

Appendix 4:
Rate of Further Progress Analysis
for Non-road Sources



Rate of Further Progress Analysis for Nonroad Sources

Draft Final Report

Prepared for:

**The Texas Commission on
Environmental Quality**

Prepared by:

Eastern Research Group, Inc.

August 31, 2006



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RATE OF FURTHER PROGRESS ANALYSIS FOR NONROAD SOURCES

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1.0 Introduction

The purpose of this project was to develop emissions inventory data for all controlled and uncontrolled source categories contained within the EPA's NONROAD 2005 model for the Dallas/Fort Worth (DFW) and Houston/Galveston/Brazoria (HGB) ozone non-attainment areas, as needed to support the Rate of Further Progress (RFP) State Implementation Plans (SIPs). These inventories include county level annual and ozone season day emissions estimates for years 2002, 2008, 2009, 2011, and 2012. This work documents all rules/regulations that apply to these sources in Texas, and quantifies the amount of emissions reduction due to each rule/regulation. The resulting information was loaded into the Texas Air Emissions Repository (TexAER) database and used to produce required reports.

The benefits of this effort include up-to-date and more accurate nonroad mobile emissions estimates, in addition to the documentation of all rules/regulations that apply to each estimate of the controlled emissions. This work also supports the Rate of Further Progress (RFP) SIPs and EPA requirements.

The following documents the findings of this analysis, along with a description of all calculation methods and assumptions.

2.0 Documentation of Rules and Regulations

ERG first developed a list of all existing Federal and State rules and regulations that apply to each Source Category Code (SCC) in EPA's NONROAD emissions model, specifying the effective date(s), developed from EPA's Office of Transportation and Air Quality (OTAQ) website¹ and the TCEQ website². The TCEQ project manager confirmed that there were no relevant proposed SIP rules or regulations that would apply the target source categories. Using these lists ERG documented all existing Federal and State rules and regulations that applied to each estimate of the controlled emissions, and quantified the emissions reductions for each rule and regulation.

2.1 Applicable Rules and Standards

2.1.1 State Rules

In consultation with TCEQ staff, three state rules were identified that are applicable to nonroad mobile vehicles and equipment in the HGB and DFW areas:

- The Texas Low Emission Diesel Rule (TxLED)
- Reformulated Gasoline (RFG)
- The California Large Spark Ignition Engine Standards Rule (Large SI)

Other rules and regulations that effect nonroad engines include multiple Memoranda of Understanding and Agreement (MOUs and MOAs) with specific fleets in different nonattainment areas, such as airport Ground Support Equipment (GSE), locomotives, and Port activities. Texas Emission Reduction Program (TERP) projects also fall under this category. However, these fleet-level control initiatives have to be modeled using fleet-specific equipment and activity profiles, which was outside the scope of the current work order.

The only other rule impacting nonroad equipment is the emergency generator use limitation in the HGB area. However, this rule just entails a *redistribution* of the hourly

¹ <http://www.epa.gov/otaq/nonroad.htm>

² <http://www.tceq.state.tx.us/implementation/air/sip/cleandiesel.html> and <http://www.tceq.state.tx.us/implementation/air/sip/calispark.html>

emissions inventory, rather than an adjustment to the daily or annual inventory (which is the subject of the current work order).

The three state rules evaluated for this analysis are discussed below.

Texas Low Emission Diesel (TxLED)³

TxLED is a specific diesel fuel formulation intended to lower emissions of NOx from diesel-powered on-road and nonroad equipment. It applies to diesel fuel producers, importers, common carriers, distributors, transporters, bulk terminal operators, and retailers. The rule covers 110 counties in the eastern half of Texas, including the ozone nonattainment areas in Beaumont-Port Arthur, Dallas-Fort Worth, and Houston-Galveston-Brazoria. The rule requires that diesel fuel produced for delivery and ultimate sale to the consumer must contain less than 10 percent by volume of aromatic hydrocarbons and must have a cetane number of 48 or greater. Some compliance options are allowed⁴.

The rule, originally adopted in December 2000, was revised in March 2005, removing the sulfur requirements, clarifying reporting requirements, modifying registration requirements, and updating references citing industry standards and federal regulations. The rule was most recently revised in May 2006, revising credit calculations for early gasoline sulfur reductions, adding a date to resubmit plans, and clarifying requirements for alternative emission reduction plans; clarifying the definition of an additive; and adding detail to the approved test methods (see 30 TAC 114, Subchapter H, Division 2).

Reformulated Gasoline (RFG)

Reformulated gasoline is required to be sold in the DFW and HGB regions year round since 1995.⁵ RFG is designed to produce significant reductions in VOC and NOx emissions from on-road gasoline vehicles equipped with three-way catalytic converters. Although few if any

³ <http://www.tceq.state.tx.us/implementation/air/sip/cleandiesel.html#Intro>

⁴

http://www.tceq.state.tx.us/assets/public/implementation/air/sip/ruledocs/txled/Draft_Compliance_Assistance_Document.pdf

⁵ The HGB adopted RFG under Federal Clean Air Act Amendment requirements. The DFW region “opted-in” to the program under its SIP requirements.

gasoline-fueled nonroad engines have catalysts at this time,⁶ emission benefits are realized from RFG use as result of lowered fuel RVP levels during summer months. Unlike diesel fuel, there is no differentiation between on and off-road gasoline fuel specifications. Therefore the reduced RVP levels of RFG will generate VOC reductions for gasoline-powered nonroad engines.

Table 2-1. TxLED Counties

Anderson	Comal	Harris	Madison	San Augustine
Angelina	Cooke	Harrison	Marion	San Jacinto
Aransas	Coryell	Hays	Matagorda	San Patricio
Atascosa	Dallas	Henderson	McLennan	Shelby
Austin	De Witt	Hill	Milam	Smith
Bastrop	Delta	Hood	Montgomery	Somervell
Bee	Denton	Hopkins	Morris	Tarrant
Bell	Ellis	Houston	Nacogdoches	Titus
Bexar	Falls	Hunt	Navarro	Travis
Bosque	Fannin	Jackson	Newton	Trinity
Bowie	Fayette	Jasper	Nueces	Tyler
Brazoria	Fort Bend	Jefferson	Orange	Upshur
Brazos	Franklin	Johnson	Panola	Van Zandt
Burleson	Freestone	Karnes	Parker	Victoria
Caldwell	Galveston	Kaufman	Polk	Walker
Calhoun	Goliad	Lamar	Rains	Waller
Camp	Gonzales	Lavaca	Red River	Washington
Cass	Grayson	Lee	Refugio	Wharton
Chambers	Gregg	Leon	Robertson	Williamson
Cherokee	Grimes	Liberty	Rockwall	Wilson
Collin	Guadalupe	Limestone	Rusk	Wise
Colorado	Hardin	Live Oak	Sabine	Wood

California Large Spark Ignition Engine Rule

This rule was effective statewide beginning in 2004, and requires that spark ignition nonroad engines greater than 25 horsepower sold in the state are certified to California Air Resources Board emission standards (30 TAC 114, Subchapter I, Division 3). Exempted equipment include agricultural and construction equipment less than 175 hp, recreational equipment, stationary engines, marine vessels, and railroad support equipment.

Since the initial adoption of the rule for the 2000 DFW and HGB SIPs, the rule has been superceded by the Federal Large Spark Ignition Rule, published in November of 2002.

⁶ Nonroad spark ignition engines are not expected to include catalysts in the near future either – see Exhaust Emission Effects of Fuel Sulfur and Oxygen on Gasoline Nonroad Engines, EPA420-R-05-016, December 2005.

Therefore the benefits of the California rule are effectively included in the Federal Rule, as described below.

2.1.2 Federal Rules

ERG identified six federal rules that impact emissions from nonroad engines. These rules were identified using EPA's OTAQ website.⁷ ERG sent this list of rules to a representative at the EPA for review, to ensure all the applicable rules had been identified.⁸ The applicable rules are:

- Rule #1: Emission Standards for New Nonroad Spark-ignition Engines at or below 19 Kilowatts (Phase I Small SI Rule)⁹
- Rule #2: Federal Emission Standards for Heavy-Duty and Nonroad Engines (1998 HD and Nonroad Rule)¹⁰
- Rule #3: Tier 1, 2 and Tier 3 Emission Standards: Control of Emissions of Air Pollution from Nonroad Diesel Engines (Tier 1, 2 and 3 Rule)¹¹
- Rule #4: Final Phase II Standards for Small Nonroad SI Handheld Engines (Phase II Small SI Rule)¹²
- Rule #5: Emission Standards for New Nonroad Engines - Large Industrial SI Engines, Recreational Vehicles, and Diesel Recreational Marine Engines (Large SI Rule)¹³
- Rule #6: Clean Air Nonroad Diesel - Tier 4 Final Rule (Tier 4 Rule)¹⁴

Table 2-2 below shows the phase-in dates, equipment types and horsepower ranges for each rule. Each of these rules is discussed in more detail below.

⁷ <http://www.epa.gov/otaq/>.

⁸ Craig Harvey, US EPA, Office of Transportation and Air Quality, July 2006.

⁹ <http://www.epa.gov/fedrgstr/EPA-AIR/2004/January/Day-12/a458.pdf>

¹⁰ 40 CFR 89.1003(a)(1)(i) and <http://www.epa.gov/nonroad-diesel/regulations.htm>

¹¹ <http://www.epa.gov/nonroad-diesel/frm1998/nr-fr.pdf>

¹² <http://www.epa.gov/otaq/regs/nonroad/equip-ld/hhsfrm/f00007.pdf>

¹³ <http://www.epa.gov/otaq/largesi.htm>

¹⁴ <http://www.epa.gov/nonroad-diesel/2004fr.htm>

Table 2-2. Phase-in Dates by Rule

Rule Reference #	Rule	Sub-categories	Spark Ignition (Gasoline, LPG, CNG)				Compression Ignition (Diesel)				
			< 25 hp	> 25 hp	MARINE < 25 hp	MARINE > 25 hp	< 50 hp	> 50 hp	MARINE < 50 hp	MARINE > 50 hp	
1	Phase I Small SI		1997-								
2	1998 HD and Nonroad				1998-2006			1998-2000			
3	Tier 1, Tier 2 and Tier 3	Tier 1					1999-2000				
		Tier 2					2001-2006	2001-2006	2001-2006		
		Tier 3						2006-2008	2006-2008		
4	Phase II Small SI		2002-2007								
5	Large SI	Large Industrial Spark-Ignition Engines (Tier 1)		2004		2004					
		Large Industrial Spark-Ignition Engines (Tier 2)		2007		2007					
		Recreational Vehicles		2006							
		Diesel Recreational Marine Engines									2006
6	Tier 4					2008	2008-2013				

Rule #1: Emission Standards for New Nonroad Spark-ignition Engines At or Below 19 kW (25 hp)

This rule is applicable to new nonroad SI engines at or below 19 KW and manufactured during or after 1997 model year, including farm and construction equipment, lawnmowers, string trimmers, edgers, chainsaws, commercial turf equipment, small construction equip, and lawn and garden tractors. Exempt vehicles and equipment include competition or combat vehicles, research, training, investigations, demonstrations, and national security vehicles and equipment, engines used to propel marine vessels, engines used in underground mining equip, motorcycles, aircraft, and recreational vehicles. The standards for this rule are presented in Table 2-3 below.

Table 2-3. Phase I Small SI Rule Standards (g/bhp-hr)

Class	Year	CO	HC	HC + NOx	NOx	Equipment Description
I	1997+	387		12		Nonhandheld <225 CC
II	1997+	387		10		Nonhandheld>~225 CC
III	1997+	600	220		4	Handheld<20 CC
IV	1997+	600	180		4	Handheld>~20 <50 CC
V	1997+	450	120		4	Handheld >~ 50 CC

Rule #2: Federal Emission Standards for Heavy-Duty and Nonroad Engines

This rule is applicable to nonroad compression ignition (CI – diesel) engines greater than 50 hp, and marine SI outboard manufactured as early as 1998 and personal watercraft and jet boat engines manufactured as early as 1999. This rule does not include standards for nonroad SI engines greater than 25 hp or marine CI engines. The standards are presented below in Tables 2-4 and 2-5.

Table 2-4. 1998 Nonroad CI Engine Standards in g/bhp-hr

Rated Power	Year	CO	HC	NOx	PM	Smoke (%) acceleration/lug/peak modes
50 ≤hp< 100	1998+			6.9		20/15/50
100 ≤hp< 175	1997+			6.9		20/15/50
175 ≤hp< 750	1996+	8.5	1	6.9	0.4	20/15/50
hp = 750+	2000+	8.5	1	6.9	0.4	20/15/50

Table 2-5. 1998 Marine SI Engine Standards

Year	HC+NOx			
	P* < 4.3		P* ≥ 4.3	
	g/kW-hr	g/hp-hr	g/kW-hr	g/hp-hr
1998	278	207.3	$(0.917 \times (151 + 557/P^{0.9})) + 2.44$	$[(0.917 \times (151 + 557/P^{0.9})) + 2.44] \times 0.7457$
1999	253	188.7	$(0.833 \times (151 + 557/P^{0.9})) + 2.89$	$[(0.833 \times (151 + 557/P^{0.9})) + 2.89] \times 0.7457$
2000	208	155.1	$(0.750 \times (151 + 557/P^{0.9})) + 3.33$	$[(0.750 \times (151 + 557/P^{0.9})) + 3.33] \times 0.7457$
2001	204	152.1	$(0.667 \times (151 + 557/P^{0.9})) + 3.78$	$[(0.667 \times (151 + 557/P^{0.9})) + 3.78] \times 0.7457$
2002	179	133.5	$(0.583 \times (151 + 557/P^{0.9})) + 4.22$	$[(0.583 \times (151 + 557/P^{0.9})) + 4.22] \times 0.7457$
2003	155	115.6	$(0.500 \times (151 + 557/P^{0.9})) + 4.67$	$[(0.500 \times (151 + 557/P^{0.9})) + 4.67] \times 0.7457$
2004	130	96.9	$(0.417 \times (151 + 557/P^{0.9})) + 5.11$	$[(0.417 \times (151 + 557/P^{0.9})) + 5.11] \times 0.7457$
2005	105	78.3	$(0.333 \times (151 + 557/P^{0.9})) + 5.56$	$[(0.333 \times (151 + 557/P^{0.9})) + 5.56] \times 0.7457$
2006+	81	60.4	$(0.250 \times (151 + 557/P^{0.9})) + 6.00$	$[(0.250 \times (151 + 557/P^{0.9})) + 6.00] \times 0.7457$

*P=power rating in kilowatts

Rule #3: Tier 1, 2 and 3 Diesel Engine Emission Standards

These emission standards apply to all nonroad mobile diesel engines and equipment of all sizes, except for locomotives, marine engines above 50 hp, underground mining equipment, and engines with less than 50 CC that are typically used in model airplanes. The standards are presented in Table 2-6 below.

Table 2-6. Tier 1, 2 and 3 Diesel Engine Standards in g/kW-hr (g/hp-hr)

Engine Size	Tier	Model year	NMHC + NOx	CO	PM
kW < 8 (hp < 11)	Tier 1	2000	10.5 (7.8)	8.0 (6.0)	1.0 (0.75)
	Tier 2	2005	7.5 (5.6)	8.0 (6.0)	0.8 (0.6)
8 ≤ kW < 19 (11 ≤ hp < 25)	Tier 1	2000	9.5 (7.1)	6.6 (4.9)	0.8 (0.6)
	Tier 2	2005	7.5 (5.6)	6.6 (4.9)	0.8 (0.6)
19 ≤ kW < 37 (25 ≤ hp < 50)	Tier 1	1999	9.5 (7.1)	5.5 (4.1)	0.8 (0.6)
	Tier 2	2004	7.5 (5.6)	5.5 (4.1)	0.6 (0.45)
37 ≤ kW < 75 (50 ≤ hp < 100)	Tier 2	2004	7.5 (5.6)	5.0 (3.7)	0.4 (0.3)
	Tier 3	2008	4.7 (3.5)	5.0 (3.7)	
75 ≤ kW < 130 (100 ≤ hp < 175)	Tier 2	2003	6.6 (4.9)	5.0 (3.7)	0.3 (0.22)
	Tier 3	2007	4 (3.0)	5.0 (3.7)	
130 ≤ kW < 225 (175 ≤ hp < 300)	Tier 2	2003	6.6 (4.9)	3.5 (2.6)	0.2 (0.15)
	Tier 3	2006	4 (3.0)	3.5 (2.6)	
225 ≤ kW < 450 (300 ≤ hp < 600)	Tier 2	2001	6.4 (4.8)	3.5 (2.6)	0.2 (0.15)
	Tier 3	2006	4 (3.0)	3.5 (2.6)	
450 ≤ kW < 560 (600 ≤ hp < 750)	Tier 2	2002	6.4 (4.8)	3.5 (2.6)	0.2 (0.15)
	Tier 3	2006	4 (3.0)	3.5 (2.6)	
kW ≥ 560 (hp ≥ 750)	Tier 2	2006	6.4 (4.8)	3.5 (2.6)	0.2 (0.15)

Rule #4: Phase II Standards for Small Nonroad SI Handheld Engines

The Phase II Standards for small handheld nonroad spark-ignition engines apply to the following classes of engines shown in Table 2-7. Phase II standards are presented in Table 2-8.

Table 2-7. Phase II Small Nonroad SI Engine Categories

Class	Type	CC*
I-A	Nonhandheld	CC<66
I-B	Nonhandheld	66 to 100 CC
I	Nonhandheld	100 to 225 CC
II	Nonhandheld	>~ 225 CC
III	Handheld	< 20 CC
IV	Handheld	20 to 50 CC
V	Handheld	>~ 50 CC

* cubic centimeters

Table 2-8. Phase II HC+NOx Standards for handheld engines in g/kW-hr (g/hp-hr)

Model Year	Class III	Class IV	Class V
2002	238 (177)	196 (146)	
2003	175 (130)	148 (110)	
2004	113 (84)	99 (74)	143 (107)
2005	50 (37)	50 (37)	119 (89)
2006	50 (37)	50 (37)	96 (72)
2007 and later	50 (37)	50 (37)	72 (54)

Rule #5: Large Industrial SI Engines, Recreational Vehicles, and Diesel Recreational Marine Engines

This rule applies to large industrial spark-ignition engines powered by gasoline, natural gas, or propane gas, rated over 19 kW (25 hp). The rule also applies to diesel marine engines over 37 kW (50 hp) used in recreational boats, such as yachts and cruisers. The standards are presented in Tables 2-9 through 2-12.

Table 2-9. Large SI Engine Standards in g/kW-hr (g/hp-hr)

Tier/Year	HC+NOx	CO
Tier 1 Starting in 2004	4 (3.0)	50 (37.3)
Tier 2 Starting in 2007	2.7 (2.0)	4.4 (3.3)

Table 2-10. Recreational Vehicles Standards in g/kW-hr (g/hp-hr)

Vehicle	Model Year	HC	CO	Phase-in %
Snowmobiles	2006	100 (74.6)	275 (205.1)	50
	2007 through 2009	100 (74.6)	275 (205.1)	100
	2010	75 (55.9)	275 (205.1)	
	2012	75 (55.9)	200 (149.1)	
Off-highway Motorcycles	2006	2 (1.5)	25 (18.6)	50
	2007 and later	2 (1.5)	25 (18.6)	100
ATVs	2006	1.5 (1.1)	35 (26.1)	50
	2007 and later	1.5 (1.1)	35 (26.1)	100

Table 2-11. Permeation Standards for Recreational Vehicles

Emission Component	Implementation Date	Standard	Test Temperature
Fuel Tank Permeation	2008	1.5 g/sq meters/day	28 Degree C (82 degree F)
Fuel Hose Permeation	2008	15 g/sq meters/day	23 Degree C (73 degree F)

Table 2-12. Recreational Diesel Marine Standards in g/kW-hr (g/hp-hr)

Engine size	Implementation Date	HC+NOx	PM	CO
0.5 L/cyl ≤Displacement< 0.9 L/cyl	2007	7.5 (5.59)	0.4 (0.30)	5 (3.73)
0.9 L/cyl ≤Displacement< 1.2 L/cyl	2006	7.2 (5.37)	0.3 (0.22)	5 (3.73)
1.2 L/cyl ≤Displacement< 2.5 L/cyl	2006	7.2 (5.37)	0.2 (0.15)	5 (3.73)
Displacement ≥ 2.5 L/cyl	2009	7.2 (5.37)	0.2 (0.15)	5 (3.73)

Rule #6: Tier 4 Diesel Rule

This rule introduces new emission standards for nonroad diesel engines and sulfur reductions for nonroad diesel fuel. This rule will reduce PM emissions by 95% and NOx emissions by 90% and virtually eliminate sulfur oxides. The sulfur level in nonroad diesel fuel will be reduced from 3,000 ppm to 500 ppm starting in 2007, and then to 15 ppm starting in 2010, as shown in Table 2-13a. The sulfur reductions make it possible for manufacturers to use clean engine technologies to reduce pollution, similar to those being introduced in on-road vehicles. These new engine standards will take effect, based on engine horsepower, beginning in

2008. This rule applies to diesel engines used primarily in most construction, agricultural, industrial, and airport support equipment. The standards will be fully phased in by 2014, though engines greater than 750 hp will have an additional year (2015) to comply. The Tier 4 standards are presented in Table 2-13b.

Table 2-13a. Tier 4 Diesel Fuel Sulfur Standards (ppm)

Year	Cap
2007	500
2010	15

Table 2-13b. Tier 4 Emissions Standards (g/bhp-hr)

Rated Power	First year the standards apply	PM	NOx
hp < 25	2008	0.3	-
25 ≤ hp < 75	2013	0.02	3.5
75 ≤ hp < 175	2012-2013	0.01	0.3
175 ≤ hp < 750	2011-2013	0.01	0.3
hp ≥ 750	2011-2014	0.075	0.5 (gensets greater than 1200 HP); 2.6 (all other)
	2015	0.02 (gensets); 0.03 (all other engines)	0.5 (gensets only)

3.0 Emission Inventory Development

In order to evaluate Rate of Progress requirements, each analysis year requires two emissions inventories: one with controlled emissions and one with uncontrolled emissions. ERG developed county-level controlled and uncontrolled emissions inventories for the entire state of Texas for the years 2002, 2008, 2009, 2011, and 2012, using the most recent inventory data available. The process for creating these inventories is discussed below.

3.1 Controlled and Uncontrolled Emissions Estimates

ERG obtained the most recent, complete statewide controlled inventory for 2002 from the TCEQ to use as the base year inventory. TCEQ also supplied the supporting NONROAD model files used to create the 2002 base year inventory¹⁵. However, since this inventory was created, ERG has completed a number of projects for TCEQ to improve emissions inventories for individual equipment categories. Using the most up-to-date data, ERG executed EPA's NONROAD model to create inventories for these improved categories for the years of interest. NONROAD input files (i.e., containing EPA default values for Texas) were used to create an initial inventory for each analysis year. This default data was then swapped with the improved data for the categories listed below in Table 3-1.

Table 3-1. Updated Inventory Categories

Equipment Categories	Applicable Area	Applicable SCC(s)
Diesel Construction Equipment	Statewide	2270002XXX
Forklifts	HGB and DFW	22XX003020
Terminal Tractors	DFW	2270003070
Transportation Refrigeration Units (TRUs)	Collin, Dallas, Denton, and Tarrant Counties	2270003060
Lawn and Garden Equipment	Statewide	22XX004XXX
Recreational Marine Equipment	Statewide	22820XXXXX

These discrete inventories were then substituted into the 2002 base year inventory supplied by TCEQ, creating a new 2002 base year inventory for the analysis. ERG quality

¹⁵ TCEQ NRD data.zip – delivered to TCEQ Project Manager with this report.

assured the new inventory to ensure all of the latest inventory data was accurately incorporated and to ensure reproducibility. Once this was done, ERG repeated the process to create the controlled emissions inventories for the remaining years of interest. ERG then repeated this entire process removing the effects of all controls in the NONROAD technology file (tech-exh.dat), thus creating the corresponding uncontrolled emissions inventories for each region and analysis year. For example, in order to simulate emissions from uncontrolled diesel engines, ERG set the fraction of diesel engines corresponding to the “Base” technology category equal to 1.0, while setting all other technology categories equal to 0, for all years listed in the tech-exh.dat file. Similar adjustments were made for spark ignition engines as well.

Once the inventories were created, they were loaded into TCEQ’s TexAER database on the development server. The names of these inventories as they appear in the TexAER web application, and their associated emission inventory ID numbers as they are found in the TexAER Oracle database on the development server are listed in Table 3-2.

Table 3-2. TexAER ROP Inventory Names and IDs

Controlled ROP Emission Inventory Name	Controlled ROP Emission Inventory ID #	Uncontrolled ROP Emission Inventory Name	Uncontrolled ROP Emission Inventory ID #
ROP_2002_controlled_20060707	558	ROP_2002_uncontrolled_20060707	563
ROP_2008_controlled_20060707	559	ROP_2008_uncontrolled_20060707	564
ROP_2009_controlled_20060707	560	ROP_2009_uncontrolled_20060707	565
ROP_2011_controlled_20060707	561	ROP_2011_uncontrolled_20060707	566
ROP_2012_controlled_20060707	562	ROP_2012_uncontrolled_20060707	567

The following tables show emissions summary data for the HGB and DFW nonattainment areas for each of the years of interest.

Table 3-3. Controlled Emissions Estimates

	VOC		NOX		CO		PM10		PM25		SO2		CO2	
	TPY	TPD	TPY	TPD	TPY	TPD	TPY	TPD	TPY	TPD	TPY	TPD	TPY	TPD
2002														
DFW	34,789	115.64	28,908	110.49	423,835	1,500	2,851	11.05	2,705	10.51	1,981	8.05	2,870,153	10,803
HGB	34,041	110.25	29,044	110.30	403,151	1,403	2,589	10.02	2,450	9.52	1,739	7.24	2,812,416	10,593
2008														
DFW	25,691	83.41	22,619	87.01	458,489	1,620	2,399	9.23	2,272	8.76	114	0.38	3,196,513	12,071
HGB	25,672	81.23	21,929	84.36	431,069	1,500	2,164	8.31	2,044	7.88	119	0.37	3,119,945	11,836
2009														
DFW	24,613	79.51	21,482	82.63	461,494	1,630	2,369	9.13	2,243	8.66	115	0.53	3,259,251	12,307
HGB	24,616	77.54	20,695	79.75	432,822	1,505	2,143	8.24	2,024	7.81	120	0.37	3,181,578	12,082
2011														
DFW	23,656	76.05	19,746	75.67	469,101	1,656	2,313	8.88	2,189	8.43	118	0.40	3,410,367	12,857
HGB	23,564	73.96	18,582	71.75	438,154	1,523	2,098	8.06	1,982	7.64	124	0.38	3,308,197	12,582
2012														
DFW	23,466	75.37	18,867	72.13	473,559	1,671	2,218	8.49	2,099	8.05	119	0.40	3,485,739	13,141
HGB	23,299	73.10	17,527	67.56	441,522	1,534	1,995	7.65	1,884	7.24	125	0.39	3,372,257	12,834

Table 3-4. Uncontrolled Emissions Estimates

	VOC		NOX		CO		PM10		PM25		SO2		CO2	
	TPY	TPD	TPY	TPD	TPY	TPD	TPY	TPD	TPY	TPD	TPY	TPD	TPY	TPD
2002														
DFW	50,204	170.35	38,989	150.94	467,914	1,656	4,826	18.87	4,592	17.99	1,983	7.93	2,971,692	11164
HGB	48,105	159.8	38,864	150.47	443,682	1,546	4,609	18.06	4,373	17.19	1,741	7.37	2,906,916	10924
2008														
DFW	57,256	194.37	45,759	177.07	528,068	1,868	5,482	21.41	5,214	20.41	132	0.45	3,447,980	12962
HGB	54,779	182.34	45,498	176.71	497,929	1,736	5,250	20.58	4,981	19.6	133	0.42	3,364,073	12691
2009														
DFW	58,447	198.43	47,049	181.9	538,561	1,906	5,625	21.97	5,350	20.94	135	0.6	3,534,729	13283
HGB	55,902	186.17	46,768	181.71	507,471	1,770	5,386	21.13	5,111	20.12	135	0.43	3,449,497	13022
2011														
DFW	60,637	206.67	48,241	191.79	558,405	1,980	5,718	23.07	5,435	21.99	139	0.48	3,650,457	13979
HGB	58,119	193.69	49,269	191.51	526,513	1,837	5,651	22.19	5,363	21.13	140	0.44	3,617,737	13669
2012														
DFW	62,054	210.71	51,103	197.03	570,183	2,017	6,073	23.65	5,778	22.55	142	0.48	3,819,627	14324
HGB	59,197	197.36	50,478	196.27	535,983	1,870	5,776	22.69	5,482	21.61	143	0.45	3,699,162	13983

3.2 Rule Benefit Analysis

3.2.1 State Controls

Texas Low Emission Diesel (TxLED)

Emissions reductions from TxLED were calculated by applying a 6.2% reduction in NOx emissions to the controlled emissions inventory for each year.¹⁶ NOx benefits for the HGB and DFW nonattainment areas resulting from TxLED are summarized below in Table 3-5.

Table 3-5. TxLED NOx Emission Reduction Benefits

Region	TPY	TPD
2002		
DFW	1,911	7.30
HGB	1,920	7.29
2008		
DFW	1,495	5.75
HGB	1,449	5.58
2009		
DFW	1,420	5.46
HGB	1,368	5.27
2011		
DFW	1,305	5.00
HGB	1,228	4.74
2012		
DFW	1,247	4.77
HGB	1,158	4.47

Reformulated Gasoline (RFG)

RFG benefits were calculated by running NONROAD for all SI equipment categories and all scenario years, with RVP values set to 7.2 (representative of RFG) and 8.7 (federal default RVP for summer fuel in Texas). The resulting difference in exhaust and evaporative VOC levels is reported in Table 3-6 for each region and analysis year.

¹⁶ Memorandum from Karl Eklund of EPA Region VI to Robert Larson of EPA OTAQ Re: Texas Low Emission Diesel (LED) Fuel Benefits, September 27, 2001 (see Table 1).

Table 3-6. RFG VOC Benefit

Region	TPY	TPD
2002		
DFW	484	1.33
HGB	496	1.36
2008		
DFW	541	1.48
HGB	553	1.51
2009		
DFW	549	1.50
HGB	562	1.54
2011		
DFW	567	1.55
HGB	580	1.59
2012		
DFW	577	1.58
HGB	589	1.61

3.2.2 Federal Controls

The emissions benefits for federal controls were evaluated using EPA’s NONROAD2005 model. In order to evaluate the benefits of each rule, ERG executed a series of model runs for each year of interest. Given the difficulty in executing NONROAD runs for each individual equipment inventory (see Table 3-1 above) and each scenario year, NONROAD defaults were used for equipment population and activity. The initial run for each inventory year reflected a completely uncontrolled emissions scenario, prior to the application of any federal rules for nonroad engines. This was done by setting the “Episode Year” in the model to the year of interest (i.e. 2002, 2008, 2009, 2011, or 2012), and the “Tech Year”¹⁷ to 1988. (The “Tech Year” entry indicates the most recent year for which federal standards are assumed to apply.) Each subsequent run phased-in new control technologies by incrementing the “Tech Year” by one, beginning with 1995 and ending when the “Tech Year” equaled the episode year. (1995 was selected as the start year, since the earliest federal rule took effect in 1996. Alternatively, when the Episode and “Tech Years” are equal, NONROAD effectively models a fully-controlled scenario.) This process was repeated for each year of interest

¹⁷ “Tech Year” is an input into the NONROAD2005 Graphical User Interface (GUI). It defines the level of controls to be applied in the run. It is fully described in the NONROAD2005 Users Guide at <http://www.epa.gov/otaq/models/nonrdmdl/nonrdmdl2005/420r05013.pdf>.

ERG used the NONROAD2005 reporting utility to export each of the resulting emissions inventories to Excel, where reduction benefits were evaluated for each rule, for each SCC and hp bin. For example, using EPA defaults (i.e., the standard NONROAD files for Texas) for the HGB and DFW regions combined, diesel agricultural equipment between 75 and 100 hp emit 123 tons per year of NO_x, assuming all controls are in place. Uncontrolled emissions for this equipment (calculated by setting “Tech Year” equal to 1995) total 175 tons per year of NO_x. Therefore all controls result in a 52 ton per year benefit for these engines. However, multiple federal standards will have impacted this engine category by 2012, including Rule #2, Rule #3, and Rule #6. The benefit of Rule #6, which begins in 2008 for these engines, is calculated by subtracting the controlled emission total from the 2011 “Tech Year” scenario total. Reductions from Rule #3, which commences in 2008, are determined by subtracting the controlled emissions from the 2007 “Tech Year” scenario total, *less the Rule #6 benefit*, in order to avoid double counting. This process is repeated sequentially for the Rule #3 and Rule #2 standards, netting out the benefit from subsequent standards as appropriate. Incremental benefits were calculated in this way and summed across each SCC and hp bin, for each pollutant and scenario year, to obtain total benefits for each rule. Similar calculations were performed for the spark ignition engine rules.

ERG performed quality assurance on the resulting estimates, summing the calculated benefits for each rule and comparing the totals to the difference between the controlled and uncontrolled emissions estimates. The sum of the individual rule benefits were very close to the difference between the controlled and uncontrolled values. Diesel rule benefits matched precisely, while spark-ignition (SI) rule benefits matched the controlled/uncontrolled differences within roughly 1%. ERG believes the small discrepancies in the SI rule calculations result from extended phase-in schedules for these rules (especially for evaporative system requirements), which would not be modeled precisely using the discrete “Tech Year” approach described above.

Although NONROAD defaults were used for this analysis, the results were only used to obtain the *relative* contribution to emission reductions for each rule. For example, for evaluation year 2012, 38.6% of all NO_x benefits are attributable to the Rule #2 - HD standards, Rule #3 -

Tier 1 for 2.7%, Rule #3 - Tier 2 for 13.3%, and Rule #6 for 3.7%, with the remainder of benefits coming from the various SI rules. These percentages were subsequently applied to the difference between the controlled and uncontrolled inventories discussed in Section 3.1 to allocate emission benefits among the different rules. The percentage reductions for each rule and scenario year are provided below in Table 3-7 by pollutant. Note that negative values indicate emissions increases.¹⁸

Table 3-7. Percentage Reductions by Federal Rule Type and Pollutant

Scenario Year 2002				
Rule #	NOx	PM10	PM2.5	VOC
2 (HD)	110.6%	77.3%	79.3%	6.9%
3 (Tier 1)	5.2%	10.8%	9.0%	1.1%
3 (Tier 2)	4.7%	1.1%	1.2%	0.0%
3 (Tier 3)	0.0%	0.0%	0.0%	0.0%
6 (Tier 4)	0.0%	0.0%	0.0%	0.0%
2 (Marine SI)	-0.4%	1.1%	1.1%	2.5%
1	-25.2%	8.4%	8.2%	81.8%
4	5.1%	1.3%	1.2%	7.8%
5	0.0%	0.0%	0.0%	0.0%
Scenario Year 2008				
Rule #	NOx	PM10	PM2.5	VOC
2 (HD)	51.8%	65.1%	65.4%	6.2%
3 (Tier 1)	3.3%	9.3%	9.4%	1.2%
3 (Tier 2)	18.6%	18.0%	18.1%	0.4%
3 (Tier 3)	6.9%	-3.7%	-3.7%	0.3%
6 (Tier 4)	0.0%	0.0%	0.0%	0.0%
2 (Marine SI)	-0.4%	1.8%	1.7%	4.4%
1	-7.8%	4.1%	3.9%	46.9%
4	5.0%	5.4%	5.2%	37.7%
5	22.5%	0.0%	0.0%	3.0%
Scenario Year 2009				
Rule #	NOx	PM10	PM2.5	VOC
2 (HD)	47.7%	64.0%	64.4%	6.1%
3 (Tier 1)	3.1%	9.4%	9.4%	1.2%
3 (Tier 2)	19.2%	20.3%	20.4%	0.5%
3 (Tier 3)	9.1%	-5.1%	-5.1%	0.4%
6 (Tier 4)	0.0%	0.0%	0.0%	0.0%
2 (Marine SI)	-0.4%	1.8%	1.8%	4.6%
1	-7.0%	3.8%	3.7%	44.5%
4	4.9%	5.8%	5.5%	39.4%
5	23.4%	0.0%	0.0%	3.4%

¹⁸ Certain rules are anticipated to increase emissions of certain pollutants. For example, the Phase I Small SI Rule, designed to decrease VOC emissions, was expected to increase NOx emissions by a small amount.

Scenario Year 2011				
Rule #	NOx	PM10	PM2.5	VOC
2 (HD)	41.3%	68.0%	68.9%	6.1%
3 (Tier 1)	2.8%	10.3%	10.4%	1.2%
3 (Tier 2)	19.7%	26.1%	26.5%	0.6%
3 (Tier 3)	12.3%	-8.0%	-8.1%	0.7%
6 (Tier 4)	1.5%	-9.0%	-9.8%	0.0%
2 (Marine SI)	-0.4%	2.1%	2.0%	5.0%
1	-5.7%	3.8%	3.7%	41.8%
4	4.3%	6.6%	6.4%	40.5%
5	24.2%	0.0%	0.0%	4.1%
Scenario Year 2012				
Rule #	NOx	PM10	PM2.5	VOC
2 (HD)	38.6%	77.5%	78.1%	6.1%
3 (Tier 1)	2.7%	11.9%	12.0%	1.3%
3 (Tier 2)	19.4%	31.8%	32.0%	0.7%
3 (Tier 3)	13.3%	-10.5%	-10.6%	0.8%
6 (Tier 4)	3.6%	-25.1%	-25.3%	0.1%
2 (Marine SI)	-0.4%	2.5%	2.4%	5.1%
1	-5.3%	4.2%	4.0%	40.9%
4	4.0%	7.7%	7.4%	40.6%
5	24.0%	0.0%	0.0%	4.4%

The resulting reductions from each federal rule for each year of interest are summarized in Tables 3-8 and 3.9 below for the DFW and HGB regions, respectively.

Table 3-8. DFW Federal Nonroad Rule Benefits by Year

		Rule #2 (HD)	Rule #3 (Tier 1)	Rule #3 (Tier 2)	Rule #3 (Tier 3)	Rule #6 (Tier 4)	Rule #2 (Marine SI)	Rule #1	Rule #4	Rule #5
2002										
NOx	TPY	9397	445	397	0	0	-40	-2539	510	0
	TPD	38.04	1.80	1.61	0.00	0.00	-0.16	-10.19	2.05	0.00
PM10- PRI	TPY	1526	213	22	0	0	22	167	25	0
	TPD	6.04	0.84	0.09	0.00	0.00	0.09	0.66	0.10	0.00
PM25- PRI	TPY	1497	169	22	0	0	20	155	23	0
	TPD	5.94	0.67	0.09	0.00	0.00	0.08	0.62	0.09	0.00
VOC	TPY	1058	164	4	0	0	372	12174	1159	0
	TPD	3.76	0.58	0.01	0.00	0.00	1.33	43.56	4.15	0.00
2008										
NOx	TPY	11031	702	3956	1475	0	-88	-1805	1160	5215
	TPD	42.98	2.73	15.41	5.75	0.00	-0.34	-7.03	4.51	20.30
PM10- PRI	TPY	2006	288	555	-113	0	55	125	167	0
	TPD	7.93	1.14	2.19	-0.45	0.00	0.22	0.50	0.66	0.00
PM25- PRI	TPY	1926	276	533	-109	0	50	114	152	0
	TPD	7.62	1.09	2.11	-0.43	0.00	0.20	0.45	0.60	0.00
VOC	TPY	1945	380	134	93	1	1365	14515	11664	928
	TPD	6.84	1.33	0.47	0.33	0.00	4.82	51.24	41.17	3.27
2009										
NOx	TPY	11329	738	4562	2162	0	-96	-1778	1244	5986
	TPD	44.02	2.87	17.73	8.40	0.00	-0.37	-6.90	4.83	23.24
PM10- PRI	TPY	2084	305	660	-166	0	60	125	188	0
	TPD	8.22	1.20	2.60	-0.65	0.00	0.24	0.49	0.74	0.00
PM25- PRI	TPY	2000	293	633	-159	0	54	114	171	0
	TPD	7.91	1.16	2.50	-0.63	0.00	0.21	0.45	0.68	0.00
VOC	TPY	2054	408	166	147	1	1524	14774	13083	1127
	TPD	7.22	1.44	0.58	0.52	0.01	5.38	52.13	46.16	3.98

2011										
NOx	TPY	11086	753	5269	3286	410	-103	-1638	1235	6893
	TPD	45.34	3.08	21.55	13.44	1.67	-0.42	-6.68	5.03	28.09
PM10- PRI	TPY	2317	351	890	-273	-306	72	129	226	0
	TPD	9.66	1.46	3.71	-1.14	-1.28	0.30	0.54	0.94	0.00
PM25- PRI	TPY	2238	339	859	-264	-317	66	119	207	0
	TPD	9.35	1.42	3.59	-1.10	-1.33	0.27	0.50	0.87	0.00
VOC	TPY	2242	460	226	263	9	1806	15194	14711	1502
	TPD	7.92	1.63	0.80	0.93	0.03	6.40	53.87	52.16	5.33
2012										
NOx	TPY	11828	817	5954	4058	1090	-113	-1700	1302	7752
	TPD	45.86	3.17	23.09	15.73	4.23	-0.44	-6.59	5.05	30.04
PM10- PRI	TPY	2987	459	1226	-404	-969	95	162	298	0
	TPD	11.75	1.81	4.82	-1.59	-3.81	0.37	0.64	1.17	0.00
PM25- PRI	TPY	2872	441	1179	-389	-931	87	148	271	0
	TPD	11.32	1.74	4.65	-1.53	-3.67	0.34	0.58	1.07	0.00
VOC	TPY	2347	489	257	322	31	1944	15538	15398	1685
	TPD	8.23	1.71	0.90	1.13	0.11	6.84	54.70	54.20	5.93

Table 3-9. HGB Federal Nonroad Rule Benefits by Year

		Rule #2 (HD)	Rule #3 (Tier 1)	Rule #3 (Tier 2)	Rule #3 (Tier 3)	Rule #6 (Tier 4)	Rule #2 (Marine SI)	Rule #1	Rule #4	Rule #5
2002										
NOx	TPY	9100	430	385	0	0	-39	-2473	497	0
	TPD	37.74	1.79	1.60	0.00	0.00	-0.16	-10.12	2.03	0.00
PM10- PRI	TPY	1560	218	23	0	0	22	171	25	0
	TPD	6.21	0.87	0.09	0.00	0.00	0.09	0.68	0.10	0.00
PM25- PRI	TPY	1526	172	22	0	0	21	158	24	0
	TPD	6.09	0.69	0.09	0.00	0.00	0.08	0.63	0.09	0.00
VOC	TPY	966	150	3	0	0	338	11059	1053	0
	TPD	3.40	0.53	0.01	0.00	0.00	1.20	39.30	3.74	0.00
2008										
NOx	TPY	11283	718	4047	1508	0	-90	-1839	1181	5311
	TPD	44.27	2.82	15.88	5.92	0.00	-0.35	-7.21	4.63	20.81
PM10- PRI	TPY	2008	288	555	-113	0	55	126	167	0
	TPD	7.98	1.15	2.21	-0.45	0.00	0.22	0.50	0.67	0.00
PM25- PRI	TPY	1922	276	532	-109	0	50	114	152	0
	TPD	7.67	1.10	2.12	-0.43	0.00	0.20	0.45	0.61	0.00
VOC	TPY	1793	350	123	86	1	1256	13357	10734	854
	TPD	6.23	1.22	0.43	0.30	0.00	4.38	46.61	37.45	2.98
2009										
NOx	TPY	11601	756	4672	2214	0	-98	-1813	1269	6104
	TPD	45.42	2.96	18.29	8.67	0.00	-0.38	-7.09	4.96	23.87
PM10- PRI	TPY	2075	304	657	-165	0	59	124	187	0
	TPD	8.25	1.21	2.61	-0.66	0.00	0.24	0.49	0.75	0.00
PM25- PRI	TPY	1987	291	629	-158	0	54	113	170	0
	TPD	7.92	1.16	2.51	-0.63	0.00	0.22	0.45	0.68	0.00
VOC	TPY	1899	378	154	136	1	1407	13635	12074	1040
	TPD	6.59	1.31	0.53	0.47	0.00	4.90	47.54	42.10	3.63

2011										
NOx	TPY	11979	774	4864	2983	372	-100	-1927	1211	6271
	TPD	47.05	3.03	18.82	11.52	1.44	-0.39	-7.62	4.71	24.22
PM10-PRI	TPY	2241	336	759	-232	-260	65	140	196	0
	TPD	8.92	1.34	3.00	-0.92	-1.03	0.26	0.56	0.78	0.00
PM25-PRI	TPY	2165	317	732	-224	-269	59	128	180	0
	TPD	8.64	1.27	2.90	-0.89	-1.07	0.24	0.51	0.71	0.00
VOC	TPY	1868	376	173	201	7	1429	13395	11352	1141
	TPD	6.56	1.32	0.61	0.71	0.02	5.05	47.15	40.17	4.04
2012										
NOx	TPY	12148	839	6116	4168	1119	-116	-1737	1331	7924
	TPD	47.48	3.28	23.90	16.29	4.37	-0.45	-6.79	5.20	30.95
PM10-PRI	TPY	2930	450	1203	-396	-950	93	159	292	0
	TPD	11.66	1.79	4.79	-1.58	-3.78	0.37	0.63	1.16	0.00
PM25-PRI	TPY	2809	432	1153	-380	-911	85	145	265	0
	TPD	11.22	1.72	4.61	-1.52	-3.64	0.34	0.58	1.06	0.00
VOC	TPY	2183	455	239	299	29	1806	14432	14302	1565
	TPD	7.56	1.57	0.83	1.04	0.10	6.27	50.14	49.69	5.44

4.0 Study Findings

ERG loaded all inventory data developed and all documentation under this Work Order into the TCEQ TexAER Development Server. All working files were also provided to the TCEQ Project Manager in electronic format. The working files used to allocate emission benefits across individual rules can be easily updated for future RFP analyses by populating the working files with NONROAD2005 outputs for future year scenarios.