U.S. Chamber of Commerce

PFOS and PFOA Private Cleanup Costs at Non-Federal Superfund Sites

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Executive Summary

The Environmental Protection Agency (EPA) is embarking on a costly and unnecessary rule-making with significant implications for businesses, consumers, and governments alike - the designation of certain Per-and polyfluoroalkyl substances (PFAS) as hazardous under the Comprehensive Environment Response, Compensation and Liability Act (CERCLA). This report provides new analysis on the cost of cleanup for potentially responsible parties (PRP) for Perfluorooctanesulfonic acid (PFOS) and Perfluorooctanoic acid (PFOA), which total over $17.4 billion for existing non-federal national priority sites alone.

CERCLA authorizes the use of various enforcement tools to require PRPs such as private businesses, recycling and waste management companies, and governments to cleanup contaminated sites. EPA has some existing authority to address pollutants or contaminants like PFOA and PFOS found at existing CERCLA sites that present an imminent danger to the public health or welfare. Designating PFOS/PFOA as hazardous substances would create significant uncertainty regarding estimated cleanup costs for private entities. The uncertainty is driven in large part because designation would trigger new assessment and inspection, including sites with completed cleanups, and likely resulting in new NPL listings. The result is that PRPs at existing and new sites with PFOS/PFOA contamination would incur both direct cleanup costs and indirect transactional costs associated with the cleanup.[1]

The U.S. Chamber of Commerce engaged third party experts in environmental and economic modeling to estimate total private party costs for addressing PFOS/PFOA contamination at Superfund sites. CERCLA cleanup is already a complex process, and is further complicated by site specific variables, the inherent complexity of PFOS/PFOA, and EPA metrics guidance presently under review at the Agency.

These factors include:

- Difficulty in determining the scope of affected sites because PFOA/PFAS contamination remains mostly uncharacterized;
- Human health and environmental thresholds for PFOS/PFOA are not yet finalized by EPA;
- Specific NPL sites require remediation, but particular remedial actions are unknown and unclear because investigation has not yet begun;
- Size, complexity, and on-site specific factors such as the progress made in addressing the initial hazardous substance(s), and the overlap of PFOS/PFOA contamination; and
- A lack of clear PFOS/PFOA contamination goals for different cleanup pathways and receptors.

Additional uncertainty is created by pending and potential state-level action to regulate PFAS[2] and federal and state-level environmental agency action to update disposal polices that would increase cleanup costs. The decades-long process of CERCLA remediation makes it further challenging to estimate costs today, when many remediation phases will not be implemented for another five or more years. However, this complexity does not prevent a reasonable economic analysis now with the information available, as there are known economic impacts that will flow as a foreseeable consequence of a PFOS/PFOA listing.

In the past, EPA has asserted that the costs associated with designating PFOS/PFOA as hazardous would not have an annual effect, either costs or benefits, on the economy of $100 million, which is the threshold beyond which regulations are considered “economically significant” and subject to more thorough analysis and internal review. By not designating the rule as economically significant, the agency would be avoiding the responsibility of undertaking a formal regulatory impact analysis (RIA) of PFAS cleanup costs triggered by a CERCLA designation. This agency determination would be surprising given the potential for responsible private parties, not counting the federal government (particularly the Department of Defense (DoD)), to face major cleanup liabilities at a broad range of PFAS sites.

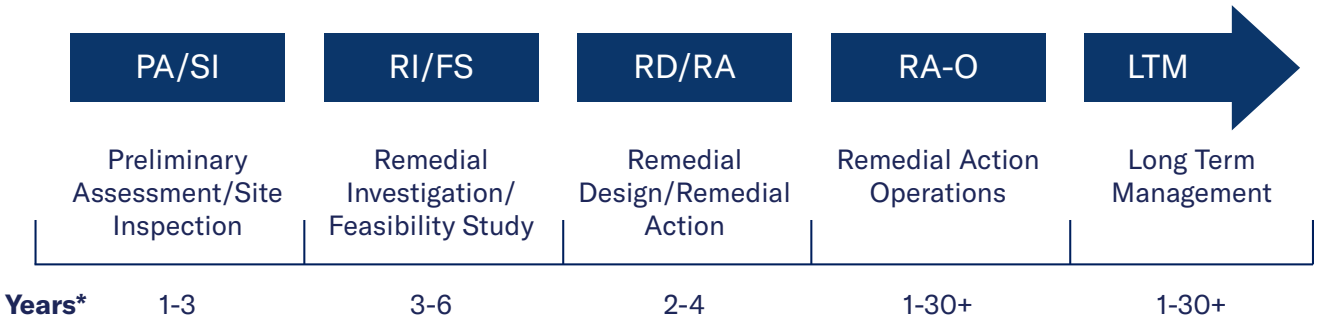
In order to ascertain a reasonable estimate of potential private cleanup costs triggered by a CERCLA designation, the Chamber's third-party experts conducted economic modeling and analysis of financial liabilities associated with cleanup of PFOS/PFOA sites. This research found:

- Private sector cleanup costs at Superfund sites alone resulting from the proposed hazardous substance designation of PFOA and PFOS are estimated to cost between $700 million and $800 million in annualized costs ($11.1 billion and $22 billion present value costs), far in excess of the $100 million annual effect threshold requiring an RIA.
- Private site cleanup costs are only one component of total costs that a CERCLA hazardous

substances designation would impose on the U.S. economy. Significant additional costs are expected to be incurred by (1) federal agencies that own and operate sites containing PFOS/PFOA, (2) municipalities responsible for community water systems, landfills, and publicly-owned treatment works, as well as at potential state and local brownfield sites. Additionally, beyond these direct cleanup costs to affected site owners that will likely be responsible for certain maintenance and operations programming, among others.

- While the Chamber acknowledges that estimating Superfund site cleanup costs is inherently uncertain, uncertainty has not prevented EPA from pursuing site cleanup and imposing these costs in the past.[3]

Figure 1: PFAS Remediation Timeline



Private Party PFOS/PFOA Cleanup Cost are Estimated to be Between $700-800 million

To facilitate a critical review, the Chamber's third-party experts developed a probabilistic model projecting future PFOS/PFOA cleanup and transaction costs at non-federal Superfund sites[4] for private parties. The model assumes the assessment and inspection of 1,638 current, proposed, and former non-federal NPL sites and 538 new sites. Researchers used Monte Carlo methods to develop a probability distribution for total private party cleanup costs. Monte Carlo simulations are used to model the probability of different outcomes in a process that cannot be easily predicted due to the intervention of random variables. It is used to help explain the impact of risk and uncertainty in prediction and forecasting models. Considering only existing NPL sites, the mean cost estimate is present value $17.4 billion ($900 million annually) using a 3% discount rate and net present value $9.8 billion ($700 million annually) using a 7% discount rate. Assuming the CERCLA designation adds to the NPL 200 of the 538 new sites assessed, present value costs increase to $22 billion ($1.1 billion annually) and $11.1 billion ($800 million annually) at 3% and

Table 1: Private Sector PFOS/PFOA Cleanup Costs at NPL Sites, Mean Estimate

Billions of 2021 Dollars

Mean PCR Cost (N=10,000)	All NPL Sites	Existing NPL Sites	New NPL Sites
Present Value, 3% Discount Rate			
Total	$22.0	$17.4	$4.3
Annualized Cost Over 30 Years	$1.1	$0.9	$0.2
Present Value, 7% Discount Rate			
Total	$11.1	$9.8	$1.3
Annualized Cost Over 30 Years	$0.8	$0.7	$0.1

Notes: Existing NPL sites include final, proposed, and deleted NPL sites. Assumes the CERCLA designation adds 200 sites to the NPL.

Methods: Model and Assumptions

The Chamber's team modeled private party PFOS/PFOA cleanup costs using three inputs:

1. The number of non-federal NPL sites subject to each CERCLA cleanup phase,
2. The typical full cost for each CERCLA cleanup phase; and
3. The incremental cost that PRPs will incur to address PFOS/PFOA contamination at each CERCLA cleanup phase.

Multiplying these variables produces undiscounted cleanup costs. Undiscounted costs are costs expected to be generated or incurred, which have not been reduced to their present value. The model projects when each phase of cleanup will occur using typical durations for CERCLA cleanup phases. Future costs are then reduced to total and annualized present values using both 3% and 7% discount rates. The Monte Carlo simulation computes 10,000 iterations of the model by randomly selecting values from the probability distributions for the variables determining the present value of PFOS/PFOA cleanup costs, and the result is a probability distribution for total private sector cleanup costs.

The Chamber's team arrived at this top-down modeling construct, as a bottom-up approach was not feasible. That is because:

- Extrapolating PFOS/PFOA cleanup costs from representative sites to all NPL sites would require previously completed cleanup data, and
- The lack of site-specific cost outcomes required the Chamber to develop probability distributions from judgments formed using data points from government sources, input from the regulated community, and input from the environmental consulting industry.

The following sub-sections explain the model inputs, assumptions, and data. A discussion of the model's results and their uncertainty follows in the nextsection.

PFOS/PFOA CERCLA Cleanup Phases for NPL Sites

1. When determining whether a site should be added to the NPL, EPA utilizes information from initial limited investigations in the Preliminary Assessment and Site Inspection (PA/SI) process to assess the potential threat to human health or the environment through the Hazard Ranking System (HRS).
2. Following an NPL listing, the site undergoes a robust Remedial Investigation and Feasibility Study (RI/FS) to determine the nature and extent of contamination at the site, test whether certain technologies can treat the contamination, and evaluate the cost and technologies that could be used to clean up its Operable Units (OUs).
3. This information informs the design and implementation of remedial action from the record of decision (ROD) during the Remedial Design and Remedial Action (RD/RA) phase.
4. Remedial actions involving groundwater or surface water require long-term monitoring and operation that EPA classifies as the Long-Term Remedial Action (LTRA) phase.

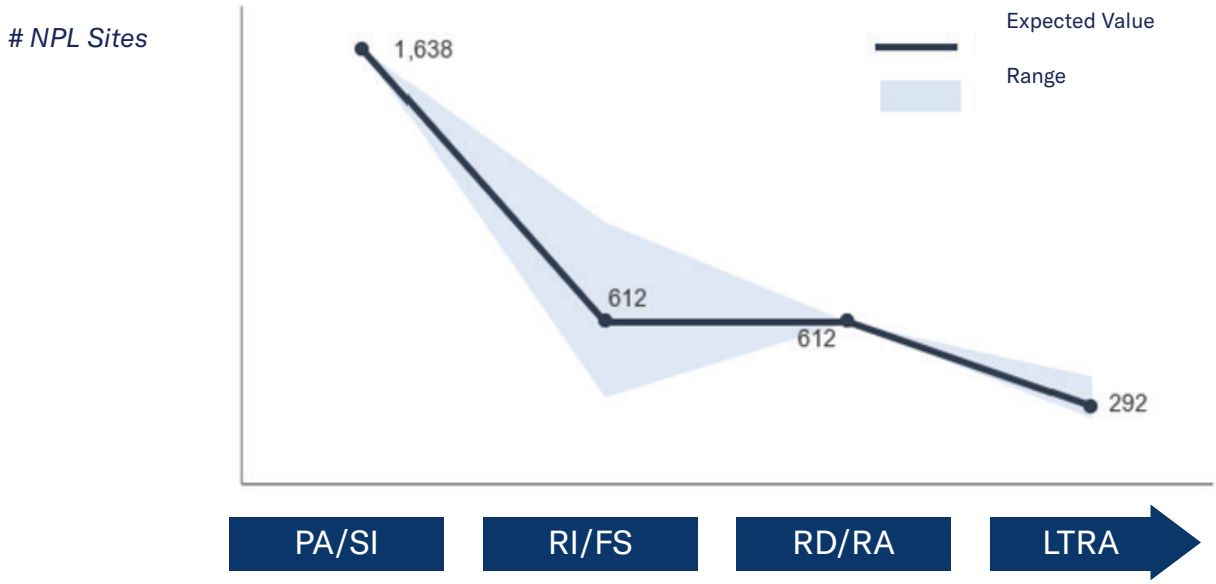
Chamber modeling assumes that EPA will require all existing non-federal NPL sites to look for PFOS/PFOA contamination through a PA/SI process. Existing NPL sites comprise the 1,638 reported in EPA's Superfund Program Superfund Public User Database LIST-008R Active Site Status Report All Action Types:

- 1,164 sites on the final NPL,
- 48 sites proposed for the final NPL, and
- 426 sites deleted from the NPL that a CERCLA designation could "reopen."

The model conservatively excluded the 335 non-federal sites that EPA identifies as "Part of an NPL site."[5] Even so, the number of sites that must be assessed and inspected for PFOS/PFOA contamination is highly uncertain. To date, EPA has identified fewer than 200 non-federal NPL sites with known or suspected PFOS/PFOA releases subsequently discussed. While we discuss the impact of this uncertainty for our cleanup cost estimates, the Chamber is confident that EPA will seek widespread assessments at existing NPL Sites.

This analysis projects the proportion of existing NPL sites advancing to each subsequent CERCLA cleanup phase using the probability distributions and their bases described in Appendix A. Use of probability

Figure 2: Existing NPL Sites at Each Phase of PFOS/PFOA CERCLA Cleanup



Notes: Preliminary Assessment / Site Inspection (PA/SI). Remedial Investigation / Feasibility Study (RI/FS). Remedial Design / Remedial Action (RD/RA). Long-Term Remedial Action (LTRA).

PA/SI-to-RI/FS:	Of the 1,638 existing NPL sites requiring PA/SI, 612 (37%) advance to the RI/FS phase within range of 328 to 983 (20% to 60%).
RI/FS-to-RD/RA:	All of the 612 existing NPL sites requiring RI/FS would require remedial action and advance to the RD/RA phase.
RD/RA-to-LTRA:	Of the 612 existing NPL sites requiring remediation, 292 (48%) require long-term treatment and monitoring of groundwater or surface water within a range of 244 to 408 (40% to 67%).

distributions intends to capture and illustrate the uncertainty for advancement rates from the absence of PFOS/PFOA Hazard Ranking System (HRS) scores for the universe of NPL sites, RI/FS outcomes, and RODs identifying sites with OUs requiring remediation and identifying the action(s) to be taken.

The Chamber's experts make the conservative assumption that PFOS/PFOA contamination will add 20 sites annually to the NPL over the next decade, for a total of 200 sites requiring RI/FS and subsequent remediation. This assumption is based off of EPA's average NPL listing rate from FY1998 through FY2007.[6] Using the same expected advancement rates and probability distributions as the existing NPL sites implies that 536 new sites would require PA/SI, and that 96 of the 200 new sites could expect LTRA.

The assumption that PFOS/PFOA adds only 200 new NPL sites is highly conservative. Using publicly available EPA data, the Chamber's expert research identified approximately 44,000 sites nationwide as "may be handling PFAS" that are neither existing NPL sites nor in the RCRA program, either as hazardous waste generators or as permitted treatment, storage, or disposal (TSD) facilities.[7] State PFAS cleanup programs will address an uncertain but not insignificant proportion of these sites. For example, as of 2002 there were 50 known or suspected contaminated state sites for every site on the final NPL, and 20 state sites needing attention for every NPL site.[8] Notably, the dataset identifies approximately 4,000 landfills, which are the most likely candidates for addition to the NPL.[9]

Cost of PFOS/PFOA CERCLA Cleanup

The model projects PFOS/PFOA cleanup costs as a percentage of (i.e., an increment to) the typical full cost that PRPs incur for each cleanup phase. An explanation of the data, assumptions, and distributions for typical full phase costs and incremental costs for PFOS/PFOA are reported in the following table. Appendix B provides backup data and supporting calculations.

The Chamber's experts obtained typical costs from EPA and Government Accountability Office (GAO) sources to complement its own data and research. EPA reported typical costs per OU at non-federal sites in its 2005 publication Cleaning Up the Nation's Waste Sites: Markets and Technology Trends: 2004 Edition. It provides costs in 2003

dollars for all phases except PA/SI. Costs are adjusted for inflation to 2021 using the GDP implicit price deflator. The model constructs site-level cleanup phase costs from the OU-level at the average of three OUs per NPL site. The DoD's PFAS response provides data to derive a PA/SI cost per site. Monte Carlo iterations sample typical costs from log-normal distributions constructed using standard deviations of 10%, 15%, or 25% of the mean, depending on the phase.

Typical costs for each cleanup phase are representative if addressing PFOS/PFOA contamination will constitute "starting over" at the site. While plausible under certain circumstances, PFOS/PFOA cleanup costs will, more likely than not, be incremental. For example, members of the regulated community have stated that a new PA/SI could easily amount to 30% of the initial cost. The degree to which PFOS/PFOA costs are incremental depend largely on uncertain factors. Some are site specific, such as the extent of overlap of contamination pathways and plumes of initial contaminants of concern (COC). Others are global, such as developing remediation goals protective of human health and the environment, which may also lead to other EPA regulatory actions (e.g., the SDWA). The next section discusses these and other uncertainties for determining incremental costs.

Although cleanup costs generally increase with the number of COCs at a site, that cost differential is not useful for modeling the incremental cost impact of a COC listed during or after the cleanup process as will be the case for existing NPL sites. The Chamber developed PERT probability distributions[10] for incremental cost impacts from conversations with the regulated community, its own research, and input from environmental consultants. Ranges and central tendencies of the distributions vary across phases and the cleanup status to illustrate the uncertainties for addressing PFOS/PFOA contamination at existing NPL sites.[11] The model adds a 10% to 50% (distributed uniformly) cost increment for new NPL sites to reflect that PFOS/PFOA cleanup costs will be closer to full cost than at existing NPL sites.[12]

PRPs also incur significant transaction costs throughout the CERCLA cleanup process. These can include legal and consultant fees for support through cleanup processes, and for litigation seeking cost recovery, contribution, and indemnification from other parties and insurance companies. According to a RAND Corporation study that EPA supported, transaction costs amount to nearly half of the investigation and remediation (IR) costs. The model samples the transaction cost ratio from a uniform distribution to compute the dollar amount from the sampled PFOS/PFOA IR costs for each Monte Carlo iteration.

Table 2: Typical PRP Costs for CERCLA Cleanup and Incremental Cost to Address PFOS/PFOA

PRP Cost Category	Cost Distributions Used in the Monte Carlo Model		
	Typical Cost, Mean (SD) 2021$M / Site	PFOS/PFOA Cost Increment (% of Typical)	
		Existing Sites	New Sites
CERCLA Cleanup Phase			
PA/SI	Log-normal(3.4, 0.3)	PERT(20%, 33%, 50%)	+Uniform(10%, 50%) of Existing Sites
RI/FS	Log-normal(6.0, 0.6)		
RD	Log-normal(6.0, 0.9)	PERT(5%, 33%, 50%)	
RA, Not stated/WIP	Log-normal(51.1, 12.8)	PERT(5%, 33%, 67%)	
RA, Completed		PERT(5%, 50%,100%)	
LTRA	Log-normal(44.3, 6.6)	PERT(5%, 33%, 67%)	
Transaction Cost	Mean = 28.7, s.d. = 4.8	Uniform(36%, 54%)	

Notes: Typical costs and for CERCLA cleanup phases follow a log-normal distribution (mean, standard deviation). "SD" abbreviates standard deviation. PFOS/PFOA cost increments for CERCLA cleanup phases follow a PERT distribution (minimum, mode, maximum). Transaction costs are computed as 45% of the total investigation and remediation (IR) costs (RI/FS, RD, and RA) and are sampled from a uniform distribution (minimum, maximum). WIP is Work-in-Progress, EPA reports 62% of the 1,164 sites currently on the NPL as Construction Complete.

Projecting PFOS/PFOA Cleanup Timelines

As PFOS/PFOA cleanup under CERCLA unfolds over the next several years, PRPs will incur costs in the future. Future cost streams are reduced to a present value at both 3% and 7% discount rates consistent with the Office of Management and Budget's (OMB) guidance to agencies on good regulatory analysis in OMB Circular A-4. Annualized equivalent costs are computed for a 30-year policy period.

The model uses GAO data for the average time-to-complete CERCLA cleanup phases to project when PRPs will incur costs at existing NPL sites. As the following table shows, cleanup at new sites will occur further into the future than cleanup at existing sites. This reflects both that EPA would add NPL sites gradually over the decade spanning from 2024 to 2033, and that new sites would have less infrastructure in place to leverage. The projection and thus the present value calculation assume that all sites must complete one phase before beginning the next.

Discussion: Results and Uncertainties

The results show that annualized costs would have annual economic effects greater than $100 million that necessitates the development of a regulatory impact analysis and should also be designated as "major" under the Congressional Review Act, the Unfunded Mandates Reform Act, and Executive Order 12866.[13] The cost estimate exceeds $100 million annually even at the lower fifth percentile of the cost distribution, considering just the impacts at existing NPL sites, and at both a 3% and 7% discount rate. Unsurprisingly, the remedial action costs exhibit the highest degree of uncertainty in both dollars and percentage terms. That is due to the difference in incremental costs between sites where the remedial action is complete and at those that require long-term treatment of groundwater and surface water. The subsections that follow include a wider discussion of uncertainties, including from changing maintained assumptions and the uncertainties implicitly captured through the model's illustrative probability distributions.

Table 3: Projected Timing of PFOS/PFOA CERCLA Cleanup for Determining Present Values for Estimated Cleanup Costs

CERCLA Cleanup Phase	Years When Cleanup Occurs	
	Existing NPL Sites	New NPL Sites
PA/SI	2024–2027 (4 years)	2024–2043 (20 years)
RI/FS through RD	2028–2036 (9 years)	2044–2062 (19 years)
RA	2037–2038 (2 years)	2063–2073 (11 years)
LTRA	2039–2068 (30 years)	2074–2104 (30 years)

Notes: Numbers in parentheses are durations for the CERCLA phase.

Table 4: Results of Monte Carlo Model Simulating PRP CERCLA Response and Cleanup Costs for PFOS/PFOA

N = 10,000	All Sites with PFOS/PFOA			Existing NPL Sites			New NPL Sites		
	Mean	90% PI		Mean	90% PI		Mean	90% P1	
Present Value Costs, Billions of 2021 Dollars									
Present Value. Discounted at 3%									
Total NVP of PRP Costs	$22.0	$13.8	$32.6	$17.4	$10.0	$27.2	$4.3	$2.8	$6.0
Annualized Cost Over 30 Years	$1.1	$0.7	$1.7	$0.9	$0.5	$1.4	$0.2	$0.1	$0.3
Present Value. Discounted at 7%									
Total NVP of PRP Costs	$11.1	$7.1	$16.3	$9.8	$5.9	$15.0	$1.3	$0.8	$1.8
Annualized Cost Over 30 Years	$0.8	$0.5	$1.2	$0.7	$0.4	$1.1	$0.1	$0.1	$0.1

Notes: PI abbreviates prediction interval.

Alternative Model Construct

The Chamber's top-down model construct is illustrative, and it does not use site-specific information. However, extrapolating from representative sites can be challenging because costs may vary across sites unsystematically. Prohibiting the representative site approach in this case is the complete absence of representative PFOS/PFOA cleanups.

Model Limitations: Number of Sites Affected

An uncertainty that the Monte Carlo does not quantify is the true number of NPL sites that EPA ultimately requires to assess and inspect for PFOS/PFOA. The model assumes that all 1,638 NPL sites conduct a PA/SI to ensure PFAS are not present. However, the current CERCLA designation is limited to PFOS/PFOA, and two EPA sources suggest there are fewer than 200 non-federal NPL sites where contamination is known or suspected[14]. As the following table shows, the number of sites requiring PA/SI may be a significant uncertainty for the total cost estimate.

The number of sites advancing to RI/FS is uncertain absent the HRS scoring process for existing and potential NPL sites. The model assumes that private NPL sites advance to RI/FS at the same rate (36%) as the more than 250 sites where DoD has responded to PFAS contamination. That assumption may over-advance private sites because virtually all DoD sites have PFOS contamination from aqueous firefighting foam (AFFF) use. It may under-advance private sites pending EPA promulgating a national drinking water standard for PFOS/PFOA more stringent than the 70 nanograms per liter (ng/L) lifetime health advisory to which DoD has responded thus far. Furthermore, PFAS have demonstrated migration through all four HRS pathways.

To illustrate the uncertainty, each Monte Carlo iteration samples advancement rates from a PERT distribution ranging from 20% to 60%. Chamber experts developed the range from State of New Hampshire data and other state PFAS investigation data. As the following table shows, varying the RI/FS advancement rate increases or decreases the baseline cost estimate by approximately 30%.

Table 5: Sensitivity of PFOS/PFOA CERCLA Cleanup Cost Estimates to Selected Inputs

Estimate	Existing NPL Sites Requiring PA/SI		Mean Value, Billions	
		% Advancing to RI/FS	Present Value, 3%	Change from Baseline
Baseline (Model)	1,638	36%	$17.4	$0.0
Sensitivity 1	212	36%	$1.5	($15.9)
Sensitivity 2	1,638	20%	$8.4	($9.0)
Sensitivity 3	1,638	60%	$15.2	($2.2)

Size, Complexity, and Type of Affected Site

Each Monte Carlo iteration uses a Superfund Site with three Operable Units (OUs) to aggregate from EPA's typical CERCLA cleanup phase costs for an OU. The 1,638 existing NPL sites average three OUs and range from one to ten. Variation from the average Superfund site size in this model construct is due to the fact that some areas that require PFOS/PFOA investigation and remediation are systematically larger or smaller than the average site.[15] There are no data available for making that determination, thus the model uses the average OUs per site.

Even so, the number of OUs may not adequately reflect a site's area. For example, the contaminated sediment sites along industrial waterways are larger in area than landfill, recycling, and manufacturing Superfund sites, yet both have the same average number of OUs.[16] These contaminated sediment sites have hundreds of parcels and PRPs, which can significantly increase transaction costs relative to actual cleanup costs.

Current EPA cleanup cost data prevents varying costs by contamination pathway (e.g., groundwater, wetlands, sediment) or the nature of the site (e.g., landfill, cement manufacturing, waste handling, mining). Both variables can influence cleanup costs, and thus the incremental PFOS/PFOA costs in the model. Further, it is unclear whether current EPA cleanup and transaction cost data the model uses represent a complex contaminated sediment site, because both EPA data studies pre-date cleanup phases for several contaminated sediment sites.

Factors Affecting Incremental Costs

Determining the degree to which PFOS/PFOA cleanup costs are incremental depends on the degree of overlap with the initial contaminants of concern (COCs) at the site. The overlap can be described by several factors, none of which the model explicitly quantifies in the absence of available data. These are:

- The degree of overlap in contamination pathways and contaminated areas within and across OUs–depending on the site type and use of PFAS, the releases (e.g., sites with AFFF releases only) may constitute an entirely new OU;
- The degree to which the remediation goals overlap in terms of pathways, receptors, and endpoints;
- The degree to which remediation technologies capable of achieving respective remediation goals overlap;
- The existence and extent of administrative, technical, and physical infrastructure developed through cleanup of the initial COC that PFOS/PFOA cleanup can leverage to achieve cost economies of scope;
- The site's progress in the cleanup of the initial COCs—it is one thing to add a COC to the beginning of the RI/FS phase, and quite another once the ROD is issued; and
- The adequacy of remedial actions designed or installed for initial COCs to achieve PFOS/PFOA remediation goals, among others.

Although the model does not explicitly quantify these uncertainties, the probability distributions for the incremental PFOS/PFOA cost are designed to implicitly capture such uncertainties through the cost distributions generated by the model. Following are additional uncertainties that could uniquely influence PFOS/PFOA cleanup costs.

SDWA Compliance

The outcome of EPA's regulation of PFOS/PFOA under the Safe Drinking Water Act (SDWA) introduces uncertainty because Superfund site cleanups would have to meet its maximum contaminant levels (MCLs). Much of the focus to date has been on EPA's 70 ng/L lifetime health advisory, whereas EPA's draft reference dose limits are near zero.[17] It is unclear whether and how typical remedial action costs used in the model would increase if all affected sites had to achieve non-detectable PFAS concentrations in groundwater and surface water sources that are used or could be used as drinking water sources. The affected sites, which could conceivably include any sites with groundwater or surface water pathways, would require larger treatment systems and/or longer-term and more frequent operations and management (O&M), the extent of which depends on source concentrations, among other technical variables.

PFAS End-of-Life Restrictions

Several potential and future requirements, including provisions in the FY 2020 National Defense Authorization Act (NDAA) and pending other legislation, would direct EPA's Administrator to promulgate regulations addressing incineration of PFAS waste. Restricting or banning PFAS waste incineration and thermal treatment methods would further raise the cost of Superfund site cleanups. PRPs with access can thermally treat PFAS-contaminated soil, rendering it non-hazardous for reuse onsite or for disposal via a municipal solid waste (MSW) landfill.[18] An analysis by the Chamber shows that prohibiting thermal treatment of PFAS contaminated soil would raise costs at a single NPL site by up to $1 million and that approximately 25% of the existing NPL sites would find onsite incineration more cost effective than disposal at a Subtitle C landfill (see Appendix C).

Ecological Remediation Goals

Much of the focus on PFAS cleanup has centered around drinking water. However, cleanups required to meet future ecological remediation goals could result in even greater costs. California, for example, proposed PFAS ecological screening levels in aquatic habitats below instrument detection capabilities.[19] Despite the absence of site characterizations, the Chamber's analysis of California NPL sites and the U.S. Fish and Wildlife Service National Wetlands Inventory suggests that ecological remediation requirements could be significant. Of the 90 non-federal NPL sites in California, 63 (70%) had at least one wetland within a half mile. That may be a significant statistic when

considering PFAS' low retardation rate and the recent evidence suggesting aerial pathways from stack emissions at manufacturing facilities.

Factors Affecting the Timing of Future Cleanup

Projecting future CERCLA cleanup timelines is another uncertainty because several unobservable factors can affect the progress of any one site. These can include the nature and extent of public involvement, the course and complexity of litigation among the PRPs or with other parties, EPA enforcement staff availability and funding levels, and absence of PRPs or significant orphan cost shares, among others. Although the GAO provided average durations for the various CERCLA phases, detailed data on OU statuses at NPL sites suggests time-to-complete phases varies widely among sites. Early investigations have uncovered PFAS substances other than PFOS/PFOA, which is likely to lengthen cleanup times. That would surely delay cleanup and lower present value costs. However, without a basis for quantifying the additional time, the Chamber used average cleanup phase durations that GAO developed from EPA's data.

Conclusion and Recommendations

The results of the model illustrate the likely significant cost of PFOS/PFOA cleanup at non-federal Superfund sites. However, there is some uncertainty around the model's estimates. A top down modeling approach was used in the absence of site-specific data due to the fact that PFOS/PFOA are not currently designated as hazardous substances under CERCLA, and that no sites have completed cleanups. It is the Chamber's view that EPA should develop simulated PFOS/PFOA cleanup costs for existing NPL sites for the regulated community's review and input. Regardless, the Chamber's Monte Carlo model illustrates that PRP costs for PFOS/PFOA cleanup will be significant. Mean estimates for existing NPL sites alone are present value $17.4 billion (90% prediction interval equaling $10 billion to $27.2 billion) using a 3% discount rate and $9.8 billion (90% prediction interval equaling $5.9 billion to $15 billion) using a 7% discount rate. Uncertainty in these estimates notwithstanding, CERCLA cleanup costs are but a single component of total costs, which include long-term operations and maintenance programming and monitoring, that the CERCLA designation for PFOS/PFOA imposes on the private sector and communities across the nation. Prior to proposing any designation, EPA should comply with its statutory and Executive Order requirements to conduct a cost-benefit analysis of the proposed action and possible alternatives.

The Chamber and our members encourage EPA to develop simulated PFOS/PFOA cleanups for a set of existing NPL sites with different attributes that influence costs.[20] EPA's simulation should consider the effectiveness of alternative cleanup technologies and the implications of future regulation and policy relating to PFAS waste management and disposal.

Endnotes

1. EPA's indirect costs cover the costs of administering the Superfund program that cannot be attributable to any specific site.
2. Another factor with the potential to significantly affect incremental costs for addressing PFOS/PFOA are cleanup standards being enacted by many states and the interaction between those state standards and CERCLA. Section 121 of CERCLA and EPA's National Contingency Plan regulations allow EPA to use state standards as "Applicable or Relevant and Appropriate Requirement" (ARARs) to set federal preliminary remediation goals for site cleanup.
3. For example, the EPA estimated the cost of cleanup at 456 non-federal NPL sites comprising 1,073 operable units (OUs) with planned remedial actions at between $15.5 and $23.3 billion in 2003 dollars (see the EPA Office of Solid Waste and Emergency Response, Cleaning Up the Nation's Waste Sites: Markets and Technology Trends: 2004 Edition. the EPA 542-R-04-015. 2005). In the same study, the EPA uses a similar approach to the Chamber's model to project future CERCLA cleanup costs and derives a range from $23billion to $50billion. The study makes key assumptions in the absence of available data; for example, "It was assumed that 50 percent of sites with RD underway have already incurred the RD costs, 50 percent of sites with study underway already have incurred RI/FS costs, and 45 percent of all sites will require LTRA."
4. Non-federal Superfund sites
5. U.S. EPA, Superfund Program Superfund Public User Database LIST-008R Active Site Status Report All Action Types, Run Date: November 11, 2021. https://www.epa.gov/superfund/superfund-data-and-reports.
6. U.S. GAO, Litigation Has Decreased and the EPA Needs Better Information on Site Cleanup and Cost Issues to Estimate Future Program Funding Requirements, GAO-09-656, July 2009.
7. Also excluded are sites the EPA classified as "Oil and Gas", "Petroleum", or "National Defense".
8. Environmental Law Institute (ELI), An Analysis of State Superfund Programs, 50-State Study, 2001 Update. Nov. 2002.
9. These are facilities the EPA classified as "Waste Management" with "Landfill" in the facility name.
10. PERT distributions are widely employed in risk analysis because the distribution is useful in circumstances of limited information, as it requires estimating the upper and lower bounds and the most likely value.
11. For example, if the remedial action is designed but not complete, there is an ability to augment it to address PFOS/PFOA contamination. That is not the case if the remedial action is complete. For that reason, the maximum incremental RA cost is 100% (i.e., starting over) for sites with completed remedial actions and 67% for sites where the remedial action is not complete.
12. Although PFOS/PFOA would be responsible for the new sites' addition to the NPL, cleanup of other COCs may leave administrative, technical, or physical infrastructure to leverage in addressing PFOS/PFOA contamination.
13. EO 12866, Congressional Review Act, and UMRA all impose additional cost-benefit analysis requirements on agencies when the costs (or benefits) are greater than $100 million/year.
14. Approximately 90 of the 180 sites identified by the EPA to have PFAS contamination appear to be non-federal. https://www.epw.senate.gov/public/index.cfm/superfund-sites-identified-by-epa-to-have-pfas-contamination. As of June 2020, the EPA had identified 233 private and federal facility NPL sites with PFOS and PFOA contamination. The document does not provide a breakdown between private and federal sites. https://www.epa.gov/sites/default/files/2021-01/documents/frl-10019-13-olem_addressing_pfoa_pfos_anprm_20210113_admin-508.pdf
15. Varying the number of OUs for each iteration introduces false uncertainty because extreme values are generated when all Superfund sites are very large (e.g., 8 OUs) or very small (e.g., 1 OU).
16. See the EPA Large Sediment Sites Tiers 1 and 2 (https://www.epa.gov/sites/default/files/2015-10/tier1_sites_forwebsite_july-2015.xls)
17. See the EPA's Analyses to support the EPA's National Primary Drinking Water Rulemaking for PFAS.
18. According to the EPA data, 8% of Superfund remedial actions use thermal treatment and another 17% use offsite or onsite incineration.
19. See https://www.waterboards.ca.gov/rwqcb2/water_issues/programs/ESL/PFAS_ESL_Memo.pdf
20. For example, site type, size, pathways, media, number, and type of initial COCs, degree of overlap with initial COCs, geographic locations, proximate environmental and human receptors, PFOS/PFOA concentrations, preliminary remediation goals.

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Appendix A. Monte Carlo Model Parameters

Parameter	Units	Value	Basis
Advancement Rates to CERCLA Phases			
Sites Advanced to RI/FS	% of PA/SI Sites	PERT(20%, 36%, 60%)	GAO 21-421 (see Appendix B)
Sites Requiring RD/RA	% of RI/FS Sites	100%	Assumed, as consistent with EPA practice.
NPL Sites with Completed RA	% of RD/RA Sites	62%	Computed from EPA LIST-008R
Sites Requiring LTRA	% of RD/RA Sites	PERT(40%, 45%, 67%)	Model value uses EPA (2005), p.3-14
Typical CERCLA Cleanup and Indirect Costs			
PA/SI	$M / Site	Log-normal(3.4, 0.3)	GAO-21-421 (see Appendix B)
RI/FS	$M / Site	Log-normal(6.0, 0.6)	EPA (2005), p.3-13 (see Appendix B)
RD	$M / Site	Log-normal(6.0, 0.9)	
RA	$M / Site	Log-normal(51.1, 12.8)	
LTRA	$M / Site	Log-normal(44.3, 6.6)	
Transaction Cost	% of IR Cost	Uniform(36%, 54%)	RAND (1993) (see Appendix B)
PFOS/PFOA Cleanup Cost Increment			
PA/SI	% of Typical Cost	PERT(20%, 33%, 50%)	Assumed
RI/FS	% of Typical Cost	PERT(20%, 33%, 50%)	Assumed
RD	% of Typical Cost	PERT(5%, 33%, 50%)	Assumed
RA, Not Complete	% of Typical Cost	PERT(5%, 33%, 67%)	Assumed
RA, Construction Complete	% of Typical Cost	PERT(5%, 50%,100%)	Assumed
LTRA	% of Typical Cost	PERT(5%, 33%, 67%)	Assumed
Other Parameters			
Operable Units	# / Site	3	EPA Search Superfund Site Information and EPA's LIST-008R
Cleanup (i.e., Policy) Duration	# Years	50	Assumed
Discount Rate, low	%	3	Circular A-4
Discount Rate, high	%	7	Circular A-4

Notes: Distributions are: Log-normal (mean, standard deviation), PERT (minimum, mode, maximum), and Uniform (minimum, maximum). Investigation and remediation (IR) costs equal the sum of RI/FS, RD, and RA.

Appendix B. Cleanup Cost Data

Typical CERCLA Cleanup Costs and Associated Transaction Costs Used as the Basis for Incremental PFOS/PFOA Cleanup Costs

Millions of 2021 Dollars

PRP Cleanup Costs	$ / OU	$ Site
Preliminary Assessment / Site Inspection (PA / SI)	1.1	3.4
Remedial Investigation / Feasibility Study (RI / FS)	2.0	6.0
Remedial Design (RD)	2.0	6.0
Remedial Action (RA)	17.0	51.1
Transaction Costs	9.6	28.7
Total, Sites without Long-term Remedial Action (LTRA)	31.8	95.3
Long-Term Remedial Action (LTRA)	14.8	44.3
Total, Sites Requiring LTRA of Groundwater or Surface Water	46.5	139.5

Notes: Site-level cleanup costs for all but the PA / SI phase (note a) and Transaction Costs (note b) are EPA averages per operable unit (OU) and 3 OUs per site. OUs per site is the average from the 1,638 existing NPL sites. Primary sources for private party cleanup costs are USEPA (2005), GAO-21-421, and RAND (1993). Costs stated in 2003 dollars are inflation-adjusted to 2021 dollars using the GDP Implicit Price Deflator, the same deflator EPA (2005) used.

[a] GAO-21-421 reports total expenditures and the number of sites. The cost per OU displayed here uses the 3 OU per site average.

[b] Computed as 45% of investigation and remediation cost (IR) based on RAND (1993). IR costs are the total of RI / FS, RD, and RA cost.

Typical CERCLA Cleanup Costs per Operable Unit Adjusted for Inflation to 2021 Dollars

Millions of 2021 Dollars

CERCLA Cleanup Phase	Cost per OU, 2003	Cost per OU, 2021
Remedial Investigation / Feasibility Study (RI / FS)	1.4	2.0
Remedial Design (RD)	1.4	2.0
Remedial Action (RA)	11.9	17.0
Subtotal before Long-term Remedial Action (LTRA)		21.1
Long-Term Remedial Action (LTRA)	10.3	14.8
Total Including LTRA		35.8

Notes: Source is EPA (2005), Cleaning Up the Nation's Waste Sites: Markets and Technology Trends: 2004 Edition, EPA 542-R-04-015, p.1-7, https://nepis.epa.gov/Exe/ZyPDF.cgi/30006113.PDF?Dockey=30006113.PDF. The Long-Term Remedial Action phase for "sites that require long-term treatment to restore groundwater or surface water." Costs stated in 2003 dollars are inflation-adjusted to 2021 dollars using the GDP Implicit Price Deflator (https://fred.stlouisfed.org/series/GDPDEF#0), the same deflator USEPA (2005) used.

PRP Transaction Costs for Investigaton and Remediation of Superfund Sites

Millions of 2021 Dollars

Cost Element	90% CI		
	Estimate	Lower	Upper
Investigation & Remediation Costs (IR) Transaction costs	40	25	41
	18	14	20
Total cost	58	43	83
Ratio of Transaction Costs-to-IR Costs	45%		

Notes: Source is Lloyd S. Dixon, Deborah S. Drezner, James K. Hammitt (RAND), 1991, Private-Sector Cleanup Expenditures and Transaction Costs at 18 Superfund Sites, Table 5.1. This study was "Supported by the U.S. Environmental Protection Agency". "Investigation & Remediation Costs" include Remedial Investigation / Feasibility Study (RI / FS), Remedial Design / Remedial Action (RD / RA) and reimbursements to EPA (per Table 3.4). Costs stated in 1991 dollars are inflation-adjusted to 2021 dollars using the GDP Implicit Price Deflator, https://fred.stlouisfed.org/series/GDPDEF#0

PRP Transaction Costs for Investigaton and Remediation of Superfund Sites

#Sites								
DoD Agency	Total Expenditure through FY2020,$M	Complemented Preliminary Assessment	Started Remedial Investigation	Started Long-term Cleanup	Total	% Sites in Remedial investigation	Total expenditure per Site, $M	Estimated Preliminary Assessment Cost per Site, $M
Army	74.6	54	7	0	61	11%	1.2	1.0
Navy	272.1	13	28	0	41	68%	6.6	5.3
Air Force	737.6	111	43	0	154	28%	4.8	3.8
						Average:	4.2	3.4

Notes: Source is GAO (2021), DoD Is Investigating PFAS and Responding to Contamination, but Should Report More Cost Information, GAO-21-421, Table 1 and Figure 4. Estimated preliminary assessment cost per site assumes 80% of total expenditures through FY2020 were for preliminary assessment and 20% for remedial investigation.

Appendix C. Cost Impact from Restricting PFAS Incineration and Thermal Treatment

A PFAS incineration ban would significantly raise cleanup costs at NPL sites. PRPs with access can thermally treat PFAS-contaminated soil, rendering it non-hazardous for reuse onsite or disposal at municipal solid waste (MSW) landfills. According to EPA, 8% of Superfund remedial actions use thermal treatment and another 17% use offsite or onsite incineration.[1] As the following table shows, an incineration ban could increase costs for removing 3,500 tons of PFAS-contaminated soil[2] by between $0.08 million (5%) to $0.98 million (134%) per NPL site, depending on the baseline technology.

Incremental Cost for Removing 3,500 Tons of PFAS-Contaminated Soil at NPL Sites

State	Technology	Cost of Alternative		Incremental Cost ($M / Site)
		$ / ton	$M / Site	
Ban	RCRA (Subtitle C) landfill disposal	489	1.71	NA
Baseline	Thermal desorption, onsite reuse	208	0.73	0.98
	Thermal desorption, MSW (Subtitle D) landfill disposal	467	1.63	0.08

Notes: Both States of the World assume 3,500 tons contaminated soil and hauling costs (where applicable) using a 15-ton dump truck including loading/unloading, demurrage, manifest, and minimum trip charge (233 trips) amounting to $134 / ton. Ban: Adds $356 / ton ($277 / ton disposal fee plus $78 / ton hauling charge at the 380-mile average distance from an NPL site to the nearest Subtitle C landfill) for a total of $489 / ton. Baseline: Thermal desorption is $208 / ton. Onsite reuse assumes treated soil and water is clean for spreading or replacement at the site. Offsite disposal adds $334 / ton ($208 / ton for thermal desorption, plus a $56 / ton tipping fee, plus a $69 / ton hauling charge at the assumed 25-mile average one-way distance from an NPL site to the nearest MSW (Subtitle D) landfill) for a total of $467 / ton. Cost elements may not sum to the total cost per ton due to rounding. The primary source is DPRA, Inc. (2000).

A ban may impose higher costs on certain PRPs with boilers or industrial furnaces. The marginal cost of destroying soil onsite using incineration ($510 per ton) exceeds hazardous waste landfill disposal fees ($277 per ton). However, transporting bulk solids is expensive, and the 25 RCRA hazardous waste landfills are remote compared with many potential PFAS NPL sites. The Chamber's analysis finds that NPL sites located further than 499 miles (one-way) from a hazardous waste landfill would find onsite incineration more cost-effective. This affects 316 (24%) of the 1,322 sites currently on the NPL,[3] with most of the affected NPL sites located in the west.[4]

Endnotes

1. The EPA Office of Solid Waste and Emergency Response. Cleaning Up the Nation's Waste Sites: Markets and Technology Trends: 2004 Edition. September 2004. USEPA 542-R-04-015.
2. That is the volume that NAS-Joint Reserve Base Willow Grove in Horsham, NJ attempted to dispose of at a nearby county landfill. "Navy Official: 'Probably' no more removal of PFAS-contaminated soil". The Intelligencer. June 6, 2019
3. The analysis uses the same basic costing assumptions in the table. "Incremental Cost for Removing 3,500 Tons of PFAS-Contaminated Soil at NPL Sites". The 1,322 NPL sites are listed as reported by the EPA at "Superfund Data and Reports", https://www.epa.gov/superfund/superfund-data-and-reports. The 25 RCRA Subtitle C landfills are taken from the EPA's Toxic Release Inventory reports on waste received at RCRA Subtitle C landfills.
4. California, Oregon, and Washington account for 50% of affected NPL sites and 12% of all NPL sites

Appendix D. Acronyms and Abbreviations

AFFF	Aqueous Film Forming Foam
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	Contaminants of Concern
DoD	Department of Defense
EPA	Environmental Protection Agency
GAO	Government Accountability Office
HRS	Hazardous Ranking System
IR	Investigation and Remediation
LTRA	Long-term Remedial Action
MCL	Maximum Contaminant Level
MSW	Municipal Solid Waste
NDAA	National Defense Authorization Act
NPL	National Priority List
OUs	Operable Units
O&M	Operations and Management
PA/SI	Preliminary Assessment and Site Inspection
PERT	Program Evaluation Review Technique
PFAS	Per- and polyfluoroalkyl Substances
PFOA	Perfluorooctanoic Acid
PFOS	Perfluorooctane Sulfonic Acid
PRP	Potentially Responsible Parties
RD/RA	Remedial Design and Remedial Action
RI/FS	Remedial Investigation and Feasibility Study
ROD	Record of Decision
SDWA	Safe Drinking Water Act
TSD	Treatment, Storage, or Disposal

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