# Estimates of Emission Reductions from Performing OBDII Tests on 1997 and Newer Light-Duty Diesel Vehicles

## FINAL REPORT

**Prepared for:**

**Texas Commission on Environmental Quality (TCEQ)**

**Prepared by:**

**de la Torre Klausmeier Consulting, Inc.**

**and**

**Eastern Research Group**

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## Introduction

Currently, Texas requires gasoline powered vehicles to receive emissions inspections if they are registered in El Paso or the Dallas/Ft. Worth and Houston/Galveston metropolitan areas. In these areas, vehicles older than 1996 receive a tailpipe emission test using either the loaded-mode (ASM) or two-speed idle (TSI) test cycles. 1996 and newer vehicles receive OBDII inspections. All vehicles receive gas cap inspections and full safety inspections. TCEQ is considering requiring 1997 and newer diesel powered vehicles that are less than 8,500 lbs. GVW to receive OBDII inspections. As requested by TCEQ, ERG estimated the emissions reductions from inspecting 1997 and newer light-duty diesels.

## Background

On-board diagnostics (OBDII) is an emerging regulatory approach towards reducing in-use emissions from motor vehicles. OBDII systems have been mandated for gasoline powered vehicles less than 8,500 lbs. GVW, since the 1996 model year. Diesel powered vehicles less than 8,500 lbs. GVW have been equipped with OBDII systems since the 1997 model year. Vehicles between 8,500 and 14,000 lbs. GVW must be equipped with OBDII systems according to the following phase-in schedule:

- 2004 model year – 40%
- 2005 model year – 60%
- 2006-7 model years – 80%
- 2008+ model years – 100%

Regulations are being developed to require OBDII systems on all heavy-duty diesel engines beginning with the 2008 model year.

OBDII systems monitor all components and emission control devices that could affect emission levels. Regulations require that the system illuminate a malfunction indicator light (MIL) when a malfunction occurs that could cause emissions to exceed a level equal to 1.5 times the emissions standard that the vehicle was certified for.

Inspecting vehicles by using the OBDII system is relatively straightforward. OBDII systems mandate that vehicles use standardized communication protocols and a standardized connector, termed a diagnostic link connector or DLC. The inspector must locate the standardized diagnostic connector and plug in a test system. The inspector then downloads the status of the emission control system. In addition, the inspector usually checks for proper operation of the MIL.  Data from the inspection are recorded automatically (with the exception of the visual inspection of the MIL) and stored into a database, which is transmitted to a centralized database.  Texas has been performing OBDII checks on light-duty gasoline-powered vehicles since May 2002.  Minimal test method development is needed to begin OBDII checks on light-duty diesels. In the future, medium and heavy-duty diesels could be easily added, once they are equipped with OBDII systems.

## Percent Reductions in Light-Duty Diesel Vehicle Emissions from Performing OBDII Inspections

ERG estimated the emission reductions from performing OBDII tests on light-duty diesel powered vehicles.  We analyzed data from OBDII inspections performed in Oregon and Connecticut.  These states perform OBDII inspections on 1997 and newer light-duty diesel powered vehicles.  The following vehicle types WERE inspected:

- Light-duty diesel vehicles (LDDV – passenger cars equipped with diesel engines);
- Light-duty diesel Trucks 1 (LDDT12 – light trucks less than 6,000 lbs. GVW equipped with diesel engines); and
- Light-duty diesel Trucks 2 (LDDT34 – light trucks between 6,000 and 8,500 lbs. GVW equipped with diesel engines).

ERG also collected and analyzed data on OBDII inspections in Delaware. We focused on data from Oregon and Connecticut, since these datasets were much larger then the dataset from Delaware.  We confirmed that trends seen in Oregon and Connecticut were also seen in Delaware.  Although Vermont also performs OBDII inspections on light-duty diesels, they do not have an electronic dataset available for analysis. Following is a summary of the overall OBDII inspection results for light-duty diesels inspected in Connecticut and Oregon.

## Percent of Vehicles with MILs Commanded-on

Table 1 presents the percent of light-duty diesel vehicles that had MILs[1] commanded-on in Connecticut and Oregon.  Overall, 12% of the light-duty diesel vehicles that received OBDII

[1] Malfunction Indicator Lamp (MIL) is a term used for the light on the instrument panel, which notifies the vehicle operator of an emission related problem.  The MIL is required to display the phrase “check engine” or “service engine soon” or the ISO engine symbol.  The MIL is required to illuminate when a problem has been identified that could cause emissions to exceed a specific multiple of the standards the vehicle was certified to meet. For diesel powered LDVs, this multiple is 1.5.

inspections had MILs commanded-on. As with other OBDII test results, a greater percentage of the older model vehicles had MILs commanded-on then newer model vehicles.

**Table 1 – MIL-On Rates for Light-Duty Diesels by Model Year**

| MIL-Command Status | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | Total |
|---|---|---|---|---|---|---|---|
| **Pass** | 133 | 258 | 257 | 286 | 146 | 219 | 1401 |
| **Fail** | 40 | 54 | 32 | 43 | 13 | 1 | 185 |
| **Total** | 173 | 312 | 289 | 329 | 159 | 220 | 1586 |
| **% MIL-On** | 23.1% | 17.3% | 11.1% | 13.1% | 8.2% | 0.5% | 11.7% |

Table 2 shows a breakdown of the percent of vehicles with MILs commanded-on by vehicle make. As shown, a majority of the vehicles (87%) that had MILs commanded-on were manufactured by Volkswagen. This makes sense since Volkswagen has dominated the light-duty diesel vehicle market. All of the Volkswagens were LDDVs (passenger cars).

**Table 2 – MIL-On Rates for Light-Duty Diesels by Make**

| Make | MIL-Off | MIL-On | Total | % Fail | % of Fails |
|---|---|---|---|---|---|
| **CHEVROLET** | 64 | 3 | 67 | 4.48% | 1.69% |
| **DODGE** | 30 | 0 | 30 | 0.00% | 0.00% |
| **FORD** | 57 | 17 | 74 | 22.97% | 9.60% |
| **GMC** | 25 | 0 | 25 | 0.00% | 0.00% |
| **MERCEDES-BENZ** | 109 | 3 | 112 | 2.68% | 1.69% |
| **VOLKSWAGEN** | 1052 | 154 | 1206 | 12.77% | 87.01% |

All of the models produced by domestic manufactures have been light-duty diesel trucks. Table 3 shows a breakdown of percent of vehicles with MILs commanded-on by vehicle type. As shown, the overall percentage of vehicles with MILs commanded-on is very similar for LDDVs and LDDTs. As a result, the analysis of benefits that will be discussed later in this report assumes equal benefits on a percentage basis for OBDII inspections on LDDVs and LDDTs.

**Table 3 – MIL-On Rates for Light-Duty Diesels by Vehicle Type**

| Vehicle Type | MIL-Off | MIL-On | Total | % MIL-On |
|---|---|---|---|---|
| **LDDV** | 1238 | 164 | 1402 | 11.70% |
| **LDDT (1,2,3,4)** | 163 | 21 | 184 | 11.41% |
| **Total** | 1401 | 185 | 1586 | 11.66% |

## Estimating Benefits from OBDII Inspections

The following steps were taken to estimate the emission reductions from performing OBDII inspections on light-duty diesel powered vehicles:

- dKC tabulated diagnostic trouble codes (DTCs[2]) that were stored in vehicles with MILs commanded-on;
- dKC researched the interpretation of DTCs in diesel powered vehicles;
- Generic DTCs (those beginning with P0XXX) were interpreted using an IATN (International Automotive Technician Network) DTC look-up facility;
- Manufacturer specific DTCs (those beginning with P1XXX or P3XXX) were interpreted by contacting manufacturers and by performing internet searches based on DTC and make.

Based upon the interpretation of the DTC, dKC grouped them into one of the following three categories:

- DTCs that possibly affected hydrocarbons (HC) and particulate matter (PM) emissions;
- DTCs that possibly affected $NO_x$ emissions; and
- DTCs that identified problems in the OBDII monitoring system. dKC assumed that these problems affected neither HC, PM or $NO_x$ emissions.

Although grouping DTCs into the above three categories may slightly underestimate the relationship between pollutants for specific repairs (such as the relationship between HC and NOx emissions), the above groupings are believed to represent the largest emission reduction impact of certain DTC repairs. Since insufficient DTC-specific test and repair emissions information is available for diesel vehicles, DTCs were assigned to one of the three above groups based on operational knowledge of the diesel engine and control system components.

Due to a lack of true DTC-specific emission information for diesel vehicles, dKC assumed that problems affecting HC and PM emissions increased HC and PM emissions by 50% over their certification standards; problems affecting $NO_x$ emissions increased $NO_x$ emissions by 50% over their certification standard. Since the presence of a DTC may not immediately result in an emissions increase, this assumption may result in an overestimate of emissions benefit.

[2] DTCs are how OBDII identifies and communicates to technicians the nature and location of on-board problems. Whenever the MIL is illuminated, a DTC should be present.

This potential overestimate may be partially offset by those DTCs which happen to increase emissions more than 50% over certification standards. Also inherent in the above assumption is that vehicles without a set DTC will be polluting exactly at their certification standard emission level for all pollutants.

Using the observed MIL commanded-on rate that was previously presented, dKC calculated the percent reduction in HC, PM, and $NO_x$ emissions from correcting the problem causing the MIL to illuminate.

Table 4 presents a tabulation of all the DTCs that were observed in vehicles failing OBDII tests in Oregon and Connecticut. As shown, the most common DTC was P0380 which indicated a problem in the glow plug circuit. Glow plugs are used in diesel powered vehicles to warm up the combustion chamber when the engine is cold. By warming up the combustion chamber, the vehicle starts easier when it is cold. dKC assumed the problems in the glow plug circuit primarily affected HC and PM emissions, since they could be excessive if the combustion chamber wasn't warmed up prior to a cold start. $NO_x$ related problems such as problems in the exhaust gas recirculation (EGR) system occurred much less frequently then HC and PM problems. Overall, dKC estimated that 69% of the DTCs affected HC and PM emissions and 10% of the DTCs affected NOx emissions.

### Table 4 – DTCs in Light-Duty Diesel Vehicles Failing Their OBDII Inspection

| DTC | # Found | % of MIL-On Cases | Description | Assumed Emissions Impact |
|---|---|---|---|---|
| P0380 | 135 | 55.79% | Glow Plug/Heater Circuit "A" Malfunction | HC, PM |
| P1256 | 14 | 5.79% | ECT Sensor Short | Minimal |
| P1550 | 12 | 4.96% | idle speed control | HC, PM |
| P1403 | 11 | 4.55% | EGR Flow Deviation | NOx |
| P0101 | 7 | 2.89% | Mass or Volume Air Flow Circuit Performance Problem | Minimal |
| P1144 | 7 | 2.89% | MAF Sensor Short To Ground | Minimal |
| P3130 | 6 | 2.48% | EGR System Regulation Limit Exceeded | NOx |
| P0605 | 5 | 2.07% | Internal Control Module Read Only Memory (ROM) Error | Minimal |
| P1156 | 5 | 2.07% | IAT Sensor Short To Ground | Minimal |
| P1556 | 3 | 1.24% | Symptom -- Black Smoke | HC, PM |
| P0400 | 3 | 1.24% | Exhaust Gas Recirculation Flow Malfunction | NOx |
| P0236 | 2 | 0.83% | Turbocharger Boost Sensor A Circuit Range/Performance | HC, PM |
| P1248 | 2 | 0.83% | Injection Start Control | HC, PM |
| P1562 | 2 | 0.83% | Quantity Adjuster (N146): Upper Limit Reached | HC, PM |
| P1619 | 2 | 0.83% | Glow Plug Relay Short To Ground | HC, PM |
| P0100 | 2 | 0.83% | Mass or Volume Air Flow Circuit Malfunction | Minimal |

| DTC | # Found | % of MIL-On Cases | Description | Assumed Emissions Impact |
|---|---|---|---|---|
| P0118 | 2 | 0.83% | Engine Coolant Temperature Circuit High Input | Minimal |
| P1557 | 2 | 0.83% | Unknown | Minimal |
| P0401 | 2 | 0.83% | Exhaust Gas Recirculation Flow Insufficient Detected | NOx |
| P0128 | 1 | 0.41% | Coolant Temp Below Thermostat Regulating Temperature | HC, PM |
| P0200 | 1 | 0.41% | Injector Circuit Malfunction | HC, PM |
| P0238 | 1 | 0.41% | Turbocharger Boost Sensor A Circuit High | HC, PM |
| P0251 | 1 | 0.41% | Injection Pump Fuel Metering Control "A" Malfunction | HC, PM |
| P0674 | 1 | 0.41% | Cylinder 4 Glow Plug Circuit | HC, PM |
| P1252 | 1 | 0.41% | Cold Start Injector Short To Ground | HC, PM |
| P1563 | 1 | 0.41% | Quantity Adjuster Control Lower Limit Value | HC, PM |
| P1656 | 1 | 0.41% | Wastegate Solenoid Control Circuit | HC, PM |
| P0102 | 1 | 0.41% | Mass or Volume Air Flow Circuit Low Input | Minimal |
| P0103 | 1 | 0.41% | Mass or Volume Air Flow Circuit High Input | Minimal |
| P1161 | 1 | 0.41% | IAT Sensor Short | Minimal |
| P1163 | 1 | 0.41% | Fuel Temperature Sensor Short To B+. | Minimal |
| P1354 | 1 | 0.41% | Modulating Piston Displacement Sensor Circuit | Minimal |
| P1367 | 1 | 0.41% | Unknown | Minimal |
| P1409 | 1 | 0.41% | Tank Ventilation Valve | Minimal |
| P1810 | 1 | 0.41% | TFP Valve Position Switch Circuit Malfunction | Minimal |
| P1443 | 1 | 0.41% | Unknown | Minimal |
| P3131 | 1 | 0.41% | Assumed to be EGR Related | NOx |

Table 5 summarizes the assumed certification standards and impact of malfunctions by pollutant (HC, PM, NOx). Note that light-duty diesel vehicles have less stringent $NO_x$ standards (i.e., numerically higher) then light-duty gasoline powered vehicles

**Table 5 – Assumed Vehicle Certification Standards**

| Pollutant | 100K Std. (g/mi) | Assumed Malfunction Impact (g/mi) |
|---|---|---|
| **NMHC** | 0.25 | 0.125 |
| **NOx** | 1.25 | 0.625 |
| **PM** | 0.10 | 0.05 |

Table 6 shows the calculated emission benefits from correcting problems in light-duty diesel powered vehicles that cause their MIL to illuminate. As shown, HC and PM emissions are estimated to be reduced by 4% and $NO_x$ emissions are estimated to be reduced by 0.6% by performing OBDII inspections on light-duty diesel powered vehicles. These estimates only apply to 1997 and newer light-duty diesel vehicle categories (LDDV, LDDT12, LDDT34). The reductions shown in Table 6 are based on the assumption that similar fail rates and DTCs would be seen in Texas as seen in Oregon and Connecticut.

**Table 6 – Estimated Percent Emissions Reductions from Performing OBDII Inspections on Light-Duty Diesels**

| Pollutant | 100K Std. (g/mi) | Assumed Malfunction Impact (g/mi) | % MIL-On | % Affected | Net Emissions Increase (g/mi) | % Reduction from I/M |
|---|---|---|---|---|---|---|
| **NMHC** | 0.25 | 0.125 | 11.7% | 68.60% | 0.0100 | 4.01% |
| **NOx** | 1.25 | 0.625 | 11.7% | 9.50% | 0.0069 | 0.56% |
| **PM** | 0.10 | 0.05 | 11.7% | 68.60% | 0.0040 | 4.01% |

## Fleet Emissions Impact from Performing OBDII Inspections on Light-Duty Diesel Powered Vehicles

Texas counties currently participating in the Air Check Texas program include nine counties in the Dallas/Forth Worth nonattainment area, eight counties in the Houston/Galveston nonattainment area, and El Paso county. Travis and Williamson counties will begin I/M programs of their own in the near future.

In order to generate estimates of emissions benefits from implementing OBD testing for LDDVs and LDDTs, MOBILE6 modeling runs were performed for each county for both the 2007 and 2010 model years. The I/M reduction factors listed above in Table 6 were then applied to emission factors obtained from these MOBILE runs for 1997 and newer model year vehicles.

## MOBILE6 Input File Generation and Execution

In order to run MOBILE6 and obtain emission factors for each county and year of interest listed under Task 1 of the work order, it was necessary to first create appropriate MOBILE6 input files (SPEEDVMT, FACILITY VMT, and VMT BY HOUR). These files were created using a SAS script developed by ERG (rdtab.sas – see Appendix A), using input files obtained from the Texas Transportation Institute (TTI). These input files contained hourly data, aggregated by roadway type and MOBILE6 vehicle type, for parameters such as vehicle miles traveled (VMT), VMT Mix, average operational speed, and other information.

The first step in the process of creating the MOBILE6 input files listed above was to read in the data for each county, as provided by TTI, and assign MOBILE 6 facility types (freeway, arterial, ramp, or local) to each roadway type, based on the description of the roadway itself.

To create the SPEEDVMT file, VMT were calculated for each roadway type by hour, regardless of MOBILE6 vehicle type. Next, using the average operational speed obtained from the TTI data, the VMT were separated into appropriate speed “bins” using the harmonic mean procedure, as outlined in the MOBILE6 guidance. At this point, the VMT, having been separated into “bins”, were converted to VMT fraction by MOBILE6 facility type and hour. A file containing this information was then created in a format readable by MOBILE6.

The FACILITY VMT file was created by separating the VMT obtained from the TTI data into “bins” based on MOBILE6 facility type (freeway, arterial, ramp, or local). This was done for each hour of the day, and for each MOBILE6 vehicle type. At this point, the VMT, having been separated into “bins”, were converted to VMT fraction by MOBILE6 facility type and hour. Again, a file containing this information was created in a format readable by MOBILE6.

The VMT BY HOUR file was created by calculating a VMT sum for each hour of the day, regardless of vehicle type or facility type. The VMT were converted to VMT fraction at this point, and once again a file containing this information was output in a format readable by MOBILE6.

Other MOBILE6 inputs, such as registration distributions, diesel fractions, and trip lengths were extracted from sample MOBILE6 files supplied by TTI. 2007 and 2010 inventory data was available for all Dallas/Fort Worth and Houston/Galveston counties. Only 2007 data was available for Travis and Williamson counties, and neither 2007 nor 2010 data was available for El Paso county. In these cases, earlier available inventory data was used, and a standard VMT factor of 3% per year was applied to approximate 2007 and 2010 VMT. Tables 7 and 8 present a summary of the input files used in the MOBILE6 modeling.

# Table 7 - 2007 LDDV OBD MOBILE INPUT SUMMARY

| Area | County | 2007 Tab Available? | Reg Dist | VMT by Hour | Speed VMT | VMT by facility | Diesel Fraction | Trip Length |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| El Paso | El Paso | No, Used 2005 (2008 next available) | ELP04.rgd | elpaso_h.def | elpaso_s.def | elpaso_f.def | Taken from provided MOBILE inputs | Not Available |
| | | | | | | | | |
| Austin | Travis | Yes | AUSmsa02.rgd | travis_h.def | travis_s.def | travis_f.def | Taken from provided MOBILE inputs | Not Available |
| | Williamson | Yes | AUSmsa02.rgd | willia_h.def | willia_s.def | willia_f.def | Taken from provided MOBILE inputs | Not Available |
| | | | | | | | | |
| Dallas/ Fort Worth | Dallas | Yes | reg03_w.dal | dallas_h.def | dallas_s.def | dallas_f.def | Taken from provided MOBILE inputs | 07wdtrip.ubn |
| | Tarrant | Yes | reg03tar.rgd | tarran_h.def | tarran_s.def | tarran_f.def | Taken from provided MOBILE inputs | 07wdtrip.ubn |
| | Collin | Yes | reg03_w.col | collin_h.def | collin_s.def | collin_f.def | Taken from provided MOBILE inputs | 07wdtrip.rrl |
| | Denton | Yes | reg03_w.den | denton_h.def | denton_s.def | denton_f.def | Taken from provided MOBILE inputs | 07wdtrip.rrl |
| | Ellis | Yes | reg03.ell | ellis_h.def | ellis_s.def | ellis_f.def | Taken from provided MOBILE inputs | 07wdtrip.per |
| | Johnson | Yes | reg03.joh | johnso_h.def | johnso_s.def | johnso_f.def | Taken from provided MOBILE inputs | 07wdtrip.per |
| | Kaufman | Yes | reg03.kau | kaufma_h.def | kaufma_s.def | kaufma_f.def | Taken from provided MOBILE inputs | 07wdtrip.per |
| | Parker | Yes | reg03.par | parker_h.def | parker_s.def | parker_f.def | Taken from provided MOBILE inputs | 07wdtrip.per |
| | Rockwall | Yes | reg03.roc | rockwa_h.def | rockwa_s.def | rockwa_f.def | Taken from provided MOBILE inputs | 07wdtrip.per |
| | | | | | | | | |
| Houston/ Galveston | Harris | Yes | harr03.rgd | harris_h.def | harris_s.def | harris_f.def | Taken from provided MOBILE inputs | HG07.tld |
| | Galveston | Yes | galv03.rgd | galves_h.def | galves_s.def | galves_f.def | Taken from provided MOBILE inputs | HG07.tld |
| | Brazoria | Yes | braz03.rgd | brazor_h.def | brazor_s.def | brazor_f.def | Taken from provided MOBILE inputs | HG07.tld |
| | Fort Bend | Yes | fort03.rgd | fortbe_h.def | fortbe_s.def | fortbe_f.def | Taken from provided MOBILE inputs | HG07.tld |
| | Montgomery | Yes | mont03.rgd | montgo_h.def | montgo_s.def | montgo_f.def | Taken from provided MOBILE inputs | HG07.tld |
| | Liberty | Yes | libe03.rgd | libert_h.def | libert_s.def | libert_f.def | Taken from provided MOBILE inputs | HG07.tld |
| | Waller | Yes | wall03.rgd | waller_h.def | waller_s.def | waller_f.def | Taken from provided MOBILE inputs | HG07.tld |
| | Chambers | Yes | cham03.rgd | chambe_h.def | chambe_s.def | chambe_f.def | Taken from provided MOBILE inputs | HG07.tld |

Table 8 - **2010 LDDV OBD MOBILE INPUT SUMMARY**

| Area | County | 2010 Tab Available? | Reg Dist | VMT by Hour | Speed VMT | VMT by facility | Diesel Fraction | Trip Length |
|---|---|---|---|---|---|---|---|---|
| El Paso | El Paso | No, Used 2008 (2011 next available) | ELP04.rgd | elpaso_h.df2 | elpaso_s.df2 | elpaso_f.df2 | Taken from provided MOBILE inputs | Not Available |
| Austin | Travis | No, Used 2007 (2012 next available) | AUSmsa02.rgd | travis_h.def | travis_s.def | travis_f.def | Taken from provided MOBILE inputs | Not Available |
| | Williamson | No, Used 2007 (2012 next available) | AUSmsa02.rgd | willia_h.def | willia_s.def | willia_f.def | Taken from provided MOBILE inputs | Not Available |
| Dallas/ Fort Worth | Dallas | Yes | reg03_w.dal | dallas_h.df2 | dallas_s.df2 | dallas_f.df2 | Taken from provided MOBILE inputs | 10wdtrip.ubn |
| | Tarrant | Yes | reg03tar.rgd | tarran_h.df2 | tarran_s.df2 | tarran_f.df2 | Taken from provided MOBILE inputs | 10wdtrip.ubn |
| | Collin | Yes | reg03_w.col | collin_h.df2 | collin_s.df2 | collin_f.df2 | Taken from provided MOBILE inputs | 10wdtrip.rrl |
| | Denton | Yes | reg03_w.den | denton_h.df2 | denton_s.df2 | denton_f.df2 | Taken from provided MOBILE inputs | 10wdtrip.rrl |
| | Ellis | Yes | reg03.ell | ellis_h.df2 | ellis_s.df2 | ellis_f.df2 | Taken from provided MOBILE inputs | 10wdtrip.per |
| | Johnson | Yes | reg03.joh | johnso_h.df2 | johnso_s.df2 | johnso_f.df2 | Taken from provided MOBILE inputs | 10wdtrip.per |
| | Kaufman | Yes | reg03.kau | kaufma_h.df2 | kaufma_s.df2 | kaufma_f.df2 | Taken from provided MOBILE inputs | 10wdtrip.per |
| | Parker | Yes | reg03.par | parker_h.df2 | parker_s.df2 | parker_f.df2 | Taken from provided MOBILE inputs | 10wdtrip.per |
| | Rockwall | Yes | reg03.roc | rockwa_h.df2 | rockwa_s.df2 | rockwa_f.df2 | Taken from provided MOBILE inputs | 10wdtrip.per |
| Houston/ Galveston | Harris | Yes | harr03.rgd | harris_h.df2 | harris_s.df2 | harris_f.df2 | Taken from provided MOBILE inputs | HG10.tld |
| | Galveston | Yes | galv03.rgd | galves_h.df2 | galves_s.df2 | galves_f.df2 | Taken from provided MOBILE inputs | HG10.tld |
| | Brazoria | Yes | braz03.rgd | brazor_h.df2 | brazor_s.df2 | brazor_f.df2 | Taken from provided MOBILE inputs | HG10.tld |
| | Fort Bend | Yes | fort03.rgd | fortbe_h.df2 | fortbe_s.df2 | fortbe_f.df2 | Taken from provided MOBILE inputs | HG10.tld |
| | Montgomery | Yes | mont03.rgd | montgo_h.df2 | montgo_s.df2 | montgo_f.df2 | Taken from provided MOBILE inputs | HG10.tld |
| | Liberty | Yes | libe03.rgd | libert_h.df2 | libert_s.df2 | libert_f.df2 | Taken from provided MOBILE inputs | HG10.tld |
| | Waller | Yes | wall03.rgd | waller_h.df2 | waller_s.df2 | waller_f.df2 | Taken from provided MOBILE inputs | HG10.tld |
| | Chambers | Yes | cham03.rgd | chambe_h.df2 | chambe_s.df2 | chambe_f.df2 | Taken from provided MOBILE inputs | HG10.tld |

Having created each of the MOBILE6 input files described above for each county of interest, two MOBILE6 runs were performed for each county - one for the 2007 calendar year, and one for 2010. The emission factors obtained from the MOBILE6 output for each run were then used to determine the benefits of implementing a light duty diesel OBD program.

To accomplish this, a SAS program (emproc.sas – see Appendix A) was created to process the output from the two MOBILE6 runs performed for each county. For each vehicle type and pollutant, a travel fraction (by age) was calculated. VMT for each vehicle type were read in from TTI data processed above, and these VMT were weighted by the travel fraction to obtain an adjusted VMT value for each combination of age, vehicle type, and pollutant. This adjusted VMT was then multiplied by the applicable emission factor obtained from MOBILE6 to come up with a total number of grams for each pollutant of interest, which were then converted to tons. At this point, the I/M reduction factors set forth in Table 6 were applied (4.01% for NOx and PM, 0.56% for HC) to calculate light duty diesel OBD benefits.

All MOBILE6 inputs, SAS scripts, and outputs are provided electronically in Appendix A.

## Results Summary

Table 9 presents estimated benefits for each of the counties of interest. As previously described, these estimated benefits are based on assumed emission reductions derived from certification standards and knowledge of OBD monitoring system. True "in-program" emission reductions could vary from these estimated benefits. Note that the primary reason the estimated reductions are so low is the relatively small number of vehicles miles traveled by LDDVs and LDDTs. VMT from these vehicle categories is sometimes three orders of magnitude less than LDGVs, for instance.

### Table 9 – Estimated Emissions Benefits of LDDV & LDDT OBD Implementation

| | | *2007* | | | *2010* | | |
|---|---|---|---|---|---|---|---|
| **COUNTY** | **POLLUTANT** | **DAILY BENEFIT (TONS)** | **DAILY BENEFIT (LBS)** | **ANNUAL BENEFIT (TONS)** | **DAILY BENEFIT (TONS)** | **DAILY BENEFIT (LBS)** | **ANNUAL BENEFIT (TONS)** |
| BRAZORIA | NOX | 0.0000848 | 0.17 | 0.031 | 0.00010 | 0.19 | 0.035 |
| CHAMBERS | NOX | 0.0000550 | 0.11 | 0.020 | 0.00006 | 0.12 | 0.021 |
| COLLIN | NOX | 0.000124 | 1.24 | 0.226 | 0.00071 | 1.41 | 0.258 |
| DALLAS | NOX | 0.000716 | 5.99 | 1.093 | 0.00325 | 6.50 | 1.187 |
| DENTON | NOX | 0.000123 | 1.18 | 0.215 | 0.00066 | 1.32 | 0.241 |
| ELLIS | NOX | 0.0000544 | 0.57 | 0.104 | 0.00038 | 0.76 | 0.139 |
| EL PASO | NOX | 0.000179 | 0.36 | 0.065 | 0.00019 | 0.37 | 0.068 |
| FORT BEND | NOX | 0.000135 | 0.27 | 0.049 | 0.00015 | 0.31 | 0.056 |
| GALVESTON | NOX | 0.0000728 | 0.15 | 0.027 | 0.00009 | 0.18 | 0.033 |
| HARRIS | NOX | 0.00133 | 2.66 | 0.485 | 0.00146 | 2.91 | 0.532 |
| JOHNSON | NOX | 0.0000376 | 0.37 | 0.067 | 0.00025 | 0.50 | 0.091 |
| KAUFMAN | NOX | 0.0000392 | 0.46 | 0.084 | 0.00031 | 0.62 | 0.113 |
| LIBERTY | NOX | 0.0000356 | 0.07 | 0.013 | 0.00004 | 0.08 | 0.015 |
| MONTGOMERY | NOX | 0.000162 | 0.32 | 0.059 | 0.00018 | 0.35 | 0.065 |
| PARKER | NOX | 0.0000400 | 0.37 | 0.067 | 0.00025 | 0.49 | 0.090 |
| ROCKWALL | NOX | 0.0000196 | 0.24 | 0.044 | 0.00014 | 0.27 | 0.050 |
| TARRANT | NOX | 0.000550 | 3.84 | 0.701 | 0.00211 | 4.21 | 0.769 |
| TRAVIS | NOX | 0.000302 | 0.60 | 0.110 | 0.00034 | 0.69 | 0.126 |
| WALLER | NOX | 0.0000279 | 0.06 | 0.010 | 0.00005 | 0.09 | 0.017 |
| WILLIAMSON | NOX | 0.000108 | 0.22 | 0.039 | 0.00012 | 0.25 | 0.045 |
| | | | | | | | |
| BRAZORIA | HC | 0.000163 | 0.33 | 0.059 | 0.00020 | 0.40 | 0.073 |
| CHAMBERS | HC | 0.0000724 | 0.14 | 0.026 | 0.00008 | 0.16 | 0.028 |
| COLLIN | HC | 0.000328 | 3.24 | 0.591 | 0.00188 | 3.76 | 0.686 |
| DALLAS | HC | 0.00162 | 15.40 | 2.811 | 0.00863 | 17.26 | 3.150 |
| DENTON | HC | 0.000291 | 2.84 | 0.519 | 0.00166 | 3.32 | 0.606 |
| ELLIS | HC | 0.0000963 | 1.04 | 0.190 | 0.00071 | 1.41 | 0.258 |
| EL PASO | HC | 0.000457 | 0.91 | 0.167 | 0.00050 | 0.99 | 0.181 |
| FORT BEND | HC | 0.000275 | 0.55 | 0.100 | 0.00035 | 0.70 | 0.128 |
| GALVESTON | HC | 0.000154 | 0.31 | 0.056 | 0.00020 | 0.40 | 0.074 |
| HARRIS | HC | 0.00291 | 5.82 | 1.061 | 0.00385 | 7.70 | 1.406 |
| JOHNSON | HC | 0.0000862 | 0.84 | 0.154 | 0.00058 | 1.16 | 0.212 |
| KAUFMAN | HC | 0.0000808 | 0.95 | 0.174 | 0.00065 | 1.29 | 0.236 |
| LIBERTY | HC | 0.0000624 | 0.12 | 0.023 | 0.00007 | 0.15 | 0.027 |
| MONTGOMERY | HC | 0.000292 | 0.58 | 0.106 | 0.00035 | 0.70 | 0.128 |
| PARKER | HC | 0.0000770 | 0.75 | 0.136 | 0.00051 | 1.01 | 0.185 |

| | | *2007* | | | *2010* | | |
|---|---|---|---|---|---|---|---|
| **COUNTY** | **POLLUTANT** | **DAILY BENEFIT (TONS)** | **DAILY BENEFIT (LBS)** | **ANNUAL BENEFIT (TONS)** | **DAILY BENEFIT (TONS)** | **DAILY BENEFIT (LBS)** | **ANNUAL BENEFIT (TONS)** |
| ROCKWALL | HC | 0.0000337 | 0.46 | 0.084 | 0.00027 | 0.55 | 0.100 |
| TARRANT | HC | 0.00120 | 9.52 | 1.737 | 0.00543 | 10.85 | 1.980 |
| TRAVIS | HC | 0.000807 | 1.61 | 0.295 | 0.00094 | 1.87 | 0.342 |
| WALLER | HC | 0.0000433 | 0.09 | 0.016 | 0.00007 | 0.14 | 0.025 |
| WILLIAMSON | HC | 0.000247 | 0.49 | 0.090 | 0.00029 | 0.57 | 0.105 |
| | | | | | | | |
| BRAZORIA | PM10 | 0.00002 | 0.04 | 0.008 | 0.00001 | 0.03 | 0.005 |
| CHAMBERS | PM10 | 0.00001 | 0.02 | 0.004 | 0.00001 | 0.01 | 0.002 |
| COLLIN | PM10 | 0.00014 | 0.29 | 0.053 | 0.00008 | 0.17 | 0.031 |
| DALLAS | PM10 | 0.00067 | 1.35 | 0.246 | 0.00038 | 0.76 | 0.138 |
| DENTON | PM10 | 0.00013 | 0.27 | 0.049 | 0.00008 | 0.16 | 0.029 |
| ELLIS | PM10 | 0.00006 | 0.11 | 0.021 | 0.00004 | 0.08 | 0.014 |
| EL PASO | PM10 | 0.00006 | 0.11 | 0.020 | 0.00004 | 0.07 | 0.013 |
| FORT BEND | PM10 | 0.00003 | 0.06 | 0.012 | 0.00002 | 0.04 | 0.008 |
| GALVESTON | PM10 | 0.00002 | 0.04 | 0.007 | 0.00001 | 0.03 | 0.005 |
| HARRIS | PM10 | 0.00033 | 0.65 | 0.119 | 0.00022 | 0.44 | 0.080 |
| JOHNSON | PM10 | 0.00005 | 0.09 | 0.017 | 0.00003 | 0.07 | 0.012 |
| KAUFMAN | PM10 | 0.00005 | 0.10 | 0.018 | 0.00003 | 0.07 | 0.012 |
| LIBERTY | PM10 | 0.00001 | 0.02 | 0.003 | 0.00001 | 0.01 | 0.002 |
| MONTGOMERY | PM10 | 0.00004 | 0.07 | 0.013 | 0.00002 | 0.05 | 0.009 |
| PARKER | PM10 | 0.00004 | 0.08 | 0.014 | 0.00003 | 0.05 | 0.010 |
| ROCKWALL | PM10 | 0.00002 | 0.04 | 0.008 | 0.00001 | 0.02 | 0.004 |
| TARRANT | PM10 | 0.00044 | 0.88 | 0.161 | 0.00025 | 0.50 | 0.091 |
| TRAVIS | PM10 | 0.00009 | 0.18 | 0.033 | 0.00006 | 0.12 | 0.021 |
| WALLER | PM10 | 0.00001 | 0.01 | 0.002 | 0.00001 | 0.01 | 0.002 |
| WILLIAMSON | PM10 | 0.00003 | 0.06 | 0.011 | 0.00002 | 0.04 | 0.007 |