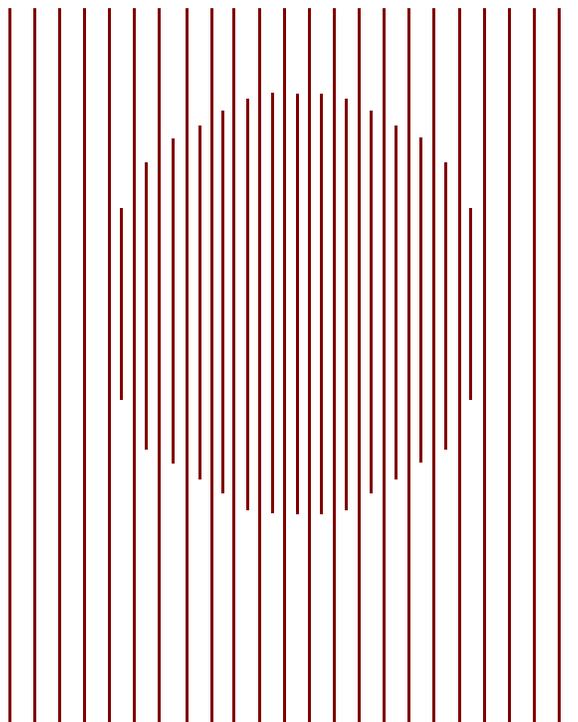


CBO PAPERS

**CLEANING UP
DEFENSE INSTALLATIONS:
ISSUES AND OPTIONS**

January 1995



CONGRESSIONAL BUDGET OFFICE

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**CONGRESSIONAL BUDGET OFFICE
SECOND AND D STREETS, S.W.
WASHINGTON, D.C. 20515**

NOTE

Unless otherwise noted, all dollar amounts are in 1995 dollars, and all years are fiscal years.

PREFACE

The Department of Defense (DoD) has devoted more than 10 years and \$11 billion to identifying, studying, and cleaning up contamination on thousands of military installations across the nation. During the past decade, the Congress has provided funding for DoD's environmental cleanup program that DoD considers sufficient to meet existing legislative and regulatory requirements. Given the rising costs of cleanup and budget increases in recent years, the department will probably need additional funds beyond those in the current budget plan to continue to meet the program's objectives. If the Congress chooses not to provide funding to meet existing requirements, legislative and regulatory relief may be required to enable the department to proceed with the cleanup program in accordance with cost-effective priorities that protect the health and safety of the population. Meanwhile, the department and the Congress could consider policy alternatives on which to base such priorities.

This Congressional Budget Office (CBO) paper describes the progress of DoD's cleanup program, examines its cost and budget history, and discusses current issues affecting the potential for successful implementation of future remediation efforts. It also discusses various steps that DoD and the Congress could take to control costs in the near and long term. The paper was requested by the Chairman and the Ranking Minority Member of the Senate Committee on Armed Services.

Wayne Glass prepared this paper under the direction of Neil M. Singer; Frances Lussier and Shaun Black provided important assistance. The author appreciates the thoughtful critiques and suggestions of Perry Beider, John Klotz, Bob Oswald, and Vic Weiszek. Many individuals at the Department of Defense, the Army Corps of Engineers, and the General Accounting Office provided helpful information, and their cooperation is gratefully acknowledged. The information, discussion, and analysis contained in the paper, however, remain the responsibility of the author and CBO.

Sherry Snyder edited the paper, and Chris Spoor provided editorial assistance. Cynthia Cleveland and Judith Cromwell prepared it for publication.

Robert D. Reischauer
Director

January 1995

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SUMMARY

Environmental contamination of thousands of military facilities is a costly legacy of the Cold War for which the nation is paying increasing costs. The Department of Defense (DoD) has spent about \$11 billion on investigating, studying, and cleaning up contamination on military bases since 1984 and recently estimated that finishing the job could cost as much as \$30 billion. In 1995, the Congress authorized the department to spend about \$2.5 billion on environmental cleanup projects. According to current plans, the department expects to request another \$2.6 billion in 1996.

The current Administration has undertaken an ambitious, comprehensive plan to clean up defense installations in accordance with federal and state laws and regulations within the constraints of increasingly tight defense budgets. To date, the Congress has been able to authorize sufficient funding to meet DoD's requirements. Given the increasing costs of remediation, however, DoD may not be able to meet the requirements of its cleanup program on schedule and within budgetary projections. The Department of Defense and the Congress could consider alternative approaches to the cleanup program to ensure that the department's most important cleanup requirements are met within increasingly constrained budgetary allowances. This paper outlines the scope and nature of the cleanup tasks that DoD faces and assesses the department's progress and problems in implementing effective remediation actions. The study also discusses near- and long-term strategies for meeting cleanup goals, should the current plan prove unachievable.

SCOPE OF THE CLEANUP PROBLEM

The Department of Defense faces a massive environmental cleanup problem extending to some 27,700 potentially contaminated sites located on more than 9,700 military installations and former defense properties in all 50 states. Most of the contaminated sites are in states such as California, Texas, Alaska, Pennsylvania, and Virginia in which numerous defense facilities are located. The department has determined that many of those sites pose no hazard to public health and safety and require no further cleanup action. As a result, the number of active sites--those being studied and remediated--totaled about 13,200 as of March 1994. After years of study, DoD believes that it has identified virtually all potentially contaminated sites on its property. The

number of such sites, including the most seriously polluted--those that are on the National Priorities List (NPL)--continues to grow each year. DoD manages cleanup efforts at 107 bases that are on or proposed for inclusion on the NPL; those bases are located in 39 states.

The department's cleanup tasks are, for the most part, similar to those found in the civilian sector. With few exceptions such as buried ordnance and mixed waste containing radioactive materials, DoD requires no unique remediation technology to meet its needs. Common contaminants on military bases include petroleum, oil, and lubricants needed to operate and maintain equipment, as well as solvents, heavy metals, paint, acid, asbestos, and pesticides. The types of contaminated sites located on defense properties are also similar to those in the civilian sector. Storage areas, underground storage tanks, landfills, contaminated buildings, and polluted lagoons are characteristic problems for both military and civilian authorities. Consequently, investments by DoD in research and development of new technologies for locating, characterizing, and remediating contamination could have widespread dual-use applications.

The focus of DoD's environmental program during the past 20 years has been on locating and studying the characteristics of contaminated sites. Virtually all of the preliminary work is complete. As of the end of fiscal year 1993, DoD reported that it had finished about 96 percent of its initial assessments. About half of the active sites are now in the middle phase of the cleanup process--the remedial investigation/feasibility study phase--during which the sites are tested and sampled and initial plans for remediation are formulated. Only about 20 percent of DoD's active cleanup sites have completed that phase, however, making it unlikely that the department will achieve its goal of completing all studies by 1996.

Although the department has completed more than a thousand interim cleanup measures needed to protect human health and safety, almost all of the actual cleanup work for all sites, including NPL sites, has yet to be done. As of the end of fiscal year 1993, about 5 percent of all active sites and about 3 percent of the NPL sites had been cleaned up. Actual completion rates could be lower, however, since by the definition of the Environmental Protection Agency (EPA), a site has been "cleaned up" once contamination has been remediated or technology has been put in place and is operational, even though cleanup standards have not yet been achieved.

COST OF THE CLEANUP

Defense spending for environmental cleanup has increased dramatically during the past decade and could necessitate additional increases if current legal and regulatory requirements are to be met. In 1984, DoD spent about \$200 million for environmental cleanup; today's budget is about \$2.5 billion. On average, spending for cleanup has increased 23 percent each year during the past decade while budgets for research, development, and procurement of military weapons have decreased by about 7 percent each year. According to current plans, DoD projects significant reductions in spending for environmental cleanup during the next few years, when many projects will begin the transition from study and analysis to remediation. Until last year, most of the cleanup budget was allocated for studies; cleanup costs first exceeded 50 percent in 1994 when relatively few sites were actually in the final phase of cleanup. Competition for funding among various environmental programs is likely to become increasingly intense during the next several years, requiring trade-offs between meeting near-term cleanup requirements and long-term investments in more efficient cleanup methods.

Changes in DoD's cost estimates and budget plans continue to reveal the high degree of uncertainty that characterizes the cleanup program. In 1985 DoD estimated that completing the cleanup program would cost between \$6.9 billion and \$13.7 billion (1995 dollars). DoD recently estimated that the program could cost about \$30 billion. Annual budget requests have also risen. In 1989, the department estimated that it would need between \$900 million and \$1.2 billion to fund cleanup requirements in 1994; the Congress authorized about twice the higher estimate. Similar trends in cost growth have occurred at individual military bases. The Inspector General of DoD found that average cleanup costs for defense facilities scheduled to be closed were about 60 percent higher than initial estimates.

Although DoD now knows much more about the cleanup job it must do, much uncertainty remains about future costs. For example, each year the department identifies new contaminants on existing sites as well as additional polluted sites. Furthermore, most sites are still in the study phase, and plans to remediate them have yet to be decided, thereby adding to the uncertainty of cost estimates. The time needed to complete studies, analyses, and remediation also remains highly uncertain. Recent court rulings could also drive up costs by leading to stricter cleanup standards than those DoD planned to meet.

ALTERNATIVE STRATEGIES FOR MEETING DoD's CLEANUP GOALS

Given the dramatic growth in spending for environmental cleanup, the limited progress made to date, and the probability that if current cost trends continue, the department will be unable to afford to meet requirements within current budget plans, the Congress and DoD may want to consider various ways to meet the concurrent goals of efficiency and cleanup requirements. In doing so, both near-term and long-term strategies could be useful.

An important first step in meeting near-term needs could be to establish priorities for cleanup and then to rank all contaminated sites on defense installations and former defense properties. Future funding for cleanup could vary from year to year, but high-priority cleanup projects would be assured stable funding. Such guidance could maintain the present policy to remediate first the most seriously contaminated sites that are dangerous to human health and safety. Within that category, however, lower priority would be appropriate for those sites that, although located on NPL installations and technically considered as part of an NPL site, do not present immediate threats to health or the environment. In order to assist in establishing priorities among such sites and other sites that are not on the NPL, the Congress could consider requiring the department to improve its methods of determining the relative hazards posed at each site.

In setting priorities, DoD could also consider which sites at closing military bases would warrant the most immediate attention. DoD could give priority to sites that could be sold and generate revenues to finance other defense cleanup activities and to sites that are likely to generate significant commercial activity to aid in local economic recovery. Indeed, the department could rank the sites based in part on some measure of the relative impact of cleanup activities on the local economy. Under that approach DoD could give priority to cleaning up bases in small communities whose economies have depended heavily on nearby military installations, or to larger communities affected by numerous base closings that, individually, might not be considered to have a significant local economic impact.

The department could also achieve near-term savings by delaying its most difficult and costly remediation projects that do not pose an immediate danger to public health and safety. Cleaning up buried ordnance and groundwater are among the most expensive and difficult remediation tasks. DoD could reduce near-term spending by billions of dollars by delaying remediation for sites contaminated with such materials. The department

would have to determine at which sites cleanup could safely be delayed before postponing cleanup activities.

A similar approach could apply to remediating groundwater sites. Potential near-term savings from delaying groundwater cleanup could total hundreds of millions of dollars. Such delays, however, could in some cases require renegotiating existing interagency agreements between DoD, the Environmental Protection Agency, and the states.

The department could achieve long-term savings by developing more efficient technologies while delaying the most difficult and expensive types of cleanups and perhaps other types of remediation. Data from laboratory and field tests indicate that emerging technologies could achieve significant savings in cleaning up a wide variety of contaminants. Although DoD has increased its spending on research and development (R&D) of new cleanup technologies, in 1994 it allocated about 6 percent of its environmental budget for that purpose. According to DoD's strategic plan for research and development, many R&D projects remain unfunded. Additional R&D funding could help to reduce long-term costs, but it should be examined for redundancy with other R&D projects funded either by the Department of Energy or EPA.

A new approach to setting cleanup standards could also contribute to achieving long-term savings. Current legislation and regulations favor the stricter cleanup standards when agencies disagree over appropriate cleanup goals. They also favor using permanent measures of remediation, which, when combined with stricter standards rather than the reasonably anticipated use of a property, could support unlimited future use. The Congress could consider legislation that approved using more flexible standards or, alternatively, that adopted less restrictive standards on a generic basis for various types of contaminants. The latter would create uniform cleanup standards for all federal EPA regions and could preempt disagreements that now occur as a result of differing standards required by the Resource Conservation and Recovery Act and the Comprehensive Environmental Response, Compensation, and Liability Act.

CHAPTER I

INTRODUCTION

The Cold War era focused U.S. defense efforts on building, training, equipping, and operating a military force to deter the Soviet Union and Warsaw Pact from initiating a military conflict. The history of the arms competition between East and West is well known, but awareness of the hidden costs of the Cold War has evolved only slowly. It is increasingly clear that the environmental contamination of the Department of Defense's (DoD's) military installations, which affected thousands of bases and communities throughout the nation, is a costly legacy of the Cold War era. Cleaning up that legacy has become a national priority.

The current Administration has committed itself to pursuing environmentally conscious defense programs and policies and has undertaken an ambitious, comprehensive plan to clean up the nation's military installations. However, it faces serious difficulties in achieving DoD's cleanup goals within existing schedule and budget constraints. DoD will probably not be able to meet the objectives of its cleanup program on schedule and within budgetary plans. The department and the Congress have therefore begun considering alternative approaches for overcoming various cost and schedule constraints.

DoD initiated a major environmental cleanup program in 1975 when it established the Installation Restoration Program to study and clean up contaminated sites located on defense installations. Later, DoD integrated that program into a more comprehensive one, the Defense Environmental Restoration Program (DERP).¹ The Congress authorized DERP in 1984 and at the same time established the Defense Environmental Restoration Account (DERA) to ensure visibility for the program and to encourage sufficient funding for environmental cleanup of defense facilities.

Funding for DERA has grown from about \$200 million in 1984 to over \$2 billion in 1995. Total funding for cleanup in 1995 is about \$2.5 billion, including DoD's request for funds to clean up bases affected by recommendations of the Defense Base Closure and Realignment Commission. Although the department's plans call for a reduction in funding over the next

1. The Defense Environmental Restoration Program includes the following programs: Hazardous Waste Disposal, Building Demolition/Debris Removal, Other Hazardous Waste, and the Installation Restoration Program. Funding for those programs is allocated to the Defense Environmental Restoration Account.

few years, budget requests could continue to grow if DoD is to meet the current cleanup plans and requirements.

Cleanup costs are likely to grow for several reasons. First, much remains unknown about the nature and scope of work to be done. Although DoD has made considerable progress in identifying and characterizing contaminated sites nationwide, it continues to discover new sites each year and to find out that some sites are more contaminated than originally thought. Even now, about 20 years after DoD established a cleanup program, the department is still primarily involved in locating and characterizing hazardous materials at its facilities. Actual cleanup activities are under way at very few sites; permanent remedial actions, for example, are under way at only 333 of some 10,400 of DoD's most hazardous sites.

Cleanup standards also have an effect on the ultimate cost of remediation; stricter standards than those preferred by DoD can increase costs considerably beyond original estimates and have done so in the case of cleaning up groundwater at Mather and George Air Force bases in California. National standards do not exist for the most common contaminants; therefore, DoD must negotiate cleanup standards for its most contaminated sites with the Environmental Protection Agency (EPA) and the affected state. Negotiated standards could be stricter--and more expensive--than those underlying DoD's initial cost estimates. Under current legislation, if standards set by the state exceed those of EPA or DoD, the state standards must be met. In fact, disagreements over standards have occurred, and the courts have ruled in favor of state-sponsored standards that could result in higher costs than anticipated for cleaning up defense facilities such as the Rocky Mountain Arsenal.²

Uncertainty in estimating costs has also contributed to unanticipated cost growth for cleanup and is likely to continue to do so. DoD's initial cost estimates for the cleanup program were not supported by extensive research or analysis and have proved overly optimistic. In 1985, for example, DoD estimated that cleaning up all hazardous waste sites would cost between \$7.0 billion and \$13.7 billion.³ Recently, DoD officials estimated that completing the program could cost about \$30 billion.⁴ Of course, the Defense

2. General Accounting Office, *Environmental Cleanup: Too Many High Priority Sites Impede DoD's Program*, GAO/NSIAD-94-133 (April 1994), pp. 23-24.

3. General Accounting Office, *Hazardous Waste: DoD Estimates for Cleaning Up Contaminated Sites Improved but Still Constrained*, GAO/NSIAD-92-37 (October 1991), p. 3.

4. General Accounting Office, *Environmental Cleanup*, p. 6.

Department knows considerably more about the nature and scope of the cleanup work to be done than it did 10 years ago, but significant uncertainty exists even for more recent estimates. The General Accounting Office observed that DoD estimates were prepared using a "top-down" approach based on historical costs for various phases of the cleanup process, not on the estimated cost for individual sites.⁵

Cleanup costs have also increased beyond initial estimates because early plans for cleanup did not fully consider the costs of remediating hundreds of bases that are to be closed. In its first round of recommendations in 1988, the Defense Base Closure and Realignment Commission did not require precise cost estimates for cleaning up bases, because the government was liable for cleanup costs under any circumstances and such costs would not have affected the long-term savings to be gained by closing a facility. DoD currently estimates that cleaning up the bases already directed to be closed will cost about \$4.3 billion through 1999. Next year, the department will decide to close additional bases, which could add significantly to the total cleanup cost.

Given the increasing costs of the cleanup program and the legislative and budgetary constraints that govern its future, the time is right to consider various approaches to ensuring the future affordability of cleaning up the nation's defense facilities. This paper seeks to assist the Congress by reviewing DoD's progress in cleaning up its facilities, highlighting the major issues that affect the efficiency and costliness of the cleanup program, and outlining various ways to reduce program costs.

5. General Accounting Office, *Federal Facilities: Agencies Slow to Define the Scope and Cost of Hazardous Waste Site Cleanups*, GAO/RCED-94-73 (April 1994), p. 23.

CHAPTER II

DoD's EXTENSIVE AND COMPLEX

CLEANUP TASKS

Environmental contamination is widespread among active and former military facilities and constitutes a formidable cleanup task for the Department of Defense. DoD estimates that it is responsible for about 27,700 contaminated sites that could require remediation. Those sites are dispersed among thousands of bases to be cleaned up through DoD's Installation Restoration Program and on formerly used defense sites (FUDS) located nationwide. As more research is done, the size of the potential cleanup task continues to increase significantly each year.

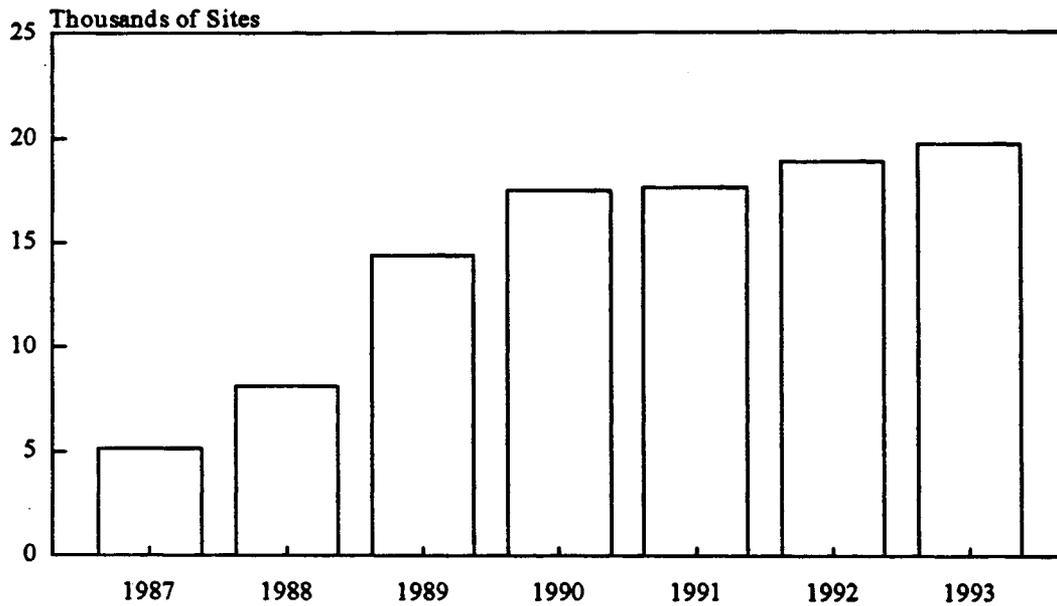
ESTIMATES OF POTENTIALLY CONTAMINATED SITES

The number of potentially contaminated sites identified by DoD on active military installations has increased dramatically--almost 25-fold--during the past decade. Most of the increase occurred during the late 1980s when DoD began a comprehensive program to locate and investigate potentially contaminated sites. For example, in 1985, DoD estimated that some 400 to 800 sites would require remediation.¹ Two years later, the department reported over 5,000 sites.² In the following year, it reported over 12,000 sites.³ In recent years, the rate of increase has begun to slow, however; according to DoD, the total number of sites included in the Installation Restoration Program had increased by only about 5 percent during fiscal years 1992 and 1993, from 18,795 sites to 19,694 (see Figure 1).

The number of the most seriously contaminated areas identified by DoD--those listed on the National Priorities List (NPL)--has also increased dramatically. (NPL sites are those that score above 28.5 according to the Hazard Ranking System, an evaluation system used by the Environmental Protection Agency to measure the toxicity of contaminants; their mobility through air, water, and soil; and the potential danger they pose to the health

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1. General Accounting Office, *Hazardous Waste: DoD Estimates for Cleaning Up Contaminated Sites Improved but Still Constrained*, GAO/NSIAD-92-37 (October 1991), p. 3.
 2. Department of Defense, Defense Environmental Restoration Program, *Annual Report to Congress for Fiscal Year 1987* (March 1988), p. 6.
 3. General Accounting Office, *Hazardous Waste*, p. 3.

FIGURE 1. NUMBER OF POTENTIALLY CONTAMINATED SITES IN DoD's INSTALLATION RESTORATION PROGRAM, 1987-1993



SOURCE: Congressional Budget Office using data from the Department of Defense, Defense Environmental Restoration Program, *Annual Report to Congress*, Fiscal Years 1987-1994.

of the local population.) Between 1987 and 1992, that number rose from 44 to 101, an increase of almost 130 percent. That rate has since slowed--to about 6 percent during the 1992-1993 period, at the end of which DoD had 107 listings on the NPL (see Figure 2).⁴

DoD has also identified an increasing number of potentially contaminated sites on former military properties that the department remains responsible for remediating. The increase in the number of formerly used defense sites, however, has been less dramatic than that of other categories of sites. At the end of 1993, DoD reported about 8,000 contaminated FUDS, up from about 7,200 in 1987--an increase of about 11 percent.

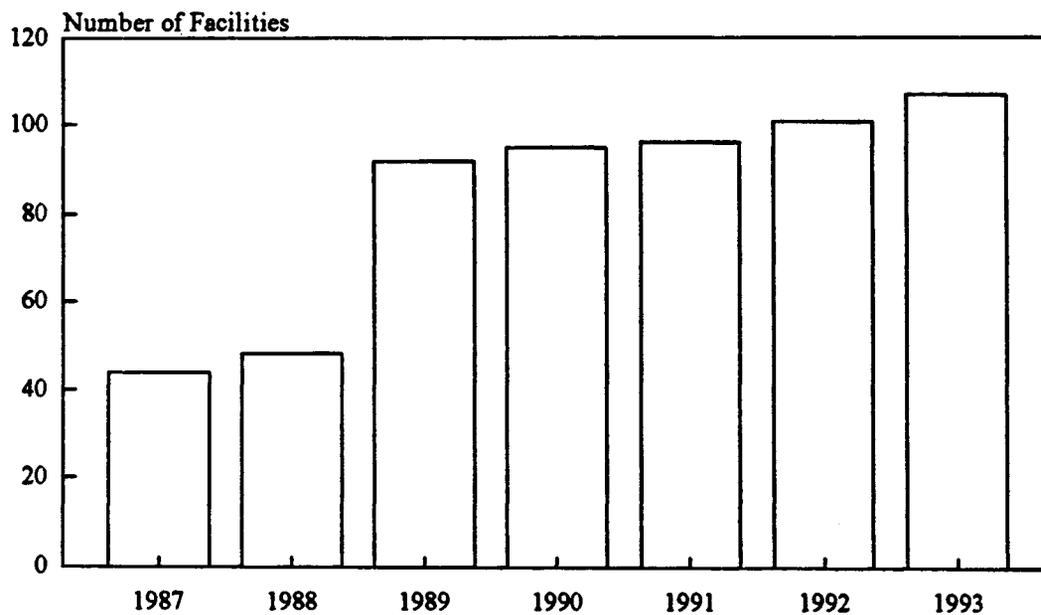
DoD's cleanup task, though massive by any standard, might prove to be less formidable than the preceding numbers suggest. Of the 19,694 potentially contaminated sites that DoD has identified on active military facilities, the department has completed cleanup actions at 570 sites and determined that no further action is necessary at more than 8,600 sites. That means that 10,439 sites, or slightly more than 50 percent of the total number of potentially contaminated sites on operational military installations, will require further work. DoD also estimates that 2,815 active FUDS at which cleanup actions have been ongoing require further remediation. As a result, a total of approximately 13,250 sites--by DoD's count--will require additional cleanup work.

The number of sites actually requiring remediation could be higher than DoD's estimate, however, since the department's finding that no further cleanup action at a site is necessary may be challenged by the Environmental Protection Agency, the states' regulatory authorities, or both. If those organizations disagree with DoD's determination, the department could be required to proceed with remediation activities that it had previously concluded were unnecessary.

Contaminated sites are located at 1,722 installations in all 50 states. Not surprisingly, the states most affected are those in which defense plays a significant role. California has more than 2,500 contaminated sites on some 150 installations and leads the nation with 19 NPL sites. Texas has almost 1,100 sites and Alaska nearly 900 sites. More than 700 sites each are located in Pennsylvania, Virginia, New York, and Florida (see Table 1).

4. A listing on the NPL generally corresponds with an installation. Many individual contaminated sites, however, may exist on an installation that is listed. According to DoD, about 5,500 contaminated sites are located on installations listed on the NPL.

FIGURE 2. DEPARTMENT OF DEFENSE FACILITIES ON THE NATIONAL PRIORITIES LIST, 1987-1993



SOURCE: Congressional Budget Office using data from the Department of Defense, Defense Environmental Restoration Program, *Annual Report to Congress*, Fiscal Years 1987-1994.

TYPES OF CONTAMINANTS AND SITES REQUIRING CLEANUP

With the exception of ordnance and explosive chemicals, the contaminants at DoD facilities are similar to those found on civilian property. The most common contaminants--the petroleum, oil, and lubricants used to operate and maintain military equipment--have been identified at more than 5,300 DoD sites. Solvents, heavy metals, and paint have been found at thousands of sites. Other common hazardous materials such as acid, asbestos, and pesticides are also found on military bases. The 10 most common types of contaminants found at DoD sites are listed in Table 2.

The types of contaminated sites found on defense facilities are also similar to those found in the civilian sector. DoD reports more than 3,000 contaminated storage areas, about 2,700 underground storage tanks, and more than 2,000 landfills (see Table 3). Thousands of spill areas, surface and subsurface disposal areas, and contaminated buildings must also be cleaned up. Hundreds of polluted lagoons, waste treatment plants, and burn areas dot DoD's landscape. Training areas for fire fighting and aircraft accidents, which require extensive remediation efforts, are also common to military facilities. Most of the contaminants at those sites can be cleaned up using the same technologies that are used in the civilian sector.

TABLE 1. STATES WITH THE LARGEST NUMBER OF CONTAMINATED DEFENSE SITES

State	Sites Under the Installation Restoration Program	Formerly Used Defense Sites	Total
California	2,491	60	2,551
Texas	1,010	61	1,071
Alaska	700	196	896
Pennsylvania	817	39	856
Virginia	777	11	788
New York	686	43	729
Florida	681	28	709
Alabama	645	21	666
Illinois	583	50	633
Maryland	567	19	586

SOURCE: Congressional Budget Office using data from the Department of Defense, Defense Environmental Cleanup Program, *Annual Report to Congress for Fiscal Year 1993* (March 31, 1994).

Contaminated sites of types rarely found in the civilian sector are less numerous but still constitute a major challenge for the DoD cleanup program and may require the development of new technologies for their remediation. DoD reports that unexploded ordnance and munitions, for example, exist on some 220 sites; explosive and ordnance disposal areas have been located at another 268 sites.

SPECIAL PROBLEMS POSED BY UNEXPLODED ORDNANCE AND CONTAMINATED GROUNDWATER

Cleaning up unexploded ordnance and chemical warfare materials is among the most difficult, dangerous, time-consuming, and expensive tasks DoD faces. The U.S. Army Corps of Engineers has identified almost 1,700 sites on which these hazardous materials have been reported.

Current technology to remediate buried ordnance is time consuming and costly. Most ordnance sites are surveyed by operators on foot using hand-held metal-detecting equipment. Bulldozers and specially protected heavy equipment are used to dig up buried ordnance and transport it to facilities where it will be de-armed or exploded. Some ordnance sites, such as the

**TABLE 2. MOST COMMON TYPES OF CONTAMINANTS
ON DEFENSE FACILITIES**

Type of Contaminant	Number of Sites
Petroleum, Oil, Lubricants	5,324
Solvents	1,857
Heavy Metals	1,344
Paint	1,017
Ordnance Components	620
Polychlorinated Biphenyls	606
Acid	555
Refuse Without Hazardous Waste	429
Explosive Chemicals	405
Pesticides	402

SOURCE: Congressional Budget Office using data from the Department of Defense.

former naval artillery practice range at Kahoolawe, Hawaii, are located in remote areas with extremely difficult terrain. Other sites are wooded and difficult to survey.

Experts have testified that buried ordnance sometimes migrates toward the surface over time, so that remediation may be effective only temporarily before an area must be cleaned again. Ordnance sites that have been remediated to a specified depth thus may require periodic monitoring to ensure that undetected ordnance, or ordnance buried below the level that was cleaned up, does not migrate to the surface and become a hazard.

Cleaning up buried ordnance is also among the more expensive remediation tasks the department must perform. DoD recently estimated that, using current technology, it costs about \$65,000 per acre to survey and remediate a site with unexploded buried ordnance. The Army Corps of Engineers estimates that tens of thousands of acres will require remediation. Cleanup costs for buried ordnance and chemical warfare materials could total several billion dollars.

TABLE 3. MOST COMMON TYPES OF CONTAMINATED SITES ON DEFENSE FACILITIES

Type of Site	Number of Sites	Number of Active Sites ^a
Storage Areas	3,479	994
Underground Storage Tanks	2,689	1,485
Landfill	2,016	1,402
Spill Areas	1,904	1,273
Surface Disposal Areas	1,475	874
Disposal Pit/Dry Well	849	640
Contaminated Building	709	309
Oil/Water Separator	573	149
Surface Impoundment/Lagoon	557	430
Fire/Crash Training Area	532	401

SOURCE: Congressional Budget Office using data from Department of Defense, Defense Environmental Cleanup Program, *Annual Report to Congress for Fiscal Year 1993* (March 31, 1994), p. 40.

- a. Sites at which study, design, or cleanup actions are under way or those awaiting a decision that cleanup work is complete.
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Remediation of groundwater remains one of the department's most vexing problems. Groundwater at many DoD facilities is contaminated by trichloroethene, a hazardous material found in solvents used for cleaning equipment. Although the time and money required to remediate groundwater vary greatly according to the cleanup standard that is set, current cleanup technology is slow and costly. Determining the location and extent of contamination requires expensive wells for sampling and monitoring the pollutants. Current systems that pump water from the ground and treat it with scrubbing devices can take years, even decades, to achieve cleanup standards. Scientists believe that some groundwater cannot be permanently or entirely cleaned no matter how long it is treated.⁵

The potential total cost of remediating groundwater on defense facilities is unknown. Although DoD currently plans to remediate 113 sites, it is unable to estimate the total amount of groundwater that must be treated. But characterizing and cleaning groundwater are expensive tasks that could cost billions of dollars by the time the department has studied the sites, put remediation technology in place, and cleaned up groundwater to standards.⁶

DoD has also identified about 130 sites that could be expensive and difficult to remediate because they contain low-level radioactive waste or mixed waste. Since such wastes can be hazardous to human health and safety, they require special handling and treatment. The Department of Energy estimates that the cost of cleaning up radioactive waste buried in trenches using current technology ranges from \$14,000 to \$26,000 per cubic meter.⁷

HOW MUCH REMAINS TO BE DONE?

Although DoD has made considerable progress in identifying its environmental problems since the cleanup program began almost 20 years ago, much work remains to be done in both characterizing and cleaning up contaminated defense facilities. DoD has devoted most of its efforts during the past two decades to locating and studying the characteristics of contaminated sites. Having essentially completed the initial investigatory

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5. "Some Water Cleanups Not Feasible, Study Says," *Washington Post*, June 24, 1994, p. A3.
 6. In 1991, the Department of Defense estimated that, on average, it cost \$6.2 million to remediate a site with contaminated groundwater and about \$0.9 million to operate and maintain the cleanup operation each year. If DoD completed cleanup of a site in 20 years, the average cost of such remediation could approach \$25 million.
 7. Congressional Budget Office, *Cleaning Up the Department of Energy's Nuclear Weapons Complex* (May 1994), p. 74.

phase at all its sites, it is devoting most of its current efforts to characterizing contaminated sites and developing technical plans and schedules for cleaning them up. Although DoD has completed more than a thousand interim cleanup measures to minimize environmental threats to health and safety, it has completed relatively few permanent cleanup actions. More and more sites are approaching the cleanup phase, however, and if goals and schedules are met, the cost of remediation will continue to rise.

Phases of the Cleanup Process

Cleanup activities are divided into three major phases: the preliminary assessment/site inspection (PA/SI) phase in which a site is located and initial sampling and analysis are done; the remedial investigation/feasibility study (RI/FS) phase in which further characterization analysis is completed and alternative methods of cleanup are examined; and the remedial design/remedial action (RD/RA) phase in which detailed cleanup plans are chosen and implemented.⁸

Preliminary Assessment/Site Inspection. During the preliminary assessment, defense employees review records and study installations to determine whether contamination exists that may pose a hazard to public health or the environment. Researchers collect information on the source, nature, and magnitude of hazardous substances believed to be released on the facility. As part of the assessment, personnel inspect the property, take samples, and analyze materials to determine whether a site is contaminated. If it is not, the department declares that no further cleanup action is required.

Remedial Investigation/Feasibility Study. This second phase of the cleanup process includes further sampling and analysis to determine the type, quantity, and location of contaminants. Researchers also measure and evaluate the health and safety risks that the contaminants could pose to residents of the facility and to the nearby population. Findings from sampling and analysis suggest possible methods of remediation that DoD considers as it completes a feasibility study.

Remedial Design/Remedial Action. Once the appropriate oversight authorities--including the Environmental Protection Agency, state regulators, and DoD--agree on how to clean up a contaminated site, DoD prepares detailed plans for implementing a remedial action. All cleanup actions that are taken, including in some cases installing equipment used for long-term

8. General Accounting Office, *Hazardous Waste*, p. 9.

cleanup operations, occur during the remedial action phase. Monitoring, maintenance, treatment, and operation of equipment may follow that phase for long-term remediation projects.

Modest Progress Made on Cleaning Up Active Installations and Bases That Are Closing

Overall, DoD has completed most of the work required for the first phase of the cleanup process for sites located on active military facilities and on bases that are being closed. As of the end of fiscal year 1993, DoD had completed about 96 percent of the preliminary assessments required for some 19,694 potentially contaminated sites. As a result of investigations during each phase and of completed cleanups, the department concluded that no further action would be necessary for 9,255 sites--almost 47 percent of the total.

In March 1994, the department reported that it had begun the second phase of the cleanup process at approximately 5,000 sites. However, only about 20 percent of DoD's active sites have completed the intermediate RI/FS phase. The department will probably not be able to achieve the goal it set in 1991 to finish all RI/FS activities by 1996.

The department has cleaned up only a small fraction--about 5 percent--of the contaminated sites needing remediation. Indeed, some of the 571 sites the department has "cleaned up" may not have yet met final cleanup standards. DoD considers a cleanup action complete when it has successfully remediated a hazardous waste problem or when cleanup technology and equipment are put into place and operating. A completed action could include instances, for example, in which technology is in place to remediate groundwater even though cleanup standards have not yet been met.

Evidence indicates, however, that completion rates may be accelerating. Between 1991 and 1992, DoD completed cleanup actions on 44 sites. In 1993, it completed cleanups at 155 sites--three and a half times as many as in the year before.

Progress on Cleaning Up NPL Sites and Formerly Used Defense Sites

DoD is still in the early stages of cleaning up its most highly contaminated sites--many of those located on the 107 military facilities listed on the National Priorities List. Of the 5,500 sites on NPL facilities, about 70 percent are in the PA/SI phase, and about 30 percent have completed that phase.

Relatively few sites have entered or completed the RI/FS phase. As of the end of fiscal year 1993, only 402 contaminated sites on bases on the NPL--about 7 percent of the total--had either started or completed the design phase. Slightly more than 300 sites--about 6 percent of the total--had entered the final (RD/RA) phase of the remediation process. DoD has completed cleanup of 157 sites on NPL facilities, only about 3 percent of the total.

Similarly, DoD has made only limited progress in cleaning up contamination at formerly used defense sites. Most of those sites are still being studied: remedial designs are complete for only about 10 percent, and cleanup work is complete at only about 6 percent. Those figures may not capture the full extent of the work to be done, however, since DoD has not yet determined whether cleanup of many FUDS is necessary and whether the department is liable for implementing cleanup actions. Last year, for example, DoD identified 660 new FUDS that the department could be responsible for remediating.

