MEMORANDUM

TO: EPA Docket No. EPA-HQ-OAR-2025-0207

FROM: U.S. EPA/OCAP/IASD/EAB

DATE: December 2025

SUBJECT: Economic Impact Analysis for the Proposed National Emission Standards for Hazardous Air Pollutants (NESHAP) for Marine Tank Loading Vessels

1. Introduction

The U.S. Environmental Protection Agency (EPA) is proposing amendments to the National Emission Standards for Hazardous Air Pollutants (NESHAP) under the Clean Air Act (CAA) that apply to marine vessel loading (MVL) operations. The source category that is the subject of this proposal is the MVL operation source category subject to 40 CFR 63, subpart Y. The MVL NESHAP regulates emissions from the direct loading of bulk liquids from marine vessels at marine terminals. The EPA completed a risk and technology review (RTR) as part of the 2011 MVL NESHAP amendments. The rule is proposing enhanced flare monitoring requirements, requirements to perform periodic performance testing, and electronic reporting provisions.

Current standards require flares to complete a one-time evaluation to demonstrate they meet the requirements in 40 CFR 63.11 and have continuous pilot flame monitoring. Under a previous NESHAP for petroleum refineries (80 FR 75178, amendments to 40 CFR part 63, Subpart CC - the "Refinery Sector Rule"), the EPA evaluated flare test data and determined that a one-time performance evaluation with pilot flame monitoring is not expected to be adequate to ensure continuous compliance with a control standard. The Refinery Sector Rule (40 CFR 63.670) requires operating limits and monitoring requirements for the following: continuous pilot or flame, visible emissions, maximum flare tip velocity, flare gas flow rate, combustion zone net heating value and for perimeter air-assisted flares, net heating value dilution parameter.

Additionally, MVL facilities co-located with petroleum refineries are already required to comply with the increased monitoring requirements. We are proposing increased monitoring compliance options consistent with the Refinery Sector Rule. Additionally, we are proposing to

include burden reduction measures by allowing MVL liquid loading rate as a proxy for flare gas flow rate consistent with the 2024 bulk gasoline terminals NSPS (40 CFR Part 60 Subpart XXa).

In addition, we are proposing to require flares used to comply with the MVL control requirements to meet new operating limits. Most of the revisions are focused on tailoring the petroleum refinery requirements to MVL terminals. Consistent with the impact analysis conducted for the Refinery Sector Rule, we estimated that the average control efficiency of devices that are subject only to pilot flame monitoring have an average control device efficiency of approximately 94 percent, while those with meeting the operating limits for flares in the Refinery Sector Rule have an average control device efficiency of 99 percent.

We are also proposing revisions to the 14-day sampling requirement and proposing to allow liquid loading rates as an alternative to waste gas flow rate monitoring. For a complete discussion on the proposed requirements of this rule see the rule preamble located in the docket.

We are proposing to provide up to 3 years to comply with the additional monitoring requirements proposed for flares. In addition, we are proposing that the first periodic performance test be conducted within 180 days of the effective date of the final rule. We estimated impacts for 15 years from 2027 to 2041. Capital costs are projected to be incurred in their entirety in 2027 (Year 1) and every 5 years after that through the analysis period. For the purposes of this analysis, we assume all capital costs are incurred in 2027, rather than being spread out over the compliance period. While the affected firms may instead spread out these capital costs over the compliance timeframe, our methodological approach presents a worst-case scenario where all capital costs across the affected industry are incurred in a single year.

2. Industry Overview

The source category includes only emissions that are directly generated or displaced from the marine vessel's cargo tank when loading bulk liquids onto marine tank vessels, including vapor collection and control systems, but does not include storage tanks and leaking equipment associated with terminal unloading or ballasting operations. Nor does this source category include emissions from offshore vessel-to-vessel bulk liquid transfer operations (*i.e.* lightering operations). As part of the initial NESHAP subpart Y rulemaking, the EPA removed unloading operations (ballasting) from the source category in response to public comments (60 FR 48391,

September 19, 1995). The 2022 North American Industry Classification System (NAICS) code for MVLs is 4883 (Support Activities for Water Transportation), although this is not intended to be exhaustive, but rather provides a guide for readers regarding the entities that this proposed action is likely to affect.

Marine vessels, such as tankships and barges, are commonly used to transport liquids from one port or facility to another. Petroleum products, particularly crude oil, diesel fuel, and gasoline, are high volume liquid commodities that are commonly transported using marine vessels, as shown in Table 1.

Table 1. Marine Vessel Liquid Loading Volumes by Commodity (2022)

Commodity	# of Terminals Loading	Total National Throughput	
		1000 bbl/yr	*1000 gal/yr*
Crude Oil	75	1,879,317	78,931,321
Gasoline	137	1,280,756	53,791,769
Kerosene	68	249,631	10,484,494
Distillate Fuel	177	1,144,580	48,072,378
Residual Fuel	141	232,162	9,750,784
Naphtha and Solvents	88	312,476	13,123,999
Benzene and Toluene	59	49,251	2,068,556
Alcohols	133	250,272	10,511,413

Commodity loading volumes obtained from U.S. Army Corps of Engineers' Waterborne Commerce of the United States (WCUS) Annual Report for calendar year 2022.

When tankships and barges are loaded with volatile liquids, volatile organic compounds/hazardous air pollutant (VOC/HAP) containing vapors are expelled from the cargo tanks and, if uncontrolled, emitted to the atmosphere as shown in Figure 1. These vapors, primarily hydrocarbons, form ozone in the presence of sunlight; ozone contributes to smog, which exacerbates respiratory problems in the general population.[1] In addition, some or all of the VOC emitted during MVL may also be HAPs and have direct health impacts (see Section 4.2.1).

The VOC/HAP containing vapors can be routed to control device or vapor balancing system. Emissions can escape to the atmosphere in controlled loading operations either due to leaks in the vessel's cargo tank compartments or from leaks in the vapor collection system.

[1] See the discussion in Section 4.2.2 Human Health Effects from Exposure to VOCs and Related Pollutants, $PM_{2.5}$, which describes that VOC emissions may form organic $PM_{2.5}$ by photochemical oxidation, but that formation of $PM_{2.5}$ by photochemical oxidation of VOC is less well resolved than other sources of $PM_{2.5}$. The section concludes that is unlikely that changes to the VOC emissions projected to occur under this rule would have a large contribution to ambient $PM_{2.5}$ concentrations. Therefore, this rule is expected to primarily impact ozone emissions.

Leaks in the vessel's cargo tank compartments will continue to release emissions after the compartment is loaded (*e.g.*, during transport of the commodity to its final unloading destination). Vapor-tightness requirements can be used to reduce emissions from leaks in the vessel's cargo tank compartment

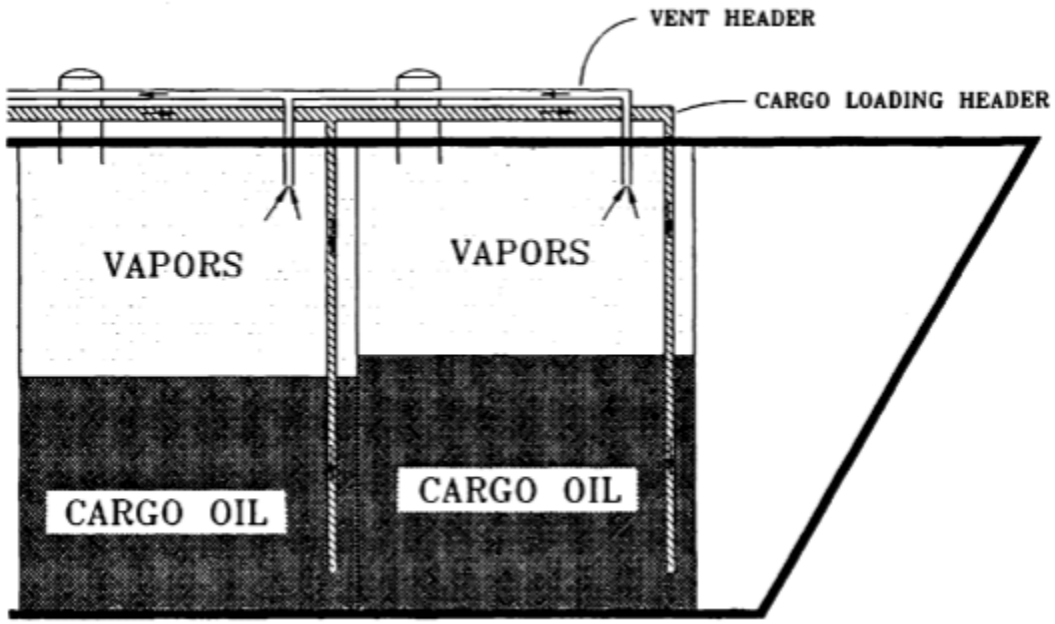

Figure 1. Emissions from Marine Vessel Cargo Tank Loading

As of April 21, 2025, the EPA identified 190 facilities in operation that are subject to the MVL NESHAP. The list of facilities located in the United States and on the outer continental shelf is presented in the document titled *List of Facilities Subject to the MVL NESHAP*, which is available in the docket for this action (Docket ID No. EPA-HQ-OAR-2025-0207).

3. Regulatory Cost Impacts

This section summarizes the regulatory cost estimates for the proposed revisions to the NESHAP. We estimated costs for three regulatory requirements that this proposed rule is amending, which include: electronic reporting requirements, periodic performance testing, and enhanced flare monitoring.

In general, we expect the cost of switching to electronic reporting will lead to lower annual costs in the long-term; however, facility owners and operators may be required to update their recordkeeping systems to provide the information in the format required in the electronic

reporting forms. This may increase reporting costs in the first year as reporters become familiar with the reporting form and potentially update their current recordkeeping systems. We estimated that first year reporting, including understanding the rule revisions, would increase the level of effort by 2 technical hours per facility. These costs were annualized over an 8-year period aligning with required technical review periods. We expect the overall costs associated with recordkeeping and reporting will decrease after Year 1 due to time savings associated with electronic reporting. We estimated electronic reporting would reduce subsequent reporting burden by 2 hours per year per facility. Thus, we expect any additional Year 1 costs will be offset in costs savings in subsequent years of electronic reporting.

The MVL NESHAP subpart Y requires only an initial performance test. It is common for the control efficiency of a control device to degrade somewhat over time as the device ages or wears. Periodic performance testing provides a means to update operating parameters that can assure compliance as the control device ages. Because of this, the EPA commonly includes periodic performance testing, typically at a minimum of once every 60 calendar months, as part of technology reviews. The cost for performance test was estimated as $25,400 per test, with annualized costs of $6,280 over a 5-year period.

Annualization of capital costs involves establishing an annual "payment" sufficient to finance the investment over the expected lifetime of the equipment or loan period. This payment is often referred to as the "capital recovery cost." To obtain annualized capital costs, a capital recovery factor is applied to the total capital cost estimate. The capital recovery factor is based on the lifetime of the capital equipment as well as the interest rate. To annualize the capital costs, the EPA assumed a 7.5 percent interest rate, a 5-year lifetime for the monitoring equipment.

Some of the 190 MVL facilities are offshore and subject only to submerged loading requirements and would not have control devices. However, some larger facilities are expected to have multiple control devices. We estimated that there would be approximately 200 control devices at major source MVL facilities. We assumed that 150 of these use carbon adsorbers, refrigerated condensers, or thermal oxidizers subject to periodic performance testing and 50 flares subject to enhanced monitoring requirements. Of the 50 flares, we assumed 80 percent (40 flares) could use the one-time assessment for systems with consistent net heating value (NHV).

We assumed 8 flares would require a continuous NHV monitor and use loading rates as proxy for flow rates, and 2 flares would need both NHV and flow monitors.

Table 2 summarizes the nationwide costs for revisions to the testing, monitoring, recordkeeping, and reporting requirements. For a detailed discussion on the cost estimates methodology please see the memo titled "*Technology Review for National Emission Standards for Marine Tank Vessel Loading Operations*" in the docket for this action.

Table 2. Nationwide Costs for Testing, Monitoring, Recordkeeping, and Reporting Revisions (in 2024$)

Requirement	First Year Cost	Total Capital Investment	Annual Operating Cost ($/yr)	Total Annualized Cost ($/yr)
Electronic Reporting	42,000	-	(42,000)	(35,000)
Periodic Performance Testing*	3,400,000	-	360,000	1,400,000
Enhanced Flare Monitoring	250,000	3,100,000	430,000	840,000
Total	**3,600,000**	**3,100,000**	**750,000**	**2,200,000**

* Periodic performance testing costs will occur every 5 years

4. Emission Reductions and Benefits Analysis

The proposed rule aims to reduce emissions of HAP and VOC from marine tank vessel loading operations, targeting improvements in air quality, public health, and welfare.

The rule is projected to decrease annual emissions of specific HAPs significantly over the analysis period from 2027 to 2041. Additionally, the reduction in VOC emissions is expected to contribute to lower ground-level ozone (O_3) concentrations, thereby potentially reducing ozone-attributable health and welfare effects. While the quantification of direct health and welfare benefits from decreased exposure to HAPs is limited due to data and methodological constraints, a qualitative discussion is provided to assess the potential impacts. We also provide qualitative discussions of the health and welfare effects of VOC emissions and of related secondary pollutants.

4.1. Emission Reductions

This rulemaking is projected to decrease annual emissions of hexane by 118 tpy, benzene by 62 tpy, methanol by 56 tpy, toluene by 34 tpy, xylene by 8.4 tpy, and ethylbenzene by 2.8 tpy. Table 3 presents a summary of the anticipated nationwide emission reductions in HAPs and VOCs, highlighting specific pollutants such as hexane, benzene, methanol, toluene, xylene, and

ethylbenzene. With the data available, it was not possible to estimate the change in emissions of other air toxics that might be affected by this rule. These reductions are expected to result from the proposed enhanced testing, monitoring, recordkeeping, and reporting requirements.

Table 3. Nationwide Emission Impacts Estimated for Testing, Monitoring, Recordkeeping, and Reporting Revisions

Requirement	Specific HAP Emission Reductions (tpy)						VOC Emission Reductions (tpy)
	Hexane	Benzene	Methanol	Toluene	Xylene	Ethyl-benzene	
Periodic Performance Testing	76	40	36	22	5.4	1.8	2,250
Enhanced Flare Monitoring	42	22	20	12	3.0	1.0	1,250
TOTAL	**118**	**62**	**56**	**34**	**8.4**	**2.8**	**3,500**

Summer season VOC emissions undergo chemical reactions in the presence of sunlight resulting in ground-level ozone formation; therefore, this rulemaking is expected to reduce ozone concentrations. Air quality modeling was not conducted for this rule. In the absence of air quality modeling, the EPA typically assumes a reduction in ozone equal to the quantity of annual VOC reduction weighted by the number of months in the April through September season during which conditions most strongly favor the formation of ground-level ozone (i.e., half of the total 12-month VOC reduction). This rule is therefore assumed to reduce ground-level ozone by an estimated 1,750 tons per year.

4.2. Human Health Benefits

Historically, the EPA estimated the monetized benefits of avoided $PM_{2.5}$- and ozone-related impacts, which accounted for most, if not all, of the monetized benefits of many air regulations–even when the regulation was not regulating $PM_{2.5}$ or ozone. The OMB, in its annual report of the Benefits and Costs of Federal Regulations, routinely provides estimates that the monetized benefits from reducing $PM_{2.5}$ and/or ozone exceed hundreds of millions or even billions of dollars and result in most of the monetized benefits from Federal regulations.

In previous Regulatory Impact Analyses (RIAs), the Agency's approach to estimating the impacts to human health of the changes in concentrations of ozone and $PM_{2.5}$ relied substantially on information from the Integrated Science Assessments for ozone and particulate matter (e.g., (U.S. EPA, 2020a), (U.S. EPA, 2019a). These documents synthesize the toxicological, clinical, and epidemiological evidence to determine whether PM and ozone are causally related to an

array of adverse human health outcomes associated with either acute (i.e., hours or days-long) or chronic (i.e., years-long) exposure; for each outcome, the ISA reports this relationship to be causal, likely to be causal, suggestive of a causal relationship, inadequate to infer a causal relationship or not likely to be a causal relationship. The ISAs reflect the Agency most up-to-date evaluation of the strength and limitations of the available scientific evidence, and clearly identify the health and welfare endpoints for which the evidence is strongest. The Agency continues to focus on these endpoints in considering how regulatory actions may impact public health and welfare. Historically, the Agency has estimated the incidence of air pollution effects for those health endpoints that the ISA classified as either causal or likely-to-be-causal and these endpoints are shown in Table 4. The table below omits welfare effects such as acidification and nutrient enrichment.

Table 4. Health Effects of Ambient Ozone and $PM_{2.5}$

Category	Effect	Causal/Likely-to-be-causal	More Information
Premature mortality from exposure to $PM_{2.5}$	Adult premature mortality based on cohort study estimates and expert elicitation estimates (age 65-99 or age 30-99)	✓	PM ISA
	Infant mortality (age <1)	✓	PM ISA
Nonfatal morbidity from exposure to $PM_{2.5}$	Heart attacks (age > 18)	✓	PM ISA
	Hospital admissions—cardiovascular (ages 65-99)	✓	PM ISA
	Emergency department visits— cardiovascular (age 0-99)	✓	PM ISA
	Hospital admissions—respiratory (ages 0-18 and 65-99)	✓	PM ISA
	Emergency room visits—respiratory (all ages)	✓	PM ISA
	Cardiac arrest (ages 0-99; excludes initial hospital and/or emergency department visits)	✓	PM ISA
	Stroke (ages 65-99)	✓	PM ISA
	Asthma onset (ages 0-17)	✓	PM ISA
	Asthma symptoms/exacerbation (6-17)	✓	PM ISA
	Lung cancer (ages 30-99)	✓	PM ISA
	Allergic rhinitis (hay fever) symptoms (ages 3-17)	✓	PM ISA
	Lost work days (age 18-65)	✓	PM ISA
	Minor restricted-activity days (age 18-65)	✓	PM ISA
	Hospital admissions—Alzheimer's disease (ages 65-99)	✓	PM ISA
	Hospital admissions—Parkinson's disease (ages 65-99)	✓	PM ISA
	Other cardiovascular effects	✓	PM ISA
	Other respiratory effects	✓	PM ISA
	Other nervous system effects	✓	PM ISA
	Cancer	✓	PM ISA
	Reproductive and developmental effects	—	PM ISA
	Metabolic effects	—	PM ISA
Mortality from exposure to ozone	Premature respiratory mortality based on short-term study estimates (0-99)	✓	Ozone ISA
	Premature respiratory mortality based on long-term study estimates (age 30–99)	✓	Ozone ISA
Nonfatal morbidity from exposure to ozone	Hospital admissions—respiratory (ages 0-99)	✓	Ozone ISA
	Emergency department visits—respiratory (ages 0-99)	✓	Ozone ISA
	Asthma onset (0-17)	✓	Ozone ISA
	Asthma symptoms/exacerbation (asthmatics age 2-17)	✓	Ozone ISA
	Allergic rhinitis (hay fever) symptoms (ages 3-17)	✓	Ozone ISA
	Minor restricted-activity days (age 18–65)	✓	Ozone ISA
	School absence days (age 5–17)	✓	Ozone ISA
	Metabolic effects (e.g., diabetes)	✓	Ozone ISA

For regulatory analyses, the Agency estimated changes in health effects in response to modeled air quality changes for each health endpoint identified as causal or likely-to-be-causal in Table 4. The environmental Benefits Mapping and Analysis Program—Community Edition (BenMAP-CE) software program was used to quantify counts of premature deaths and illnesses

attributable to photochemical modeled changes in annual mean $PM_{2.5}$ and summer season average ozone. This approach to estimating health impacts involved two major steps: (1) developing spatial fields of air quality across the U.S. for the baseline and regulatory scenarios using nationwide photochemical source apportionment modeling and related analyses; and (2) using these spatial fields in BenMAP-CE to quantify selected endpoints under each scenario and each year as compared to the baseline in that year while accounting for the changes in population size, income growth, and baseline incidence and prevalence rates.

Figure 2 summarizes the key data inputs and modeling steps for estimating the health impacts of a regulatory impact analysis using $PM_{2.5}$ inputs as an example.

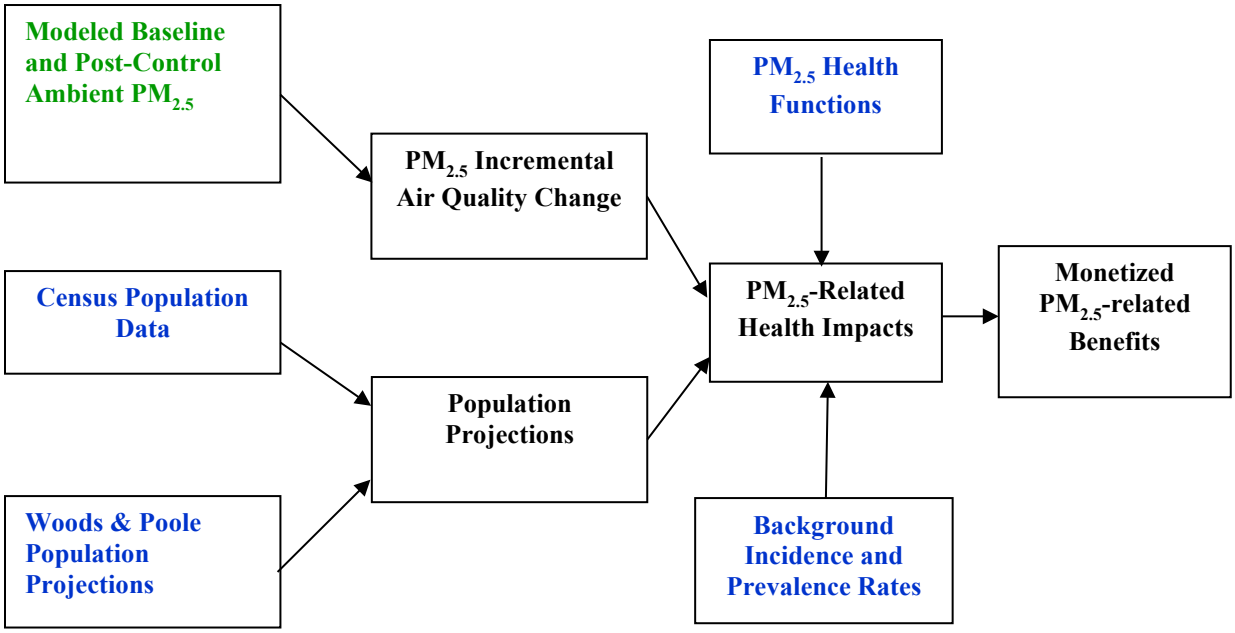

Figure 2. Data Inputs and Outputs for the BenMAP-CE Model Using $PM_{2.5}$ as an Example

As the diagram above illustrates, the approach for estimating $PM_{2.5}$ and O_3 benefits included health effect risk estimates from epidemiologic studies, population data, population growth estimates, economic data for monetizing risk reductions, and assumptions regarding the future state of the world (e.g., on-the-books regulations). Each of these inputs has unique uncertainties associated with it. When the uncertainties from each stage of the analysis are compounded, even small uncertainties can have large effects on the total quantified benefits. Where possible, the EPA in the past has attempted to quantitatively assess uncertainty in each

input parameter. In some cases, quantitative analysis has not been possible due to lack of data, so the Agency instead characterized the sensitivity of the results to alternative plausible input parameters. And, for some inputs into the benefits analysis, such as the air quality data, we lacked the data to perform either a quantitative uncertainty analysis or sensitivity analysis.

Throughout prior regulatory impact analyses, the EPA acknowledged these significant uncertainties around input parameters and employed various techniques for characterizing the resulting uncertainty in estimates of regulatory impacts. For example, the Agency has estimated the fraction of avoided health effects occurring at various concentration ranges, conducted sensitivity analyses, and employed alternate concentration-response assumptions to show how much estimates could vary depending on which assumptions and inputs were used in primary estimates vs. sensitivity estimates.

Chapter 6 of the EPA Health Benefits TSD, Estimating PM2.5- and Ozone-Attributable Health Benefits: 2024 Update, details our approach to characterizing uncertainty associated with the estimation of $PM_{2.5}$ and O_3 benefits in both quantitative and qualitative terms (U.S.EPA, 2024). Some of the key types of uncertainty highlighted in this chapter include:

- Statistical uncertainty around the risk estimate
- Uncertainty around low concentration exposures and the potential for thresholds
- Uncertainty in exposure estimates
- Co-pollutant confounding
- Confounding by other individual risk factors
- Effect modification
- Application of risk estimates to other locations and populations
- Uncertainties regarding at-risk populations
- Baseline incidence rate uncertainties
- Economic valuation estimate uncertainties (e.g. income elasticity of willingness to pay, statistical estimates of VSL, Alzheimer's and Parkinson's onset lifetime costs)
- Unquantified uncertainties (e.g. causality determination, estimating and assigning exposures in epidemiology studies, risk attributable to long-term and short-term exposures, shape of the concentration-response relationship)

Despite substantial investments by the EPA in approaches to characterizing uncertainties, the regulatory impact analyses have still tended to focus on point estimates for PM2.5 and ozone-related benefits. Frequently, the Agency has utilized more than one epidemiologic study to estimate mortality impacts because these estimates drive overall benefits for a given regulatory action due to the large monetary value assigned to such impacts. Risk estimates using the top epidemiologic studies sometimes differ by a factor of two or more. Presenting multiple estimates drawn directly from the primary literature is one way to convey the prevailing uncertainty. While this leads to an estimated range of benefits, it is not a range that reflects the true uncertainties in the underlying parameters supporting each study, either for mortality or for other effects. Because of the significant impacts of environmental regulations on the U.S. economy, it is essential that the Agency have confidence in the estimated benefits of an action, and their underlying uncertainties, prior to utilizing these estimates in a regulatory context.

A 2024 Scientific Advisory Board reviewed EPA's methods for estimating the health effects of $PM_{2.5}$ and clearly and repeatedly recommended that EPA improve its approach to characterizing and presenting the uncertainty in estimating the health effects of $PM_{2.5}$.[2] A Tier 1 SAB recommendation was that the EPA present a single probabilistic mortality estimate based on pooled risk estimates with associated uncertainty ranges rather than present multiple estimates of mortality outcomes from the epidemiologic studies. EPA was encouraged to explore meta-analysis methods or other forms of information synthesis, and support research and development of modified methods as needed.

The OMB "2017 Report to Congress on the Benefits and Costs of Federal Regulations" listed six key assumptions underpinning $PM_{2.5}$ health effect estimation which introduce substantial uncertainties in the health effect estimates[3]:

[2] U.S. EPA. (2024). *Review of BenMAP and Benefits Methods.* (EPA/SAB/24/003). Washington DC: U.S. Environmental Protection Agency. Available at: https://sab.epa.gov/ords/sab/r/sab_apex/sab/advisoryactivitydetail?p18_id=2617&clear=18&session=15054897040198#report.

[3] See the OMB's "2017 Report to Congress on Benefits and Costs of Federal Regulations and Agency Compliance with the Unfunded Mandates Reform Act" for a fuller discussion on uncertainties. Available at https://trumpwhitehouse.archives.gov/wp-content/uploads/2019/12/2019-CATS-5885-REV_DOC-2017Cost_BenefitReport11_18_2019.docx.pdf.

1 That inhalation of fine particles is causally associated with premature death at concentrations near those experienced by most Americans on a daily basis;
2 That the concentration-response function for fine particles and premature mortality is approximately linear, even for concentrations below the levels established by the NAAQS;
3 That all fine particles, regardless of their chemical composition, are equally potent in causing premature mortality;
4 That the forecasts for future emissions and associated air quality modeling accurately predict both the baseline (state of the world absent a rule) and the air quality impacts of the rule being analyzed;
5 That BPT approaches, when used to estimate benefits, are based on regional or national-level analysis that may not reflect local variability in population density, meteorology, exposure, baseline health incidence rates, or other local factors; and
6 That the estimated value of mortality risk reductions is an accurate reflection of what people would be willing to pay for incremental reductions in mortality risk from air pollution exposure, and that these values are constant across the life-cycle.

To the extent that any of these assumptions is incorrect, the benefit estimates will change, though the magnitude and direction of change are not known with certainty. The EPA is interested in improving understanding in each of these six areas. EPA understands that additional research is needed, and will begin to develop approaches that reduce these uncertainties. The EPA will seek peer review for new methods developed from this work consistent with the OMB's Peer Review Guidance.[4]

In particular, the EPA is interested in reevaluating the validity of the approach for estimating the benefits of air quality improvements relative to the National Ambient Air Quality Standards (NAAQS) for $PM_{2.5}$ and ozone. These standards, which have been set at a level which the Administrator judges to be requisite to protect public health or welfare with an adequate margin of safety, are widely understood to represent the divide between clean air and air with an unacceptable level of pollution. Even in instances where an assumption is found to be justified based on scientific evidence, the EPA is interested in reevaluating its approach to characterizing and communicating underlying uncertainty to the public.

[4] OMB (2005). *Memorandum M-05-03, Memorandum for the Heads of Executive Departments and Agencies: Issuance of OMB's Final Information Quality Bulletin for Peer Review*. Available at: https://www.federalregister.gov/documents/2005/01/14/05-769/final-information-quality-bulletin-for-peer-review.

In the past, the EPA has explored a variety of approaches to shed light on how the estimated benefits of an action relate to the level of the NAAQS. For example, in estimating PM benefits, the Agency has employed techniques such as cutpoint analyses and Lowest Measured Level analyses, noting that we are most confident in the magnitude of the risks we project at $PM_{2.5}$ concentrations that coincide with the bulk of the observed $PM_{2.5}$ concentrations in the epidemiological studies that are used to estimate the benefits (Regulatory Impact Analysis for the Repeal of the Clean Power Plan, and the Emission Guidelines for Greenhouse Gas Emissions from Existing Electric Utility Generating Units, Section 4.4.4, p. 4-26). However, such approaches address only a few of the sources of uncertainty that influence PM-related air quality benefits.

The limitations of reduced-form approaches, such as the BPT approach are even more pronounced than photochemical modeling/BenMAP-CE approaches due to:1) the compounding effects of emissions reductions typically occurring across many geographic areas simultaneously, with varying proximity to population centers; 2) differing atmospheric transformation pathways for nitrous oxides (NO_x), volatile organic compounds (VOCs), and secondary $PM_{2.5}$; and 3) region-specific photochemical and meteorological conditions. Using a national BPT estimate implicitly assumes uniform marginal health benefits for each ton of reduced emissions, an assumption not supported given heterogeneity in exposure patterns and atmospheric chemistry. As more areas achieve or maintain attainment with the NAAQS, the uncertainties associated with low-concentration health effects grow, and marginal benefits become more difficult to characterize with precision.

Therefore, it may be appropriate for the EPA to separate exposures and impacts above the level of the standard from those occurring at lower ambient concentrations. The EPA will investigate this prior to estimating these impacts in a regulatory analysis even for informational purposes.

4.2.1. Human Health Effects from Exposure to Hazardous Air Pollutants

This rulemaking is expected to decrease emissions of HAP. The main HAP affected by this rule include hexane, benzene, methanol, toluene, xylene, and ethylbenzene. Due to methodology and data limitations, we did not attempt to quantify and monetize the health effects associated with HAP emitted from sources subject to this rule. Quantifying and monetizing the

economic value of reducing the risk of cancer effects due to HAP exposure is made difficult by the frequent lack of a central estimate of cancer risk as well as estimates of the value of an avoided case of cancer (fatal and non-fatal) and morbidity effects (LaPenta et al., 2024). Assessing population incidence of non-fatal health effects, and risk from threshold carcinogens also pose unique challenges (National Resource Council, 2009). We therefore provide a qualitative discussion of health effects associated with exposure to HAP affected by this rule.

Hexane (C_6H_{14})

Hexane is used to extract edible oils from seeds and vegetables, as a special-use solvent, as a cleaning agent, and for instrument calibration (ATSDR, 2025). Acute (short-term) inhalation exposure in animals causes reduced motor function and adverse developmental and reproductive effects. In humans some associations with developmental effects such as low birth weight and developmental immunotoxicity have been reported. Chronic (long term) exposure to hexane in air can cause peripheral nerve damage in humans with tingling sensation and muscular weakness observed. In animal studies, neurotoxic effects as well as pulmonary and nasal lesions have been observed with chronic exposure (ATSDR, 2025). EPA has classified hexane as a Group D, not classifiable as to human carcinogenicity (EPA, 2005a).

Benzene (C_6H_6)

Benzene is used as a constituent in motor fuels and is found in gasoline service station and motor vehicle exhaust emissions into air. Acute effects of benzene inhalation exposure in humans include neurological symptoms such as drowsiness, dizziness, headaches, and unconsciousness. Exposure to benzene vapor can cause eye, skin, and upper respiratory tract irritation. Chronic exposure to benzene is associated with blood disorders, such as preleukemia and aplastic anemia (ATSDR, 2007). EPA classified benzene as a known human carcinogen (causing leukemia) by all routes of exposure (EPA, 2000). IARC has also determined that benzene is a human carcinogen (IARC, 2018).

Methanol (CH_3OH)

Methanol has many commercial uses and is a basic building block for many chemicals. Exposure may occur from ambient air and during the use of solvents. Acute (short-term) exposure to high levels of methanol by inhalation or ingestion is known to cause adverse

neurological and immunological effects, nasal irritation, blurred vision/blindness, coma, convulsions/tremors, nausea, headache, abdominal pain, diminished motor skills, acidosis, and difficulty breathing in humans (IRIS, 2013). Chronic (long-term) exposure to methanol by inhalation or ingestion may result in adverse effects in the brain and liver at higher doses based on animal data. At lower doses, birth defects and developmental neurotoxicity have been observed with sufficient inhalation exposure across an array of animal studies. EPA has not classified methanol with respect to carcinogenicity (IRIS, 2013).

Toluene ($C_6H_5CH_3$)

Toluene is used as a gasoline additive, in benzene production, and as a solvent. The main source of atmospheric toluene is the production, transport, and use of gasoline. Commercial and consumer solvent use also contribute significantly to ambient levels. Inhalation of toluene most sensitively affects the central nervous system. Human studies show that acute (short-term) toluene inhalation causes reversible neurological effects, including fatigue, headache, decreased manual dexterity, and, at higher exposures, narcosis. Chronic (long-term) exposure can produce cognitive and neuromuscular performance decrements, hearing loss, and color vision deficits. Some evidence indicates that toluene exposure may also affect immune, kidney, liver, and reproductive function (ATSDR, 2017). EPA has concluded that that there is inadequate information to assess the carcinogenic potential of toluene (EPA, 2005b).

Xylene (C_8H_{10})

Xylenes (mixtures of ortho-, meta-, and para-xylene isomers) are released into the atmosphere as fugitive emissions from industrial sources, from auto exhaust, and through volatilization from their use as solvents. The individual isomers have similar physiochemical, toxicokinetic, and toxicological properties (ATSDR, 2007). Acute (short-term) inhalation of mixed xylenes in humans can cause eye, nose, and throat irritation, as well as mild neurological effects such as headache, dizziness, nausea, and impaired balance (ATSDR, 2007; EPA, 2003). Data on chronic (long-term) xylene inhalation in humans is somewhat limited, but animal studies provide evidence of additional neurological effects including impaired motor coordination, cognitive deficits, and increased pain sensitivity (EPA, 2003). EPA has concluded that the data are inadequate for an assessment of human carcinogenic potential, and genotoxicity evaluations have consistently yielded negative results (EPA, 2003).

Ethylbenzene (C_8H_{10})

Ethylbenzene is a natural component of petroleum and is used in the production of styrene. It can be released into the atmosphere from fuel and solvent use, and through chemical manufacturing and production activities. Acute (short-term) inhalation of ethylbenzene in humans can cause irritation of the eyes, nose, and respiratory tract and reversible neurological effects such as dizziness. Chronic (long-term) inhalation can damage the inner ear and cause hearing loss in humans and animals (ATSDR, 2010). Animal studies report additional effects on the blood, liver, and kidneys following chronic inhalation of ethylbenzene. Limited information is available on the carcinogenic effects of ethylbenzene in humans; however, a study by the National Toxicology Program (NTP) found that ethylbenzene inhalation increased incidence of kidney and testicular tumors in rats, and of lung and liver tumors in mice (ATSDR, 2010). Based on these data, IARC classified ethylbenzene as Group 2B, possibly carcinogenic to humans (IARC, 2000).

4.2.2 Human Health Effects from Exposure to VOCs and Related Pollutants

This rulemaking is expected to decrease emissions of volatile organic compounds (VOCs). The human health effects of changes in emissions of VOCs were not quantified for this rule. A qualitative description of related human health effects is provided instead.

Volatile Organic Compounds

VOCs are a diverse group of organic chemicals that are emitted as gases from both biogenic and anthropogenic sources, including industrial processes. Direct exposure to VOCs may result in short- and long-term adverse health effects. Once emitted, VOCs may react in the atmosphere to produce ozone and $PM_{2.5}$ and may also affect human health through these pathways.

Ozone

Following a comprehensive review of toxicological, clinical, and epidemiological evidence, the *Integrated Science Assessment for Ozone and Related Photochemical Oxidants* (Ozone ISA) (U.S. EPA, 2020) found both short-term (*i.e.*, less than one month) and long-term (*i.e.*, one month or longer) ozone exposure to be related to an array of adverse human health effects. For each effect, the Ozone ISA reports relationships to be causal, likely to be causal, suggestive of a causal relationship, inadequate to infer a causal relationship, or not likely to be a

causal relationship. This assessment is based on the body of scientific evidence which can include observational human studies, experimental human exposure studies, animal model studies, and mechanistic studies.

The Ozone ISA found short-term exposure to ozone is causally related to respiratory effects, including respiratory mortality, and likely to be causally related to metabolic effects. For short-term exposure, evidence was suggestive of a causal relationship for cardiovascular and nervous system effects as well as total mortality. The Ozone ISA reported that long-term exposure to ozone is likely-to-be-causally related to respiratory effects, including respiratory mortality. Evidence on metabolic, cardiovascular, reproductive, and nervous system effects as well as total mortality was suggestive of a causal relationship with long-term ozone exposure.

When adequate data and resources are available, the EPA has generally quantified health effects which the Ozone ISA classified as causally related or likely-to-be-causally related to short- or long-term ozone exposure. Health effects classified as suggestive-of-causality or weaker have not historically been quantified. Historically quantified health effects include premature respiratory mortality, hospital admissions and emergency department visits, asthma onset and related symptoms (chest tightness, cough, shortness of breath, and wheeze), allergic rhinitis symptoms, as well as restricted activity days and school absences.

The EPA did not quantify or monetize the benefits or disbenefits associated with changes in the incidence of the listed health effects for this rule.

$PM_{2.5}$

Particulate matter is composed of some or all of the following components: nitrate (NO_3^-), sulfate (SO_4^{2-}), ammonium (NH_4^+), metals, minerals (dust), and organic and elemental carbon. Secondary $PM_{2.5}$ forms through atmospheric photochemical oxidation reactions of both inorganic and organic gas-phase precursors. Anthropogenic NO_X and SO_2 are the predominant precursor gases in the formation of secondary $PM_{2.5}$, and the gas-to-particle equilibrium between ammonia (NH_3) and ammonium (NH_4^+) are relatively well understood. However, formation of secondary organic $PM_{2.5}$, often referred to as secondary organic aerosol, by photochemical oxidation of VOCs is less well resolved. Additionally, biogenic emissions of VOC are the predominant organic precursor at the national scale (71%), while only a fraction of secondarily formed organic aerosols is of anthropogenic origin. Given that only a portion of secondary PM is

from anthropogenic VOC emissions, it is unlikely that changes to the VOC emissions projected to occur under this rule would have a large contribution to ambient $PM_{2.5}$ concentrations. Consequently, we do not expect significant changes in the incidence of $PM_{2.5}$-related health effects from this rulemaking. For more information on $PM_{2.5}$-related health effects, see the *Integrated Science Assessment for Particulate Matter* and the *Supplement to the Integrated Science Assessment for Particulate Matter* (U.S. EPA, 2019; U.S. EPA, 2022).

4.3 Welfare Effects

The economic justification for regulatory actions targeting reductions in emissions of air pollutants generally follows that the regulation mandates the subject of such actions to internalize unpriced social costs, or "negative externalities." Cost analyses therefore explore the magnitude and incidence of compliance costs, such as by capital investment borne by producers or via increased market prices, while benefits analyses provide reference points for determining whether a regulation is efficient to the extent that it results in greater benefits from improved air quality than the costs that society must pay. Due to operational constraints and data limitations, most benefits analyses focus on human health effects expected to occur because of changes in primary and secondary pollutant concentrations resulting from the rulemaking; however, the benefits of reductions in emissions of air pollutants include additional effects that extend beyond direct impacts to economic interests.

The Clean Air Act encourages consideration of the welfare effects of air pollutants, which it defines as including, but not limited to, effects on soils, water, crops, vegetation, manmade materials, animals, wildlife, weather, visibility, and climate, damage to and deterioration of property, and hazards to transportation, as well as effects on economic values and on personal comfort and well-being, whether caused by transformation, conversion, or combination with other pollutants (42 U.S.C. §7602(h)). In this section, we provide qualitative discussions of select welfare effects.

Ozone Vegetation and Ecosystem Effects

Exposure to ozone has been found to be associated with a wide array of vegetation and ecosystem effects in the published literature (U.S. EPA, 2020). Sensitivity to ozone is highly variable across species, with over 66 vegetation species identified as "ozone-sensitive," many of

which occur in state and national parks and forests. These effects include those that cause damage to, or impair the intended use of the plant or ecosystem. Such effects are considered adverse to public welfare and can include reduced growth and/or biomass production in sensitive trees, reduced yield and quality of crops, visible foliar injury, changes to species composition, and changes in ecosystems and associated ecosystem services (U.S. EPA, 2020).

Ozone Animal Welfare Effects

While effects can be context- and species-specific, a large body of scientific evidence links ozone exposure to health effects in animals. When exploring environmental pathways through which environmental effects of ozone may impact animals, the Ozone ISA found a likely-to-be-causal relationship between ambient ozone concentrations and alterations of herbivore growth and reproduction (U.S. EPA, 2020; Girón-Calva et al., 2016; Habeck and Lindroth, 2013; Hong et al., 2016; Ueno et al., 2016). In addition, many animal toxicological studies served as evidence for determining the causality of relationships between human exposure to ozone and human health effects, including respiratory and metabolic effects. The Ozone ISA states, "A large body of experimental animal toxicological studies demonstrates (short- and long-term) ozone-induced changes in measures of lung function, inflammation, increased airway responsiveness, and impaired lung host defense" (U.S. EPA, 2020). Additionally, animal studies report relationships between short-term ozone exposure and metabolic effects in various stocks and strains of animals across multiple laboratories (U.S. EPA, 2020; Gordon et al., 2017; Miller et al., 2015; Ying et al., 2016).

5. Small Entity Analysis

This section describes the methods used to perform the small entity screening analysis, as well as the results of the screening analysis for this proposed rule. A small entity screening analysis is used to determine whether a regulatory action may have a significant economic impact on a substantial number of small entities (SISNOSE). Guidelines for what constitutes 'significant' for economic impacts and 'substantial' for the number of small entities are outlined in guidance prepared for the Regulatory Flexibility Act (RFA) as amended by SBREFA.

The small entity impact analysis determined that this proposed rule will not have significant cost impacts on a substantial number of small entities, thus EPA made a 'no SISNOSE' determination for this proposed rule.

To conduct a small entity screening, the EPA first identifies the ultimate parent companies that own affected facilities, and obtains those companies' most recent annual revenues, number of employees, and North American Industrial Classification System (NAICS) code using the Dun & Bradstreet (D&B) Hoover's online database. The annual revenues for each entity should correspond to the year 2022 in most cases. U.S. Small Business Administration (SBA) size standards are defined for each NAICS code based on either annual revenues or number of employees. To determine whether an entity is small, the EPA identifies the size standard corresponding to the NAICS code of the ultimate parent company and compares the company's annual revenues (or number of employees) to the size standards. To assess potential impacts on small entities, the EPA calculates cost-to-sales ratios, which compare facility-level total annual compliance cost estimates aggregated to the ultimate parent company level (in case one company owns multiple affected facilities) to the annual sales revenues of the ultimate parent company. This metric for evaluating impacts is known as the "sales test" and is consistent with guidance published by SBA's Office of Advocacy.

The sales test is an impact methodology the EPA employs in analyzing entity impacts as opposed to a "profits test," in which annualized compliance costs are calculated as a share of profits. The sales test is frequently used because revenues or sales data are commonly available for entities impacted by EPA regulations, and profits data normally made available are often not the true profit earned by firms because of accounting and tax considerations.

We identified 190 facilities, owned by 98 parent companies, using information from D&B Hoover's[5], that could be affected by the proposed rule. Of the parent companies, 26 companies, or 27 percent, are small entities. We also used information from D&B Hoover's for the parent company revenues and employee counts. We identified the NAICS code for all parent companies and applied the most current version of SBA's table of size standards to determine

[5] D&B Hoovers is a subscription-based database that compiles publicly available information and can be found at https://www.dnb.com/products/marketing-sales/dnb-hoovers.html.

which of the companies were small entities Table 5 below identifies the most prominent NAICS code for parent companies identified in this analysis.

Table 5. Small Business Administration Size Standards by Industry

Industry	NAICS	SAB Size Standards (Revenue – millions of dollars)	SAB Size Standards (Employees)
Petroleum Refineries	3241		1,500
Plastics Material and Resin Manufacturing	3252		1,250
Pipeline Transportation of Natural Gas	4862	$41.5	
Management of Companies and Enterprises	5511	$45.5	

Source: Small Business Administration

In addition, we identified port facilities owned by government entities at the county or city level. When evaluating the small entity impact on a government-owned facility the size of the population served by that government should be used as the basis for the small entity screening. In our analysis we identified 23 facilities owned by government jurisdictions. Three of the populations served by those governments are below the threshold for inclusion as a small entity, which are Haines, Nome, and King Cove in Alaska.

We calculated the cost-to-sales ratios for all the affected facilities to determine (i) the magnitude of the costs of the rule, and (ii) whether there would be a significant impact on small entities compared to large entities. Table 6 shows, by business size, the average annual sales, employees, capital cost, total annual cost, cost-to-sales ratio, and the max cost-to-sales ratio. Table 6 also shows the number and percent of businesses above the one and three percent cost-to-sales ratio thresholds by business size.

The average total annual cost per entity of the proposed requirements is about $16,500. The costs could not be differentiated between large and small entities, so we took an average cost across the whole source category as a conservative approach for allocating costs. Average annual sales for the 26 small entities are $130 million while the 72 affected large businesses have average annual sales of about $116 billion. On average, small entities are estimated to experience a 0.50 percent cost-to-sales ratio to comply with the proposed rule, compared to an average of 0.00 percent for large entities and about 0.13 percent for all entities. The highest cost-sales-ratio estimated is 4.11 percent and is experienced by a small entity.

Table 6. Summary of Sales Test Ratios for 2026 for Firms Affected by Proposed Rule

	All Businesses	Large Businesses	Small Businesses
Average Annual Revenues (millions)	$85,600	$116,500	$130
Average Employees	17,200	23,500	130
Average Capital Cost	$16,500	$16,500	$16,500
Average Cost-to-Sales Ratio	0.13%	0.00%	0.50%
Maximum Cost to Sales Ratio	4.11%	0.01%	3.64%
Number and Percent of Businesses with Cost-to-Sales ratio greater than or equal to 1%	5 (5%)	0 (0%)	5 (5%)
Number and Percent of Businesses with Cost-to-Sales ratio greater than or equal to 3%	1 (1%)	0 (0%)	1 (1%)
Number of Businesses	98	72	26
Number of Facilities	190	159	31

Table 7 shows the number of small and large entities, with cost-to-sales ratios above one percent and three percent. These cost-to-sales ratios were estimated using the total annual costs without the cost savings from product recovery to be conservative. There are five small entities, which account for about 19 percent of the 26 affected small entities, with estimated cost-to-sales ratios greater than or equal to one percent. There is one small entity, which accounts for about four percent of all 26 small entities, with an estimated cost-to-sales ratio greater than or equal to three percent. This small entity has an estimated cost-to-sales ratio of about 4.11 percent (this entity has comparatively low annual revenues). Thus, four small entities have estimated cost-to-sales ratios between one and three percent. No large entities have a cost-to-sales ratio estimated to exceed one percent.

Table 7. Small Entity Screening Summary

	Capital Cost (Million 2024$)	Total Annual Cost (Million 2024$)	Entities with 1% or greater Cost-to-Sales	Entities with 3% or greater Cost-to-Sales
All Entities (n=98, Facilities=190)	$3.1	$2.2	5	1
Small Entities (n=26, Facilities=31)	$2.6	$1.8	5	1
Large Entities (n=72, Facilities=159)	$0.5	$0.4	0	0

The results of this small entity screening analysis do not indicate that a substantial share of the small entities affected by this rule would incur potentially high costs relative to their revenues. EPA guidance on RFA implementation suggests that when less than 20 percent of small entities are estimated to experience annual compliance costs greater than or equal to one percent of their annual revenues, it may be appropriate to determine that the rule would not have a significant impact on small entities. The EPA believes the example thresholds provided in the guidance are appropriate for the small entity analysis of this rule. Since a low percentage of small entities that own MVL facilities have estimated cost-to-sales ratios that exceed the example thresholds in the guidance, the EPA does not expect this proposed rule to have significant economic impacts on a substantial number of small entities, therefore the EPA has certified a no SISNOSE determination for the proposed rule.

6. Economic and Present Value Analysis

For economic impact analyses of rules that directly affect a single or a few industries, the EPA often prepares a partial equilibrium analysis. In this type of economic analysis, the focus of the effort is estimating impacts on a single affected industry or several affected industries, and all impacts of this rule on industries outside of those affected are assumed to be zero or so inconsequential to not be considered in the analysis. If the compliance costs, which are key inputs to an economic impact analysis, are quite insignificant, then the impact analysis could consist of a calculation of annual (or annualized) costs as a percentage of sales for affected companies. This latter type of analysis is called a screening analysis and is applied when a partial equilibrium or more complex economic impact analysis approach is deemed not necessary given the expected size of the impacts.

The screening analysis was described in the previous section for small businesses and includes the results for the source category. On average the cost impacts of this proposed rule, as a percentage of company revenue, are expected to be small. The average cost to sales ratio for all firms is estimated at 0.13 percent.

In addition to the screening analysis, we also prepared a present value analysis to capture the stream of costs and benefits over time. A 15-year period from 2027 to 2041 was selected as the best measure of the economic impacts of this action. This allows for a reasonable and consistent timeframe over which to examine impacts of this action from a present value (PV)

perspective and aligns with several cycles of performance testing and emission monitor procurement.

Table 8 shows the undiscounted and discounted costs per year for the proposed rule in 2024 dollars. It also shows the PV in 2025 of total costs and the equivalent annualized values (EAV) of the costs in millions of 2024 dollars, using a three and seven percent discount rates to be consistent with the guidance for Executive Order 12866 found in Circular A-4 (OMB, 2003). The EAV is the annualized present value of the costs, and represents a flow of constant annual values that, had they occurred in each year from 2027 to 2041, would yield an equivalent present value.

Table 8. Present Value Cost Analysis (millions 2024$)

Year	Description of costs	Undiscounted Costs[a]	Discounted Costs	
			3 Percent	7 Percent
2027	First year costs, including performance testing, plus total capital investment	6.8	6.4	5.9
2028	Annual operating costs begin	0.8	0.7	0.6
2029		0.8	0.7	0.6
2030		0.8	0.7	0.5
2031		0.8	0.6	0.5
2032	5-year periodic performance testing	4.1	3.3	2.6
2033		0.8	0.6	0.4
2034		0.8	0.6	0.4
2035		0.8	0.6	0.4
2036		0.8	0.5	0.4
2037	5-year periodic performance testing	4.1	2.9	1.8
2038		0.8	0.5	0.3
2039		0.8	0.5	0.3
2040		0.8	0.5	0.3
2041		0.8	0.5	0.3
Present Value (PV)[b]			**19**	**15**
Equivalent Annualized Value (EAV)[b]			**1.6**	**1.7**

[a] Table 2 further describes the cost components used to compute the undiscounted costs presented here.
[b] The PV and EAV presented in this table are based on a 15-year analytic timeframe using a 2025 present value year and beginning-of-period discounting. For E.O. 14192 regulatory accounting purposes, EPA has prepared an alternative analysis that estimates costs in perpetuity. This requires EPA to extrapolate costs beyond the 15-year analytic timeframe. For this rule, EPA projects that the annual operating costs and 5-year performance testing costs continue indefinitely. The estimated present value and annualized value of the costs of this rule are $20 million and $1.4 million, respectively (7% discount rate, 2024$, 2024 present value year, perpetuity time horizon). This analysis is provided in the file named "EO14192_MarineVesselLoading_Proposal.xlsx."

Given the results of the analysis, these economic impacts are relatively low for affected industries and entities impacted by this proposed rule, and there will not be substantial impacts on the markets for affected products. The costs of the proposed rule are not expected to result in a significant market impact, regardless of whether they are passed on to the purchaser or absorbed by the firms. We also expect minimal to no impacts on employment.

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