

**Final Report**

**Review of Emission Reduction Control Strategies  
for Nitrogen Oxides (NO<sub>x</sub>) and  
Volatile Organic Compounds (VOCs) for the  
North Central Texas Ozone Nonattainment Area**

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## **PREFACE**

This report presents results of analyses of potential ozone precursor control strategies in support of the development of the 8-hour ozone attainment demonstration State Implementation Plan (SIP) revision for the Dallas – Fort Worth ozone nonattainment area. During the course of this effort, the ENVIRON project team consisting of ENVIRON International Corporation and its subcontractors (the Sierra Nevada Air Quality Group (SNAQG) and Earth Matters) and consultants (Darcy J. Anderson), worked closely with staff from the North Central Texas Council of Governments (NCTCOG) who provided much valuable information and assistance. As the ENVIRON team had been assigned the task of evaluating stationary and non-road source control measures (subject to certain restrictions), NCTCOG focused its efforts primarily on the evaluation of potential control measures for on-road vehicles. In addition, NCTCOG prepared an initial version of the Master List of control measures (which was then finalized with input from the ENVIRON team) as well as the final compilations of evaluation results for all control measures. For the sake of completeness, this report includes and is based on results from both the work performed by the ENVIRON team and the work performed by NCTCOG itself.

## 1. INTRODUCTION

On June 15, 2004, EPA designated nine counties in the Dallas-Ft. Worth (DFW) area (Collin, Dallas, Denton, Tarrant, Ellis, Johnson, Kaufman, Parker and Rockwall) as a moderate 8-hour ozone nonattainment area with an attainment date of 2010. In accordance with EPA's 8-hour ozone implementation procedure, the Texas Commission on Environmental Quality (TCEQ) adopted an "Early Increment of Progress" plan in April, 2005 showing a 5% reduction in emissions from a 2002 baseline, effective by June of 2007. The DFW Increment of Progress (IOP) plan adopted by the TCEQ included new emission standards for lean-burn and rich-burn engines, an extension of existing requirements for both surface coating and Stage I gasoline unloading to the five counties included in the 8-hour nonattainment area that were not part of the original 1-hour ozone nonattainment area, and a statewide portable fuel container rule. TCEQ is currently working in conjunction with the North Central Texas Council of Governments (NCTCOG) on development of a State Implementation Plan (SIP) revision including an attainment demonstration based on ozone modeling which is due to be submitted to EPA by June, 2007. The new ozone SIP must demonstrate attainment of the 8-hour ozone standard by 2010.

Working with TCEQ, NCTCOG has taken on the role of lead agency for identifying and evaluating candidate NO<sub>x</sub> and VOC control measures in support of the 8-hour ozone SIP development. Acting in this capacity, NCTCOG contracted with ENVIRON to provide technical assistance with the evaluation of candidate control measures. Based on the current regulatory situation and results of inventory development and modeling conducted by TCEQ, NCTCOG requested that ENVIRON perform analyses focused primarily on evaluation of emissions reduction techniques or controls for area and off-road sources. ENVIRON was also requested to evaluate certain selected on-road mobile source control measures to supplement the more extensive on-road analyses performed by NCTCOG and to include a number of point source control measures in our analyses that were not otherwise being examined by TCEQ. ENVIRON subcontracted with three other consultants to help perform this work: David Calkins, Ron Friesen, and Bill Sylte of The Sierra Nevada Air Quality Group (SNAQG), working with Darcy Anderson (an independent consultant) focused on stationary source control measures, and Kamala Joy of Earth Matters provided analyses of various transportation control measures. Control strategies for off-road sources were analyzed by Chris Lindhjem of ENVIRON.

To identify the most appropriate and effective control measures applicable to the DFW 8-hour ozone SIP, NCTCOG, with assistance from ENVIRON, prepared a Master List of potential control measures based on reviews of numerous previous control measure development studies conducted for the DFW area as well as for other ozone nonattainment areas in Texas and other states. As described in more detail in Section 2, ENVIRON performed a qualitative screening analysis of the Master List measures and selected a smaller list of high priority measures for further analysis. For the qualitative analysis of measures on the Master List, each measure was assigned a relative priority based on its practicality, likely acceptability, the expected magnitude of emission reductions, and cost effectiveness. Generally speaking, NO<sub>x</sub> reduction measures were given priority for inclusion in the Short List over VOC measures as preliminary photochemical modeling results prepared by TCEQ indicated a significantly greater sensitivity of peak ozone levels to cuts in NO<sub>x</sub> as compared to VOCs. Nevertheless, a number of VOC measures were included in the final Short List. In addition, as a number of point source control measures had been or were scheduled to be evaluated by TCEQ and other groups, an emphasis

was placed on measures aimed at area and non-road sources as well as those on-road measures which could be implemented under state or local authority; only a limited number of high-ranking point source measures were included in the Short List. A more detailed, quantitative evaluation of measures included in the final Short List was then performed. Procedures and results for the quantitative evaluation of Short List measures are described in Section 3.

NCTCOG arranged substantial opportunities for the stakeholder community to be involved in the control measure development process. This included posting of project materials on the NCTCOG public web site (<http://www.nctcog.org/trans/air/sip/future/lists.asp>), and holding a series of face-to-face meetings open to the public at which NCTCOG and ENVIRON presented interim results and sought comments from interested groups and individuals. Public meetings were held on 21 September and 22 September in Fort Worth and Richardson, respectively, to discuss the procedures and results by which potential control measures were selected for quantitative evaluation. A follow-up public meeting was held 16 December 2005 in Arlington to present results of the quantitative evaluation. NCTCOG sent announcements of these meetings to a wide array of stakeholder groups in the DFW area. In addition, the control measure evaluation study was included as an agenda item at meetings of the North Texas Clean Air Steering Committee (NTCASC) held 11 November 2005 and 13 January 2006. The NTCASC has given further consideration to control strategies in subsequent meetings. The NTCASC meetings were also widely advertised and open to the public. All comments made at the public hearings, or subsequent comments to the record, were reviewed by NCTCOG and/or members of the ENVIRON project team and responded to appropriately.

## 2. IDENTIFICATION OF CANDIDATE CONTROL STRATEGIES

A screening and qualitative evaluation of a wide range of potential control measures was performed. This evaluation was designed to result in the identification of a subset of high priority control measures that would then be qualitatively evaluated. The evaluation process consisted of the following activities:

- Produce a final Master List of control measures.
- Perform an initial, qualitative evaluation of control measures included in the Master List.
- Recommend measures for inclusion in a Short List of measures to be subject to more refined, quantitative evaluation.

### CONTROL STRATEGY MASTER LIST

Prior to the beginning of this project, NCTCOG staff had developed a large database of potential VOC and NO<sub>x</sub> control measures compiled from work performed by ENVIRON and others in support of the DFW 1-hour ozone SIP (ENVIRON et al., 2000) and various other sources. Members of the ENVIRON project team worked with NCTCOG and TCEQ to update and organize this Master List of control strategies, making additions based on inputs from local stakeholder groups, TCEQ, and previous ozone SIP measure development projects performed for other ozone nonattainment areas. A list of source materials used to generate the Master List is presented in Table 2-1. The objective of this effort was to produce a list of potential control measures that is as comprehensive as possible, reflecting input from all available sources. No attempt was made at this stage to refine or eliminate any possible control measures based on *a priori* judgments with respect to feasibility, legality, cost, or other considerations. The collected set of measures was then reorganized so that similar measures were grouped together and clearly duplicative measures removed. The final Master List consists of a total of 996 measures (176 area source measures, 86 non-road source measures, 628 on-road source measures, and 106 point source measures). An additional 54 Policy and Outreach measures reflecting various miscellaneous suggestions not targeted at any specific source categories or control technologies were also included in the Master List. The complete control measures Master List is provided in Appendix A.

**Table 2-1.** Source materials used in developing the control strategy Master List (partial listing).

No.	Source
1	2000 DFW SIP - <a href="http://www.tnrcc.state.tx.us/oprd/rule_lib/4dfwsip.pdf">http://www.tnrcc.state.tx.us/oprd/rule_lib/4dfwsip.pdf</a>
2	2000 ENVIRON Report - Evaluation of Alternative Control Strategies for the Dallas Fort Worth SIP - October 2000
3	2004 Texas Transportation Institute (TTI) Report - Emissions Reduction Measures to Help Meet the Eight-Hour Ozone and PM <sub>2.5</sub> Standards
4	EPA Air Innovations Conference Proceedings
5	EPA Ozone Early Action Compacts (EAC) - Proposed and Final EAC Control Measures: <a href="http://www.epa.gov/ttn/naaqs/ozone/eac/20030616_eac_measures_full_list2.pdf">http://www.epa.gov/ttn/naaqs/ozone/eac/20030616_eac_measures_full_list2.pdf</a> and <a href="http://www.epa.gov/ttn/naaqs/ozone/eac/20041231_eac_measures_full_list.pdf">http://www.epa.gov/ttn/naaqs/ozone/eac/20041231_eac_measures_full_list.pdf</a>
6	Lake Michigan Air Directors Consortium (LADCO) / MACTEC 2005 <a href="http://ladco.org">http://ladco.org</a> and <a href="http://64.27.125.175/reports/rpo/MWRPOprojects/Strategies/Final%20Control%20Measures.pdf">http://64.27.125.175/reports/rpo/MWRPOprojects/Strategies/Final%20Control%20Measures.pdf</a>

**Table 2-1.** (cont.)

No.	Source
7	North Central Texas Regional Transportation Council Air Quality Program <a href="http://www.dfwcleanair.com/programs/Description_strategies.pdf">http://www.dfwcleanair.com/programs/Description_strategies.pdf</a>
8	Ozone Transport Commission (OTC) <a href="http://www.otcair.org/document.asp?Fview=Report -Control Measure Development Support Analysis of Ozone Transport Commission Model Rules March 31, 2001">http://www.otcair.org/document.asp?Fview=Report -Control Measure Development Support Analysis of Ozone Transport Commission Model Rules March 31, 2001</a>
9	PECHAN – Control Measure Development Support Analysis of Ozone Transport Commission Model Rules <a href="http://dep.state.ct.us/air2/siprac/2001/pec.pdf">http://dep.state.ct.us/air2/siprac/2001/pec.pdf</a>
10	Port of Long Beach (POLB) <a href="http://www.polb.com/pdfs/4_environment/GreenPort/POLB-POLA_NNIv21.pdf">http://www.polb.com/pdfs/4_environment/GreenPort/POLB-POLA_NNIv21.pdf</a>
11	Port of Los Angeles (POLA) <a href="http://www.portoflosangeles.org/DOC/NNI_Strategy_March_2005.pdf">http://www.portoflosangeles.org/DOC/NNI_Strategy_March_2005.pdf</a> and <a href="http://www.cunninghamreport.com/NNIdraftPlan60605.pdf">http://www.cunninghamreport.com/NNIdraftPlan60605.pdf</a>
12	South Coast Air Quality Management District (SCAQMD) 2003 Air Quality Management Plan (AQMP) -Chapter 4 (AQMP Control Strategy), Appendix IV-C (Regional Transportation Strategy and Control Measures), <a href="http://www.aqmd.gov/aqmp/AQMD03AQMP.htm">http://www.aqmd.gov/aqmp/AQMD03AQMP.htm</a> and Regulation XVI-Mobile Source Offset Programs <a href="http://www.aqmd.gov/rules/reg/reg16_tofc.html">http://www.aqmd.gov/rules/reg/reg16_tofc.html</a>
13	Texas Commission on Environmental Quality (TCEQ) Potential Control Strategies to Consider for the Dallas-Fort Worth 8-Hour Ozone Attainment Demonstration ( <a href="http://www.tnrcc.state.tx.us/oprd/sips/sipdfw.html#Control">http://www.tnrcc.state.tx.us/oprd/sips/sipdfw.html#Control</a> )
14	San Joaquin Valley Extreme Ozone Demonstration Plan, Chapter 4, Tables 4-1 and 4-2
15	Sacramento Metropolitan Air Quality Management District, Clean Air Plan Update, Further Analysis Control Measures ( <a href="http://www.airquality.org/cleanairplan/FurtherAnalysis.shtml">http://www.airquality.org/cleanairplan/FurtherAnalysis.shtml</a> )

## SCREENING AND QUALITATIVE EVALUATION OF MASTER LIST MEASURES

Development of detailed, quantitative analyses of all of the potential control measures included on the Master List was neither practical nor feasible. An initial, qualitative evaluation of control measures on the Master List was therefore performed. This evaluation was designed to determine which measures should be given highest priority for further, quantitative analysis. The qualitative analysis began with an initial screening to identify those Master List measures which could ultimately qualify for inclusion in the SIP on the basis of the four acceptability criteria applied by EPA in the evaluation of proposed SIPs. These criteria specify that SIP control measures must be 1) permanent, 2) quantifiable, 3) surplus, and 4) enforceable. Measures not satisfying these four criteria were dropped from further consideration. Measures that have been formally approved or proposed for approval by EPA for inclusion in SIPs elsewhere in the United States were automatically presumed to pass this screening test. In some cases, there remained some doubt as to whether a particular measure, as formulated on the Master List, could meet all four SIP criteria; these measures were placed in a “further review needed” category.

Measures passing the above SIP acceptability criteria screening test were then qualitatively evaluated with respect to the following criteria:

- Practical to implement, based on technical or implementation feasibility
- Likely acceptability to both the regulated sources as well as the general public
- Expected magnitude of emissions benefit
- Likely cost effectiveness

Each measure was assigned a score ranging from 1 to 4 for each of the above criterion with a score of “4” representing the highest valuation (i.e., most practical, most acceptable, highest benefit, most cost effective) and 1 the lowest. It should be noted that all of the consultant’s team members who performed the qualitative analysis have considerable experience in reviewing SIP control measures at both the Federal and state level. Scoring for each criterion was based on:

Practical to implement (feasibility): A subjective judgment based on reviewer’s regulatory experience of the measure’s technical or implementation feasibility.

Likely acceptance by public and regulated entities: A subjective judgment based primarily on reviewer’s regulatory experience. Highest scores were assigned to measures to which the public or regulated entities are likely to react positively, lowest scores were assigned to measures unlikely to gain much public acceptance or likely to result in overwhelming opposition from potentially regulated entities.

Emissions benefit: A relative ranking based on likely degree of VOC or NO<sub>x</sub> reduction, with greater emphasis placed on NO<sub>x</sub> reduction measures. Rankings were based on results of evaluations of similar measures previously performed in Dallas or other nonattainment areas. In some instances, especially for measures which had not been previously evaluated, professional judgment was relied upon to arrive at an appropriate ranking. More refined, quantitative analyses of emission reductions were subsequently performed for measures ultimately selected for further analysis.

Cost Effectiveness: A relative ranking based on \$/ton cost effectiveness estimates available from analyses of similar measures previously conducted in Dallas or other nonattainment areas. In some instances, especially for measures which had not been previously evaluated, professional judgment was relied upon to arrive at an appropriate cost-effectiveness score. More refined, quantitative analyses of cost-effectiveness were subsequently performed for measures ultimately selected for further analysis.

Results of the above rankings were examined to identify high ranking measures for inclusion in the Short List. All four of the above criteria were considered, but additional review was applied to identify measures ranked highly with respect to the feasibility and likely emissions benefit criteria so as to more clearly identify potentially significant measures which might, however, be considered less practical to implement or which are likely to face some significant opposition in the community.

Results of the qualitative evaluation were reviewed and further refined based on discussions between the ENVIRON project team, NCTCOG, and TCEQ. This resulted in a Short List of control measures intended to be *quantitatively* evaluated in the manner described in Section 3 below. Measures were selected for inclusion in the Short List based on several key considerations:

- Relative ranking assigned to the measure as a result of the qualitative evaluation.
- Availability of information, which could be used to quantify the measures, e.g., measures based on rules already in place in other nonattainment areas are more readily quantifiable.
- Greater importance of NO<sub>x</sub> control relative to VOC (but recognizing that measures offering significant VOC reductions in the urban core will also have value for ozone control and for meeting the Clean Air Act 5% rate of progress requirements).
- Comments received from the stakeholder community.
- Studies being performed by other groups that focus on emission controls for certain source categories (cement kilns, electric generating utilities, and energy conservation).<sup>1</sup> To avoid duplication of effort, measures aimed at these source categories were not quantitatively evaluated although some were included in the final Short List for sake of completeness.

The resulting Short List of control measures selected for further evaluation is shown in Table 2-2 (area sources), Table 2-3 (point sources), Table 2-4 (non-road sources), and Table 2-5 (on-road sources). Each measure is identified by its name and a brief description. The group which performed the quantitative evaluation of each measure as described in Section 3 is indicated along with the effected emissions source category. In some cases, several measures from the Master List were combined into a single measure for purposes of the Short List.

**Table 2-2.** Area source control measures Short List.

Name	Description	Source Category	Analysis Performed By	Industry Affected
Area Source Credit for Energy Conservation and Efficiency	Implementation of Senate Bills 5 and 7.	Area	NCTCOG	Area & Point
Architectural & Industrial Coatings	Require low VOC coatings	Area	ENVIRON	Over 40 categories of coatings in 9-county area
Cold Cleaning Regulations	Require low VOC solvent	Area	ENVIRON	Degreasing, cold cleaning (all industries; 9 county)
Commercial and Consumer Products Requirements	Reformulate coatings and related products; adhesives and sealants; and misc.	Area	ENVIRON	Manufacturers of commercial and consumer products (all manufacturers; 9 county)
Fuel Hose Permeation	Replace hoses with marine hoses	Area	ENVIRON	Gasoline refueling, Stage II; 9 county)
Glycol Dehydrators	Control or recycle vented VOC	Area	ENVIRON	Natural gas production (all 9 counties)

<sup>1</sup> Specifically with regard to energy efficiency measures, the May, 2005 consent decree and adjunct agreements with Tarrant and Collin counties in the matter of Blue Skies Alliance et al. v U.S. EPA include three measures that, although not explicitly included in the Short List, are being reviewed by NCTCOG and others: 1) energy efficiency codes that achieve an additional 15% energy savings above previous energy codes; 2) building codes requiring cool roofs, cool pavements, and strategic shading techniques on new and some existing commercial buildings; 3) municipal codes requiring periodic "energy efficiency tune-ups" for certain commercial buildings.

**Table 2-2.** (cont.)

<b>Name</b>	<b>Description</b>	<b>Source Category</b>	<b>Analysis Performed By</b>	<b>Industry Affected</b>
NOxEAT Software	Compliance assistance. Install software to increase energy efficiency.	Area	ENVIRON	Refineries & Chemical, Plants, 9-counties
Oil & Gas Production	Better identify and repair leaking components	Area	ENVIRON	Oil & gas production and gas processing; 9 county)
Small boilers & heaters	Replace boilers & heaters with better controlled units	Area	ENVIRON	Commercial and institutional buildings; 9 county
Stationary IC Engines	Replace engines with lower emitting units	Area	ENVIRON	Manufacturing, schools, universities

**Table 2-3.** Point source control measures Short List.

<b>Name</b>	<b>Description</b>	<b>Source Category</b>	<b>Analysis Performed By</b>	<b>Industry Affected</b>
Aggregate Kilns	Control of NO <sub>x</sub> from Aggregate Kilns	Point	ENVIRON	Unknown number of kilns
Alternate Energy Sources to Reduce Emissions from Electricity Generation	Use of renewable energy rather than fossil fuel energy for electricity generation.	Point	NCTCOG	EGUs
Brick Kilns	Control of NO <sub>x</sub> from Brick Kilns	Point	ENVIRON	1 kiln located in Denton and 2 located in Parker County
ICI Boilers #7	Reduce NO <sub>x</sub> Emissions by 80 Percent	Point	ENVIRON	ICI boilers > 10 MMBtu/hr in 9 counties
ICI Boilers #9	Control of NO <sub>x</sub> from Industrial, Commercial and Institutional (ICI) Boilers	Point	ENVIRON	Expand DFW to 5 or 9 County area
Lime Kilns	Control of NO <sub>x</sub> from Rotary Kilns	Point	ENVIRON	One Large Source in Johnson County
Refinery Boilers and Heaters	NO <sub>x</sub> reductions from refinery boilers, steam generators, and process heaters–NO <sub>x</sub> .	Point	ENVIRON	Process Heaters(all 9 counties)

**Table 2-4.** Non-road control measures Short List.

<b>Name</b>	<b>Description</b>	<b>Source Category</b>	<b>Analysis Performed By</b>	<b>Industry Affected</b>
Freight Rail Infrastructure Improvements	Tower 55 bottleneck improvements to reduce locomotive idling	Nonroad	NCTCOG	Nonroad – locomotive
Lawn Mower Replacement Program	Replacement or exchange of residential mowers	Nonroad	NCTCOG	Nonroad – lawn and garden
Enhanced TERP program	Continue and increase TERP funded projects	Nonroad	ENVIRON	Offroad (except aircraft)
Aircraft Emissions Standards	Encourage lower emitting aircraft	Nonroad	ENVIRON	Vehicles/ Equipment
Emission Reduction Contract Incentives with Public Funding	Encourage lower emitting engines used on Publicly-funded projects	Nonroad	ENVIRON	Nonroad Construction – Public Funded Projects
Limitations on idling of heavy-duty construction equipment	Reduce Idling from construction and all nonroad engines	Nonroad	ENVIRON	Nonroad
Hybrid-electric locomotives	TERP funded Green Goat	Nonroad	ENVIRON	Nonroad – switching locomotive
Tier II	Tier II Locomotives	Nonroad	ENVIRON	Nonroad – locomotive
Rail Efficiency	System efficiency improvement	Nonroad	ENVIRON	Line-haul locomotives
Locomotive Idling Reductions	Install start/stop devices on locomotives	Nonroad	ENVIRON	Nonroad – switching locomotive
California Portable Engine Rule	Registration and accelerated engine turnover	Nonroad	ENVIRON	Nonroad engines

**Table 2-5.** On-road control measures Short List.

Name	Description	Source Category	Analysis Performed By	Affected Vehicles <sup>2</sup> /Roadway Type
1974 and Older Model Year Vehicles I/M Exemption	Expand I/M Program to include additional vehicles	Onroad	NCTCOG	LDG
AirCheck Texas Repair and Replacement Assistance Program	Financial assistance program to for out of compliance vehicles.	Onroad	NCTCOG	LDG
Bicycle and Pedestrian Programs	Implementation of bicycle and pedestrian projects with supporting programs.	Onroad	NCTCOG	LDG+MC
California Low Emitting Vehicle (LEV) II Standards	Require vehicles sold in DFW region to be LEV II vehicles or cleaner.	Onroad	NCTCOG	LDG
CARB 2007 On-Highway Diesel Engine Standards	Adopt California's heavy-duty diesel vehicle standards for all vehicles sold in the Dallas Fort Worth nine-county nonattainment area.	Onroad	NCTCOG	HDDV
Clean Fleet Vehicle Procurement Policy/Clean Fleet Program	Create a fleet program that addresses the clean vehicle acquisitions of public and private fleets.	Onroad	NCTCOG	HDDV
Drive-Thru Service Restrictions	Prohibit drive-thrus during the ozone season/ encourage parking	Onroad	NCTCOG	LDV+MC
Enhanced AirCheck Texas Repair and Replacement Assistance Program	Financial assistance program to for out of compliance vehicles	Onroad	NCTCOG	LDG
Expanded I/M to Include Diesel Vehicles	Expand I/M Program to include additional vehicles.	Onroad	NCTCOG	LDV
Expanding I/M to Surrounding Counties	Expand I/M Program to include additional vehicles	Onroad	NCTCOG	LDG
Freeway and Arterial Bottleneck Program	Freeway interchange and arterial intersection improvements	Onroad	NCTCOG	Freeway + Arterial
Heavy-Duty Vehicle Idling Restriction and Policy	Implement a regional ordinance restricting idling for public/private heavy-duty vehicles.	Onroad	NCTCOG	HDV
Higher Vehicle Occupancies	Additional HOV implementation	Onroad	NCTCOG	Freeway
Idle Reduction Infrastructure	Electrification projects	Onroad	NCTCOG	HDV

<sup>2</sup> MC = motorcycles; LDG = Light-duty gas vehicles; GV = gas vehicles; LDV = light-duty vehicles (all); HDV = heavy-duty vehicles (gas and diesel); HDDV = heavy-duty diesel vehicles

Table 2-5. (cont.)

Name	Description	Source Category	Analysis Performed By	Affected Vehicles <sup>3</sup> /Roadway Type
Stricter I/M Policy Enforcement	Additional enforcement of I/M policies	Onroad	NCTCOG	LDG
Intelligent Transportation Systems	Further system implementation	Onroad	NCTCOG	Freeway
Light-Duty Vehicle Idling Restriction and Policy	Develop city and/or regional ordinance to restrict idling for both public and private light-duty vehicles	Onroad	NCTCOG	LDV
Military Ground Equipment Emissions Testing, Measure	Expand I/M Program to include additional vehicles	Onroad	NCTCOG	Various
Lower Reid Vapor Pressure (RVP)	Lower the maximum RVP in Dallas Fort Worth nine-county nonattainment area	Onroad	NCTCOG	GV+MC
Additional Taxi Fleet Emissions Testing	More frequent testing	Onroad	NCTCOG	LDGV
Traffic Signal Improvements	Planning, programming, and implementation of traffic signal improvement programs and projects	Onroad	NCTCOG	Arterial
Transit	Additional implementation	Onroad	NCTCOG	LDV+MC
Fare-Free Transit, System-Wide on Ozone Action Days	Transit Incentive	Onroad	NCTCOG	LDV+MC
Transit Off-Peak Pass	Transit Incentive	Onroad	NCTCOG	LDV+MC
Carsharing	1,000 shared cars	Onroad	Earth Matters	LDV
Congestion (value) pricing	Vary tolls to manage facility demand relative to capacity.	Onroad	Earth Matters	Freeway
ETR-Vanpool Programs	Continue and increase Vanpool programs projects under ETR programs	Onroad	Earth Matters	LDV+MDV
ETR-Best Workplaces Program	Continue and increase BWC projects	Onroad	Earth Matters	LDV+MDV
ETR-Carpooling programs	Continue and increase carpooling projects under ETR programs	Onroad	Earth Matters	LDV+MDV
ETR-Transit Subsidy Programs	Continue and increase transit subsidy projects under ETR programs	Onroad	Earth Matters	LDV+MDV+Transit Vehicles

<sup>3</sup> MC = motorcycles; LDG = Light-duty gas vehicles; GV = gas vehicles; LDV = light-duty vehicles (all); HDV = heavy-duty vehicles (gas and diesel); HDDV = heavy-duty diesel vehicles

**Table 2-5.** (cont.)

<b>Name</b>	<b>Description</b>	<b>Source Category</b>	<b>Analysis Performed By</b>	<b>Affected Vehicles<sup>4</sup>/Roadway Type</b>
Parking Cash-Out	Cash-Out for 10% of area employees	Onroad	Earth Matters	LDV+MDV
Pay-As-You-Drive	Mileage based auto insurance	Onroad	Earth Matters	LDV+MDV
Speed Limit Decrease for Heavy Duty Diesel Trucks	Decrease and enforce and 55 mph speed limit for heavy duty diesel trucks	Onroad	Earth Matters	Freeway

<sup>4</sup> MC = motorcycles; LDG = Light-duty gas vehicles; GV = gas vehicles; LDV = light-duty vehicles (all); HDV = heavy-duty vehicles (gas and diesel); HDDV = heavy-duty diesel vehicles.

### 3. QUANTITATIVE EVALUATION

#### APPROACH

Quantitative evaluations were performed for control strategies included on the Short List as described in Section 2 above. These evaluations included quantifications of emissions benefits and costs so that measures could be ranked according to their cost/benefit ratio. Evaluation results for each measure included on the final Short List were summarized in a series of Measure Evaluations, each containing the following information:

**Control Measure Title And Reference No:** Summary title

**Category/Type:** Emissions category effected and type of measure

**Author:** Name and affiliation of individual(s) responsible for the evaluation

**Description:** A concise narrative description of the control measure, including applicable technologies and legal/administrative procedures to be employed.

**Analysis Methodology:** Description of analysis methods used to determine emissions benefit and cost effectiveness valuations

**Results:** Summary of results used to determine quantitative ranking

*Emissions Benefit:* estimated tons/day reduction within the 8-hour DFW ozone nonattainment area of each affected pollutant

*Cost:* estimated direct cost of implementation (cost accounting methods are described in the Analysis Methodology section).

*Implementation Feasibility:* Results of a refined version of the technical and administrative feasibility review originally performed in the screening analysis

*Acceptability:* An expanded discussion and refined judgment of the political/social/public acceptability of the measure

**References:** References used to develop the evaluation

The analysis of each strategy was based on the latest available information and tools as described in the individual white papers. Evaluations were performed in a defensible manner consistent with available resources. However, additional analysis will be needed in order for any of these measures to be included in the SIP.

#### SUMMARY OF RESULTS

Results of the quantitative evaluations of the selected control measures are summarized in Table 3-1. Each measure is identified by its name and a brief description. Estimates of the NO<sub>x</sub> and/or VOC emissions associated with sources potentially affected by the measure are provided together with the estimated emission reductions and cost effectiveness values as determined from the quantitative analysis methods described in the individual Measure Evaluations. Note that some measures effect only VOC emissions whereas other effect only NO<sub>x</sub> emissions. In many cases, estimates are given in Table 3-1 as ranges rather than a single number. These ranges reflect both uncertainties in the calculations as well as differences in emissions benefits and costs

associated with different measure implementation options. Details of the implementation options and calculations are provided in the corresponding Measure Evaluations (Appendix B). *In reviewing the results in Table 3-1, readers should take particular note of the caveats described in each Measure Evaluation: in many cases, the quantitative estimates shown in these tables are based on limited data and subject to considerable uncertainty. It is also important to note that emission reductions associated with different measures are not independent of one another and therefore the total emission reductions which could be achieved by a group of measures is likely to be less than the sum of the reductions shown in these tables. This is particularly true in the case of mobile source control measures.* For example, implementation of a Clean Fleet vehicle program will tend to reduce the total reductions which could be achieved by implementation of other clean vehicle measures such as the CARB 2007 on-highway diesel standards, among others. Estimating total emissions reductions likely to result from adoption of a given suite of control measures is beyond the scope of this study. Readers should also note that several of the measures evaluated here cannot, practically speaking, be fully implemented by 2009, thus reducing the extent of emission reduction credits which could be used in the SIP. No attempt is made here to gauge the practicality of implementing measures within the 2009 timeframe but this issue is discussed in the individual Measure Evaluations.

Quantification of potential emission reductions was not possible within the scope of this project for some measures. For example, the magnitude of VOC reductions which might accrue from identification and repair of leaking compressors used in oil and gas production and processing could not be ascertained because this would require very specific information about existing conditions which is not readily available.

Among the measures evaluated here, the most significant potential for NO<sub>x</sub> reductions would result from implementation of an enhanced TERP program for non-road equipment as described in the associated Measure Evaluation. Potential emission reductions from control measures targeted at on-road vehicles vary widely; some of the more significant NO<sub>x</sub> reduction measures include implementation of 2007 California on-highway diesel engine standards, implementation of the Clean Fleet Program, further implementation of Intelligent Transportation Systems, and reducing the truck speed limit to 55 mph. However, some or all of these measures may ultimately be judged unsuitable for inclusion in the SIP for any number of reasons.

Final selection of control measures to be included in the DFW ozone SIP will depend on many factors. Additional control measures beyond those evaluated in this study may be chosen based on the results of other on-going analyses and further study will be needed to fine tune the results of measures of interest chosen from among those listed in Table 3-1.

## **DETAILED RESULTS**

Detailed analyses of each control measure in the Measure Evaluation format described above are presented in Appendix B. These results are intended to provide the central documentation needed for subsequent analyses and rule adoption considerations in the SIP revision.

**Table 3-1.** Summary of quantitative analysis results.

SUMMARY OF RESULTS					*Legend located at end					NOx			VOC			SIP Eligible*? ✓ = yes
Name	Description	Source	Analysis Performed by	Vehicles/ Equipment / Industry Affected*	Affected Emissions (tpd NOx)	Expected Emission Reduction (NOx)		Cost Effectiveness (\$/ton NOx)	Affected Emissions (tpd VOC)	Expected Emission Reduction (VOC)		Cost Effectiveness (\$/ton VOC)				
						tons/day				tons/day						
						Low	High			Low	High					
<b>On-Road Sources</b>																
1974 and Older Model Year Vehicles I/M Exemption	Expand I/M Program to include additional vehicles	Onroad	NCTCOG	LDG	91.22	0.43	0.43	-\$2,199	92.76	1.71	1.71	Cost effectiveness is based upon NOx reductions.	L			
AirCheck Texas Repair and Replacement Assistance Program	Financial assistance program to for out of compliance vehicles.	Onroad	NCTCOG	LDG	91.22	0.25	0.25	\$12,035	92.76	0.01	0.01	\$106,686	M			
Bicycle and Pedestrian Programs	Implementation of bicycle and pedestrian projects with supporting programs.	Onroad	NCTCOG	LDG+MC	91.88	0.07	0.07	\$35,045	93.42	0.04	0.04	Cost effectiveness is based upon NOx reductions.	✓			
California Low Emitting Vehicle (LEV) II Standards	Require vehicles sold in DFW region to be LEV II vehicles or cleaner.	Onroad	NCTCOG	LDG	91.22	0.19	0.29	\$124,856 – \$135,662 / ton w/o fuel savings -\$468,979 – -\$559,984 / ton with fuel savings	93.02	1.37	1.52	\$18,060 – \$23,821/ ton w/o fuel savings -\$74,549 – -\$89,476/ ton with fuel savings	L			
CARB 2007 On-Highway Diesel Engine Standards	Adopt California's heavy-duty diesel vehicle standards for all vehicles sold in the Dallas Fort Worth nine-county nonattainment area.	Onroad	NCTCOG	HDDV	88.17	7.13	7.13	\$995	3.82	-0.51	-0.51	\$13,901	L			



**SUMMARY OF RESULTS**

\*Legend located at end

Name	Description	Source	Analysis Performed by	Vehicles/ Equipment / Industry Affected*	NOx				VOC				SIP Eligible*? ✓ = yes
					Affected Emissions (tpd NOx)	Expected Emission Reduction (NOx)		Cost Effectiveness (\$/ton NOx)	Affected Emissions (tpd VOC)	Expected Emission Reduction (VOC)		Cost Effectiveness (\$/ton VOC)	
						tons/day				tons/day			
		Low	High			Low	High						
Higher Vehicle Occupancies	Additional HOV implementation	Onroad	NCTCOG	Freeway	107.21	0.27	0.27	\$95,097	40.12	0.28	0.28	\$93,724	✓
Idle Reduction Infrastructure	Electrification projects	Onroad	NCTCOG	HDV	93.21	0.06	0.06	\$8,711	4.06	Unkn nown	Unknown	n/a	✓
Stricter I/M Policy Enforcement	Additional enforcement of I/M policies	Onroad	NCTCOG	LDG	91.22	0.4	0.4	\$4,521	92.76	0.35	0.35	\$5,166	M
Intelligent Transportation Systems	Further system implementation	Onroad	NCTCOG	Freeway	107.21	4.87	4.87	\$1,714	40.12	1.99	1.99	Cost effectiveness is based upon NOx reductions.	✓
Light-Duty Vehicle Idling Restriction and Policy	Develop city and/or regional ordinance to restrict idling for both public and private light-duty vehicles	Onroad	NCTCOG	LDV	91.88	0.05	0.05	Unknown	93.42	0.19	0.19	Cost effectiveness is based upon NOx reductions.	E
Military Ground Equipment Emissions Testing, Measure	Expand I/M Program to include additional vehicles	Onroad	NCTCOG	Various	data currently unavailable				data currently unavailable				I
Lower Reid Vapor Pressure (RVP)	Lower the maximum RVP in Dallas Fort Worth nine-county nonattainment area	Onroad	NCTCOG	GV+MC	99.73	0	0	Cost effectiveness is based upon VOC reductions.	95.35	0.01	0.01	\$129,408	N
Additional Taxi Fleet Emissions Testing	More frequent testing	Onroad	NCTCOG	LDGV	92.11	0.001	0.001	(\$137,883)	92.76	n/a	n/a	n/a	✓
Traffic Signal Improvements	Planning, programming, and implementation of traffic signal improvement programs and	Onroad	NCTCOG	Arterial	63.75	1.11	1.11	\$13,300	41.54	3.07	3.07	\$4,809 / ton	✓

**SUMMARY OF RESULTS**

\*Legend located at end

Name	Description	Source	Analysis Performed by	Vehicles/ Equipment / Industry Affected*	NOx			Cost Effectiveness (\$/ton NOx)	VOC			SIP Eligible*? ✓ = yes	
					Affected Emissions (tpd NOx)	Expected Emission Reduction (NOx)			Affected Emissions (tpd VOC)	Expected Emission Reduction (VOC)			Cost Effectiveness (\$/ton VOC)
						tons/day				tons/day			
		Low	High			Low	High						
	projects												
Transit	Additional implementation	Onroad	NCTCOG	LDV+MC	91.88	0.07	0.07	\$170,761	93.42	0.07	0.07	Cost effectiveness is based upon NOx reductions.	✓
Fare-Free Transit, System-Wide on Ozone Action Days	Transit Incentive	Onroad	NCTCOG	LDV+MC	91.88	0.71	0.71	\$839,662	93.42	0.72	0.72	Cost effectiveness is based upon NOx reductions.	✓
Transit Off-Peak Pass	Transit Incentive	Onroad	NCTCOG	LDV+MC	91.88	0.07	0.07	\$0	93.42	0.07	0.07	Cost effectiveness is based upon NOx reductions.	✓
Carsharing	1,000 shared cars	Onroad	Earth Matters	LDV	193	0.045	0.045	not available	99	0.057	0.057	not available	✓
Congestion (value) pricing	0	Onroad	Earth Matters	Freeway	data currently unavailable				data currently unavailable			✓	
ETR-Vanpool Programs	Continue and increase Vanpool projects under ETR programs	Onroad	Earth Matters	LDV+MDV	193	0.023	0.023	\$257,407	99	0.026	0.026	Not applicable; all costs attributed to NOx	✓
ETR-Best Workplaces Program	Continue and increase BWC projects	Onroad	Earth Matters	LDV+MDV	193	0.104	0.104	\$2,320	99	0.107	0.107	Not applicable; all costs attributed to NOx	✓
ETR-Carpooling programs	Continue and increase carpooling projects under ETR programs	Onroad	Earth Matters	LDV+MDV	193	0.02	0.02	\$4,158	99	0.02	0.02	Not applicable; all costs attributed to NOx	✓

**SUMMARY OF RESULTS**

\*Legend located at end

Name	Description	Source	Analysis Performed by	Vehicles/ Equipment / Industry Affected*	NOx			VOC			SIP Eligible*? ✓ = yes		
					Affected Emissions (tpd NOx)	Expected Emission Reduction (NOx)		Cost Effectiveness (\$/ton NOx)	Affected Emissions (tpd VOC)	Expected Emission Reduction (VOC)		Cost Effectiveness (\$/ton VOC)	
						tons/day				tons/day			
		Low	High			Low	High						
ETR-Transit Subsidy Programs	Continue and increase transit subsidy projects under ETR programs	Onroad	Earth Matters	LDV+MDV+ Transit Vehicles	193	0.37	0.37	\$4,158	99	0.38	0.38	Not applicable; all costs attributed to NOx	✓
Parking Cash-Out	Cash-Out for 10% of area employees	Onroad	Earth Matters	LDV+MDV	193	0.443	0.443	not available	99	0.46	0.46	not available	✓
Pay-As-You-Drive	Mileage based auto insurance	Onroad	Earth Matters	LDV+MDV	193	0.917	0.917	not available	99	0.948	0.948	not available	✓
Speed Limit Decrease for Heavy Duty Diesel Trucks	Decrease and enforce 55 mph speed limit for heavy duty diesel trucks	Onroad	Earth Matters	Freeway	193	3.25	3.25	\$1,186	99	0.018	0.018	Not applicable; all costs attributed to NOx	L

**Non-Road Sources**

Freight Rail Infrastructure Improvements	Tower 55 bottleneck improvements to reduce locomotive idling	Nonroad	NCTCOG	Nonroad – locomotive		0.35	0.35	\$51,914					✓
Lawn Mower Replacement Program	Replacement or exchange of residential mowers	Nonroad	NCTCOG	Nonroad – lawn and garden					7.91	0.422	0.422	\$3,000-\$10,000	✓
Enhanced TERP program	Continue and increase TERP funded projects	Nonroad	ENVIRON	Offroad (except aircraft)	99	25	50	\$5,000 – \$10,000					M
Aircraft Emissions Standards	Encourage lower emitting aircraft	Nonroad	ENVIRON	Vehicles/ Equipment	21.01	3	6	unknown					✓
Emission Reduction Contract Incentives with Public Funding	Encourage lower emitting engines used on Publicly-funded projects	Nonroad	ENVIRON	Nonroad Construction – Public Funded Projects	6	1.1	1.1	<\$14,000					✓
Limitations on idling of heavy-duty construction equipment	Reduce Idling from construction and all nonroad	Nonroad	ENVIRON	Nonroad	40-72	0.5	1	\$4,000 - \$40,000					✓

**SUMMARY OF RESULTS**

\*Legend located at end

Name	Description	Source	Analysis Performed by	Vehicles/ Equipment / Industry Affected*	NOx			VOC			SIP Eligible*? ✓ = yes		
					Affected Emissions (tpd NOx)	Expected Emission Reduction (NOx)		Cost Effectiveness (\$/ton NOx)	Affected Emissions (tpd VOC)	Expected Emission Reduction (VOC)		Cost Effectiveness (\$/ton VOC)	
						tons/day				tons/day			
		Low	High			Low	High						
	engines												
Hybrid-electric locomotives	TERP funded Green Goat	Nonroad	ENVIRON	Nonroad – switching locomotive	8	1.2	1.4	\$5,000 - \$10,000				T	
Tier II	Tier II Locomotives	Nonroad	ENVIRON	Nonroad – locomotive	7.9 - 26.8	4	9.96	\$5,000 upward				T	
Rail Efficiency	System efficiency improvement	Nonroad	ENVIRON	Line-haul locomotives	18.9	0.8	3	unknown				✓	
Locomotive Idling Reductions	Install start/stop devices on locomotives	Nonroad	ENVIRON	Nonroad – switching locomotive	26.8	0.6	3	<\$1,000				✓	
California Portable Engine Rule	Registration and accelerated engine turnover	Nonroad	ENVIRON	Nonroad engines	72	1	1	\$200 – 300				L	

**Area Sources**

Architectural & Industrial Coatings	Require low VOC coatings	Area	ENVIRON	Over 40 categories of coatings in 9-county area					32.7	6.7	12.5	\$6,400-\$20,000		✓
Area Source Credit for Energy Conservation and Efficiency	Implementation of Senate Bill 5 and 7.	Area	NCTCOG	Area & Point		0.51	0.51							M
Cold Cleaning Regulations	Require low VOC solvent	Area	ENVIRON	Degreasing, cold cleaning (all industries; 9 county)					1.88	0.71	0.71	< 1,400		✓
Commercial and Consumer Products Requirements	Reformulate coatings and related products; adhesives and sealants; and misc.	Area	ENVIRON	Manufacturers of commercial and consumer products (all manufacturers; 9 county)					48.5	11.1	11.1	\$4,800		✓

**SUMMARY OF RESULTS**

\*Legend located at end

Name	Description	Source	Analysis Performed by	Vehicles/ Equipment / Industry Affected*	NOx				VOC				SIP Eligible*? ✓ = yes
					Affected Emissions (tpd NOx)	Expected Emission Reduction (NOx)		Cost Effectiveness (\$/ton NOx)	Affected Emissions (tpd VOC)	Expected Emission Reduction (VOC)		Cost Effectiveness (\$/ton VOC)	
						tons/day				tons/day			
		Low	High			Low	High						
Fuel Hose Permeation	Replace hoses with marine hoses	Area	ENVIRON	Gasoline refueling, Stage II; 9 county)					0.11	0.063	0.063	\$14,000 to \$16,000	✓
Glycol Dehydrators	Control or recycle vented VOC	Area	ENVIRON	Natural gas production (all 9 counties)					0.47	unknown	unknown	\$280-\$570	✓
NOx/EAT Software	Compliance assistance. Install software to increase energy efficiency.	Area	ENVIRON	Refineries & Chemical, Plants, 9-counties	n/a	n/a	n/a	n/a					✓
Oil & Gas Production	Better identify and repair leaking components	Area	ENVIRON	Oil & gas production and gas processing; 9 county)					unknown	unknown	unknown	\$600	✓
Small boilers & heaters	Replace boilers & heaters with better controlled units	Area	ENVIRON	Commercial and institutional buildings; 9 county	Deferred to TCEQ measure development				Deferred to TCEQ measure development				✓
Stationary IC Engines	Replace engines with lower emitting units	Area	ENVIRON	Manufacturing, schools, universities	7.6	6.29	6.29	\$187-\$5,100					✓

**Point Sources**

Aggregate Kilns	Control of NOx from Aggregate Kilns	Point	ENVIRON	Unknown	Unknown	Unknown	Unknown	\$850					✓
Alternate Energy Sources to Reduce Emissions from Electricity Generation	Use of renewable energy rather than fossil fuel energy for electricity generation.	Point	NCTCOG	EGUs	Unknown	0.06	0.06						I



## REFERENCES

ENVIRON, E.H. Pechan and Associates, and Earth Matters. 2000. *Evaluation of Attainment Control Strategies for the Dallas – Fort Worth State Implementation Plan*. ENVIRON International Corporation, October.