

N/A = Not Available from report.