

## CHAPTER 12: Regulatory Alternatives

12.1 Overview .....	12-1
12.2 Description of Options .....	12-2
12.2.1 One-Step Options .....	12-3
12.2.2 Two-Step Options .....	12-7
12.2.2.1 Options Evaluated for Proposal .....	12-7
12.2.2.2 Option 5c .....	12-18
12.2.2.2.1 Emission Inventory Impacts .....	12-19
12.2.2.2.2 Cost Analysis .....	12-20
12.2.2.2.3 Benefits Comparison .....	12-20
12.2.2.2.4 Costs Per Ton .....	12-21

## CHAPTER 12: Regulatory Alternatives

Our final program represents a combination of engine and fuel standards and their associated timing that we believe to be superior to the alternatives considered given feasibility, cost, and environmental impact. In this chapter we present the alternative program options that we evaluated in order to make this determination. These alternatives are cast as twelve specific program options.

### 12.1 Overview

In the Draft RIA supplementing our Notice of Proposed Rulemaking, we presented a detailed analysis of twelve specific program options. These options were used to illustrate variations in both the timing and level of the engine and fuel standards, as well as the applicability of those standards to different segments of off-highway engines and fuels. To evaluate each option, we conducted emission-inventory modeling, estimated costs and benefits, and calculated cost-effectiveness. We then assessed the appropriateness of each option in comparison to our proposed engine and fuel program, and presented our rationale for not proposing to implement each of the options.

Following release of the proposal, we received comments on some of the options that we evaluated. Our detailed responses to those comments can be found in Section 8 of the Summary and Analysis of Comments document. Our reasoning set forth in Chapter 12 of the Draft RIA supporting the proposal also still applies as well for options we have not adopted.

We examined the costs, inventory impacts, benefits, and cost-effectiveness of each of the options as presented in the Draft RIA incrementally to our proposed program. Given that the final program includes some elements that differ from the proposed program, these same new elements would need to be included in each of the options in order to maintain the same incremental differences in program structure between the final program and each option. As a result, we do not believe that a complete revision to the calculated values for costs, inventory impacts, benefits, and cost-effectiveness is warranted, since we would expect them to be very similar to those presented in the Draft RIA. Also, we would not expect recent modifications to the NONROAD emissions model to change the incremental differences between the final program and each of the options. We refer the reader to the detailed evaluations of the options presented in the Draft RIA.

The remainder of this section will present a description of the twelve options originally evaluated in the context of the NPRM to remind readers of the program issues we investigated. However, during the course of reviewing comments on our proposed program, we determined that an additional evaluation of small engine standards was warranted. This additional scenario was labeled Option 5c, and the results of that evaluation are presented below In Section 12.2.2.2.

### **12.2 Description of Options**

Our proposed emission-control program consisted of a two-step program to reduce the sulfur content of nonroad diesel fuel in conjunction with the NO<sub>x</sub> and PM engine standards. During the development of our program, we also considered a one-step fuel program wherein all sulfur reductions in the diesel fuel occur in a single step. Since the fuel provisions and timing dictate to a large extent the possible engine standards, we structured this section to first discuss issues of variations in the fuel program. Thus, the Program Options are divided into One-Step and Two-Step options, to highlight the fuel sulfur program and its driving impact on the engine standards. Within each of these fuel program approaches, we considered several variations and combinations with engine standards.

This Section provides both text summaries of each Program Option as well as diagrams showing how the engine and fuel standards would be implemented over time. For the diagrams, previous standards are labelled as Tier 1, Tier 2, or Tier 3 as appropriate. For reference, Figure 12.2-1 shows the actual standards associated with Tier 1, Tier 2, and Tier 3 labels (40 CFR 89.112).

Figure 12.2-1  
Existing Engine and Fuel Standards

hp group	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Nonroad engine standards (g/bhp-hr) <sup>a</sup>											
hp <25	Tier 2: 5.6 NO <sub>x</sub> +NMHC, 0.6 PM										
25 ≤ hp hp < 50	Tier 2: 5.6 NO <sub>x</sub> +NMHC, 0.4 PM										
50 ≤ hp hp < 75	Tier 2: 5.6 NO <sub>x</sub> +NMHC 0.3 PM			Tier 3: 3.5 NO <sub>x</sub> +NMHC 0.3 PM							
75 ≤ hp hp < 100											
100 ≤ hp hp < 175	Tier 2: 4.9 NO <sub>x</sub> +NMHC 0.2 PM		Tier 3: 3.0 NO <sub>x</sub> +NMHC 0.2 PM								
175 ≤ hp hp < 750	Tier 2: 4.8 NO <sub>x</sub> +NMHC 0.1 PM		Tier 3: 3.0 NO <sub>x</sub> +NMHC 0.1 PM								
hp ≥ 750	Tier 1: 6.9 NO <sub>x</sub> 0.4 PM		Tier 2: 4.8 NO <sub>x</sub> +NMHC 0.1 PM								
Fuel sulfur standard (ppm)											
Loco & marine	Uncontrolled										
Nonroad	Uncontrolled										

<sup>a</sup> Applies to model years.

### 12.2.1 One-Step Options

One-step options were those in which the fuel sulfur standard was applied in a single step; there were no phase-ins or step changes. In all one-step options, the transient test cycle was required concurrently with the introduction of the transitional Tier 4 engine standards in any horsepower group.

Option 1a differed from Options 1 and 1b in terms of the engine standards and their associated timing. Option 1b differed from Option 1 only in the timing of the fuel sulfur standard, and was intended to generate additional early sulfate PM reductions. As a result, we did not lower the certification fuel sulfur level to 15ppm in 2007 and 2008 when modeling this Option, since doing so would permit manufacturers to take advantage of the lower sulfur and thus reduce the PM reductions associated with their certified engines.

## Final Regulatory Impact Analysis

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The one-step options are summarized in Table 12.2.1-1. The specifics of the three one-step options are shown in the standard charts in Figures 12.2.1-2, 3, and 4, while the previous Tier 1, Tier 2, and Tier 3 standards were shown in Figure 12.2-1. Only changes to the standards are shown in these three figures, i.e. if no new standard for a given pollutant is indicated, the previous standard applies.

Table 12.2.1-1  
Summary of One-Step Options

Option	Summary Description
Option 1	<ul style="list-style-type: none"> <li>• Fuel sulfur <math>\leq</math> 15ppm in June 2008 for nonroad, <math>\leq</math> 500ppm for locomotives and marine engines</li> <li>• &lt;50 hp: PM stds only in 2009</li> <li>• 25-75 hp: PM aftertreatment-based standards and EGR or equivalent NOx technology in 2013; no NOx aftertreatment</li> <li>• &gt;75 hp: PM aftertreatment-based standards phasing in beginning in 2009; NOx aftertreatment-based standards phasing in beginning in 2011</li> </ul> <p><i>See Figure 12.2.1-1</i></p>
Option 1a	<ul style="list-style-type: none"> <li>• Fuel sulfur <math>\leq</math> 15ppm in June 2008</li> <li>• PM aftertreatment-based standards introduced in 2009-10</li> <li>• NOx aftertreatment-based standards introduced in 2011-12</li> </ul> <p><i>See Figure 12.2.1-2</i></p>
Option 1b	<p>Same as Option 1a, except fuel sulfur standard required two years earlier</p> <p><i>See Figure 12.2.1-3</i></p>

Figure 12.2.1-1  
Engine and Fuel Standards Under Option 1

hp group	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015							
Nonroad engine standards (g/bhp-hr) <sup>a</sup>																		
hp <25	Tier 2				0.30 PM													
25 ≤ hp hp < 50					0.22 PM					0.02 PM, 3.3 <sup>γ</sup> NO <sub>x</sub>								
50 ≤ hp hp < 75					Tier 3				50%: 0.01 PM						0.01 PM		50%: 0.30 NO <sub>x</sub>	
75 ≤ hp hp < 100																		
100 ≤ hp hp < 175																		
175 ≤ hp hp < 750																		
hp ≥ 750	Tier 1	Tier 2					50%: 0.01 PM, 0.30 NO <sub>x</sub>											
Fuel sulfur standard (ppm) <sup>b</sup>																		
Loco & marine	Uncontrolled			500 ppm														
Nonroad	Uncontrolled			15 ppm														

<sup>a</sup> Applies to model years. If no standard is shown for a given pollutant, the previous standard applies.

<sup>b</sup> Applies to calendar years. Begins in June.

<sup>γ</sup> Actual standard is 3.5g/bhp-hr NO<sub>x</sub>+NMHC, equivalent to the Tier 3 standard for 50-75hp. For modeling purposes, NO<sub>x</sub> portion of this standard is assumed to be 3.3g/bhp-hr.

# Final Regulatory Impact Analysis

Figure 12.2.1-2  
Engine and Fuel Standards Under Option 1a

hp group	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Nonroad engine standards (g/bhp-hr) <sup>a</sup>											
hp <25	Tier 2					0.01 PM		0.30 NOx			
25 ≤ hp hp < 50											
50 ≤ hp hp < 75	Tier 3			0.01 PM							
75 ≤ hp hp < 100											
100 ≤ hp hp < 175	Tier 2		0.01 PM								
175 ≤ hp hp < 750											
hp ≥ 750	Tier 1	Tier 2		0.01 PM		0.30 NOx					
Fuel sulfur standard (ppm) <sup>b</sup>											
Loco & marine	Uncontrolled			15 ppm							
Nonroad	Uncontrolled			15 ppm							

<sup>a</sup> Applies to model years. If no standard is shown for a given pollutant, the previous standard applies.

<sup>b</sup> Applies to calendar years. Begins in June.

Figure 12.2.1-3  
Engine and Fuel Standards Under Option 1b

hp group	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Nonroad engine standards (g/bhp-hr) <sup>a</sup>											
hp <25	Tier 2					0.01 PM		0.30 NOx			
25 ≤ hp hp < 50											
50 ≤ hp hp < 75	Tier 3		Tier 3		0.01 PM						
75 ≤ hp hp < 100											
100 ≤ hp hp < 175	Tier 2		Tier 2		0.01 PM						
175 ≤ hp hp < 750											
hp ≥ 750	Tier 1	Tier 2		Tier 2		0.01 PM					
Fuel sulfur standard (ppm) <sup>b</sup>											
Loco & marine	Uncont rolled	15 ppm									
Nonroad	Uncont rolled	15 ppm									

<sup>a</sup> Applies to model years. If no standard is shown for a given pollutant, the previous standard applies.

<sup>b</sup> Applies to calendar years. Begins in June.

## 12.2.2 Two-Step Options

Two-step options were those in which the fuel sulfur standard was set first at 500ppm for several years, and then was lowered further to 15ppm. The exact timing of the introduction of the 500ppm and the 15ppm standards varied among each of the two-step options. In addition, we considered a variety of engine standards and phase-ins. In the two-step options, the transient test cycle was required concurrently with the introduction of the transitional Tier 4 engine standards. The one exception was Option 5b, under which the existing steady-state test applied indefinitely for engines below 75 hp.

### 12.2.2.1 Options Evaluated for Proposal

The proposed program formed the basis for all of the two-step alternative program options. The two-step options that we evaluated for the NPRM are summarized in Table 12.2.2-1. The specifics of these two-step options are shown in the standard charts in Figures 12.1.2-2 through



## Final Regulatory Impact Analysis

11, while the previous Tier 1, Tier 2, and Tier 3 standards were shown in Figure 12.2-1. As for the one-step standard charts, only changes to the standards are shown, i.e. if no new standard for a given pollutant is indicated, the previous standard applies.

Table 12.2.2-1  
Summary of Two-Step Options

Option	Summary Description
Proposed program	<ul style="list-style-type: none"> <li>• 500 ppm in 2007; 15 ppm in 2010 for nonroad engines only</li> <li>• &gt;25 hp: PM aftertreatment-based standards introduced 2011-2013</li> <li>• &gt;75 hp: NOx aftertreatment-based standards introduced and phased-in 2011-2014</li> <li>• &lt;25 hp: PM standards in 2008</li> <li>• 25-75 hp: PM standards in 2008 (optional for 50-75 hp)</li> <li>• &gt;750hp: PM and NOx standards phased-in 2011-2014</li> </ul> <p><i>See Figure 12.2.2-1</i></p>
Option 2a	<p>Same as our proposed program, except:</p> <ul style="list-style-type: none"> <li>• Transitional sulfur standard of 500 ppm is introduced one year earlier</li> </ul> <p><i>See Figure 12.2.2-2</i></p>
Option 2b	<p>Same as our proposed program, except:</p> <ul style="list-style-type: none"> <li>• Final sulfur standard of 15 ppm is introduced one year earlier</li> <li>• Trap-based PM standards begin one year earlier for all engines</li> </ul> <p><i>See Figure 12.2.2-3</i></p>
Option 2c	<p>Same as our proposed program, except:</p> <ul style="list-style-type: none"> <li>• Final sulfur standard of 15 ppm is introduced one year earlier</li> <li>• Trap-based PM standards begin one year earlier for 175 - 750 hp engines</li> </ul> <p><i>See Figure 12.2.2-4</i></p>
Option 2d	<p>Same as our proposed program, except:</p> <ul style="list-style-type: none"> <li>• Final NOx standard for 25 - 75 hp engines is lowered to 0.30 g/bhp-hr</li> <li>• A phase-in for the NOx standard for this horsepower group is included</li> </ul> <p><i>See Figure 12.2.2-5</i></p>
Option 2e	<p>Same as our proposed program, except:</p> <ul style="list-style-type: none"> <li>• No new Tier 4 NOx standards.</li> </ul> <p><i>See Figure 12.2.2-6</i></p>
Option 3	<p>Same as our proposed program, except:</p> <ul style="list-style-type: none"> <li>• Above-ground mining equipment &gt;750 hp remains at the Tier 2 standards</li> </ul> <p><i>See Figure 12.2.2-7</i></p>
Option 4	<p>Same as our proposed program, except:</p> <ul style="list-style-type: none"> <li>• 15 ppm final sulfur standard applies to fuel used by locomotives and marine engines in addition to all other nonroad engines</li> </ul> <p><i>See Figure 12.2.2-8</i></p>
Option 5a	<p>Same as our proposed program, except:</p> <ul style="list-style-type: none"> <li>• No new Tier 4 standards for &lt;75 hp engines</li> </ul> <p><i>See Figure 12.2.2-9</i></p>
Option 5b	<p>Same as our proposed program, except:</p> <ul style="list-style-type: none"> <li>• No trap-based PM standards for &lt;75 hp engines</li> <li>• No new Tier 4 NOx standards for &lt;75 hp engines</li> </ul> <p><i>See Figure 12.2.2-10</i></p>

Figure 12.2.2-1  
Engine and Fuel Standards under the Proposed Program

hp group	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015						
Nonroad engine standards (g/bhp-hr) <sup>a</sup>																	
hp <25	Tier 2			0.30 PM													
25 ≤ hp hp < 50				0.22 PM						0.02 PM, 3.3 <sup>ε</sup> NOx							
50 ≤ hp hp < 75				Tier 3						100% <sup>γ</sup> : 0.01 PM 50% <sup>γ</sup> : 0.30 NOx							
75 ≤ hp hp < 100														0.01 PM			
100 ≤ hp hp < 175																	
175 ≤ hp hp < 750				50% <sup>δ</sup> : 0.01 PM, 0.30 NOx													
hp ≥ 750	Tier 1	Tier 2						50% <sup>δ</sup> : 0.01 PM, 0.30 NOx									
Fuel sulfur standard (ppm) <sup>β</sup>																	
Loco & marine	Uncontrolled		500 ppm														
Nonroad	Uncontrolled		500 ppm				15 ppm										

<sup>a</sup> Applies to model years. If no standard is shown for a given pollutant, the previous standard applies.

<sup>β</sup> Applies to calendar years. Begins in June.

<sup>γ</sup> All engines must meet 0.01 PM, but only 50% of engines must meet the new NOx standard of 0.30. All engines must use the transient test cycle.

<sup>δ</sup> Only 50% of engines must meet both the new PM and NOx standards on the transient test cycle. Remaining engines meet Tier 2 standards on the steady-state test cycle.

<sup>ε</sup> Actual standard is 3.5g/bhp-hr NOx+NMHC, equivalent to the Tier 3 standard for 50-75hp. For modeling purposes, NOx portion of this standard is assumed to be 3.3g/bhp-hr.

## Final Regulatory Impact Analysis

Figure 12.2.2-2  
Engine and Fuel Standards under Option 2a

hp group	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015		
Nonroad engine standards (g/bhp-hr) <sup>a</sup>													
hp <25	Tier 2			0.30 PM									
25 ≤ hp hp < 50				0.22 PM						0.02 PM, 3.3 <sup>ε</sup> NOx			
50 ≤ hp hp < 75				Tier 3						100% <sup>γ</sup> : 0.01 PM 50% <sup>γ</sup> : 0.30 NOx		0.01 PM  0.30 NOx	
75 ≤ hp hp < 100													
100 ≤ hp hp < 175	Tier 1		Tier 2				50% <sup>δ</sup> : 0.01 PM, 0.30 NOx		0.01 PM  0.30 NOx				
175 ≤ hp hp < 750													
hp ≥ 750	Tier 1		Tier 2				50% <sup>δ</sup> : 0.01 PM, 0.30 NOx		0.01 PM  0.30 NOx				
Fuel sulfur standard (ppm) <sup>β</sup>													
Loco & marine	Uncontrolled	500 ppm											
Nonroad	Uncontrolled	500 ppm				15 ppm							

<sup>a</sup> Applies to model years. If no standard is shown for a given pollutant, the previous standard applies.

<sup>β</sup> Applies to calendar years. Begins in June.

<sup>γ</sup> All engines must meet 0.01 PM, but only 50% of engines must meet the new NOx standard of 0.30. All engines must use the transient test cycle.

<sup>δ</sup> Only 50% of engines must meet both the new PM and NOx standards on the transient test cycle. Remaining engines meet Tier 2 standards on the steady-state test cycle.

<sup>ε</sup> Actual standard is 3.5g/bhp-hr NOx+NMHC, equivalent to the Tier 3 standard for 50-75hp. For modeling purposes, NOx portion of this standard is assumed to be 3.3g/bhp-hr.

Figure 12.2.2-3  
Engine and Fuel Standards under Option 2b

hp group	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015		
Nonroad engine standards (g/bhp-hr) <sup>a</sup>													
hp <25	Tier 2			0.30 PM									
25 ≤ hp hp < 50				0.22 PM					0.02 PM	0.02 PM, 3.3 <sup>ε</sup> NO <sub>x</sub>			
50 ≤ hp hp < 75				Tier 3					0.01 PM	50% <sup>γ</sup> : 0.30 NO <sub>x</sub>		0.01 PM  0.30 NO <sub>x</sub>	
75 ≤ hp hp < 100													
100 ≤ hp hp < 175	Tier 1	Tier 2			0.01 PM	50% <sup>δ</sup> : 0.01 PM	50% <sup>δ</sup> : 0.01 PM, 0.30 NO <sub>x</sub>		100%: 0.01 PM				
175 ≤ hp hp < 750													
hp ≥ 750	Tier 1	Tier 2			0.01 PM	50% <sup>δ</sup> : 0.01 PM	50% <sup>δ</sup> : 0.01 PM, 0.30 NO <sub>x</sub>		100%: 0.01 PM				
Fuel sulfur standard (ppm) <sup>b</sup>													
Loco & marine	Uncontrolled		500 ppm										
Nonroad	Uncontrolled		500 ppm			15 ppm							

<sup>a</sup> Applies to model years. If no standard is shown for a given pollutant, the previous standard applies.

<sup>b</sup> Applies to calendar years. Begins in June.

<sup>γ</sup> All engines must meet 0.01 PM, but only 50% of engines must meet the new NO<sub>x</sub> standard of 0.30. All engines must use the transient test cycle.

<sup>δ</sup> Only 50% of engines must meet both the new PM and NO<sub>x</sub> standards on the transient test cycle. Remaining engines meet Tier 2 standards on the steady-state test cycle.

<sup>ε</sup> Actual standard is 3.5g/bhp-hr NO<sub>x</sub>+NMHC, equivalent to the Tier 3 standard for 50-75hp. For modeling purposes, NO<sub>x</sub> portion of this standard is assumed to be 3.3g/bhp-hr.

## Final Regulatory Impact Analysis

Figure 12.2.2-4  
Engine and Fuel Standards under Option 2c

hp group	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015		
Nonroad engine standards (g/bhp-hr) <sup>a</sup>													
hp <25	Tier 2			0.30 PM									
25 ≤ hp hp < 50				0.22 PM						0.02 PM, 3.3 <sup>ε</sup> NOx			
50 ≤ hp hp < 75				Tier 3						100% <sup>γ</sup> : 0.01 PM 50% <sup>γ</sup> : 0.30 NOx		0.01 PM	
75 ≤ hp hp < 100													
100 ≤ hp hp < 175	Tier 1				0.01 PM		50% <sup>δ</sup> : 0.01 PM, 0.30 NOx		0.30 NOx				
175 ≤ hp hp < 750													
hp ≥ 750	Tier 1		Tier 2				50% <sup>δ</sup> : 0.01 PM, 0.30 NOx						
Fuel sulfur standard (ppm) <sup>β</sup>													
Loco & marine	Uncontrolled		500 ppm										
Nonroad	Uncontrolled		500 ppm			15 ppm							

<sup>a</sup> Applies to model years. If no standard is shown for a given pollutant, the previous standard applies.

<sup>β</sup> Applies to calendar years. Begins in June.

<sup>γ</sup> All engines must meet 0.01 PM, but only 50% of engines must meet the new NOx standard of 0.30. All engines must use the transient test cycle.

<sup>δ</sup> Only 50% of engines must meet both the new PM and NOx standards on the transient test cycle. Remaining engines meet Tier 2 standards on the steady-state test cycle.

<sup>ε</sup> Actual standard is 3.5g/bhp-hr NOx+NMHC, equivalent to the Tier 3 standard for 50-75hp. For modeling purposes, NOx portion of this standard is assumed to be 3.3g/bhp-hr.

Figure 12.2.2-5  
Engine and Fuel Standards under Option 2d

hp group	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Nonroad engine standards (g/bhp-hr) <sup>a</sup>												
hp <25	Tier 2	0.30 PM										
25 ≤ hp hp < 50		0.22 PM							0.02 PM			0.30 NOx
50 ≤ hp hp < 75		Tier 3							50%: 0.30 NOx			
75 ≤ hp hp < 100		Tier 3							100% <sup>γ</sup> : 0.01 PM 50% <sup>γ</sup> : 0.30 NOx			0.01 PM
100 ≤ hp hp < 175		Tier 3										0.01 PM
175 ≤ hp hp < 750		Tier 3							0.30 NOx			
hp ≥ 750	Tier 1	Tier 2					50% <sup>δ</sup> : 0.01 PM, 0.30 NOx			0.30 NOx		
Fuel sulfur standard (ppm) <sup>b</sup>												
Loco & marine	Uncontrolled		500 ppm									
Nonroad	Uncontrolled		500 ppm				15 ppm					

<sup>a</sup> Applies to model years. If no standard is shown for a given pollutant, the previous standard applies.

<sup>b</sup> Applies to calendar years. Begins in June.

<sup>γ</sup> All engines must meet 0.01 PM, but only 50% of engines must meet the new NOx standard of 0.30. All engines must use the transient test cycle.

<sup>δ</sup> Only 50% of engines must meet both the new PM and NOx standards on the transient test cycle. Remaining engines meet Tier 2 standards on the steady-state test cycle.

## Final Regulatory Impact Analysis

Figure 12.2.2-6  
Engine and Fuel Standards under Option 2e

hp group	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015		
Nonroad engine standards (g/bhp-hr) <sup>a</sup>													
hp < 25	Tier 2			0.30 PM									
25 ≤ hp hp < 50				0.22 PM						0.02 PM			
50 ≤ hp hp < 75				Tier 3						0.01 PM			
75 ≤ hp hp < 100													
100 ≤ hp hp < 175													
175 ≤ hp hp < 750				Tier 1		Tier 2				50% <sup>δ</sup> : 0.01 PM		0.01 PM	
hp ≥ 750													
Fuel sulfur standard (ppm) <sup>β</sup>													
Loco & marine	Uncontrolled		500 ppm										
Nonroad	Uncontrolled		500 ppm			15 ppm							

<sup>a</sup> Applies to model years. If no standard is shown for a given pollutant, the previous standard applies.

<sup>β</sup> Applies to calendar years. Begins in June.

<sup>δ</sup> Only 50% of engines must meet the new PM standard on the transient test cycle. Remaining engines meet Tier 2 standards on the steady-state test cycle.

Figure 12.2.2-7  
Engine and Fuel Standards under Option 3

hp group	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015		
Nonroad engine standards (g/bhp-hr) <sup>a</sup>													
hp <25	Tier 2			0.30 PM									
25 ≤ hp hp < 50				0.22 PM						0.02 PM, 3.3 <sup>ε</sup> NOx			
50 ≤ hp hp < 75				Tier 3			100% <sup>γ</sup> : 0.01 PM 50% <sup>γ</sup> : 0.30 NOx				0.01 PM  0.30 NOx		
75 ≤ hp hp < 100													
100 ≤ hp hp < 175	Tier 1			50% <sup>δ</sup> : 0.01 PM, 0.30 NOx Mining equipment remains at Tier 2				0.01 PM 0.30 NOx Mining equipment at Tier 2					
175 ≤ hp hp < 750													
hp ≥ 750	Tier 2												
Fuel sulfur standard (ppm) <sup>β</sup>													
Loco & marine	Uncontrolled		500 ppm										
Nonroad	Uncontrolled		500 ppm				15 ppm						

<sup>a</sup> Applies to model years. If no standard is shown for a given pollutant, the previous standard applies.

<sup>β</sup> Applies to calendar years. Begins in June.

<sup>γ</sup> All engines must meet 0.01 PM, but only 50% of engines must meet the new NOx standard of 0.30. All engines must use the transient test cycle.

<sup>δ</sup> Only 50% of engines not used in mining equipment must meet both the new PM and NOx standards on the transient test cycle. Remaining engines meet Tier 2 standards on the steady-state test cycle.

<sup>ε</sup> Actual standard is 3.5g/bhp-hr NOx+NMHC, equivalent to the Tier 3 standard for 50-75hp. For modeling purposes, NOx portion of this standard is assumed to be 3.3g/bhp-hr.



## Final Regulatory Impact Analysis

Figure 12.2.2-8  
Engine and Fuel Standards under Option 4

hp group	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015		
Nonroad engine standards (g/bhp-hr) <sup>a</sup>													
hp <25	Tier 2			0.30 PM									
25 ≤ hp hp < 50				0.22 PM						0.02 PM, 3.3 <sup>e</sup> NOx			
50 ≤ hp hp < 75				Tier 3						100% <sup>γ</sup> : 0.01 PM 50% <sup>γ</sup> : 0.30 NOx		0.01 PM  0.30 NOx	
75 ≤ hp hp < 100													
100 ≤ hp hp < 175	Tier 1		Tier 2				50% <sup>δ</sup> : 0.01 PM, 0.30 NOx		0.01 PM  0.30 NOx				
175 ≤ hp hp < 750													
hp ≥ 750	Tier 1		Tier 2				50% <sup>δ</sup> : 0.01 PM, 0.30 NOx		0.01 PM  0.30 NOx				
Fuel sulfur standard (ppm) <sup>β</sup>													
Loco & marine	Uncontrolled		500 ppm			15 ppm							
Nonroad	Uncontrolled		500 ppm			15 ppm							

<sup>a</sup> Applies to model years. If no standard is shown for a given pollutant, the previous standard applies.

<sup>β</sup> Applies to calendar years. Begins in June.

<sup>γ</sup> All engines must meet 0.01 PM, but only 50% of engines must meet the new NOx standard of 0.30. All engines must use the transient test cycle.

<sup>δ</sup> Only 50% of engines must meet both the new PM and NOx standards on the transient test cycle. Remaining engines meet Tier 2 standards on the steady-state test cycle.

<sup>e</sup> Actual standard is 3.5g/bhp-hr NOx+NMHC, equivalent to the Tier 3 standard for 50-75hp. For modeling purposes, NOx portion of this standard is assumed to be 3.3g/bhp-hr.

Figure 12.2.2-9  
Engine and Fuel Standards under Option 5a

hp group	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015											
Nonroad engine standards (g/bhp-hr) <sup>a</sup>																						
hp <25	Tier 2																					
25 ≤ hp hp < 50																						
50 ≤ hp hp < 75																						
75 ≤ hp hp < 100																						
100 ≤ hp hp < 175												Tier 3										
175 ≤ hp hp < 750																						
hp ≥ 750												Tier 1	Tier 2					50% <sup>δ</sup> : 0.01 PM, 0.30 NOx		100% <sup>γ</sup> : 0.01 PM 50% <sup>γ</sup> : 0.30 NOx		0.01 PM
Fuel sulfur standard (ppm) <sup>β</sup>																						
Loco & marine	Uncontrolled	500 ppm																				
Nonroad	Uncontrolled	500 ppm				15 ppm																

<sup>a</sup> Applies to model years. If no standard is shown for a given pollutant, the previous standard applies.

<sup>β</sup> Applies to calendar years. Begins in June.

<sup>γ</sup> All engines must meet 0.01 PM, but only 50% of engines must meet the new NOx standard of 0.30. All engines must use the transient test cycle.

<sup>δ</sup> Only 50% of engines must meet both the new PM and NOx standards on the transient test cycle. Remaining engines meet Tier 2 standards on the steady-state test cycle.

## Final Regulatory Impact Analysis

Figure 12.2.2-10  
Engine and Fuel Standards under Option 5b

hp group	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Nonroad engine standards (g/bhp-hr) <sup>a</sup>											
hp <25	Tier 2	0.30 PM									
25 ≤ hp hp < 50		0.22 PM									
50 ≤ hp hp < 75		Tier 3									
75 ≤ hp hp < 100											
100 ≤ hp hp < 175									100% <sup>γ</sup> : 0.01 PM 50% <sup>γ</sup> : 0.30 NOx		0.01 PM
175 ≤ hp hp < 750											0.30 NOx
hp ≥ 750	Tier 1	Tier 2					50% <sup>δ</sup> : 0.01 PM, 0.30 NOx				
Fuel sulfur standard (ppm) <sup>b</sup>											
Loco & marine	Uncontrolled	500 ppm									
Nonroad	Uncontrolled	500 ppm				15 ppm					

<sup>a</sup> Applies to model years. If no standard is shown for a given pollutant, the previous standard applies.

<sup>b</sup> Applies to calendar years. Begins in June.

<sup>γ</sup> All engines must meet 0.01 PM, but only 50% of engines must meet the new NOx standard of 0.30. All engines must use the transient test cycle.

<sup>δ</sup> Only 50% of engines must meet both the new PM and NOx standards on the transient test cycle. Remaining engines meet Tier 2 standards on the steady-state test cycle.

### 12.2.2.2 Option 5c

As described in Section 12.2.2.1, Option 5b represented an alternative program in which we would not apply trap-based PM standards or new NOx standards to engines under 75hp. As described in Sections II.A and II.B of the preamble, we continue to believe that the application of PM filters to small engines is both feasible and is an important element of our efforts to address air quality concerns associated with nonroad engines. Therefore, we have not finalized Option 5b and the proposed Tier 4 PM and NOx standards for <75hp engines are included in the program we are finalizing.

Some of the original concerns raised about <75hp engines were again raised in response to the NPRM for a smaller group of engines with rated horsepower between 25 and 50 hp. In the process of considering this issue, we evaluated a new Option 5c in which the trap-based PM

standard and the Tier 4 NOx standard would not be applied to 25 - 50 hp engines, but would continue to apply to above 50 hp engines. This specific option is a refinement of Option 5b, but was not evaluated for the NPRM. We evaluated this Option 5c as part of our overall evaluation of a wide variety of alternative options. We are presenting the results of our analysis here.

As described above, we did not repeat the analyses for Options 1 through 5b for this final rule, but instead refer the reader to the draft RIA for those analyses. The draft RIA presented the inventory impacts, benefits, costs, and cost-effectiveness of each of the options in comparison to the proposed program. For Option 5c, however, we evaluated the inventory impacts, benefits, costs, and cost-effectiveness in comparison to the final program.

*12.2.2.2.1 Emission Inventory Impacts*

Option 5c is identical to our final program, except that it would not require 25-50hp engines to meet the trap-based PM standards that are in our final program, nor would it require these engines to meet the Tier 4 NOx standards. As a result, the PM and NOx emission reductions for Option 5c would be lower than those for our final program. However, under this option pollutants other than PM and NOx would also be affected. For instance, the reductions in hydrocarbons and CO that will occur for our final program are generated primarily through the presence of catalyzed diesel particulate traps, so the removal of the trap-based PM standards for 25-50 hp engines will also produce a corresponding reduction in the HC and CO benefits.

In evaluating the inventory impacts of Option 5c, we assumed that the 2008 PM standards for 25-50 hp engines were met using a steady-state test cycle for both our final program and Option 5c. Whether these engines should be required to meet standards under a transient test procedure is a separate issue from the use of after-treatment. Our analysis was designed to focus in the impacts of requiring the use of aftertreatment.

Thus Option 5c produces fewer benefits for all pollutants starting in 2013 in comparison to our final program. Table 12.2.2.2.1-1 shows the net impact of Option 5c on the 30-year net present value inventory estimates.

Table 12.2.2.2.1-1  
50-State 30-Year Net Present Value Emission Increases  
For Option 5c In Comparison to Final Program (tons)

	3% discount rate	7% discount rate
PM	56,833	25,238
NOx + NMHC	381,459	170,819

## Final Regulatory Impact Analysis

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### 12.2.2.2.2 Cost Analysis

Option 5c would reduce the overall costs of the program since 25-50 hp engines would not need to install PM traps nor make engine modifications to comply with more stringent NOx standards. We calculated the total nationwide cost savings by summing the per-engine savings across all engines for each year starting in 2013. Table 12.2.2.2.2-1 shows the resulting 30-year net present value cost savings for Option 5c. Costs were allocated to the various pollutants according to the methodology described in Chapter 8 of the RIA.

Table 12.2.2.2.2-1  
50-State 30-Year Net Present Value Cost Savings  
For Option 5c In Comparison to Final Program (\$million)

	3% discount rate	7% discount rate
All pollutants	2,041	997
PM	1,514	735
NOx + NMHC	527	263

### 12.2.2.2.3 Benefits Comparison

We were able to estimate the benefits of Option 5c using the benefit-transfer methodology developed in Chapter 9 for estimating the monetized benefits of the final program. The specific methodology is described in Section 9.5 “Development of Intertemporal Scaling Factors and Calculation of Benefits Over Time” and will not be repeated here. To use that methodology requires input of 48-state emission reductions for NOx, PM2.5 and SO<sub>2</sub> associated with Option 5c. We cannot estimate 50-state benefits due to the fact that our air quality modeling work covers only 48 states, and we are unable to extrapolate those results to Alaska or Hawaii. PM2.5 is used for these calculations rather than PM10 because the underlying health effect studies rely on PM2.5 data.

Accounting for the reduction in monetised health and welfare benefits from the net emission inventory impacts of Option 5c in comparison to our final program produces 30-year net present value of loss in benefits of \$36.6 billion at a 3 percent discount rate, and \$14.8 billion at a 7 percent discount rate. This loss in benefits is much larger than the costs savings associated with not applying trap-based PM standards to 25-50-hp engines as shown in Table 12.2.2.2.2-1, highlighting the fact that there is a substantial net benefit to society of applying the trap-based PM standards to 25-50 hp engines.

*12.2.2.2.4 Costs Per Ton*

The cost-effectiveness of the final standards for 25-50 hp engines can be calculated from the values in Tables Table 12.2.2.2.1-1 and Table 12.2.2.2.2-1. The results are given in Table 12.2.2.2.4-1.

Table 12.2.2.2.4-1  
50-State 30-Year Net Present Value Cost-Effectiveness  
For Option 5c In Comparison to Final Program (\$/ton)

	3% discount rate	7% discount rate
PM	26,600	29,100
NO <sub>x</sub> + NMHC	1,400	1,500