EASTERN RESEARCH GROUP, INC.

MEMORANDUM

To: Bill Schrock, EPA/OAQPS

From: Danny Greene, Eastern Research Group, Inc.

Date: February 13, 2003

Subject: Summary of the Nitrogen Oxide and Particulate Matter Emission Reductions Achieved by Replacing Agricultural Diesel Engines with Tier 2 and Tier 3 Engines

1.0 PURPOSE

The goal of this analysis was to estimate the emission reductions of nitrogen oxides (NOx) and particulate matter (PM) achieved by replacing older, higher-emitting stationary agricultural diesel engines in California with newer, lower-emitting engines that meet the EPA's Tier 2 and Tier 3 emission standards for nonroad mobile sources. Attachments 1 and 2 summarize the baseline emissions and emission reductions achieved by the engine replacements for NOx and PM, respectively. The estimated actual emission reductions of NOx and PM for 2003 are 2,200 megagrams per year (Mg/yr) and 100 Mg/yr, respectively (based on annual operating hours of 2,500). The estimated actual emission reduction of NOx for 2004 is 1,700 Mg/yr for a total emission reduction of 3,900 Mg NOx/yr and 100 Mg PM/yr.

2.0 SUMMARY OF METHODOLOGY

2.1 Number of Stationary Diesel Agricultural Engines Per County/Air Pollution Control District

The number of stationary diesel engines in California (6,708) was obtained from the 1997 U.S. Department of Agriculture (USDA) Census of Agriculture. To distribute the number of stationary agricultural engines to the air pollution control districts in California, several assumptions were used. First, the assumption was made that the number of agricultural pumps is

proportional to the amount of irrigated cropland (i.e., a county with 10 percent of the state-wide irrigated cropland would have 10 percent of the total state-wide agricultural pumps). Second, the assumption was made that a one-to-one relationship exists between the number of agricultural pumps and the number of engines (i.e., one engine is used to power one agricultural pump). Third, to estimate the number of stationary diesel engines, the total number of diesel engines was multiplied by 50 percent (based on an analysis conducted by the California Air Resources Board and discussions with an EPA representative in Region 9).

2.2 Baseline Engine Age and Size Profile

The 1995/96 survey report prepared by the San Joaquin Air Pollution Control District (SJAPCD) (Emission Inventory of Agricultural Internal Combustion Engines Used for Irrigation Purposes, Final Report STI-95240-1569-FR, August 1996) was used to determine the age and size distribution profile of engines in the SJAPCD prior to the implementation of the Carl Moyer Program. The profile formats were developed to follow the format of the NOx and PM emission factors used by the Carl Moyer Program (i.e., factors reported by model year and horsepower ranges) (Attachment 3). The age and size data for the surveyed engines in the 1995/96 report (Attachment 4) were presented separately, rather than as combined age and size distribution. Consequently, the age and size distributions used in the initial engine profiles (discussed in section 2.3) may not reflect the actual engine size distributions in a given age range of the engines surveyed.

The age of the pumps in the 1995/96 survey report ranged from 1960 to 1995. As a result, the age distribution did not include engines manufactured during the period 1996 to 2000 and somewhat overestimates the number of older engines (those in the 1996 to 2000 range) that might be selected for replacement.

2.3 Adjustment of Baseline Profiles to Reflect Engines Replaced Under the Carl Moyer Program

The engine profile developed from the SJAPCD report was used to represent the initial age and size distribution of the engines in the other districts prior to the engine replacements conducted under the Carl Moyer Program. The engine profiles for each district were then modified to reflect the engines replacements that were achieved under the Carl Moyer Program.

The assumption was made that 80 percent of the engines replaced under the Carl Moyer Program were stationary engines (based on discussions with an EPA representative in Region 9). The age and size profiles of the engines replaced under the Carl Moyer Program were not available. Therefore, to adjust the initial engine counts for each district, the assumption was made that the engines replaced by the Carl Moyer Program were the oldest engines in the initial profile. For example, if the Carl Moyer Program replaced 10 diesel engines in the South Coast APCD, then 10 engines in the oldest model year category of the profile would be moved into the newest engine category (2001 for this analysis). These "corrected" engine profiles represent the baseline (2001) equipment configurations and were assumed to apply to each county in their respective APCD.

One district (Sacramento) was problematic because the number of engines replaced under the Carl Moyer Program (532 engines) far exceeded the number estimated from the county irrigation data (48 engines). The discrepancy most likely results from the fact that the engines replaced under the Carl Moyer Program for the Sacramento Metro district include replacements in the following counties or portions of counties: most of El Dorado, most of Placer, all of Sacramento, the eastern portion of Solano, the southern third of Sutter, and all of Yolo county. With the exception of Sutter county (which is included in the Feather River district), none of these areas reported engine replacements under the Carl Moyer Program.

To resolve the discrepancy, the number of engines and engine replacements for the areas included in the Sacramento district were apportioned to those areas based on the number of engines initially estimated from the county irrigation data. For example, Yolo county accounts for five percent of the initial engine assignments for the areas included under the Sacramento district. Therefore, the number of engines and engine replacements were assumed to equal five percent of the Carl Moyer Program replacements for the Sacramento district. This approach increased the total number of stationary diesel agricultural engines from 3,354 (i.e., 50 percent of 6,708 total engines in California) to 3,682. Since all of Sutter county is included in the Feather River district (which reported engine replacements under the Carl Moyer Program), this county was not included in the reapportioning of the Sacramento district engine replacements.

2.5 Baseline Emission Estimates

Baseline emission estimates for 2001 were developed using the "corrected" engine profiles for each district and the NOx and PM emission factors used by the Carl Moyer Program

(Attachment 3). The baseline emission estimates were calculated by multiplying the number of engines in a given age and horsepower range by the corresponding emission factor. However, since the emission factors are reported for a range engine horsepowers (e.g., 50 to 120 horsepower, 121 horsepower and greater), the midpoint of the range was used for the emission estimates. For example, for the engine category "50 to 120 horsepower," the midpoint of 85 horsepower was used in the emission calculations. For the ranges that did not contain an upper horsepower limit, 450 horsepower (the largest engine reported in the 1995/96 SJAPCD survey) was used as the upper limit in calculating the midpoint of the range.

2.6 Tier 2 and Tier 3 Engine Replacements and Emission Reduction Estimates

The number of engines that are candidates for replacement with engines meeting the Tier 2 and 3 emission standards reflect the number of engines remaining after the engine replacements achieved by the Carl Moyer Program from 1998/1999 to 2000/2001. For example, if a district had 10 engines at baseline and three engines were replaced under the Carl Moyer Program, then there are seven engines that are candidates for replacement with Tier 2 and Tier 3 engines. Attachment 5 summarizes the stationary diesel agricultural engines by county and air pollution control district, the number that have been replaced by the Carl Moyer Program (from 1998/1999 to 2000/2001), and the candidate replacement engines remaining.

To determine the total number of Tier 2 and 3 engines that could potentially be replaced, the assumption was made that $12,000,000 in matching funds were available for the engine replacements over the next four years. This value was divided by the average amount of funds spent per engine replaced under the Carl Moyer Program (approximately $11,000/engine). The total number of replacement Tier 2 and 3 engines (1,045) was apportioned to each district using the ratio of candidate replacements per district and the total candidate replacements state-wide. Because the funding of this program is likely to be phased in over time, the assumption was made that half of the candidate replacements would be made in 2003 with Tier 2 engines. The other half would be made in 2004 and later with Tier 3 engines, when the requirements take effect. For PM, the Tier 2 and Tier 3 emission standards are the same. Consequently, all of the engine replacements were assumed to occur in 2003. Since $12,000,000 will not fund replacement of all candidate engines, the assumption was made that the Tier 2 and 3 engines replaced the oldest engines in the baseline (post-Moyer) profiles.

Post-replacement emissions were estimated using the district engine profiles (revised to reflect the Tier 2 and Tier 3 engine replacements) and the Tier 2 and Tier 3 emission factors (Attachment 3). However, the horsepower ranges for the candidate engine replacements and the EPA Tier 2 and 3 emission factors did not match exactly. Table 1 shows the different horsepower ranges that were used for the candidate engines and EPA emission factors.

Table 1. Comparison of Horsepower Ranges Used for Emission Factors

Horsepower Ranges for the Candidate Engine Emission Factors	Horsepower Ranges for the Tier 2 and 3 Emission Factors
50 - 120	50 - 99
121 - 175	100 - 174
176 - 250	175 - 299
251 - 500	300 - 599
501 - 750	600 - 749
751 and greater	750 and greater

For this analysis, the assumption was made that the horsepower ranges in Table 1 were comparable. For example, if an old engine in the “50 to 120” horsepower range was replaced with a Tier 2 engine, the replacement engine was placed in the “50 to 99” horsepower range for estimating emissions. Attachments 6 through 10 contain the engine profiles and emissions for each district.