Appendix A: Dallas-Fort Worth Five County Stage II Motor Vehicle Emission Simulator (MOVES) Model Refueling Emissions Analyses

A.1 INTRODUCTION

Stage II gasoline vapor recovery systems are currently required in all serious, severe, and extreme ozone nonattainment areas. With the reclassification of the Dallas-Fort Worth (DFW) area from moderate to serious nonattainment area based on the 1997 eight-hour ozone standard, Stage II refueling recovery will be required in the five outlying counties in the DFW area (Ellis, Johnson, Kaufman, Parker, and Rockwall Counties). However, with the phase-in of the vehicles equipped with the 1998 and newer model year on-board refueling vapor recovery (ORVR) systems into the on-road vehicle fleet, the incremental benefit due to Stage II starts to decline turning it into a less efficient investment. Therefore, there is a need to revaluate the significance of Stage II implementation in the five outlying DFW counties.

According to 40 Code of Federal Regulations Part 51, upon demonstrating "widespread use" of ORVR, the United States Environmental Protection Agency (EPA) may waive the Federal Clean Air Act (FCAA or Act) statutory requirements for states to implement Stage II gasoline vapor recovery systems at gasoline dispensing facilities in areas classified as serious, severe, or extreme for nonattainment of the ozone National Ambient Air Quality Standard (NAAQS). "Widespread use" of ORVR throughout the motor vehicle fleet occurs when the volatile organic compounds (VOC) emissions captured only from the ORVR control are equal to or greater than the fugitive VOC emissions captured from only the Stage II control.

In this analysis, the year 2013 was identified to be the year that ORVR widespread use would occur in the five outlying counties in the DFW area.

A.2 MODEL RUN AND POST-PROCESSING OVERVIEW

EPA's MOVES2010a model was used for this analysis. Local data from the DFW area, obtained from Texas Transportation Institute (TTI), was used to prepare the input files (MOVES "runspecs") for the model in order to obtain refueling emission rates. Refueling emission rates are the amount of emissions that occur for each gallon of gas pumped at the gas pump. Since these emission rates cannot be obtained directly from MOVES, the following method was used to perform the analysis:

1. Used MOVES to estimate both refueling VOC emission totals (tons) and total energy consumption (megajoules) from all exhaust processes: running exhaust, start exhaust, and extended idle exhaust.
2. Divided the obtained total energy consumption by energy content per gallon to get total fuel consumed (gallons).
3. Obtained refueling emission rates in grams/gallon by dividing refueling emissions by gallons consumed.

4. Obtained fuel economy estimates (miles per gallon) by dividing vehicle miles traveled (VMT) estimates by gallons consumed (since we cannot get fuel economy directly from MOVES).
5. Combined all these factors together to get emission estimates for the specific refueling scenario for each county and year combination.

Using the MOVES model, alternative scenarios can be assessed by enabling or disabling the effects of various control technologies. For this analysis, three control scenarios were performed for 1990 and 1999 through 2030 analysis years. Summary of the three control scenarios are:

1. ORVR only
    - Default approach with the MOVES input database as is, in which only ORVR is assumed and no Stage II.
2. Stage II only
    - Stage II was enabled for 1999 through 2030 with overall control effectiveness ratings of 80% for evaporation and 50% for spillage. The values are left at 0% for 1990.
3. No Control (neither ORVR nor Stage II) was enabled.
    - The post-1990 Clean Air Act controls were disabled.

For each of the above mentioned scenarios TCEQ generated a detailed spreadsheet that consists of a sheet summarizing each of the following key points:

- Refueling VOC Emission Rates (grams per gallon)
- Fuel Economy (miles per gallon)

A.3 EMISSION RATE DESCRIPTION:

This analysis used the recent trends study conducted by TTI for the years 1990 and 1999 through 2030. The study can be located at ftp://amdaftp.tceq.texas.gov/pub/Mobile_EI/Trends/mvs/. TTI did not run emissions rates for all 254 Texas counties for all 33 of the aforementioned years. Instead TTI used a representative county approach for estimating emissions rates.

In general, for statewide analyses TTI develops emission rates for groups of similar fleet characteristics, meteorology, fuels, and by Inspection and Maintenance (I/M) program area. For emission rate modeling purposes with MOVES, TTI assigns each individual county group the five-digit county FIPS code of the first county in the group, going by FIPS code in ascending order. For example, since Johnson County is the first county in the group containing Johnson and Parker Counties, the county group emissions rates for this group are labeled with “48251” (Johnson County FIPS code) and are used for both Johnson and Parker Counties. Therefore, the MOVES-based 24-hour summer weekday emission rates were developed by grouping the 254 Texas counties into 42 unique combinations of MOVES input data sets for the years 1990 and 1999 through 2003 analysis years, and 44 unique combinations of MOVES input data sets for the 2004 and later analysis years. The main reason for the two set of groupings is that it allows modeling for the I/M expansion counties (before the I/M programs were implemented) separately from the earlier implementation I/M counties.

Texas counties are categorized into eight "climate zones" - Amarillo, Corpus Christi, Dallas, El Paso, Houston, Lubbock, Midland, and San Antonio. Each climate zone shares the same MOVES inputs: summer and winter temperature, summer and winter relative humidity (percent), and 24- hour barometric pressure (inches of mercury). Altitude was "low" (areas with pressure greater than 25.8404 are low altitude, *MOVES 2010a User Guide*) for all 254 counties, and meteorological inputs were based on 2005 weather station data (June through August National Weather Service data) representative of "eight climate zones" from a prior statewide emissions analysis.

TTI obtained VMT mix by Texas Department of Transportation (TxDOT) district (i.e., each county within a TxDOT district uses the same VMT mix). The following two TxDOT districts represent the DFW area.

- District 18 = Dallas (Ellis, Collin, Dallas, Rockwall, Kaufman, and Denton Counties)
- District 2 = Fort Worth (Johnson, Hood, Tarrant, Parker, and Wise Counties)

Therefore, counties that are in the same TxDOT district, climate zone, fuel formulation, and I/M program area will have the same model inputs that produce identical emission rates. For the purposes of this analysis, the county groupings extracted are shown in *Table A-1 Summary of the Representative County Approach for Estimating Emission Rates for the Five DFW Perimeter Counties*.

(For detailed information, please refer to the master spreadsheet mvs10a-refueling-analysis-dfw-5county.xlsx and 2011 *On-road Mobile source Trend emissions inventories for all 254 counties in Texas for 1999-2030 EI* located at *ftp://amdaftp.tceq.texas.gov/pub/Area_EI/Refuel/*).

Table A-1: Summary of the Representative County Approach for Estimating Emission Rates for the Five DFW Perimeter Counties

County Name	Trends Analysis Years	
	1990 & 1999-2003	2004-2030
Ellis	Ellis	Ellis
Johnson	Johnson	Johnson
Kaufman	Ellis	Kaufman
Parker	Johnson	Johnson
Rockwall	Ellis	Kaufman

Table A-1: Summary of the Representative County Approach for Estimating Emission Rates for the Five DFW Perimeter Counties is represented to show that the grouping of the counties was used because there were several group pairs of counties with identical model set-ups (as explained above).

Table A-2: MOVES2010a DFW Five Perimeter County VOC Refueling Emission Estimates for 1990 and 1999-2030 shows the VOC emissions estimated with the controls of ORVR only and Stage II only, and the emissions estimates with no controls as shown in the column No ORVR or Stage II tons per day (tpd). The column ORVR Only (tpd) shows the emissions estimates when only ORVR controls are in place and the Stage II Only (tpd) column shows the emissions

estimates when Stage II control is only in place. The column No ORVR or Stage II shows the emission estimates when neither control of ORVR nor Stage II is in place.

Table A-2: MOVES2010a DFW Five Perimeter County VOC Refueling Emission Estimates for 1990 and 1999-2030

Calendar Year	ORVR Only (tpd)	Stage II Only (tpd)	No ORVR or Stage II (tpd)
1990	2.91	2.91	2.91
1999	3.25	0.82	3.52
2000	2.91	0.80	3.37
2001	2.75	0.82	3.45
2002	2.56	0.84	3.54
2003	2.40	0.87	3.65
2004	2.32	0.92	3.88
2005	2.21	0.97	4.08
2006	2.03	0.98	4.13
2007	1.84	0.99	4.18
2008	1.57	0.96	4.07
2009	1.51	1.00	4.28
2010	1.47	1.05	4.49
2011	1.35	1.10	4.70
2012	1.24	1.13	4.84
2013	1.14	1.15	4.92
2014	1.04	1.16	4.98
2015	0.97	1.17	4.99
2016	0.92	1.18	5.02
2017	0.88	1.18	5.04
2018	0.85	1.19	5.06
2019	0.83	1.19	5.07
2020	0.82	1.20	5.09
2021	0.81	1.20	5.11
2022	0.81	1.21	5.14
2023	0.81	1.22	5.17
2024	0.81	1.23	5.21
2025	0.82	1.24	5.26
2026	0.82	1.26	5.32
2027	0.83	1.27	5.38
2028	0.83	1.29	5.45
2029	0.84	1.31	5.52
2030	0.85	1.32	5.60

Table A-3: MOVES2010a DFW Five Perimeter County VOC Refueling Emissions Benefits for 1990 and 1999-2030 shows the VOC refueling emissions benefits from ORVR only and Stage II only. To determine the benefits of each control, the emissions for each control scenario is subtracted from the no control scenario. The following equations were used to calculate the refueling emissions benefits summarized in *Table A-3: MOVES2010a DFW Five Perimeter County VOC Refueling Emissions Benefits for 1990 and 1999-2030* using the emissions values from *Table A-2: MOVES2010a DFW Five Perimeter County VOC Refueling Emission Estimates for 1990 and 1999-2030*:

$$\text{EMISSIONS}_{\text{NO CONTROL}} - \text{EMISSIONS}_{\text{CONTROLX}} = (\text{EMISSIONSBENEFITS})_{\text{CONTROL X}}$$

Where:

$\text{EMISSIONS}_{\text{NO CONTROL}}$ = Emissions from the no control scenario in tpd

NO CONTROL = No ORVR and Stage II

$\text{EMISSIONS}_{\text{CONTROLX}}$ = Emissions with CONTROL X in tpd

CONTROL X = ORVR only or Stage II only

$(\text{EMISSIONSBENEFITS})_{\text{CONTROL X}}$= Emission benefit for CONTROL X in tpd

Table A-3: MOVES2010a DFW Five Perimeter County VOC Refueling Emissions Benefits for 1990 and 1999-2030

Calendar Years	ORVR Only (tpd)	Stage II Only (tpd)
1990	0.00	0.00
1999	0.27	2.70
2000	0.46	2.57
2001	0.70	2.63
2002	0.98	2.70
2003	1.25	2.78
2004	1.56	2.96
2005	1.87	3.11
2006	2.10	3.15
2007	2.34	3.19
2008	2.50	3.12
2009	2.77	3.28
2010	3.02	3.44
2011	3.35	3.61
2012	3.60	3.71
2013	3.79	3.77
2014	3.93	3.82
2015	4.02	3.82
2016	4.10	3.84
2017	4.16	3.86
2018	4.21	3.87
2019	4.24	3.88
2020	4.27	3.89
2021	4.30	3.91
2022	4.33	3.93
2023	4.37	3.95
2024	4.40	3.98
2025	4.44	4.02
2026	4.49	4.06
2027	4.55	4.11
2028	4.61	4.16
2029	4.69	4.22
2030	4.76	4.28

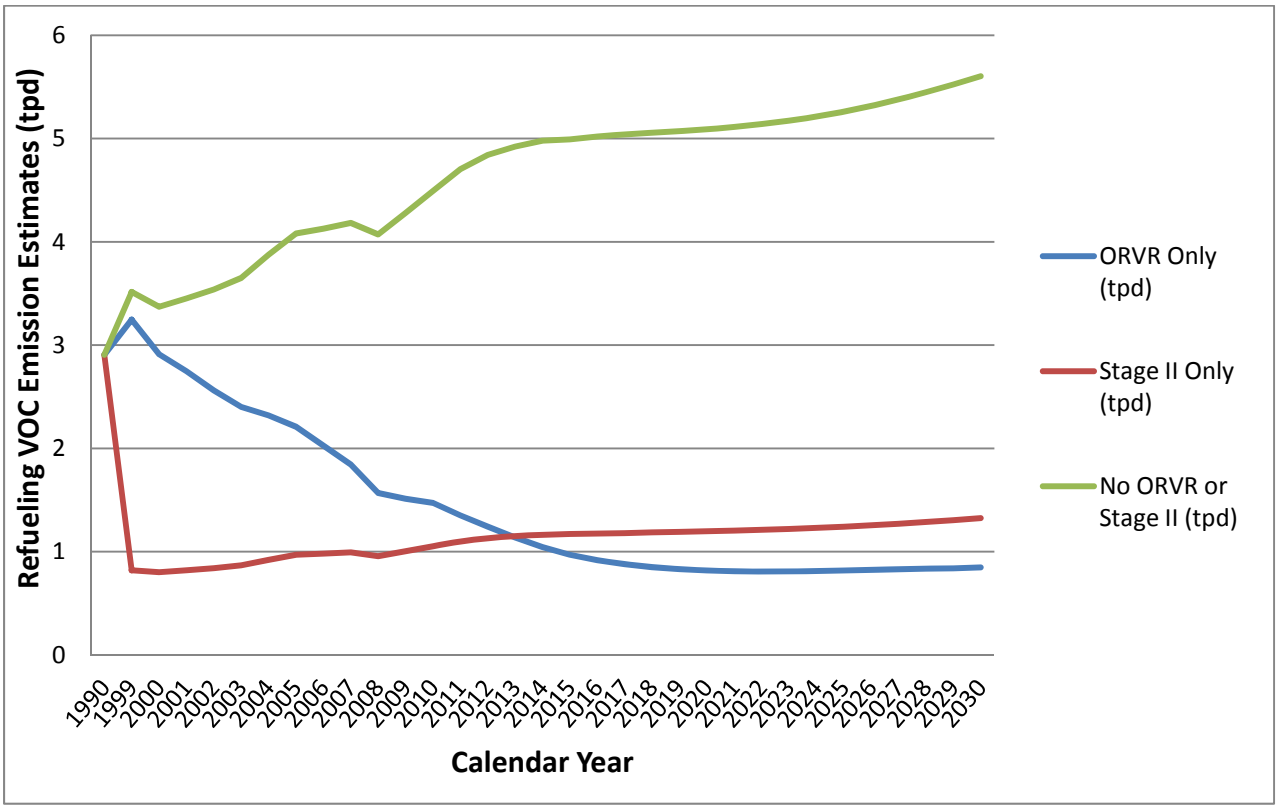

Figure A-1. MOVES2010a DFW Five Perimeter County Refueling VOC Emission Estimates for 1990 and 1999-2030 in tons per day

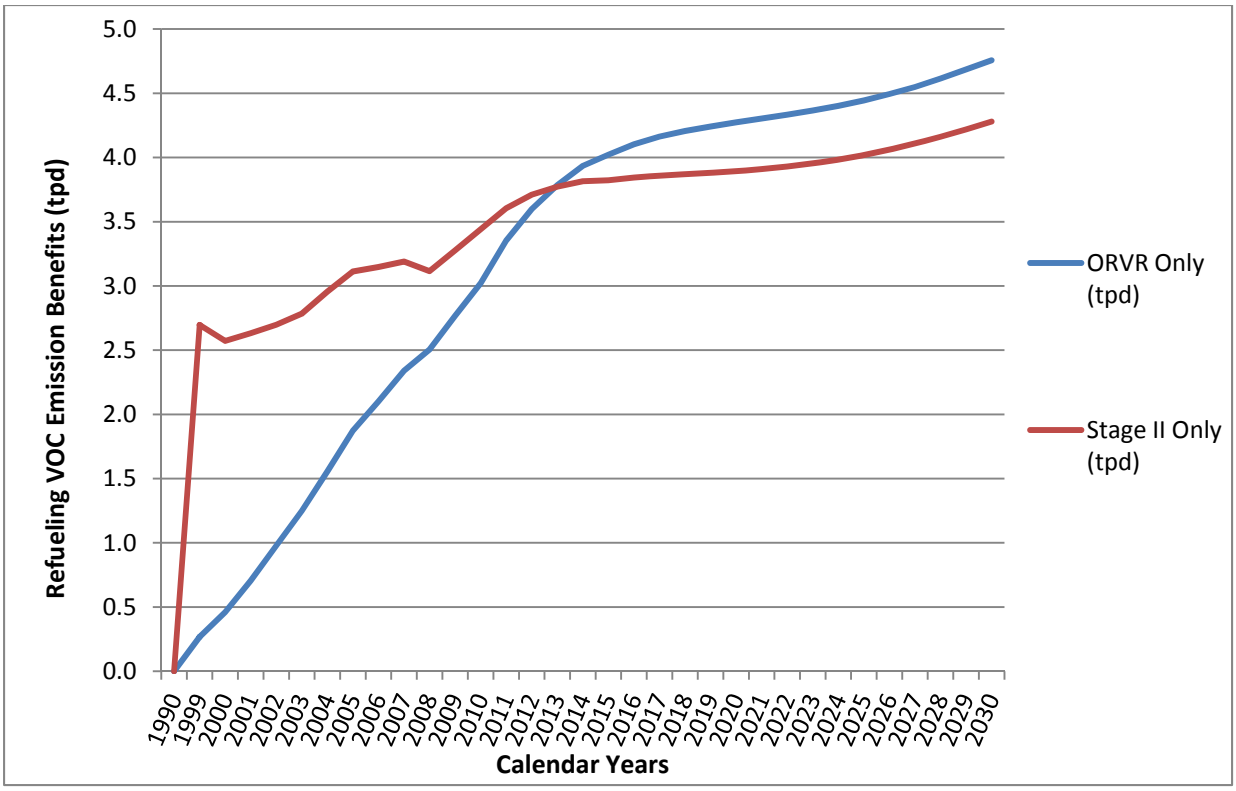

Figure A-2. MOVES2010a DFW Five Perimeter County Refueling Emissions Benefits for 1990 and 1999-2030 in tons per day

Figure A-1. MOVES2010a DFW Five Perimeter County Refueling VOC Emission Estimates for 1990 and 1999-2030 in tons per day and *Figure A-2. MOVES2010a DFW Five Perimeter County Refueling Emissions Benefits for 1990 and 1999-2030 in tons per day* are line graphs representing the calculations of the emissions estimates shown in *Table A-2: MOVES2010a DFW Five Perimeter County VOC Refueling Emission Estimates for 1990 and 1999-2030* and emissions benefits from *Table A-3: MOVES2010a DFW Five Perimeter County VOC Refueling Emissions Benefits for 1990 and 1999-2030*, respectively. *Figure A-1. MOVES2010a DFW Five Perimeter County Refueling VOC Emission Estimates for 1990 and 1999-2030 in tons per day* shows that in the absence of either control (ORVR and Stage II); there is an increasing trend in fugitive emissions. However, a decreasing trend in fugitive emissions is observed in the presence of controls (ORVR or Stage II). The benefits of controls as shown in *Table A-3: MOVES2010a DFW Five Perimeter County VOC Refueling Emissions Benefits for 1990 and 1999-2030* or *Figure A-2. MOVES2010a DFW Five Perimeter County Refueling Emissions Benefits for 1990 and 1999-2030 in tons per day* show that by the year 2013 the emissions benefits from using the ORVR control only is greater than using the Stage II control alone. This ORVR only benefit continues to increase over time in the five outlying DFW counties through the year 2030.

A.4 CONCLUSION

Based on the TCEQ's refueling analysis with MOVES2010a, TCEQ concludes:

- a Stage II only program would be slightly more effective in the summer of 2012 than an ORVR only program;
- an ORVR only program is more effective in the summer of 2013 than a Stage II only program; and,
- after the year 2013, the magnitude of ORVR only benefits increases over a Stage II only program.

Therefore, this analysis demonstrates that by the year 2013, widespread use would occur because the emissions benefits from the ORVR control alone are greater than the emissions benefits from the Stage II control alone.

Detailed Emission Rate Analysis Steps with the MOVES model (Developed by Chris Kite)

1. Start with the MOVES on-road trends inventory study done by TTI for 1990 and 1999-2030 that is available at ftp://amdaftp.tceq.texas.gov/pub/Mobile_EI/Trends/mvs/.
2. For Johnson County (FIPS code of 48251), extract the Summer Weekday run specs (ending in "...MRS") and county database input directories (ending in "...cdb_in") for all years. Store these as "clean" copies in a safe place on your hard drive so that you can easily obtain them in case of future problems.
3. Copy a set of the run specs to C:\MOVES\RunSpecs\Refuel\Johnson\. Copy a set of the county database input directories to C:\MySQL\data\.
4. Open up each run spec one at a time from the MOVES GUI. Go to the Pollutants and Processes menu and toggle off all pollutants on the left hand side to be sure everything is clear. Then toggle on all of Total Energy Consumption and CO2 Atmospheric. Then navigate to the right and toggle on the two refueling processes for VOC. You will then be forced to also toggle these on for Non-Methane Hydrocarbons and Total Gaseous Hydrocarbons. These should be the only pollutant/process combinations in your run spec so that everything will run faster and your output won't be too large.
5. Navigate up to the Time Spans menu and set the aggregation level to Day instead of Hour. Since the original run spec including evaporative emission estimates, it was forced to aggregate by hour, but this takes longer to run.
6. Navigate down to Output/General Output. Change the units to grams. Select Create Database while you're at it.
7. Save the run spec and go to the next one. When you're done with all of these, save a "clean" set somewhere in case of a mistake so you don't have to redo all of this work.
8. You should have made 33 "blank" output databases by now, so be sure to check that they are all there. Also copy a clean set of these somewhere so you don't have to recreate them. As you run each separate scenario, you will want to be able to just copy and paste a new clean set to C:\MySQL\data without going through the Create Database trouble again.
9. Find the batch file list labeled MVS10A_TRENDS_SUM_WKD_48139GRP_EI.MRS that should be under C:\MOVES\Refuel\Ellis\ORVR. Change the 48139 for Ellis to 48251 for Johnson. Then within the file, change Ellis to Johnson and 48139 to 48251 so that you have a full batch list for Johnson. Put this batch file under C:\MOVES\RunSpecs\Refuel\Johnson.
10. Be sure that you have a batch mode command file named something like runmoves.bat under C:\Program Files\MOVES20100826. An example is available at H:\Everyone\AIR QUALITY DIVISION\AIR MODELING AND DATA ANALYSIS\Air Modeling Team\MOVES\Master\. Modify runmoves.bat as necessary to include the Johnson batch file path and name.
11. Open a DOS command prompt, and then a MOVES Worker window (but not a Master one). From the DOS prompt, navigate to C:\Program Files\MOVES20100826. Type setenv.bat and hit enter. Then type runmoves.bat and hit enter. Your batch mode should start and all 33 years should run in sequence. Depending on the PC, this may take one to two hours (hopefully not longer).

12. This first run is the "with ORVR" control scenario because MOVES automatically includes it and no Stage II is assumed by the MOVES default database for Johnson County.

13. Navigate to C:\MOVES\Refuel\Ellis and look for MySQL query files named act_to_csv_ellis.sql and ems_to_csv_ellis.sql. Make copies of these and put them into C:\MOVES\Refuel\Johnson. Change "ellis" to "johnson" in the titles. Within each file, change "ellis" to "johnson" and 48139 to 48251.

14. Your PC may not be setup to do this, so follow the next steps if it isn't so you'll be able to run MySQL queries from a DOS command prompt easily. Click Start, right-click on My Computer and select Properties. Select the Advanced Tab. Select Environment Variables and go down to System Variables. Select the Path Variable and then click on Edit. Put this at the end of the Variable Value entry if it is not already in there (the semi-colon separates the different paths): ;C:\Program Files\MySQL\MySQL Server 5.1\bin; Click on OK to accept this (might have to click OK several times for each window).

15. Open a DOS command prompt and navigate to C:\MOVES\Refuel\Johnson\. Type mysql < act_to_csv_ellis.sql and hit return. Then type mysql < ems_to_csv_ellis.sql. The directory should now be loaded with 33 MOVES activity output files and 33 MOVES emission output files in CSV format.

16. Find an Excel spreadsheet named mvs10a-refuel-rates-ellis-orvr.xlsm that should be under C:\MOVES\Refuel\Ellis\ORVR. Rename ellis to johnson and put it in C:\MOVES\Refuel\Johnson\ORVR. Open the spreadsheet and be sure to enable the macro functionality. Change Ellis to Johnson as appropriate within each of the macros and save them.

17. Navigate to the ACT-1990 worksheet and click on cell A:1. Run the Load_MOVES_Activity_Output macro to open, copy, paste, and close all 33 of the activity CSV files. Then go to EMS-1990, click on cell A:1, and run the Load_MOVES_Emissions_Output macro to do the same for the emissions CSV files.

18. Study the Rates worksheet to see what's going on. MOVES does not estimate refueling emission rates directly. This worksheet extracts the refueling emissions and total energy consumption. Gallons consumed are estimated from energy consumption based on constant values in the Parameters worksheet. The gram/gallon refueling rates are then obtained by dividing refueling emissions by gallons. Fuel economy figures are obtained by dividing VMT by gallons.

19. As a quality assurance check, Atmospheric CO2 emissions are extracted as well, and gram/gallon CO2 rates are estimated. These should fall somewhere around 8,719 and 10,058 for gasoline and diesel, respectively. If they are far from these amounts, there may be a problem somewhere. Look at the chart and see if the gram/gallon refueling rates look reasonable.

20. If all went well, the next scenario is the "No Control" scenario where ORVR is disabled. Copy the run specs you previously ran to C:\MOVES\Refuel\Johnson\. Open all 33 of the run specs within C:\MOVES\RunSpecs\Refuel\Johnson\ with a multi-file text editor such as TextPad or UltraEdit. Do a search-and-replace in all files to change useParameters<tab>No to useParameters<tab>Yes. This is the equivalent of selecting the Compute Rate-of-Progress box under the Strategies/Rate of Progress window in the MOVES GUI. This disables the post-1990 Clean Air Act controls. You can find this text towards the bottom of each run spec when viewing in text mode.

21. Move all of the output databases you created from the ORVR run to C:\MOVES\Refuel\Johnson\ORVR. Copy a blank set of output databases with the same names to C:\MySQL\data\ from wherever you stored the original set.

22. Now run the no control scenario in batch mode. When done, find the spreadsheet named mvs10a-refuel-rates-ellis-none.xlsm that should be under C:\MOVES\Refuel\Ellis\None. As before, modify it and the macros within it for Johnson County. Run the MySQL queries as before to put activity and emission CSV output files into C:\MOVES\Refuel\Johnson. Then moves these output files and the spreadsheet into a C:\MOVES\Refuel\Johnson\None directory. Run the Excel macros to load the files, look at the rates, charts, etc. for quality assurance purposes.

23. Make a directory called C:\MOVES\Refuel\Johnson\CDB\No_StageII\. Copy all of the "...cdb_in" directories into it from C:\MySQL\data\.

24. Find a file named mvs10a-countyyear-stageII-ellis.xlsx under C:\MOVES\Refuel\Ellis. Make a Johnson County version of it by changes the FIPS codes from 48139 to 48251.

25. Copy the run specs from the No Control run to C:\MOVES\Refuel\Johnson\None. Open the MOVES GUI and open a 1990 run spec from C:\MOVES\RunSpecs\Refuel\Johnson. Navigate over to the Domain Input Database under Geographic Bounds. Select Enter/Edit Data to get into the County Data Manager. Select Generic and navigate down to the countyyear table as something you want to modify. Select Browse and navigate to C:\MOVES\Refuel\Johnson to find the mvs10a-countyyear-stageII-ellis.xlsx spreadsheet. Select the Stage II worksheet and import it. You may get some warnings about multiple years in the table, but that should be okay. These actions enable Stage II for 1999-2050 with overall control effectiveness ratings of 80% for evaporation and 50% for spillage. The values are left at 0% for 1990.

26. Go to the 1990 "...cdb_in" directory under C:\MySQL\data\ with Windows Explorer and copy the following three files all at once: countyyear.frm, countyyear.MYD, and countyyear.MYI. Paste copies of these into all of the 1999-2030 directories. This non-elegant brute force method doesn't always work for all MySQL MOVES tables, but it works okay for countyyear.

27. Now run a batch mode with the same "no control" run specs, but with Stage II turned on. This is the Stage II only scenario where ORVR is disabled. Navigate to C:\MOVES\Refuel\Ellis\StageII\ to find the mvs10a-refuel-rates-ellis-stageII.xlsm spreadsheet. Make changes as necessary to convert this to Johnson. Run the MySQL queries to get the CSV output files that can be loaded into the spreadsheet. Save all the run specs, output databases, CSV files, etc. to C:\MOVES\Refuel\Ellis\StageII\.

28. For each of the three scenarios, there should be folders labeled ORVR, None, and StageII, under C:\MOVES\Refuel\Johnson\. Each folder should have run specs, output databases, output CSV files, and an analysis spreadsheet. Also, there should be both a StageII and a No_StageII folder under C:\MOVES\Refuel\Johnson\CDB\. Each should have a set of "...cdb_in" directories for all years. The No_StageII directories should be consistent with those used for the trends work, while the StageII directories will have the countyyear files in them.

29. You now should have successfully run three refueling scenarios:

    a. ORVR only which is just the default approach with the input database as is.

    b. No controls (neither ORVR or Stage II), which has Rate-of-Progress toggled on in the run spec but uses the same input database as in (a).

c. A Stage II only scenario that uses the same run spec as (b), but a modified input database with countyyear added.

30. Now do the same steps all over again for Kaufman County with a FIPS code of 48257.

31. The same level of effort will not be required for Parker and Rockwall Counties because individual emission rate scenarios were not run for these with the trends analysis. Instead, a representative county group approach was done as follows:

County Name	**Trends Analysis Years**	
	1990 & 1999-2003	2004 - 2030
Ellis	Ellis	Ellis
Johnson	Johnson	Johnson
Kaufman	Ellis	Kaufman
Parker	Johnson	Johnson
Rockwall	Ellis	Kaufman

32. Once the Johnson and Kaufman analyses are completed, copy the final grams/gallon refueling emissions rates per scenario from the Summary worksheet within each spreadsheet to the Rates-Johnson and Rates-Kaufman worksheets within the mvs10a-refueling-analysis-dfw-5county.xlsx spreadsheet that is under C:\MOVES\Refuel\. When pasting, use Paste Special/Values so that there is no cumbersome spreadsheet linking. Be sure that the fuel economy figures in miles per gallon come from the ORVR only scenario. You don't want these from the no post-1990 control scenarios because they will have no fuel economy changes included.

33. The current values in the Rates-Johnson and Rates-Kaufman worksheets are placeholders from the Ellis analyses. If all goes well, the rest of the mvs10a-refueling-analysis-dfw-5county.xlsx spreadsheet should do all the work.