ESTIMATING MOBILE SOURCE AIR TOXICS EMISSIONS: A STEP-BY-STEP PROJECT ANALYSIS METHODOLOGY

UC Davis-Caltrans Air Quality Project
http://AQP.engr.ucdavis.edu /

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Prepared in response to

A Caltrans request to provide assistance with project-level mobile source air toxics (MSAT) analysis. This written material is a step-by-step guide describing how to use the companion "Project-Level Mobile Source Air Toxics Analysis Spreadsheet Tool" prepared by the U.C. Davis-Caltrans Air Quality Project.

Acknowledgments

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Introduction

The following material describes a nine-step method to estimate project-specific mobile source air toxics (MSAT) emissions. The written methodology accompanies a draft spreadsheet tool (Bai et al., 2006) built to facilitate project analyses.[1] The analysis approach is designed to answer broad questions, such as whether one project alternative would be expected to have higher or lower MSAT emissions than a different alternative. We illustrate the analysis approach using an I-5 improvement project in the South Coast Air Basin portion of Los Angeles County, for the year 2004.

The U.S. Federal Highway Administration (FHWA) published project-level MSAT assessment guidance in February 2006.[2] The federal guidance focuses on states other than California, and utilizes the U.S. Environmental Protection Agency's (EPA's) on-road motor vehicle emissions modeling tool, MOBILE, which includes MSAT emission factors. This methodology is specific to completing California project analyses. The method utilizes the California Air Resources Board's (CARB's) EMFAC2007 on-road emissions model, related MSAT data provided by CARB, and activity data provided by the project analyst.

The methodology focuses on the six MSAT pollutants identified by the U.S. Environmental Protection Agency (EPA) as being the highest priority (U.S. Environmental Protection Agency, 2001). The six pollutants are: diesel particulate matter (DPM), acrolein, acetaldehyde, formaldehyde, benzene, and 1,3-butadiene. EMFAC2007 provides emission factor information for DPM, but does not provide emission factors for the remaining five MSATs. Each of the remaining five MSATs, however, is a constituent of motor vehicle organic gas (TOG) emissions, and EMFAC2007 provides emission factors for TOG. CARB supplied Caltrans with "speciation factors" for each of the five MSATs not directly estimated by EMFAC2007. Each speciation factor represents the portion of total TOG emissions that is estimated to be a given MSAT. For example, if benzene emissions are estimated to be 3% of total TOG emissions, a 0.03 speciation factor for benzene is used as a multiplier to estimate benzene emissions once TOG emissions are

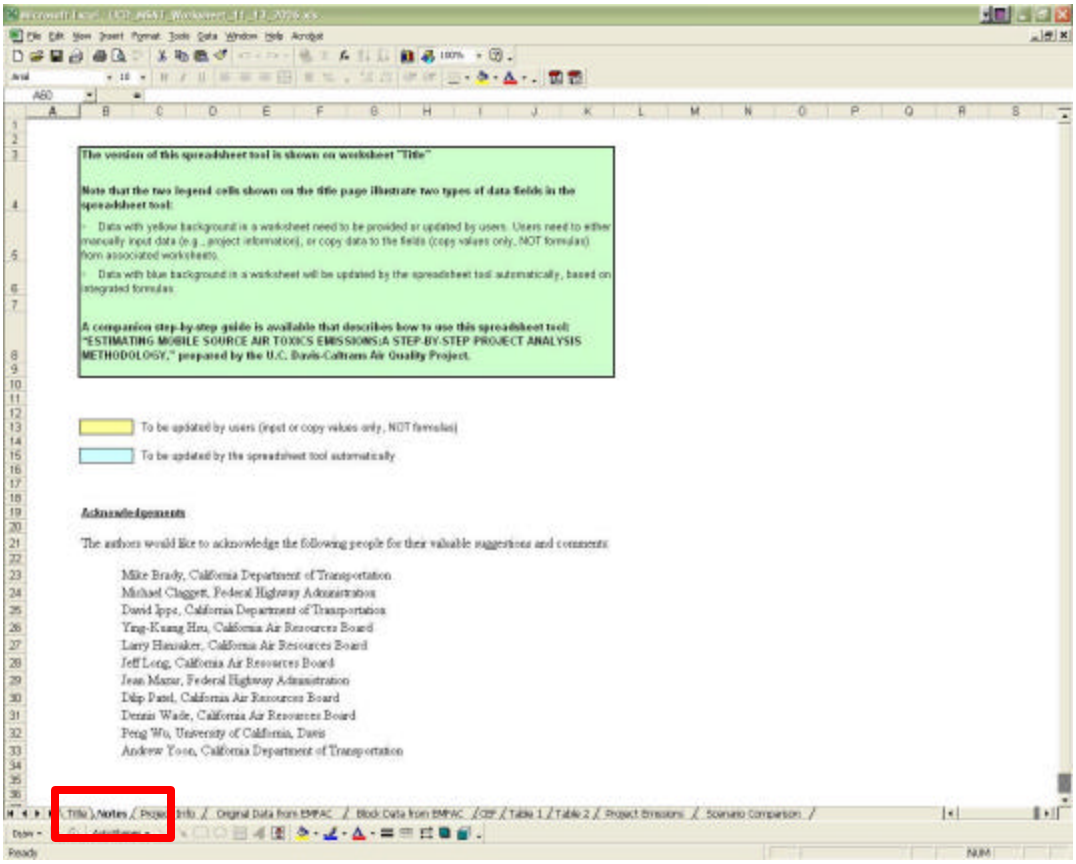
[1] Users should consult with Caltrans to obtain the latest version of the tool. At the time this report was prepared, the latest version (v1.2) was the spreadsheet file "UCD_MSAT_Worksheet_11_13_2006.xls".
[2] See: http://www.fhwa.dot.gov/environment/airtoxic/020306guidmem.htm.

known. The method uses CARB-supplied speciation factors to estimate MSAT emissions as a function of TOG emissions.

To complete analyses, U.C. Davis prepared a spreadsheet tool that incorporates EMFAC2007 emission factors and CARB speciation factors, and allows analysts to input project-specific traffic activity data such as peak and off-peak hour VMT, speed, travel times and traffic volumes (Bai et al., 2006). The spreadsheet tool applies the activity data to the emission factors, and estimates MSAT emissions for base case and alternative scenarios. This material describes the step-by-step use of the spreadsheet tool to obtain needed MSAT emissions estimates.

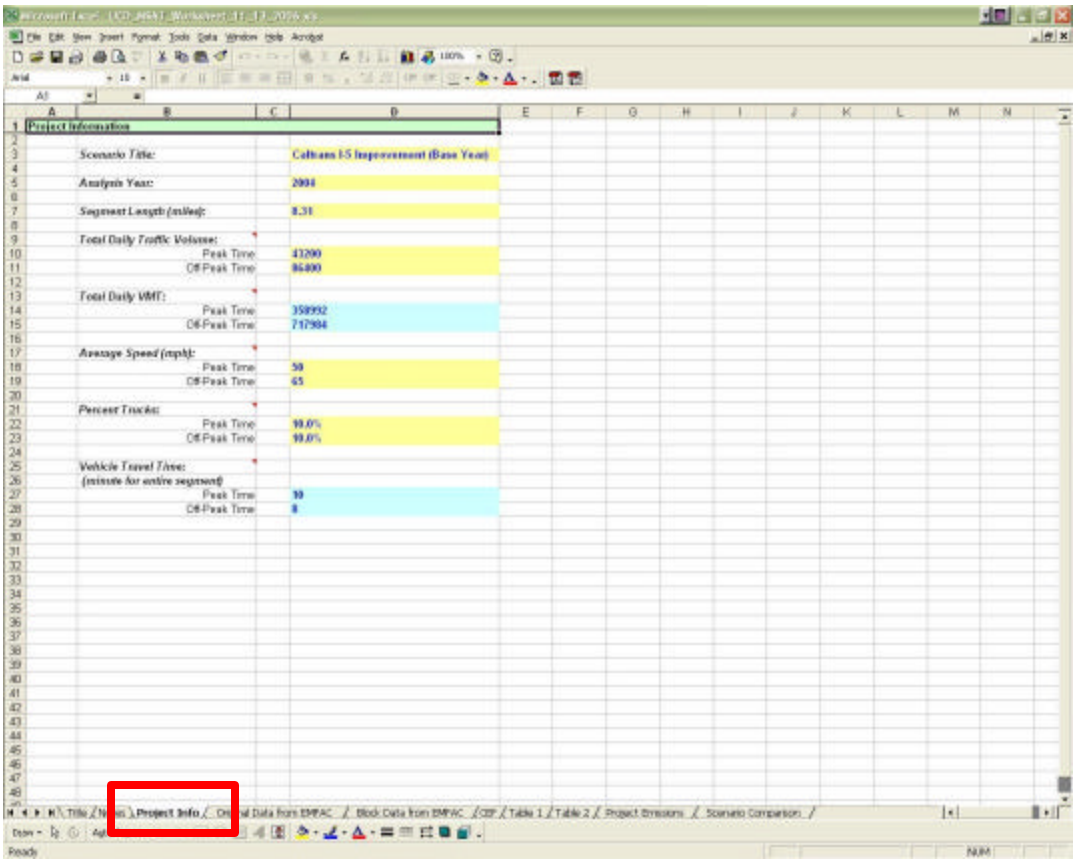
Project analysts will typically need to repeat the analysis steps described in this report for at least five scenarios: a base year (e.g., 2004), and build and no-build scenarios for the year following project completion (the operational year) and a "horizon" year which will usually be the project design year (year of completion plus 20 years). The "build" scenarios will need to reflect each of the project alternatives under consideration. The remaining text introduces how to prepare appropriate input data to use the EMFAC2007 model with the spreadsheet tool to conduct a project level MSAT analysis. Each step includes a "screen shot" of the spreadsheet tool worksheet referred to in the text.

Step 1: Review spreadsheet tool title and notes – worksheet "Title" and "Notes"



1. Check the version date of the spreadsheet tool to make sure the analysis is completed using the latest available version.
2. Note that the two legend cells shown on the note page illustrate two types of data fields in the spreadsheet tool:
   - Data with yellow background in a worksheet need to be provided or updated by users. Users need to either manually input data (e.g., project information), or copy data to the fields (copy values only, NOT formulas) from associated worksheets.
   - Data with blue background in a worksheet will be updated by the spreadsheet tool automatically, based on integrated formulas.

Step 2: Input project information – worksheet "Project Info"



1. Input project title (e.g., "Caltrans I-5 Improvement").
2. Input analysis year (in the spreadsheet example we use a 2004 base year).
3. Input the length of freeway segment (in our example we assume 8.31 miles).
4. Input daily peak and off-peak traffic volumes; for example,

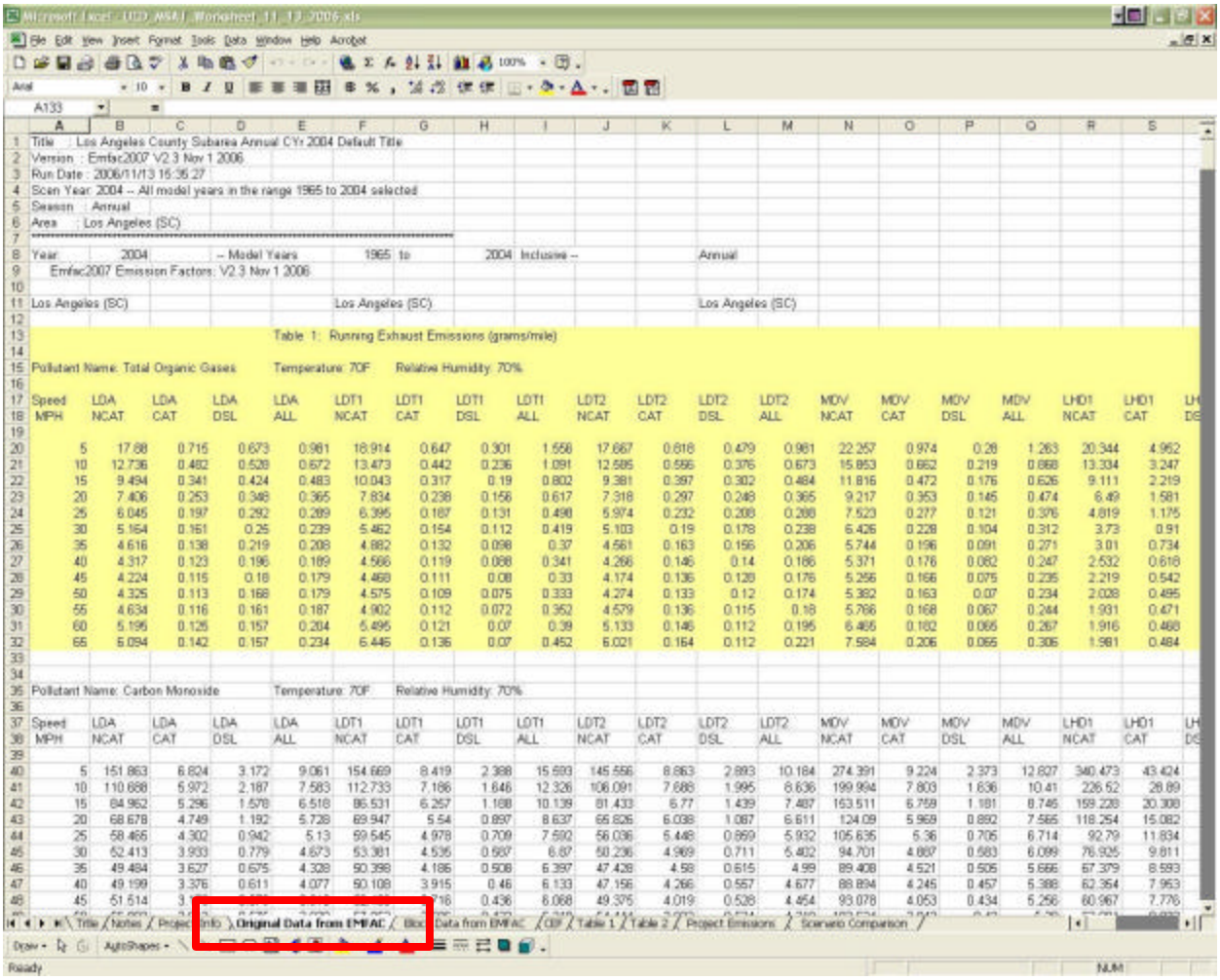
   Peak time: 1800 veh/hr/lane × 6 hours × 4 lanes = 43200 vehicles.

   Off-peak time: 1200 veh/hr/lane × 18 hours × 4 lanes = 86400 vehicles.
5. Peak and off-peak VMT are automatically calculated (Segment length × traffic volume).
6. Input estimated peak and off-peak average speed; e.g., 50 mph and 65 mph, respectively.
7. Input percent trucks at peak and off-peak time; this example assumes 10% and 10%.[3]
8. Vehicle travel time on the segment is calculated automatically, based on:

   Travel time (in minute) = 60 × (segment length/average speed).

[3] Note that here, "percent trucks" refers to all medium-duty vehicles and larger, and does not distinguish between diesel and gasoline-powered vehicles; in a separate worksheet, the spreadsheet tool uses this input information to estimate the percent of traffic that is diesel-powered.

Step 3: Prepare emission factors from EMFAC – worksheet "Original Data from EMFAC"

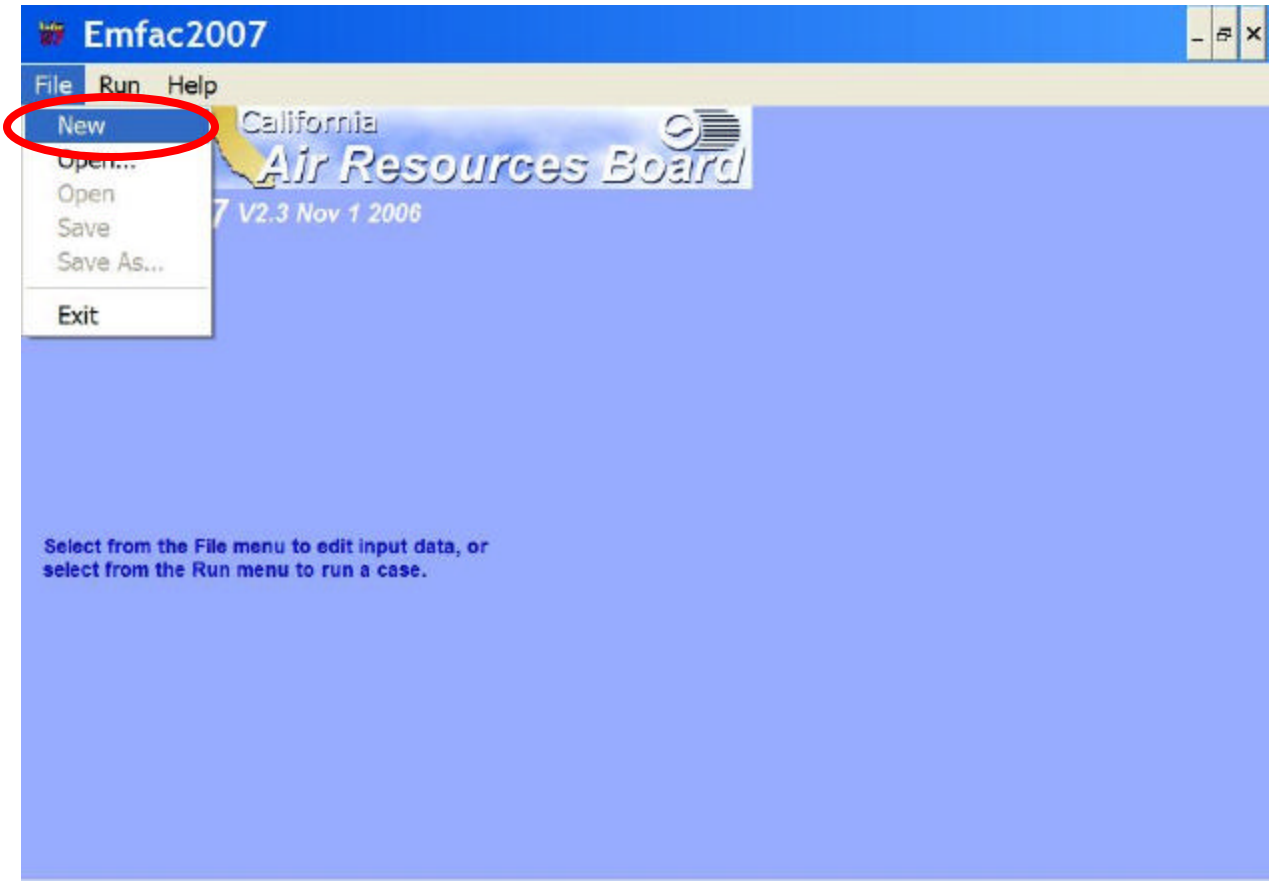


1	Title : Los Angeles County Subarea Annual CYr 2004 Default Title																			
2	Version : Emfac2007 V2.3 Nov 1 2006																			
3	Run Date : 2006/11/13 16:36:27																			
4	Scen Year: 2004 -- All model years in the range 1965 to 2004 selected																			
5	Season : Annual																			
6	Area : Los Angeles (SC)																			
7	**********																			
8	Year: 2004	-- Model Years	1965	to	2004	Inclusive --	Annual													
9	Emfac2007 Emission Factors: V2.3 Nov 1 2006																			
10																				
11	Los Angeles (SC)	Los Angeles (SC)	Los Angeles (SC)																	
12																				
13	Table 1: Running Exhaust Emissions (grams/mile)																			
14																				
15	Pollutant Name: Total Organic Gases	Temperature: 70F	Relative Humidity: 70%																	
16																				
17	Speed	LDA	LDA	LDA	LDA	LDT1	LDT1	LDT1	LDT1	LDT2	LDT2	LDT2	LDT2	MDV	MDV	MDV	MDV	LHD1	LHD1	LH
18	MPH	NCAT	CAT	DSL	ALL	NCAT	CAT	DSL	ALL	NCAT	CAT	DSL	ALL	NCAT	CAT	DSL	ALL	NCAT	CAT	DS
19																				
20	5	17.88	0.715	0.673	0.981	18.914	0.647	0.301	1.558	17.667	0.818	0.479	0.981	22.257	0.974	0.28	1.263	20.344	4.952	
21	10	12.736	0.482	0.528	0.672	13.473	0.442	0.236	1.091	12.585	0.566	0.376	0.673	15.853	0.662	0.219	0.868	13.334	3.247	
22	15	9.494	0.341	0.424	0.483	10.043	0.317	0.19	0.802	9.381	0.397	0.302	0.484	11.816	0.472	0.176	0.626	9.111	2.219	
23	20	7.406	0.253	0.348	0.365	7.834	0.238	0.156	0.617	7.318	0.297	0.249	0.365	9.217	0.353	0.145	0.474	6.49	1.581	
24	25	6.045	0.197	0.292	0.289	6.395	0.187	0.131	0.498	5.974	0.232	0.208	0.288	7.523	0.277	0.121	0.376	4.819	1.175	
25	30	5.164	0.161	0.25	0.239	5.462	0.154	0.112	0.419	5.103	0.19	0.178	0.238	6.426	0.228	0.104	0.312	3.73	0.91	
26	35	4.616	0.138	0.219	0.208	4.882	0.132	0.098	0.37	4.561	0.163	0.156	0.206	5.744	0.196	0.091	0.271	3.01	0.734	
27	40	4.317	0.123	0.196	0.189	4.566	0.119	0.088	0.341	4.266	0.146	0.14	0.186	5.371	0.176	0.082	0.247	2.532	0.618	
28	45	4.224	0.115	0.18	0.179	4.468	0.111	0.08	0.33	4.174	0.136	0.128	0.176	5.256	0.166	0.075	0.235	2.219	0.542	
29	50	4.325	0.113	0.168	0.179	4.575	0.109	0.075	0.333	4.274	0.133	0.12	0.174	5.382	0.163	0.07	0.234	2.028	0.495	
30	55	4.634	0.116	0.161	0.187	4.902	0.112	0.072	0.352	4.579	0.136	0.115	0.18	5.766	0.168	0.067	0.244	1.931	0.471	
31	60	5.196	0.125	0.157	0.204	5.495	0.121	0.07	0.39	5.133	0.146	0.112	0.195	6.465	0.182	0.066	0.267	1.916	0.468	
32	65	5.094	0.142	0.157	0.234	5.446	0.136	0.07	0.452	5.021	0.164	0.112	0.221	7.584	0.206	0.065	0.306	1.981	0.484	
33																				
34																				
35	Pollutant Name: Carbon Monoxide	Temperature: 70F	Relative Humidity: 70%																	
36																				
37	Speed	LDA	LDA	LDA	LDA	LDT1	LDT1	LDT1	LDT1	LDT2	LDT2	LDT2	LDT2	MDV	MDV	MDV	MDV	LHD1	LHD1	LH
38	MPH	NCAT	CAT	DSL	ALL	NCAT	CAT	DSL	ALL	NCAT	CAT	DSL	ALL	NCAT	CAT	DSL	ALL	NCAT	CAT	DS
39																				
40	5	151.863	6.824	3.172	9.061	154.669	8.419	2.388	15.593	145.556	8.863	2.893	10.184	274.391	9.224	2.373	12.827	340.473	43.424	
41	10	110.688	5.972	2.187	7.583	112.733	7.186	1.646	12.326	106.091	7.688	1.995	8.636	199.994	7.803	1.636	10.41	226.52	28.89	
42	15	84.952	5.296	1.578	6.518	86.531	6.257	1.188	10.139	81.433	6.77	1.439	7.487	153.511	6.759	1.181	8.746	159.228	20.308	
43	20	68.678	4.749	1.192	5.728	69.947	5.54	0.897	8.637	65.826	6.038	1.087	6.611	124.09	5.969	0.892	7.565	118.254	15.082	
44	25	58.466	4.302	0.942	5.13	59.545	4.978	0.709	7.592	56.036	5.448	0.859	5.932	105.635	5.36	0.705	6.714	92.79	11.834	
45	30	52.413	3.933	0.779	4.673	53.381	4.535	0.587	6.87	50.236	4.969	0.711	5.402	94.701	4.897	0.583	6.099	76.925	9.811	
46	35	49.484	3.627	0.675	4.328	50.398	4.186	0.508	6.397	47.428	4.58	0.615	4.99	89.408	4.521	0.505	5.666	67.379	8.593	
47	40	49.199	3.376	0.611	4.077	50.108	3.915	0.46	6.133	47.156	4.266	0.557	4.677	88.894	4.245	0.457	5.388	62.354	7.953	
48	45	51.514	3				716	0.436	6.068	49.375	4.019	0.528	4.454	93.078	4.053	0.434	5.256	60.967	7.776	

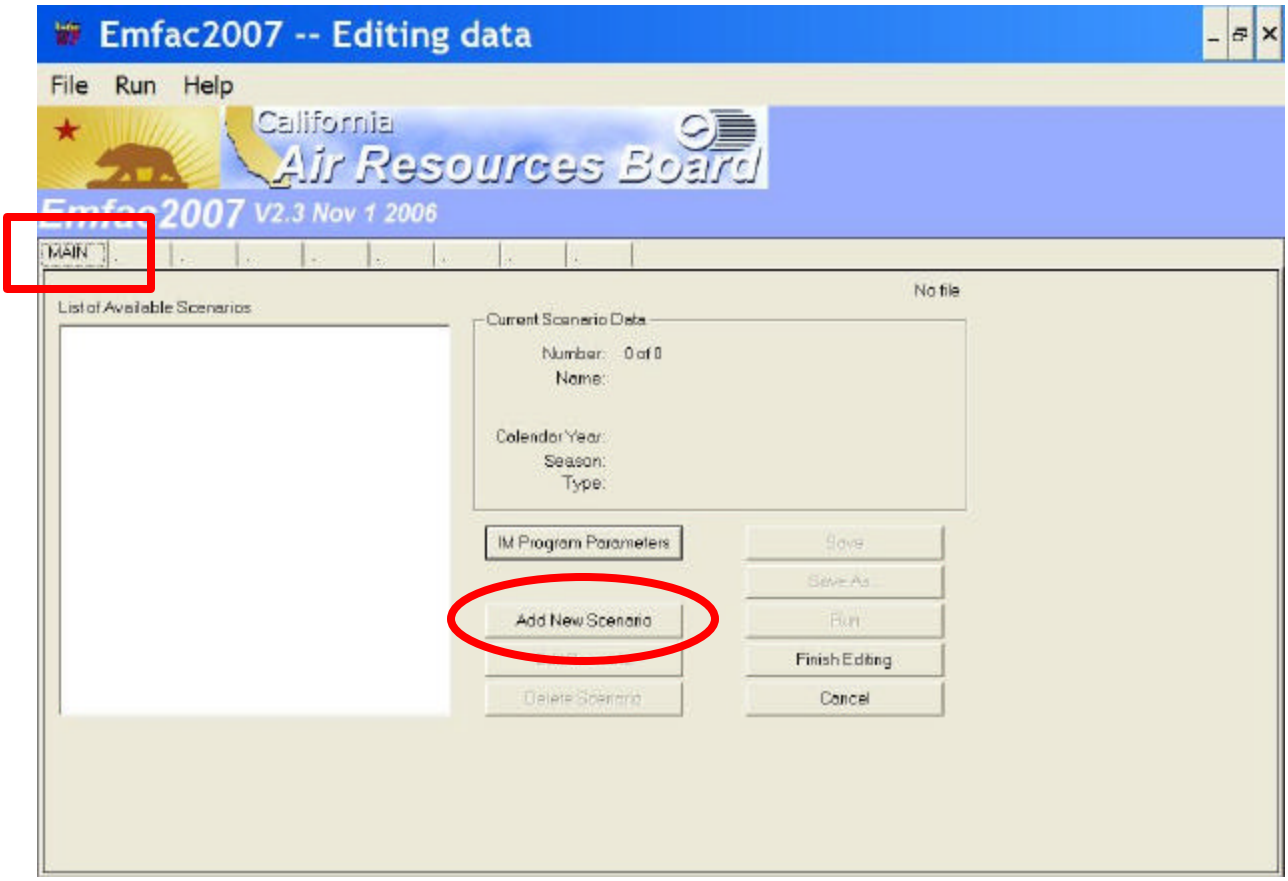
The data shown in this worksheet are copied from the EMFAC2007 model output ".rtl" file. The entire worksheet has eight tables (each table has multiple sub-tables), only some of which are used for the MSAT analysis. The following text with "screen shot" pictures, in a step-by-step manner, introduces how to prepare the ".rtl" data file based on the EMFAC2007 model and how to appropriately copy data from the ".rtl" file to update the worksheet.

1. Start EMFAC2007 (version 2.3, November 1, 2006) program.

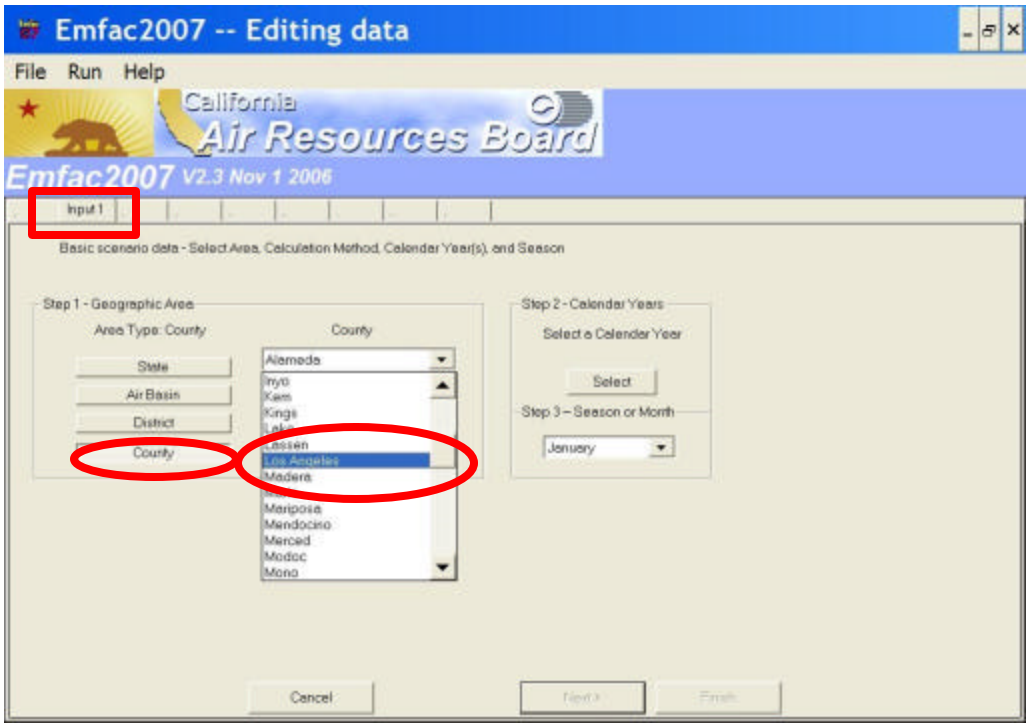
2. Create a new scenario by selecting “new” from the File menu.

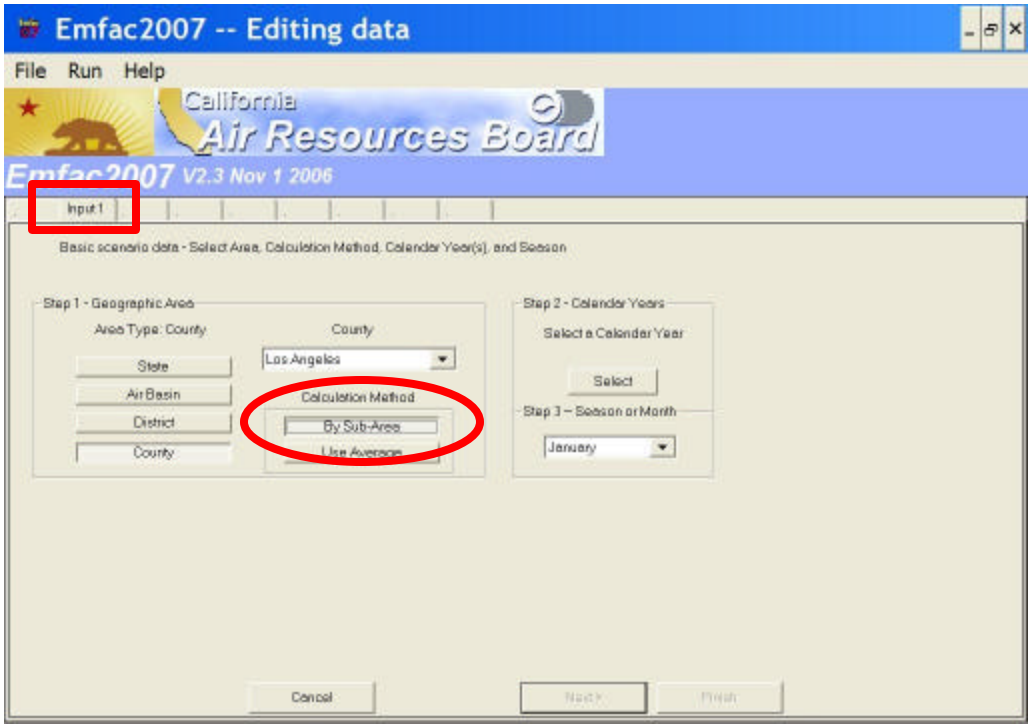


3. The EMFAC model interface shows the “MAIN” tab; click “Add New Scenario”.

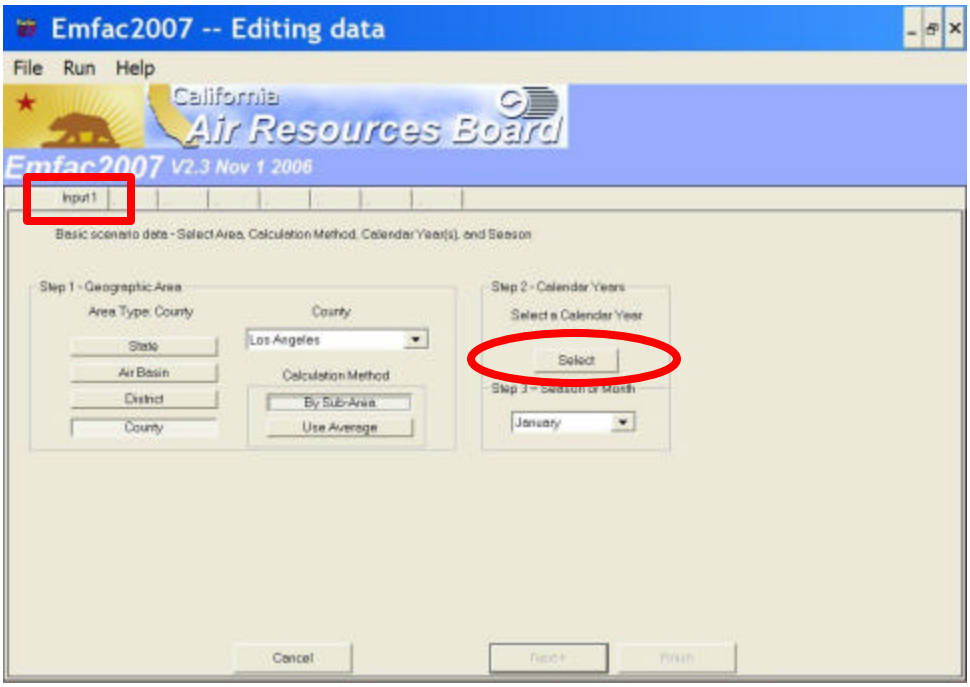


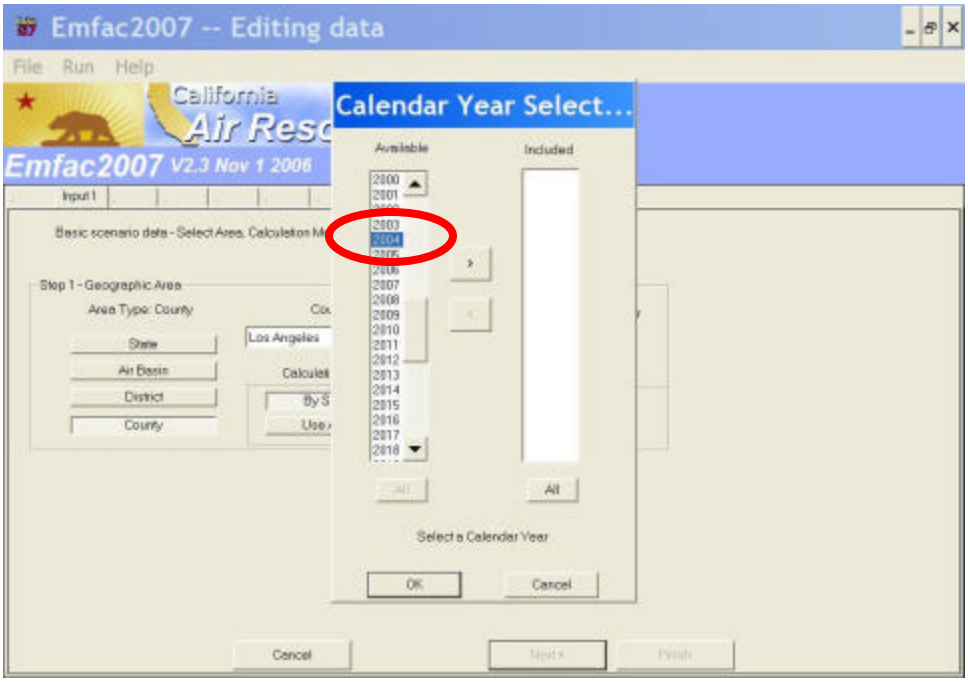
4. The EMFAC model interface shows the “Input 1” tab; in the Step 1 – Geographic Area box, select “county”; and then in the pop-up window, select “Los Angeles” ? “Do Each Sub-Area” (we use Los Angeles to illustrate the methodology).

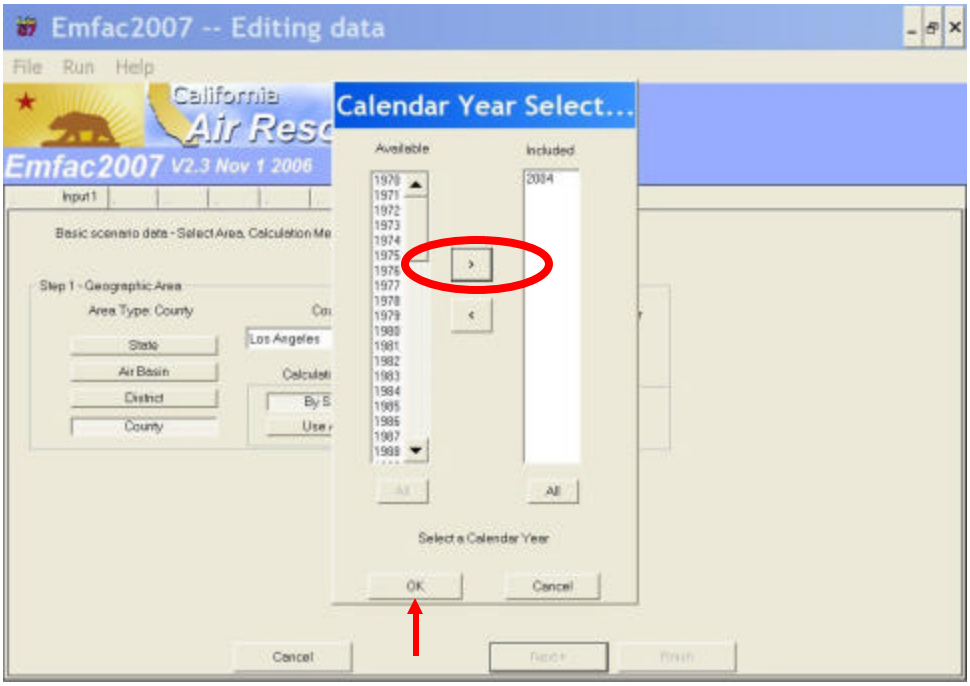


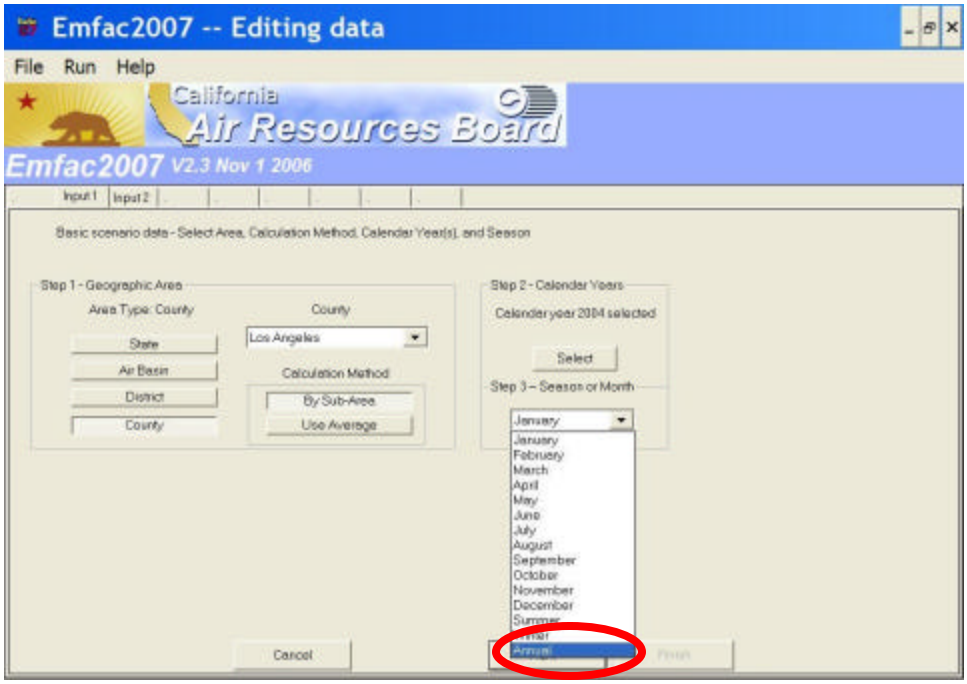


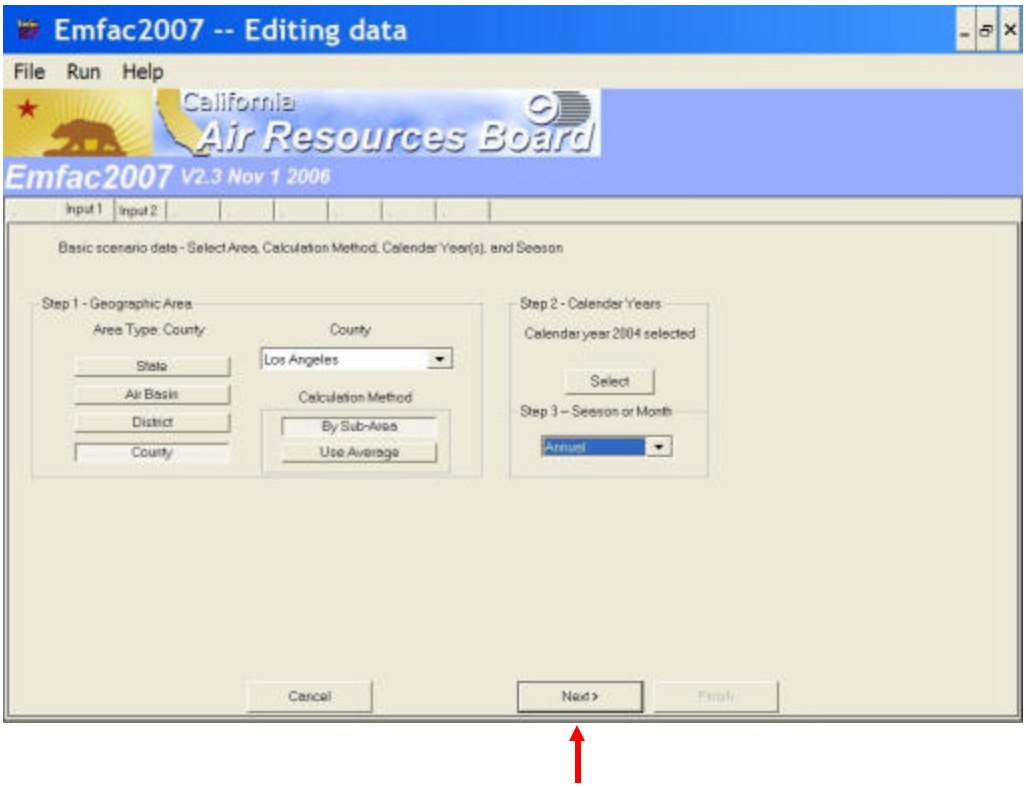
5. In the same “Input 1” tab, click “select” in the Step 2 – Calendar Years box; then in the pop-up window, do the following:
   - Select “2004” (or an appropriate analysis year) for Calendar Year.
   - Click “>” to input “2004” in the “included” data window; then click “Ok”.
   - Select “Annual” in the Step 3 – Season and Month box; then click “Next”



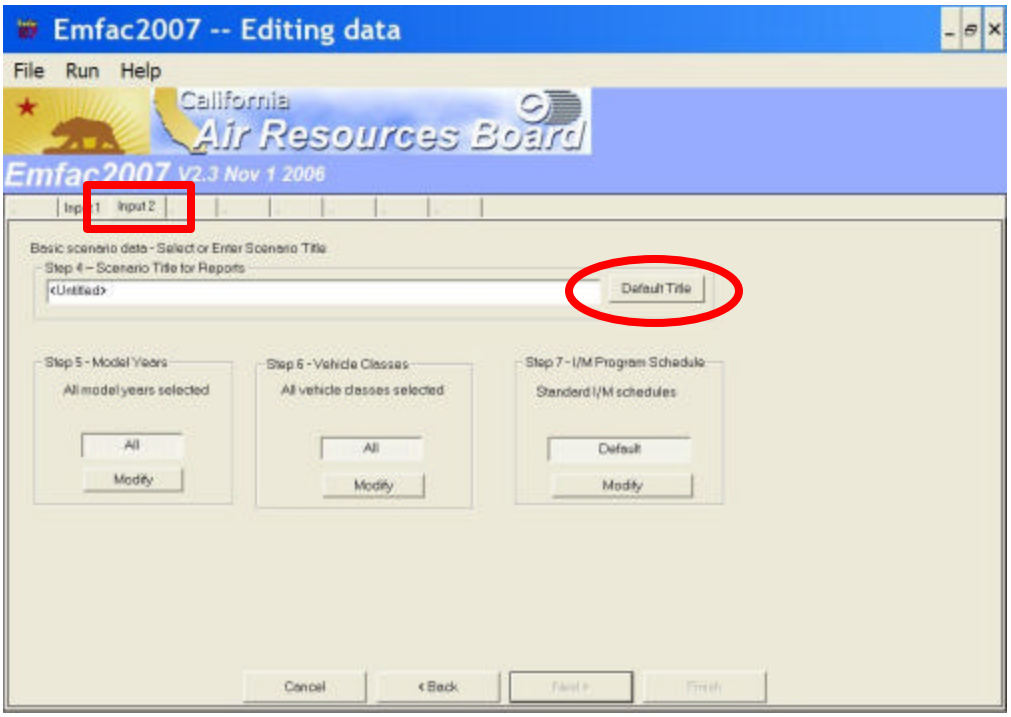


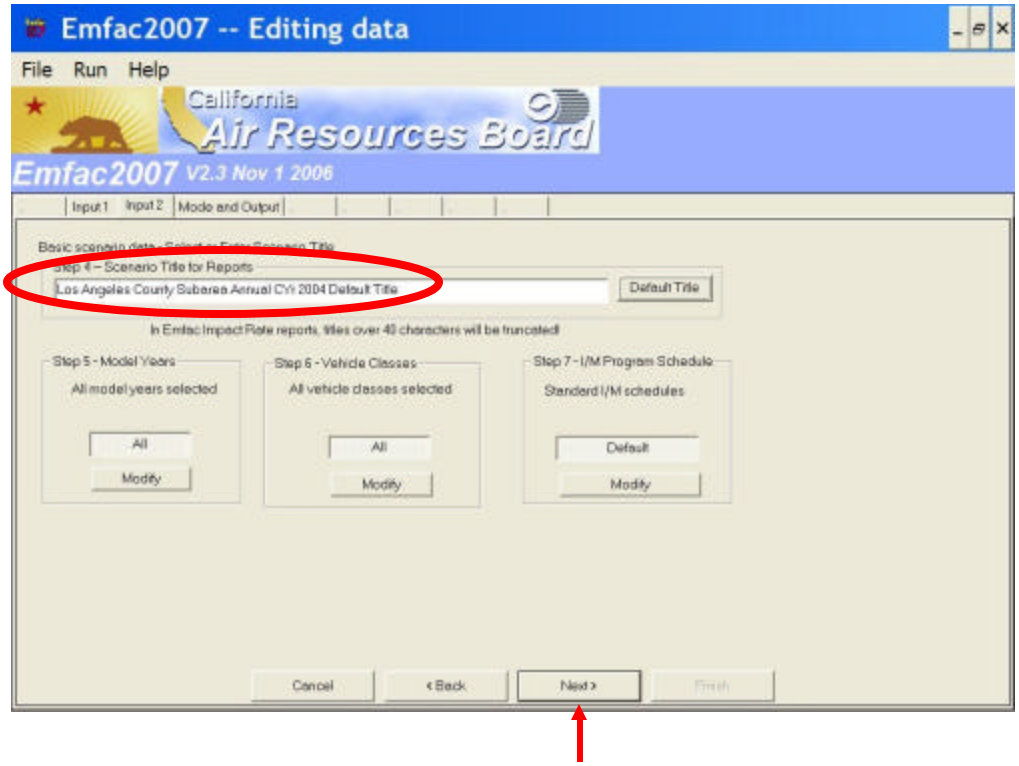

Emfac2007 -- Editing data
File Run Help
California
Air Resc
Emfac2007 V2.3 Nov 1 2006
Input1
Basic scenario data - Select Area, Calculation Me
Step 1 - Geographic Area
Area Type: County
State
Air Basin
District
County
Los Angeles
Calculati
By S
Use
Calendar Year Select...
Available
Included
2004
All
All
Select a Calendar Year
OK
Cancel
Cancel


Emfac2007 -- Editing data
File Run Help
California
Air Resources Board
Emfac2007 V2.3 Nov 1 2006
Input1 Input2
Basic scenario data - Select Area, Calculation Method, Calendar Year(s), and Season
Step 1 - Geographic Area
Area Type: County
County
State
Air Basin
District
County
Los Angeles
Calculation Method
By Sub-Area
Use Average
Step 2 - Calendar Years
Calendar year 2004 selected
Select
Step 3 – Season or Month
January
February
March
April
May
June
July
August
September
October
November
December
Annual
Cancel

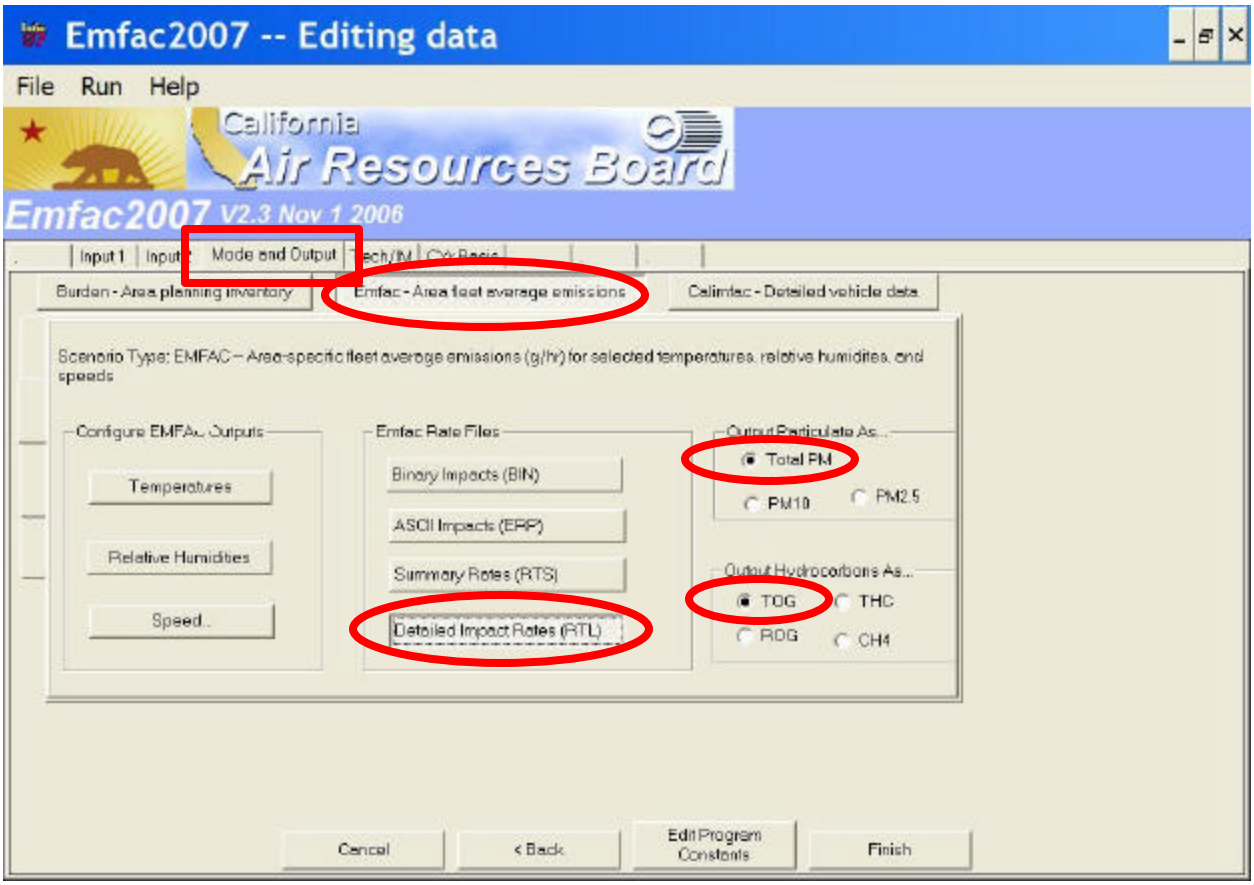

Emfac2007 -- Editing data
File
Run
Help
California
Air Resources Board
Emfac2007 V2.3 Nov 1 2006
Input 1
Input 2
Basic scenario data - Select Area, Calculation Method, Calendar Year(s), and Season
Step 1 - Geographic Area
Area Type: County
County
State
Air Basin
District
County
Los Angeles
Calculation Method
By Sub-Area
Use Average
Step 2 - Calendar Years
Calendar year 2004 selected
Select
Step 3 -- Season or Month
Annual
Cancel
Next >
Finish

6. The EMFAC model interface shows the “Input 2” tab; click “Default Title” to automatically update the scenario title for report files using the default, or manually input the scenario title in the text box; then click “Next”.

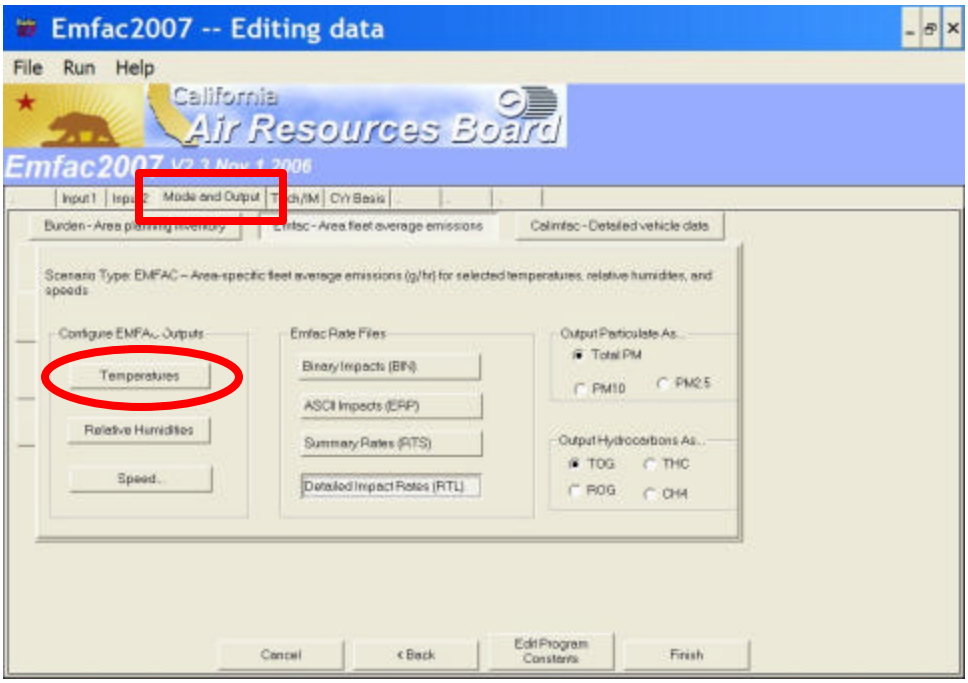


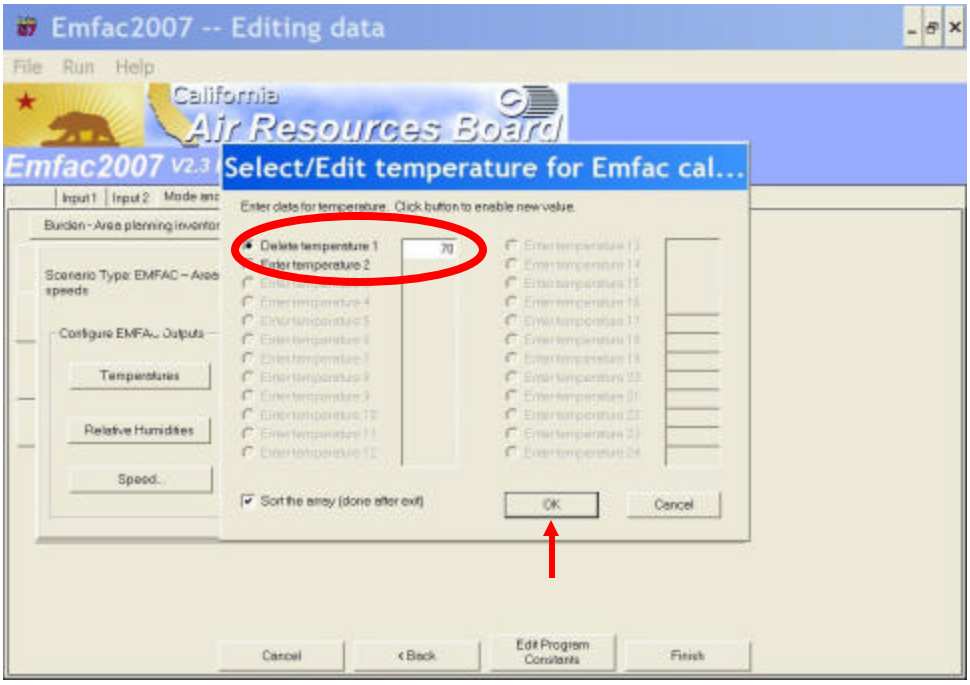


7. The EMFAC model interface shows the “Mode and Output” tab;
   - Click “EMFAC – Area fleet average emissions”.
   - Select Emfac Rate Files “Detailed Impact Rates (RTL)”.
   - Select Output Particulate As “Total PM” (this is needed to estimate total diesel PM).
   - Select Output Hydrocarbons As “TOG”.



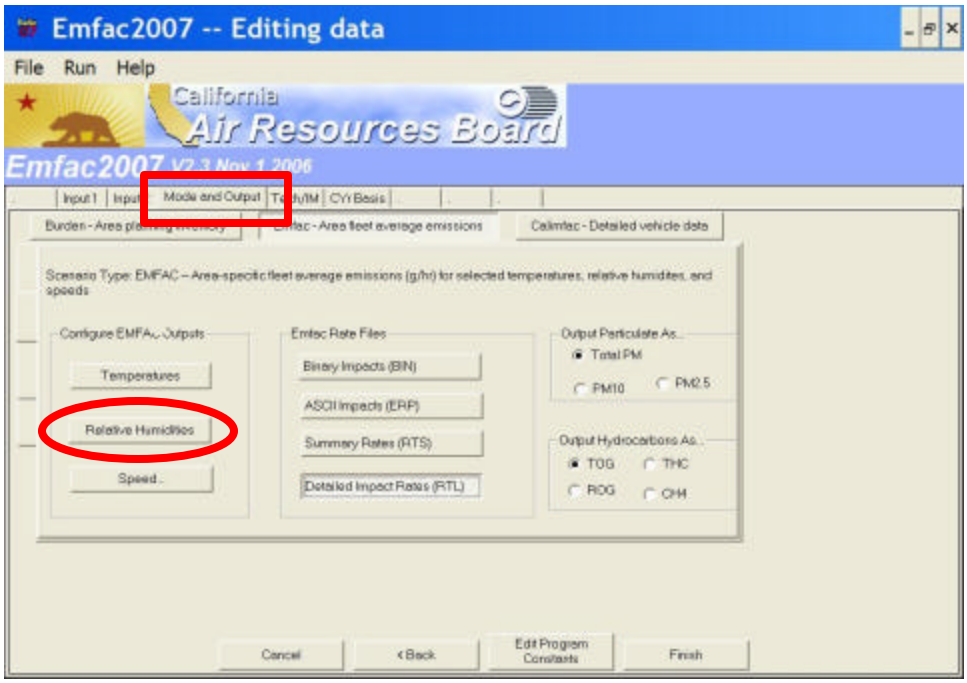
8. On the “Mode and Output” tab, click “Temperatures” in the Configure EMFAC Outputs box; in the pop-up window, input an average daily temperature used for the project (e.g., 70) in the first data box; then delete all other default data; click “OK”.[4]

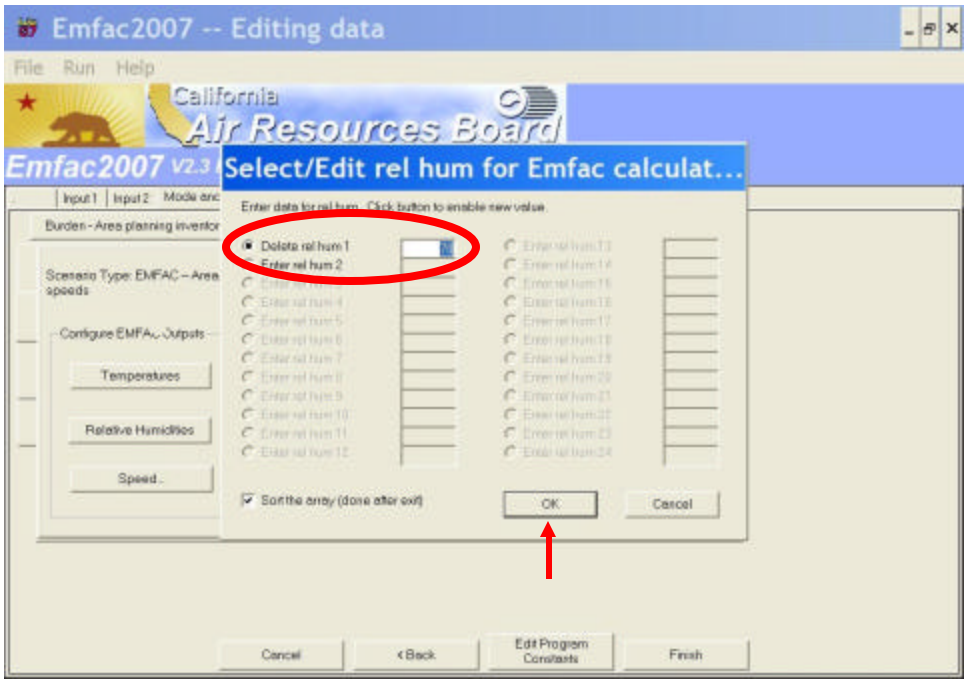




[4] Analysts will typically input an average temperature based on conditions for a summer day; this data is available by county or air basin from the “Burden” mode in the EMFAC model; alternatively, analysts can obtain temperature conditions from other sources that describe county or air basin-specific statistics.

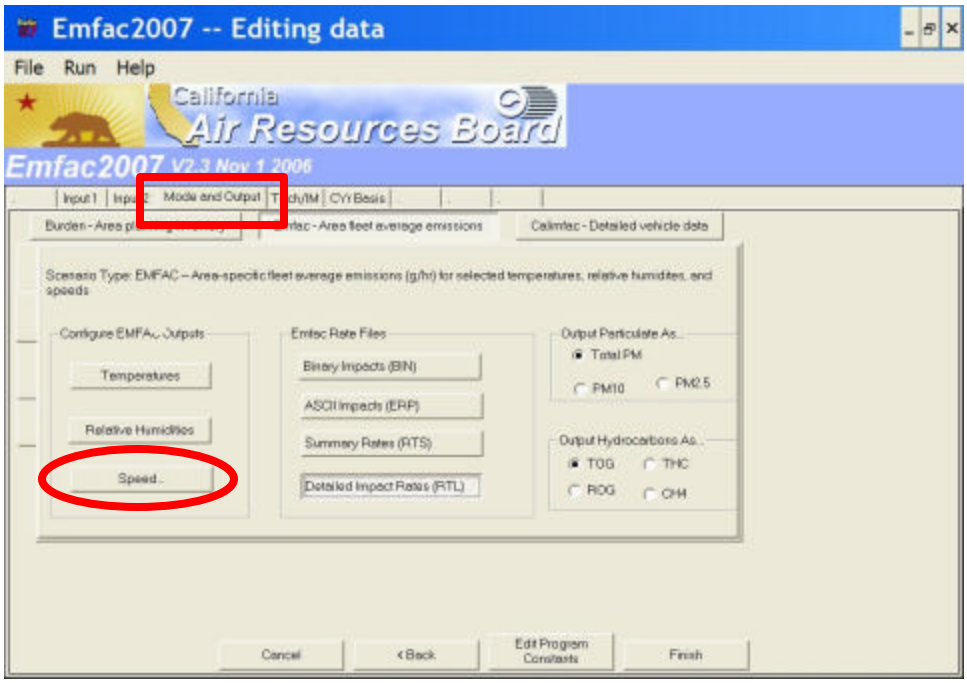
9. On the “Mode and Output” tab, click “Relative Humidities” in the Configure EMFAC Outputs box; in the pop-up window, input an average daily relative humidity used for the project (e.g., 70) in the first data box; then delete all other default data; click “OK”.[5]

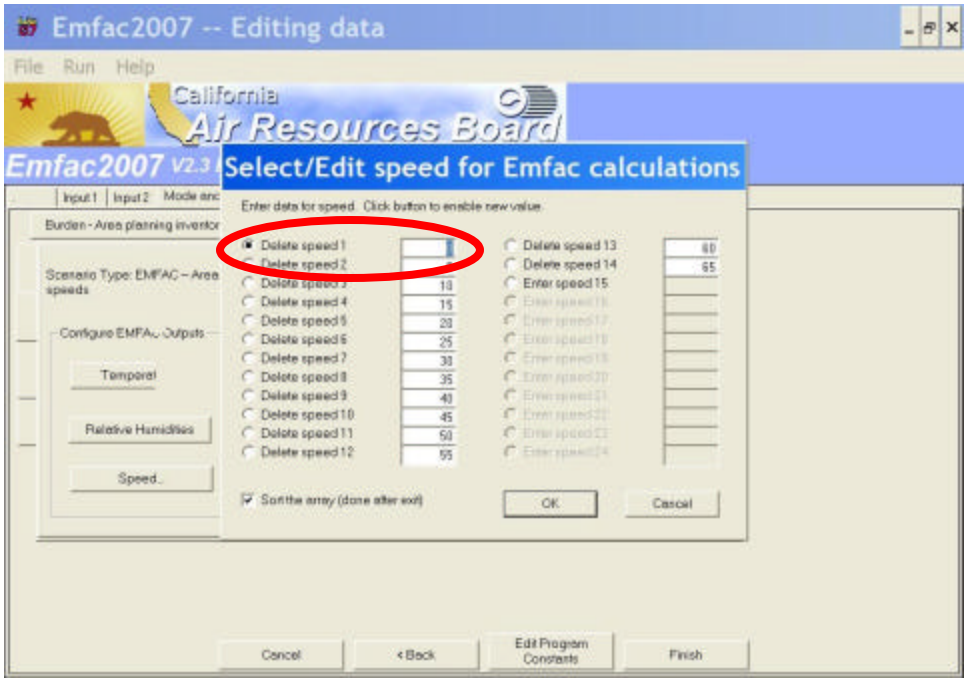


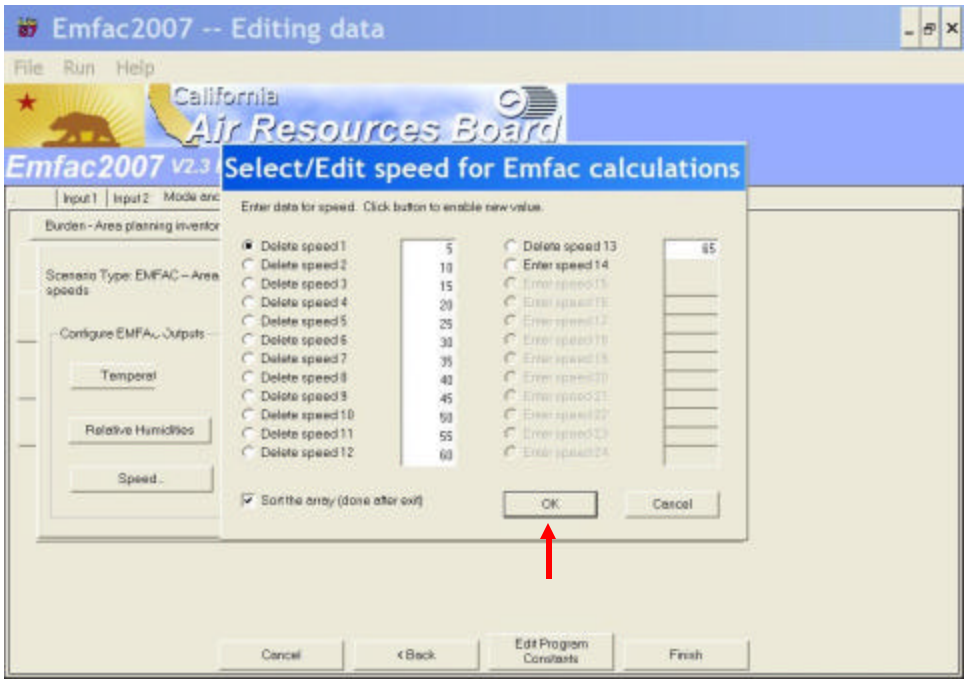


[5] Analysts will typically input an average relative humidity based on conditions for a summer day; this data is available by county or air basin from the “Burden” mode in the EMFAC model; alternatively, analysts can obtain relative humidity conditions from other sources that describe county or air basin-specific statistics.

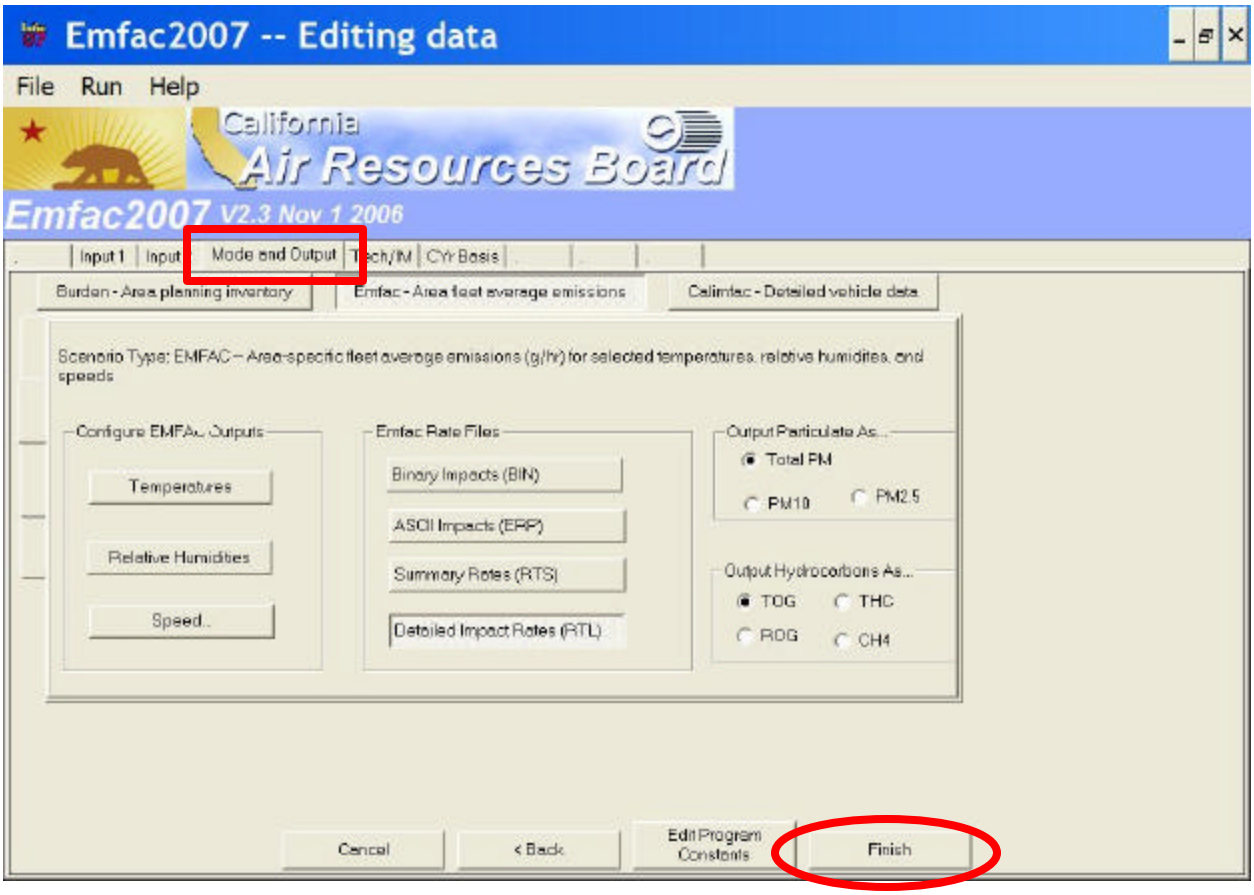
10. On the “Mode and Output” tab, click “Speed…” in the Configure EMFAC Outputs box; in the pop-up window, click the first data box with “0” to delete it (this “0” speed bin corresponds to idle emissions, which are not used for project analysis); click “OK”.



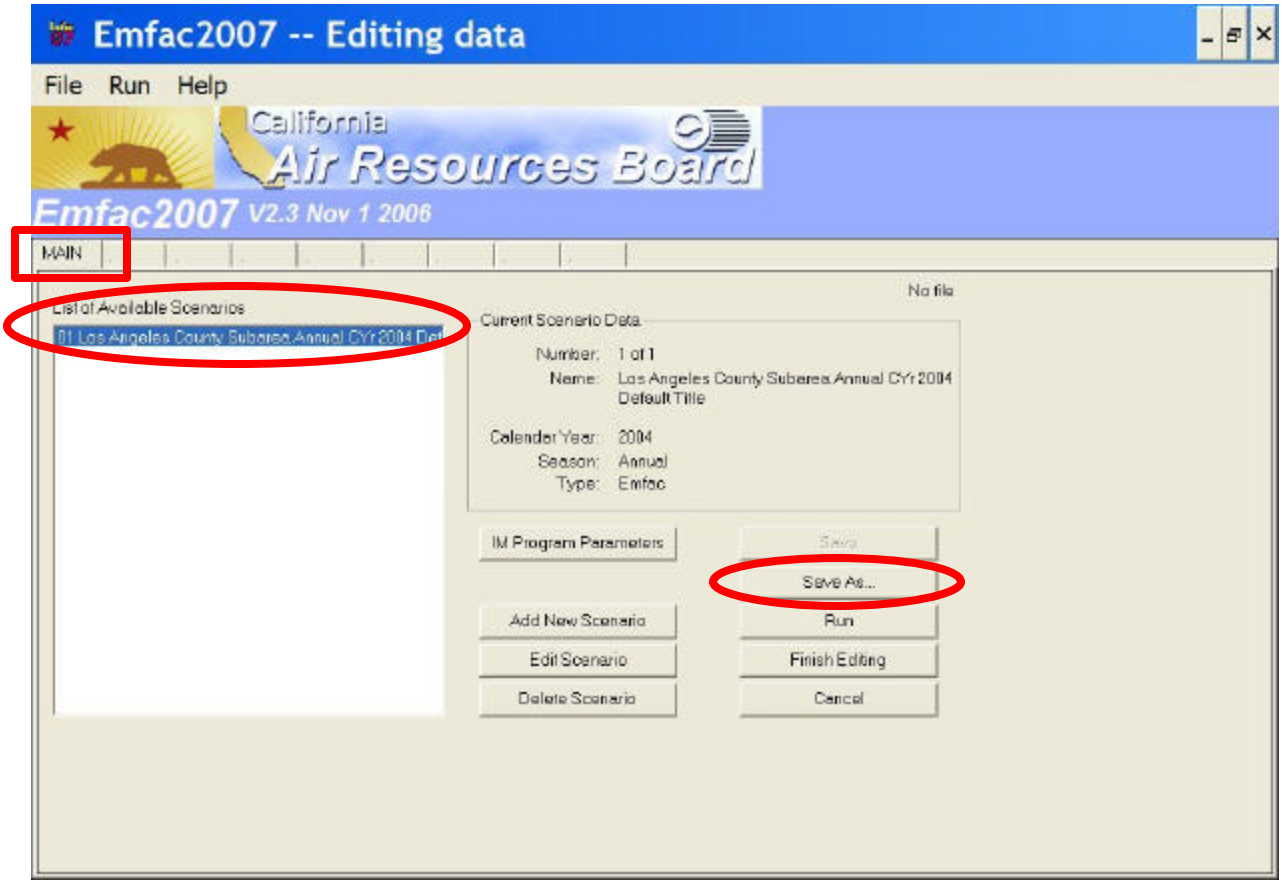



Emfac2007 -- Editing data
File Run Help
California
Air Resources Board
Emfac2007 V2.3
Select/Edit speed for Emfac calculations
Enter data for speed. Click button to enable new value.
Delete speed 1
Delete speed 2
Delete speed 3
Delete speed 4
Delete speed 5
Delete speed 6
Delete speed 7
Delete speed 8
Delete speed 9
Delete speed 10
Delete speed 11
Delete speed 12
Delete speed 13
Enter speed 14
5
10
15
20
25
30
35
40
45
50
55
60
65
Sort the array (done after exit)
OK
Cancel
Temperat
Relative Humidities
Speed...
Cancel
< Back
Edit Program Constants
Finish

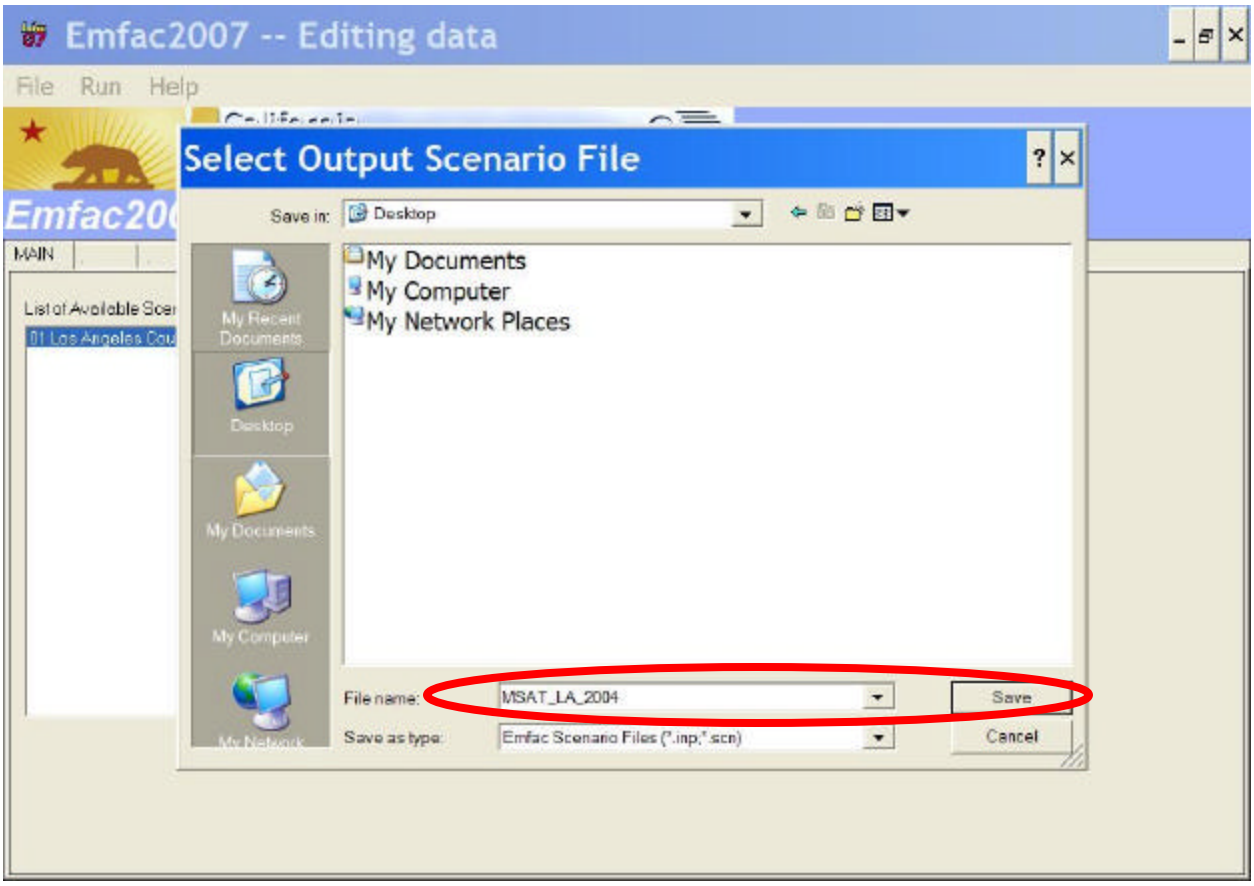
11. The EMFAC model interface goes back to the “Mode and Output” tab; click “Finish”.



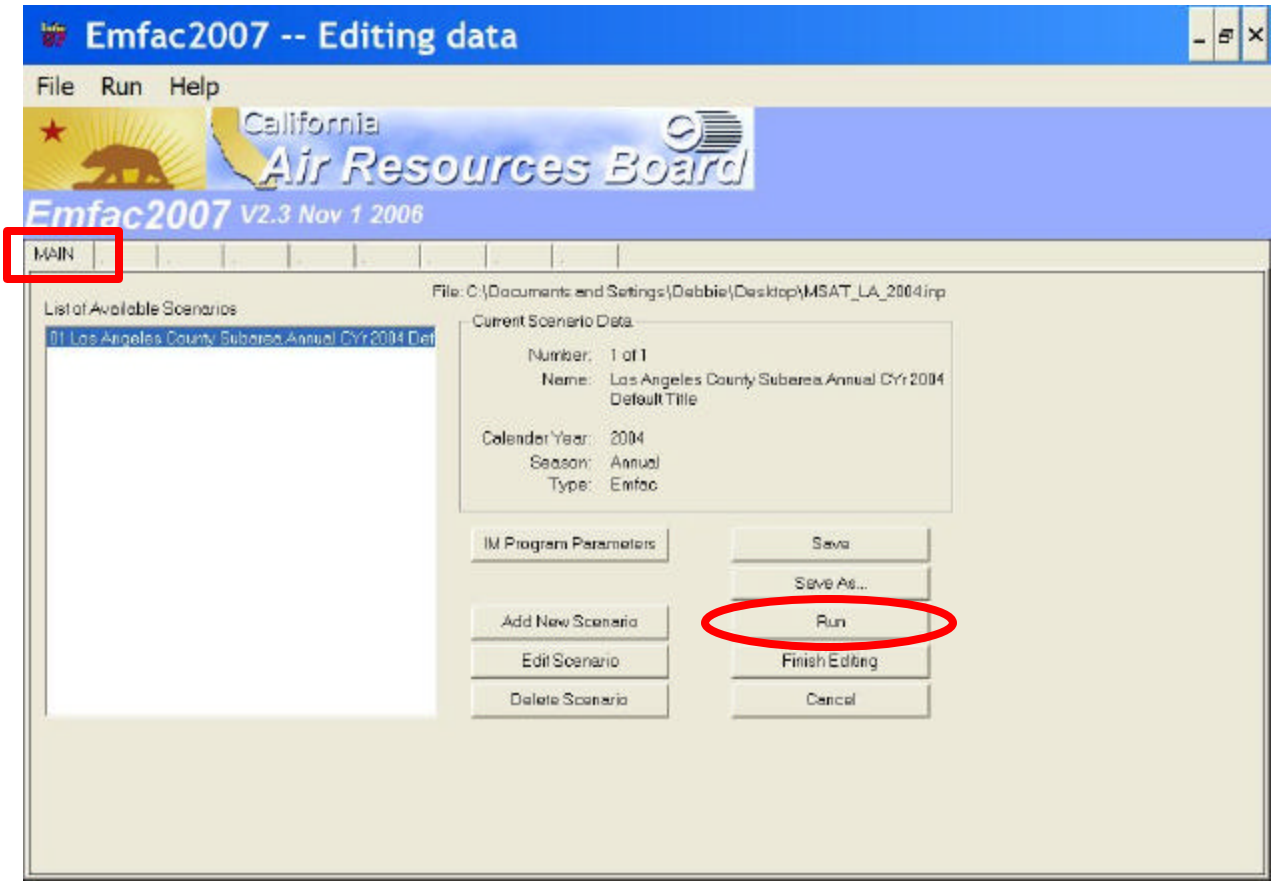
12. The EMFAC model interface goes back to the “MAIN” tab; click “Save as…” (note that the current scenario title is shown on the “List of Available scenarios” box.



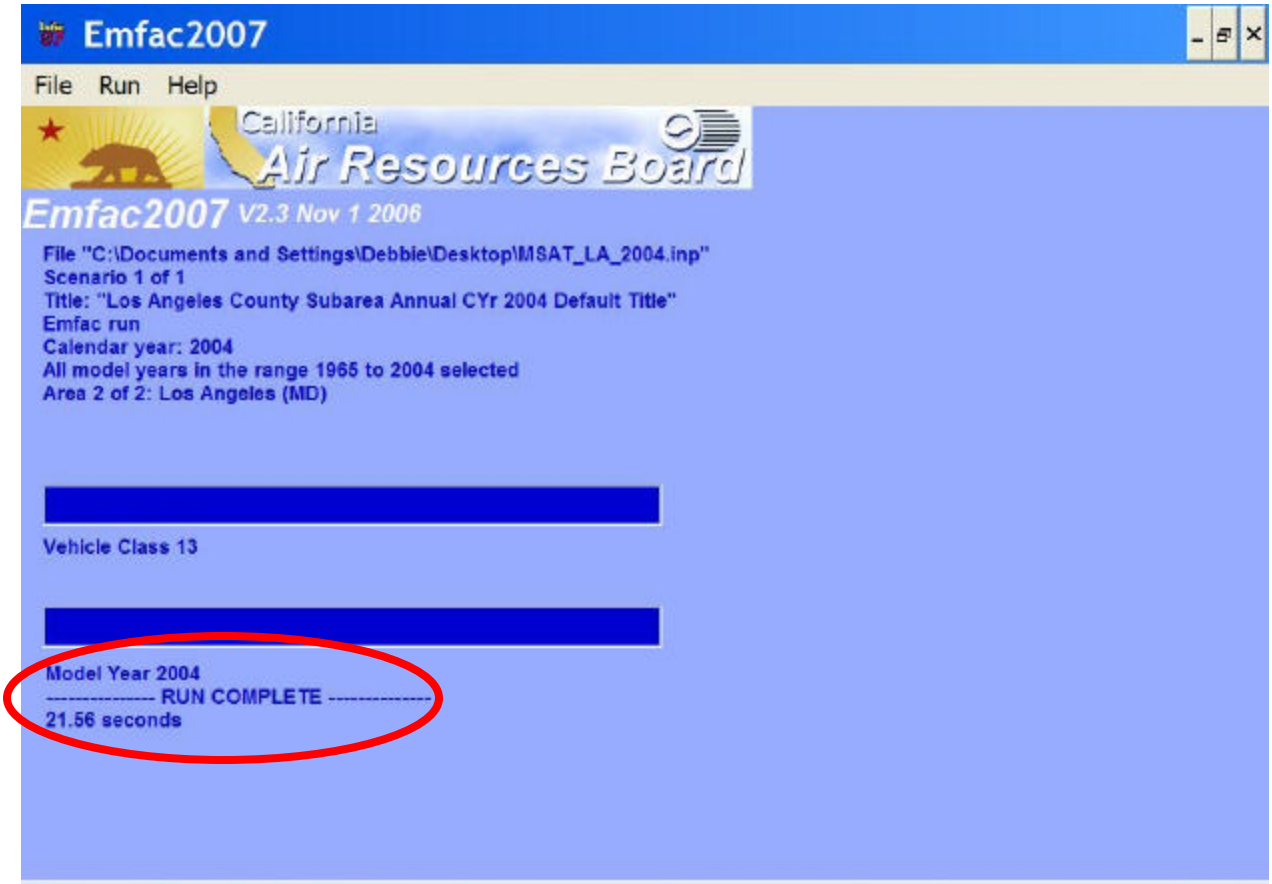
13. In the pop-up window, select a desired file directory (e.g., desktop in this example) and input a file name (e.g., “MSAT_LA_2004”); then click “Save”; EMFAC model will create a “*.inp” file including all parameters specified for the current scenario.



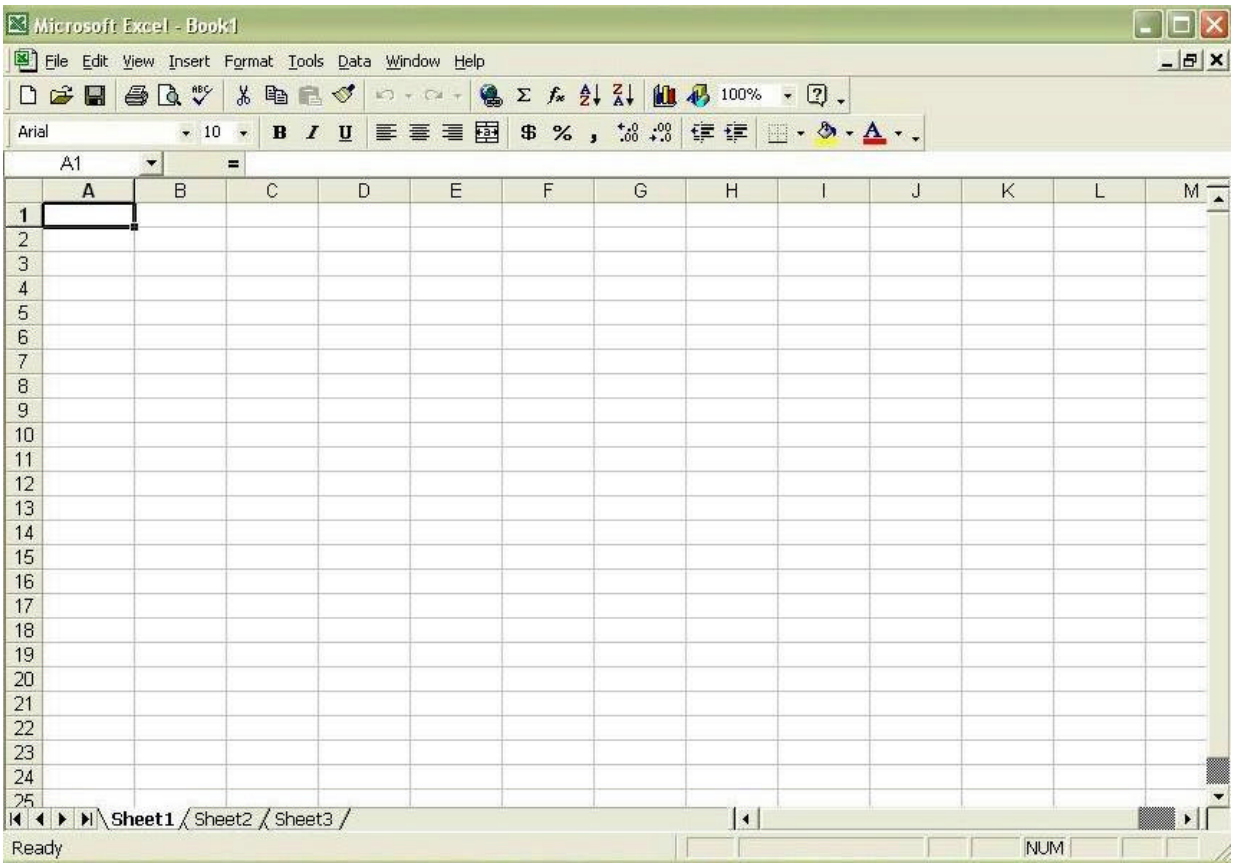
14. The EMFAC model interface goes back to the “MAIN” tab; click “Run”.



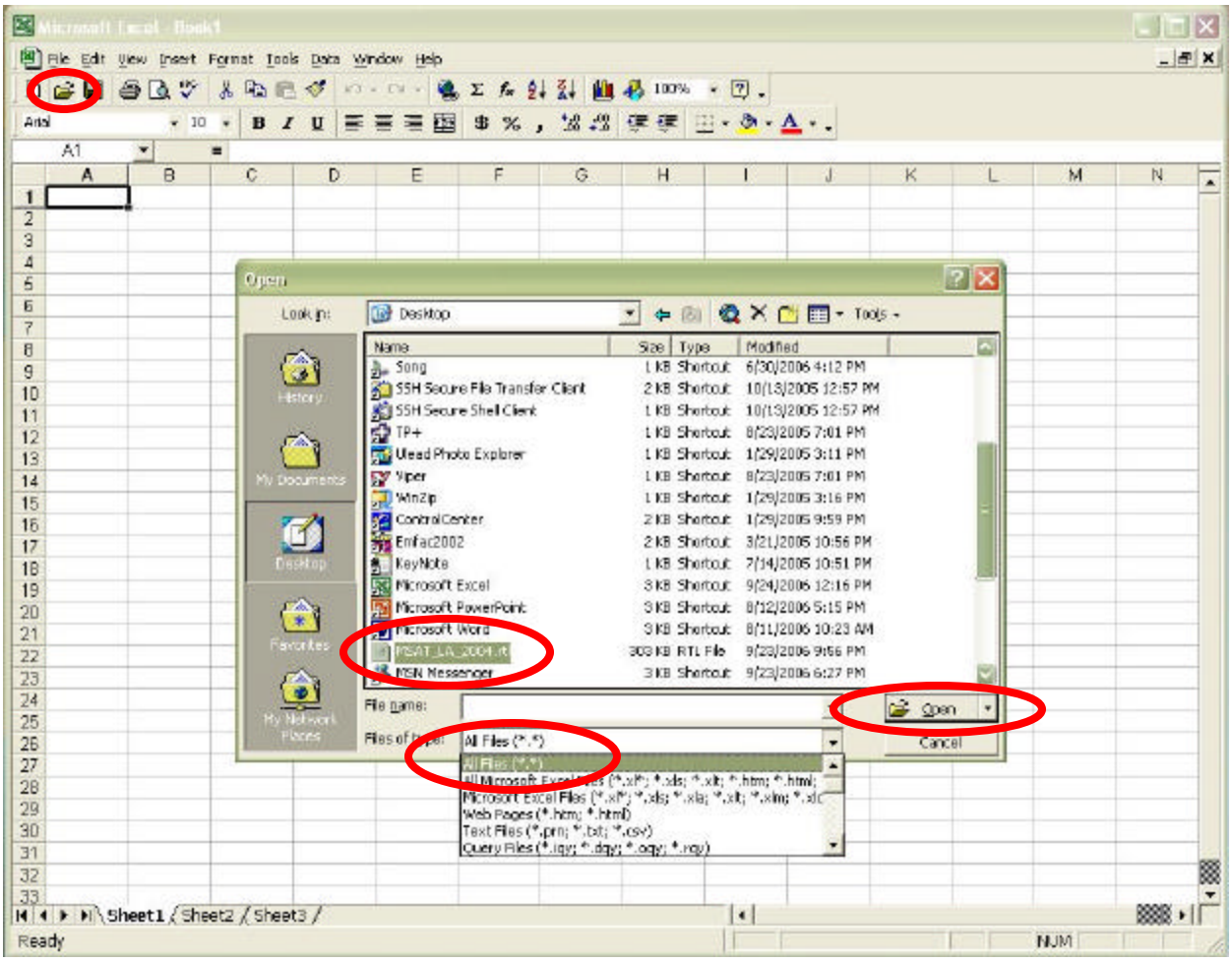
15. The EMFAC model interface shows the calculation status of the current scenario run; when the run is complete, the total calculation time is presented and a "*.rtl" file is available in the same directory (desktop in this example) with the same name as the "*.inp" file (i.e., MSAT_LA_2004.rtl in this example).



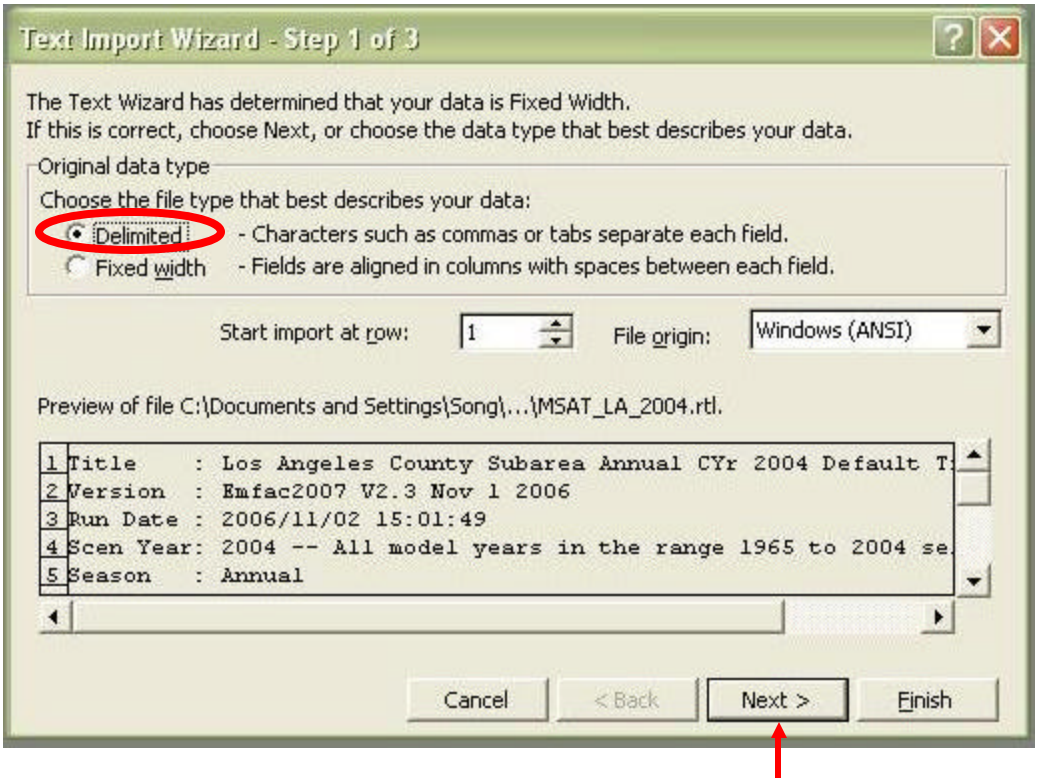
16. Now open the Microsoft Excel program; the interface is an empty worksheet file.



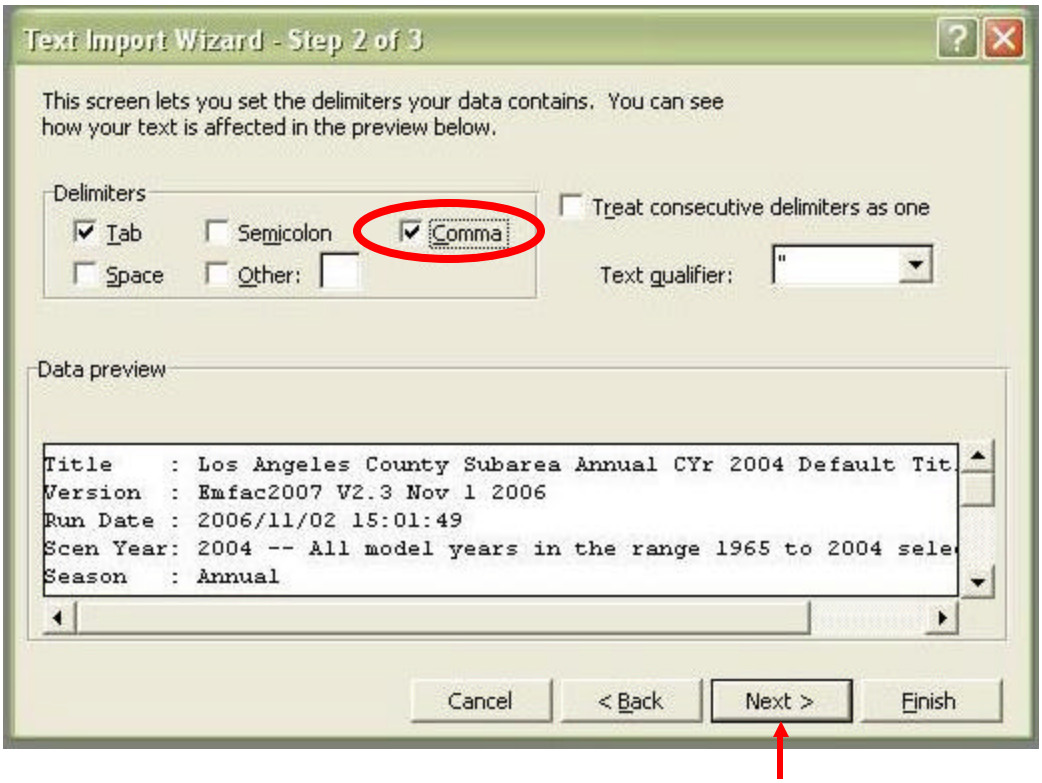
17. Select “open” from the File menu or click the “open” icon on the tool bar; in the pop-up window, browse All Files to find the “*.rtl” file in the directory where it is saved (in this example, the MSAT_LA_2004.rtl file is in the desktop directory); click “Open”.



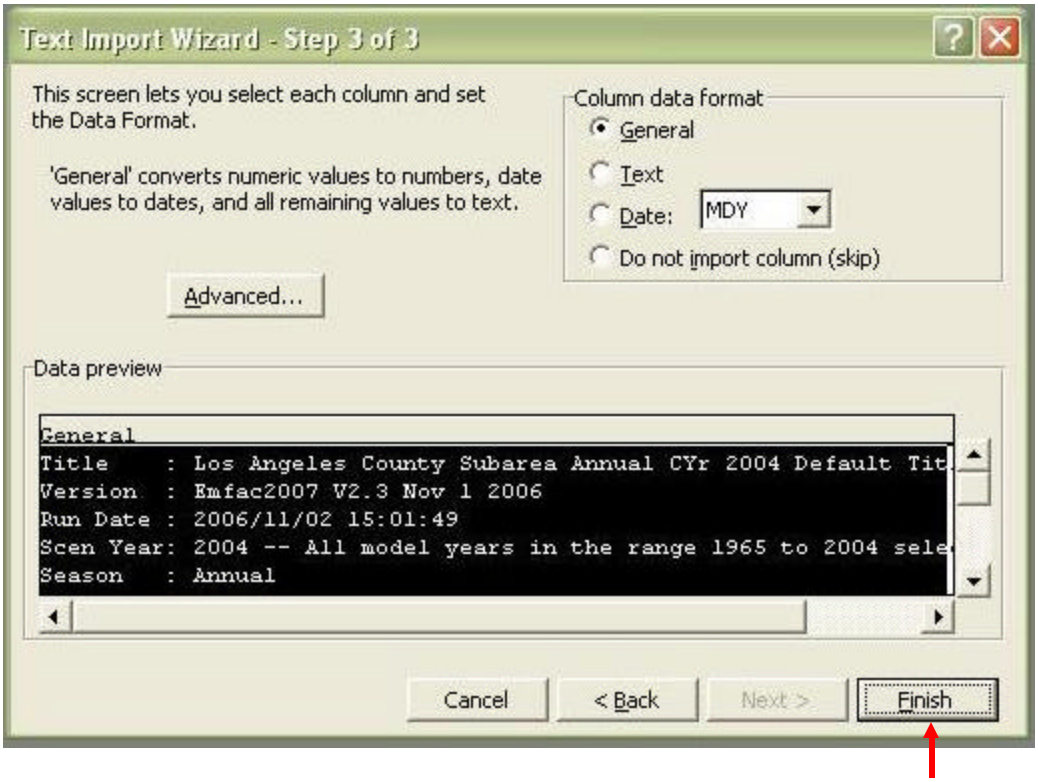
18. In the pop-up window, Text Import Wizard – Step 1 of 3, select “Delimited” as the data file type; click “Next”.



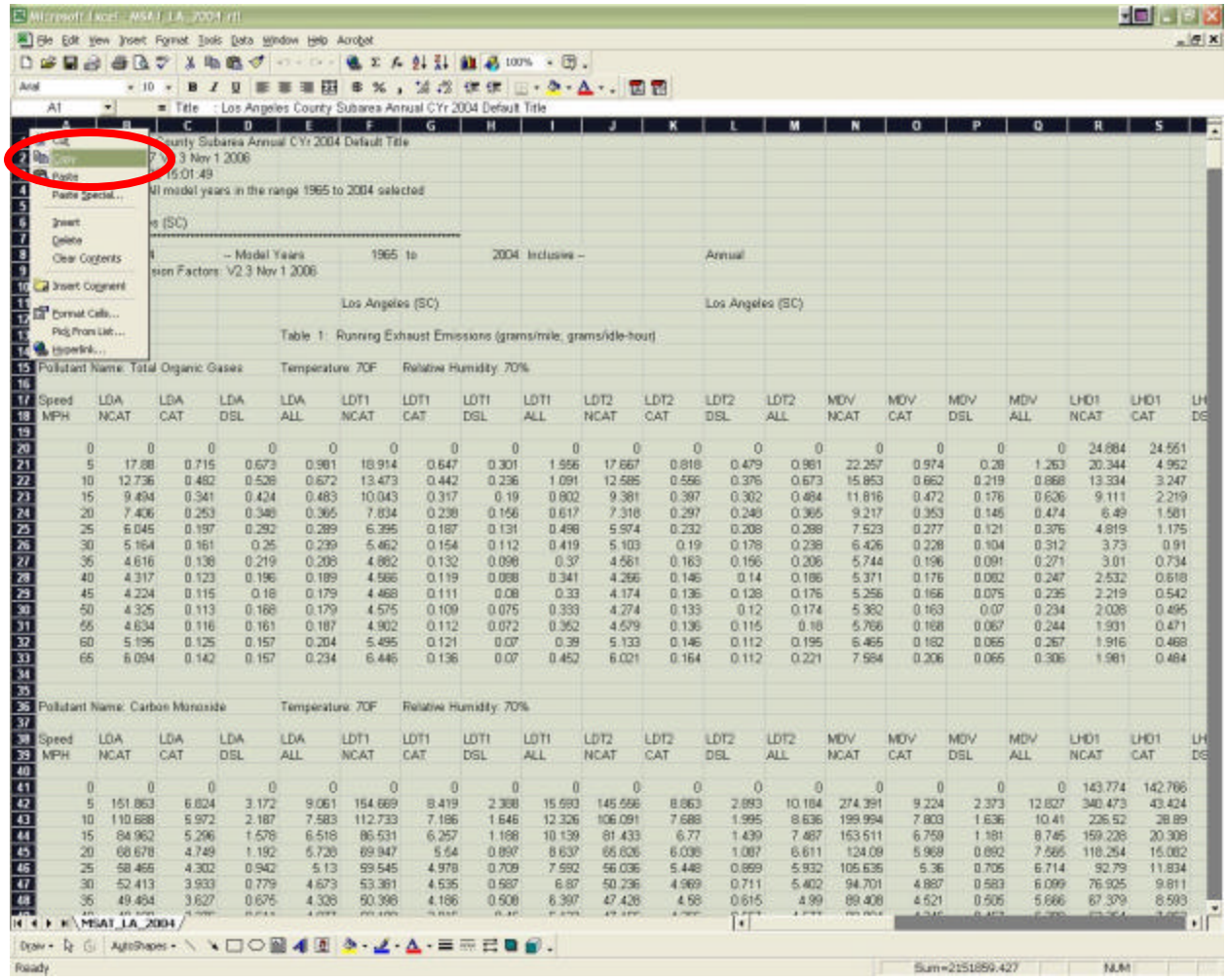
19. In the window Text Import Wizard – Step 2 of 3, check “Comma”; then click “Next”.



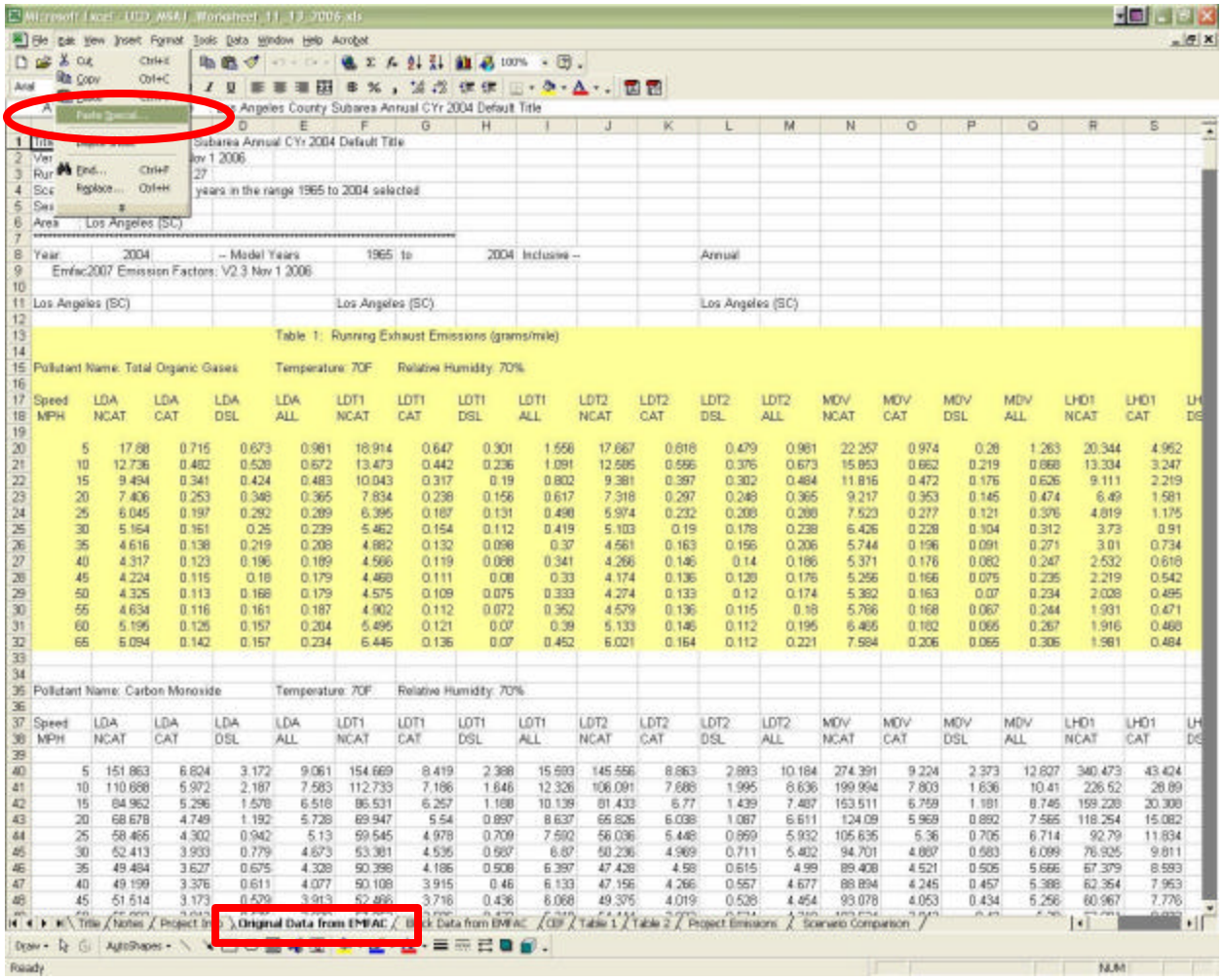
20. The window is updated to Text Import Wizard – Step 3 of 3; change nothing in this window; click “Finish”.



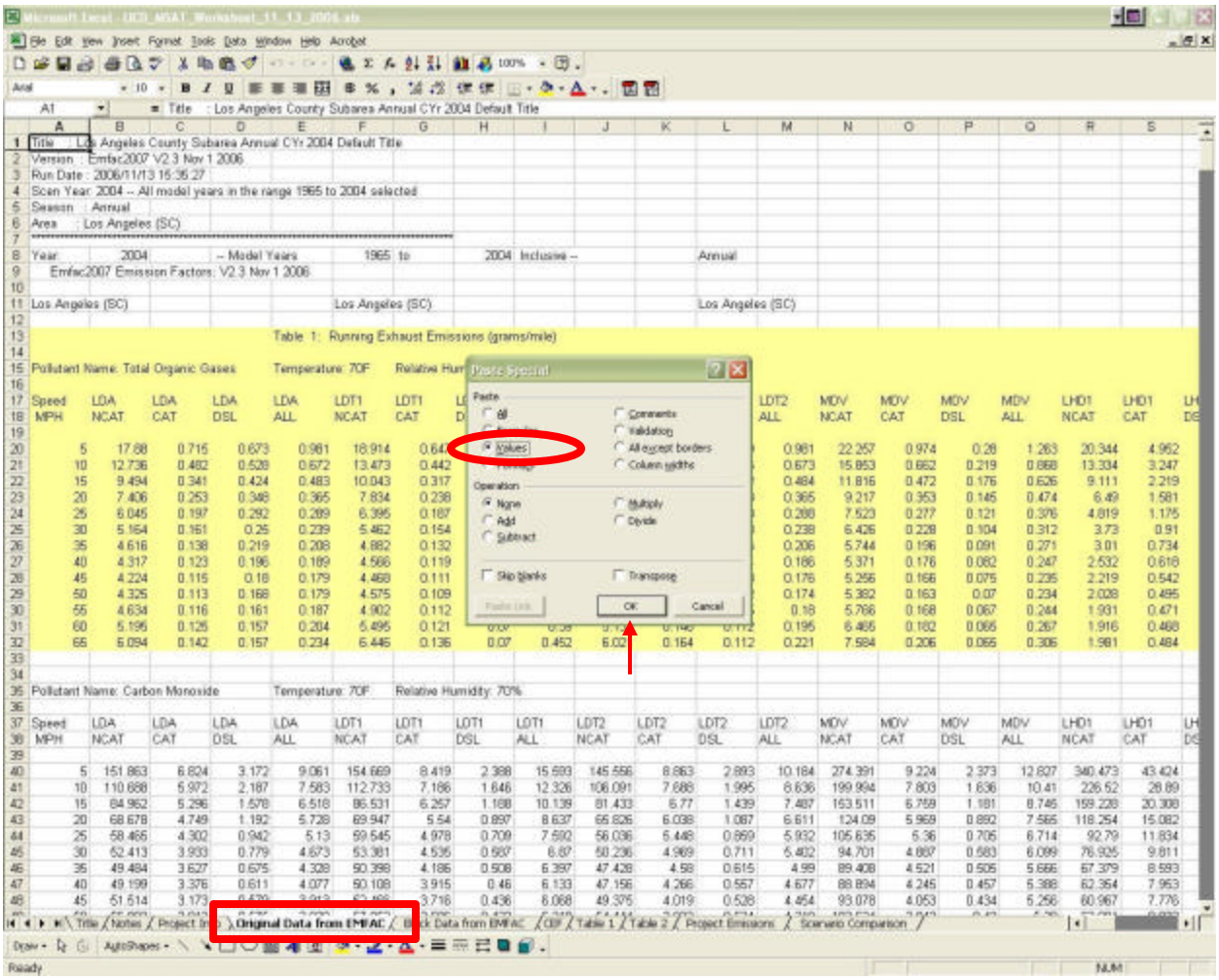
21. Now Excel opens the "*.rtl" file in a worksheet format; select the entire worksheet by clicking the left button of mouse on the left-top corner of the worksheet (the entire worksheet will be highlighted); click the right button of mouse to active a pop-up window, then select "Copy" to copy the entire worksheet.



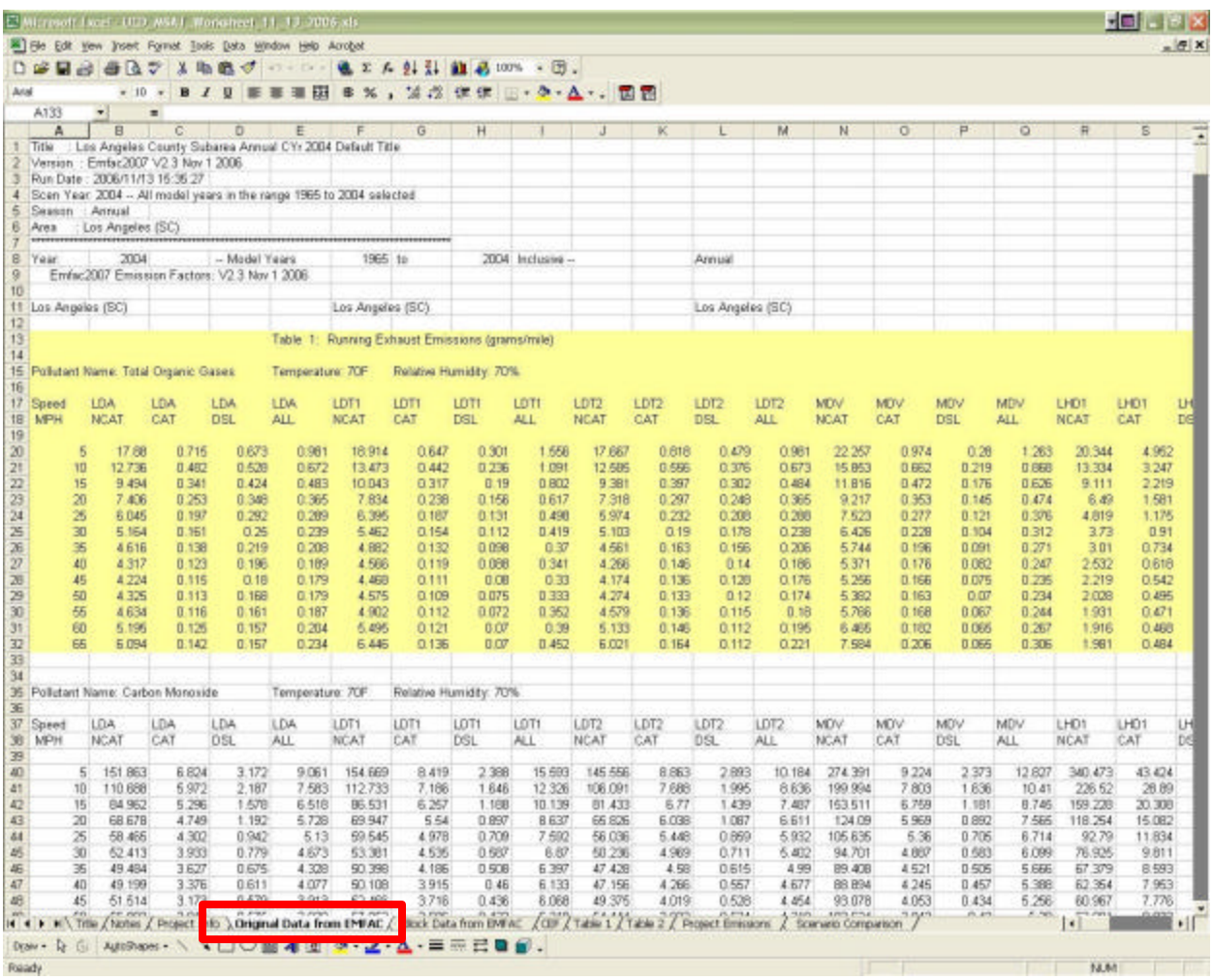
22. Go to the “Original Data from EMFAC” worksheet in the spreadsheet tool; select the entire worksheet by clicking the left button of mouse on the left-top corner of the worksheet, or just select cell A1; click the right button of mouse at the same location on the worksheet, and in the pop-up window, select “Paste Special”.



23. In the pop-up window, check “Values”; then click “OK”.

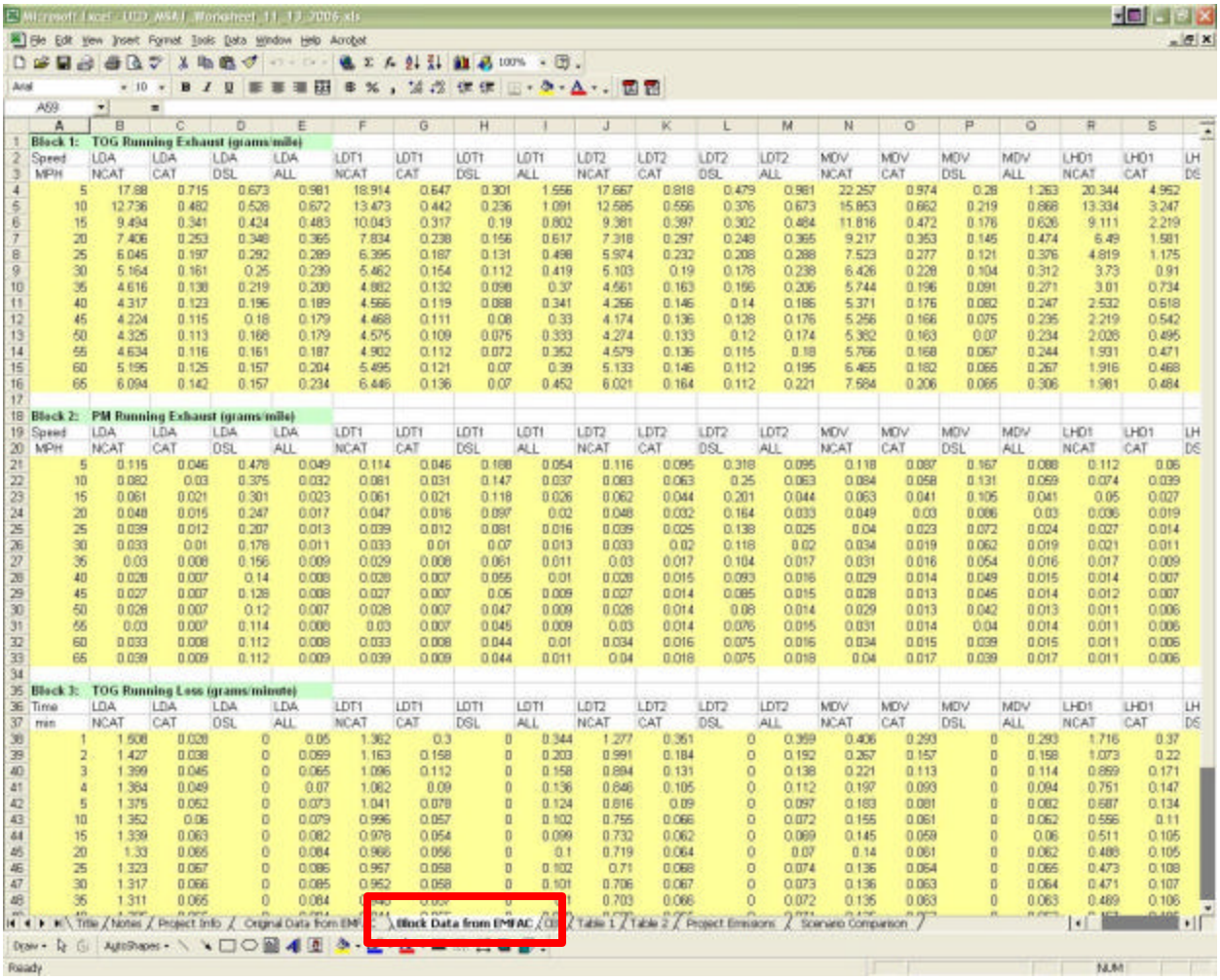


24. Now the detailed emission factors from the EMFAC model have been updated in the spreadsheet tool; review and understand the structure of this data worksheet:
    - When "Do Each Sub-Area" is selected in EMFAC runs, the output for Los Angeles County includes emission factors for both the South Coast Air Basin part and the Mojave Desert Air Basin part; we only focus on the South Coast Air Basin part, which is the first half of the "*.rtl" file. For other counties, the entire "*.rtl" file may include only a single Air Basin.
    - The "*.rtl" file is organized into 8 Tables (as can be seen from the subtitles in the file), each of which includes one or multiple data blocks (detailed emission factors by speed bins for different vehicle classes, pollutants, and emission processes); we only need to use Table 1, Table 7 and Table 8 (yellow background in the worksheet).



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	Title : Los Angeles County Subarea Annual CYr 2004 Default Title																		
2	Version : Emfac2007 V2.3 Nov 1 2006																		
3	Run Date : 2006/11/13 16:36:27																		
4	Scen Year: 2004 -- All model years in the range 1965 to 2004 selected																		
5	Season : Annual																		
6	Area : Los Angeles (SC)																		
7	**********																		
8	Year 2004			-- Model Years		1965	to	2004	Inclusive --			Annual							
9	Emfac2007 Emission Factors: V2.3 Nov 1 2006																		
10																			
11	Los Angeles (SC)					Los Angeles (SC)						Los Angeles (SC)							
12																			
13					Table 1: Running Exhaust Emissions (grams/mile)														
14																			
15	Pollutant Name: Total Organic Gases				Temperature: 70F		Relative Humidity: 70%												
16																			
17	Speed	LDA	LDA	LDA	LDA	LDT1	LDT1	LDT1	LDT1	LDT2	LDT2	LDT2	LDT2	MDV	MDV	MDV	MDV	LHD1	LHD1
18	MPH	NCAT	CAT	DSL	ALL	NCAT	CAT	DSL	ALL	NCAT	CAT	DSL	ALL	NCAT	CAT	DSL	ALL	NCAT	CAT
19																			
20	5	17.88	0.715	0.673	0.981	18.914	0.647	0.301	1.558	17.667	0.618	0.479	0.981	22.257	0.974	0.28	1.263	20.344	4.962
21	10	12.736	0.482	0.528	0.672	13.473	0.442	0.236	1.091	12.585	0.556	0.376	0.673	15.853	0.662	0.219	0.868	13.334	3.247
22	15	9.494	0.341	0.424	0.483	10.043	0.317	0.19	0.802	9.381	0.397	0.302	0.484	11.816	0.472	0.176	0.626	9.111	2.219
23	20	7.406	0.253	0.348	0.365	7.834	0.238	0.156	0.617	7.318	0.297	0.248	0.365	9.217	0.353	0.145	0.474	6.49	1.581
24	25	6.045	0.197	0.292	0.289	6.395	0.187	0.131	0.498	5.974	0.232	0.208	0.288	7.523	0.277	0.121	0.376	4.819	1.175
25	30	5.164	0.161	0.25	0.239	5.462	0.154	0.112	0.419	5.103	0.19	0.178	0.238	6.426	0.228	0.104	0.312	3.73	0.91
26	35	4.616	0.138	0.219	0.208	4.882	0.132	0.098	0.37	4.561	0.163	0.156	0.206	5.744	0.196	0.091	0.271	3.01	0.734
27	40	4.317	0.123	0.196	0.189	4.566	0.119	0.088	0.341	4.266	0.146	0.14	0.186	5.371	0.176	0.082	0.247	2.532	0.618
28	45	4.224	0.115	0.18	0.179	4.468	0.111	0.08	0.33	4.174	0.136	0.128	0.176	5.256	0.166	0.075	0.235	2.219	0.542
29	50	4.325	0.113	0.168	0.179	4.575	0.109	0.075	0.333	4.274	0.133	0.12	0.174	5.382	0.163	0.07	0.234	2.028	0.495
30	55	4.634	0.116	0.161	0.187	4.902	0.112	0.072	0.362	4.579	0.136	0.115	0.18	5.766	0.168	0.067	0.244	1.931	0.471
31	60	5.196	0.125	0.157	0.204	5.495	0.121	0.07	0.39	5.133	0.146	0.112	0.195	6.465	0.182	0.065	0.267	1.916	0.468
32	65	6.094	0.142	0.157	0.234	6.446	0.136	0.07	0.452	6.021	0.164	0.112	0.221	7.584	0.206	0.065	0.306	1.981	0.484
33																			
34																			
35	Pollutant Name: Carbon Monoxide				Temperature: 70F		Relative Humidity: 70%												
36																			
37	Speed	LDA	LDA	LDA	LDA	LDT1	LDT1	LDT1	LDT1	LDT2	LDT2	LDT2	LDT2	MDV	MDV	MDV	MDV	LHD1	LHD1
38	MPH	NCAT	CAT	DSL	ALL	NCAT	CAT	DSL	ALL	NCAT	CAT	DSL	ALL	NCAT	CAT	DSL	ALL	NCAT	CAT
39																			
40	5	151.863	6.824	3.172	9.061	154.669	8.419	2.388	15.693	145.556	8.863	2.893	10.184	274.391	9.224	2.373	12.827	340.473	43.424
41	10	110.688	5.972	2.187	7.583	112.733	7.186	1.646	12.326	106.091	7.888	1.995	8.636	199.994	7.803	1.636	10.41	226.62	28.89
42	15	84.962	5.296	1.578	6.518	86.531	6.257	1.188	10.139	81.433	6.77	1.439	7.487	153.511	6.759	1.181	8.746	159.228	20.308
43	20	68.678	4.749	1.192	5.728	69.947	5.54	0.897	8.637	65.826	6.038	1.087	6.611	124.09	5.969	0.892	7.565	118.254	15.082
44	25	58.466	4.302	0.942	5.13	59.545	4.978	0.709	7.592	56.036	5.448	0.869	5.932	105.635	5.36	0.705	6.714	92.79	11.834
45	30	52.413	3.933	0.779	4.673	53.381	4.535	0.587	6.87	50.236	4.969	0.711	5.402	94.701	4.887	0.583	6.099	76.925	9.811
46	35	49.484	3.627	0.675	4.328	50.398	4.186	0.508	6.397	47.428	4.58	0.615	4.99	89.408	4.521	0.505	5.666	67.379	8.593
47	40	49.199	3.376	0.611	4.077	50.108	3.915	0.46	6.133	47.156	4.266	0.557	4.677	88.894	4.245	0.457	5.388	62.364	7.953
48	45	51.514	3.178	[illegible]	[illegible]	[illegible]	3.716	0.436	6.068	49.375	4.019	0.528	4.454	93.078	4.053	0.434	5.256	60.967	7.776

Step 4: Copy useful emission factors – worksheet "Block Data from EMFAC"

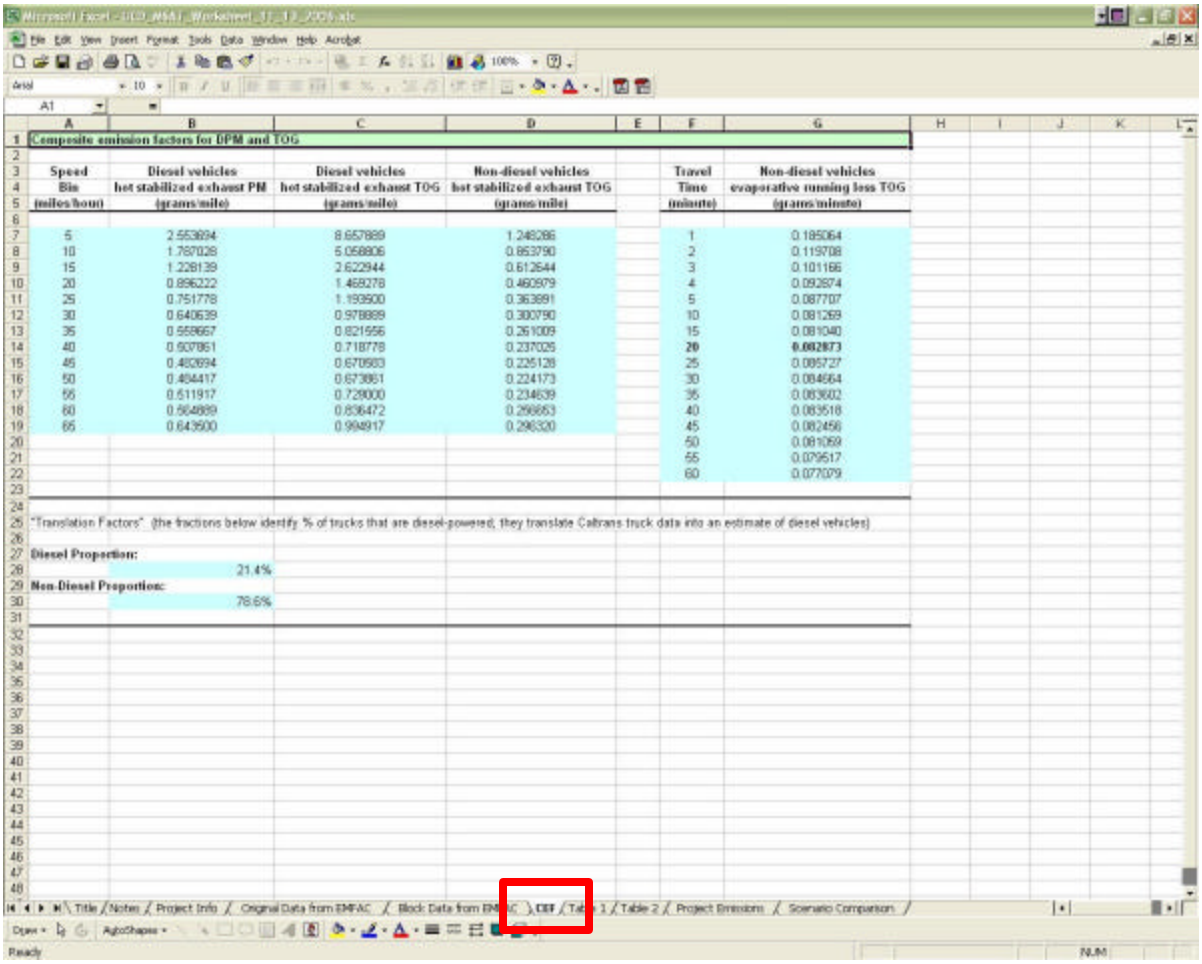


1. Copy the following four data blocks from the worksheet "Original Data from EMFAC" (with yellow background) to the worksheet "Block Data from EMFAC", which will be used for calculating composite emission factors:

Data Block	Description				
	Table #	Data	Unit	Data from worksheet	Data to worksheet
1	Table 1	TOG (running exhaust)	g/mile	Line 20 – 32	Line 4 – 16
2	Table 1	PM (running exhaust)	g/mile	Line 120 – 132	Line 21 – 33
3	Table 8	TOG (running loss)	g/minute	Line 570 – 585	Line 38 – 53
4	Table 7	VMT distribution	none	Line 542	Line 58

2. Double check the copied block data in the worksheet "Block Data from EMFAC" to ensure the entire data table covers cell A1 to cell BE58 in this worksheet.

Step 5: Calculation of the composite emission factors – worksheet "CEF"



Composite emission factors for DPM and TOG

Speed Bin (miles/hour)	Diesel vehicles hot stabilized exhaust PM (grams/mile)	Diesel vehicles hot stabilized exhaust TOG (grams/mile)	Non-diesel vehicles hot stabilized exhaust TOG (grams/mile)
5	2.553894	8.657889	1.248286
10	1.787028	6.058806	0.853790
15	1.228139	2.622944	0.612644
20	0.896222	1.468278	0.460979
25	0.751778	1.193500	0.363891
30	0.640639	0.978889	0.300790
35	0.558667	0.821556	0.261009
40	0.507861	0.718778	0.237026
45	0.482894	0.670833	0.225128
50	0.484417	0.673861	0.224173
55	0.511917	0.729000	0.234639
60	0.564889	0.836472	0.266653
65	0.643500	0.994917	0.296320

Travel Time (minute)	Non-diesel vehicles evaporative running loss TOG (grams/minute)
1	0.185064
2	0.119708
3	0.101166
4	0.092874
5	0.087707
10	0.081269
15	0.081040
20	**0.082873**
25	0.085727
30	0.084664
35	0.083602
40	0.083518
45	0.082456
50	0.081069
55	0.079517
60	0.077079

"Translation Factors" (the fractions below identify % of trucks that are diesel-powered; they translate Caltrans truck data into an estimate of diesel vehicles)

Diesel Proportion: 21.4%

Non-Diesel Proportion: 78.6%

1. The composite emission factors (CEF) for the analysis year (2004 in this example) will be automatically calculated in the worksheet "CEF"; the CEF for diesel exhaust PM, diesel exhaust TOG and non-diesel exhaust TOG are specified by speed bin; the CEF for non-diesel evaporative running loss TOG are specified by travel time.
2. Based on the VMT distribution (Data Block 4) in the worksheet "Block Data from EMFAC", a translation factor ("Diesel Proportion") is calculated and shown on the worksheet "CEF"; this factor is used to convert Caltrans truck volume (or VMT) to diesel volume (or VMT) for the project.
3. Detailed descriptions of the methodology for CEF and translation factor calculation are presented in **Appendix A** and **Appendix B** of this document, respectively.

Step 6: Prepare project-specific composite emission factors – worksheet "Table 1"

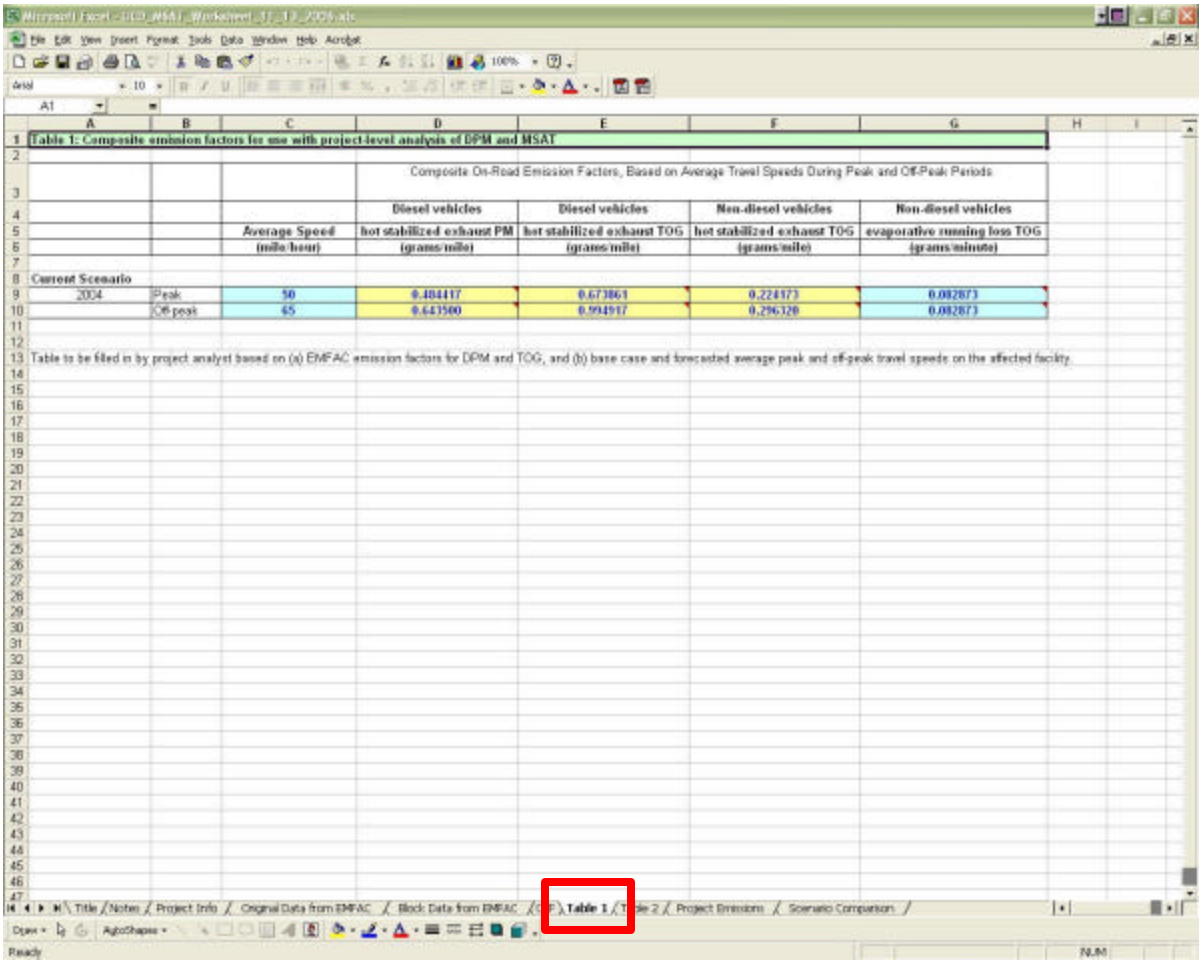


Table 1: Composite emission factors for use with project-level analysis of DPM and MSAT

			Composite On-Road Emission Factors, Based on Average Travel Speeds During Peak and Off-Peak Periods			
			Diesel vehicles	Diesel vehicles	Non-diesel vehicles	Non-diesel vehicles
		Average Speed (mile/hour)	hot stabilized exhaust PM (grams/mile)	hot stabilized exhaust TOG (grams/mile)	hot stabilized exhaust TOG (grams/mile)	evaporative running loss TOG (grams/minute)
Current Scenario						
2004	Peak	50	0.484417	0.673861	0.224173	0.082873
	Off-peak	65	0.643500	0.994917	0.296320	0.082873

Table to be filled in by project analyst based on (a) EMFAC emission factors for DPM and TOG, and (b) base case and forecasted average peak and off-peak travel speeds on the affected facility

1. The "Average Speed" data in this worksheet are presented automatically, which are consistent with the speed values shown on the worksheet "Project Info".
2. From the composite emission factors shown on the "CEF" worksheet, select appropriate composite emission factors to fill out worksheet "Table 1"; copy only the values of data; DO NOT copy formulas integrated with the data in the worksheet "CEF".
   - For diesel exhaust PM, TOG and non-diesel exhaust TOG, select emission factors based on peak speed and off-peak speed estimated for the project. In this example case, copy values of emission factors for speed bin 50 and 65, respectively.
   - For non-diesel running loss TOG, the composite emission factors associated with the travel time of 20 minutes are selected automatically for both peak time and off-peak time. **Appendix C** explains the reason why the CEF for a 20-minute trip are used.

Step 7: Prepare project-specific MSAT emission factors – worksheet "Table 2"

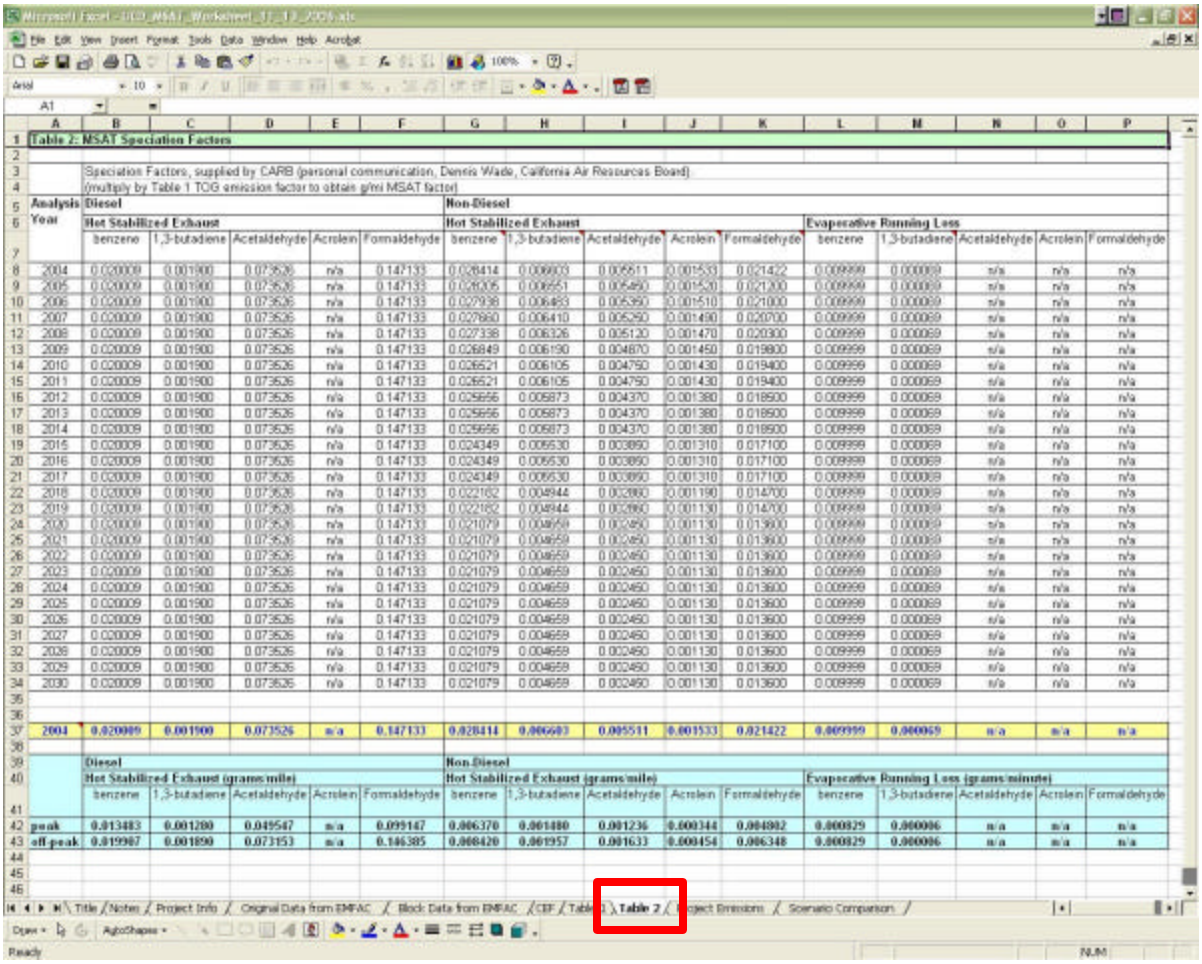


Table 2: MSAT Speciation Factors

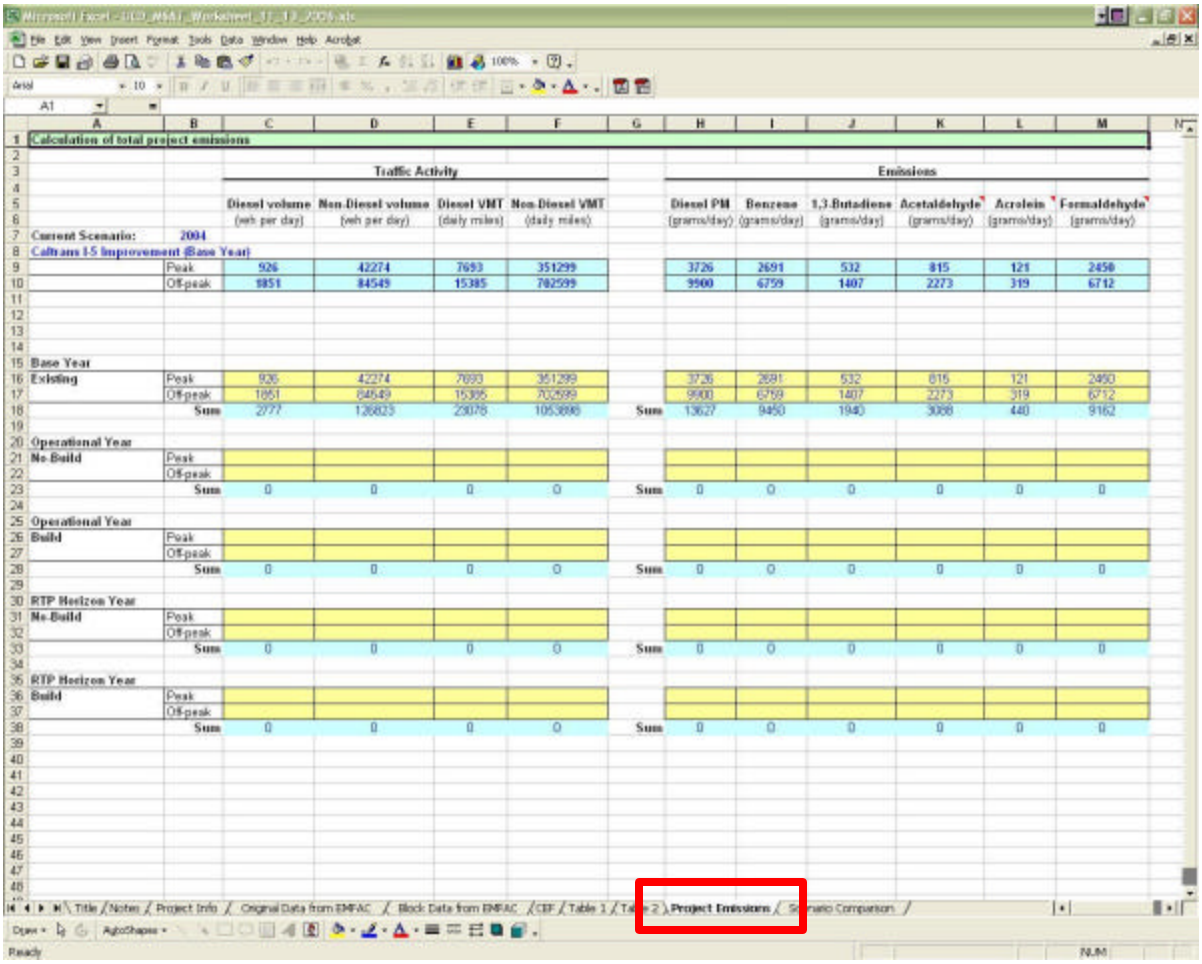
Speciation Factors, supplied by CARB (personal communication, Dennis Wade, California Air Resources Board)
(multiply by Table 1 TOG emission factor to obtain g/mi MSAT factor)

Analysis Year	Diesel					Non-Diesel									
	Hot Stabilized Exhaust					Hot Stabilized Exhaust					Evaporative Running Loss				
	benzene	1,3-butadiene	Acetaldehyde	Acrolein	Formaldehyde	benzene	1,3-butadiene	Acetaldehyde	Acrolein	Formaldehyde	benzene	1,3-butadiene	Acetaldehyde	Acrolein	Formaldehyde
2004	0.020009	0.001900	0.073526	n/a	0.147133	0.028414	0.006603	0.005511	0.001533	0.021422	0.009999	0.000069	n/a	n/a	n/a
2005	0.020009	0.001900	0.073526	n/a	0.147133	0.028035	0.006551	0.005490	0.001520	0.021200	0.009999	0.000069	n/a	n/a	n/a
2006	0.020009	0.001900	0.073526	n/a	0.147133	0.027938	0.006483	0.005390	0.001510	0.021000	0.009999	0.000069	n/a	n/a	n/a
2007	0.020009	0.001900	0.073526	n/a	0.147133	0.027860	0.006410	0.005250	0.001490	0.020700	0.009999	0.000069	n/a	n/a	n/a
2008	0.020009	0.001900	0.073526	n/a	0.147133	0.027338	0.006326	0.005120	0.001470	0.020300	0.009999	0.000069	n/a	n/a	n/a
2009	0.020009	0.001900	0.073526	n/a	0.147133	0.026849	0.006190	0.004870	0.001450	0.019800	0.009999	0.000069	n/a	n/a	n/a
2010	0.020009	0.001900	0.073526	n/a	0.147133	0.026521	0.006105	0.004750	0.001430	0.019400	0.009999	0.000069	n/a	n/a	n/a
2011	0.020009	0.001900	0.073526	n/a	0.147133	0.026521	0.006105	0.004750	0.001430	0.019400	0.009999	0.000069	n/a	n/a	n/a
2012	0.020009	0.001900	0.073526	n/a	0.147133	0.025656	0.005873	0.004370	0.001380	0.018500	0.009999	0.000069	n/a	n/a	n/a
2013	0.020009	0.001900	0.073526	n/a	0.147133	0.025656	0.005873	0.004370	0.001380	0.018500	0.009999	0.000069	n/a	n/a	n/a
2014	0.020009	0.001900	0.073526	n/a	0.147133	0.025656	0.005873	0.004370	0.001380	0.018500	0.009999	0.000069	n/a	n/a	n/a
2015	0.020009	0.001900	0.073526	n/a	0.147133	0.024349	0.005530	0.003890	0.001310	0.017100	0.009999	0.000069	n/a	n/a	n/a
2016	0.020009	0.001900	0.073526	n/a	0.147133	0.024349	0.005530	0.003890	0.001310	0.017100	0.009999	0.000069	n/a	n/a	n/a
2017	0.020009	0.001900	0.073526	n/a	0.147133	0.024349	0.005530	0.003890	0.001310	0.017100	0.009999	0.000069	n/a	n/a	n/a
2018	0.020009	0.001900	0.073526	n/a	0.147133	0.022182	0.004944	0.003860	0.001190	0.014700	0.009999	0.000069	n/a	n/a	n/a
2019	0.020009	0.001900	0.073526	n/a	0.147133	0.022182	0.004944	0.003860	0.001130	0.014700	0.009999	0.000069	n/a	n/a	n/a
2020	0.020009	0.001900	0.073526	n/a	0.147133	0.021079	0.004659	0.002460	0.001130	0.013600	0.009999	0.000069	n/a	n/a	n/a
2021	0.020009	0.001900	0.073526	n/a	0.147133	0.021079	0.004659	0.002460	0.001130	0.013600	0.009999	0.000069	n/a	n/a	n/a
2022	0.020009	0.001900	0.073526	n/a	0.147133	0.021079	0.004659	0.002460	0.001130	0.013600	0.009999	0.000069	n/a	n/a	n/a
2023	0.020009	0.001900	0.073526	n/a	0.147133	0.021079	0.004659	0.002460	0.001130	0.013600	0.009999	0.000069	n/a	n/a	n/a
2024	0.020009	0.001900	0.073526	n/a	0.147133	0.021079	0.004659	0.002460	0.001130	0.013600	0.009999	0.000069	n/a	n/a	n/a
2025	0.020009	0.001900	0.073526	n/a	0.147133	0.021079	0.004659	0.002460	0.001130	0.013600	0.009999	0.000069	n/a	n/a	n/a
2026	0.020009	0.001900	0.073526	n/a	0.147133	0.021079	0.004659	0.002460	0.001130	0.013600	0.009999	0.000069	n/a	n/a	n/a
2027	0.020009	0.001900	0.073526	n/a	0.147133	0.021079	0.004659	0.002460	0.001130	0.013600	0.009999	0.000069	n/a	n/a	n/a
2028	0.020009	0.001900	0.073526	n/a	0.147133	0.021079	0.004659	0.002460	0.001130	0.013600	0.009999	0.000069	n/a	n/a	n/a
2029	0.020009	0.001900	0.073526	n/a	0.147133	0.021079	0.004659	0.002460	0.001130	0.013600	0.009999	0.000069	n/a	n/a	n/a
2030	0.020009	0.001900	0.073526	n/a	0.147133	0.021079	0.004659	0.002460	0.001130	0.013600	0.009999	0.000069	n/a	n/a	n/a
2004	0.020009	0.001900	0.073526	n/a	0.147133	0.028414	0.006603	0.005511	0.001533	0.021422	0.009999	0.000069	n/a	n/a	n/a

	Diesel					Non-Diesel									
	Hot Stabilized Exhaust (grams/mile)					Hot Stabilized Exhaust (grams/mile)					Evaporative Running Loss (grams/minute)				
	benzene	1,3-butadiene	Acetaldehyde	Acrolein	Formaldehyde	benzene	1,3-butadiene	Acetaldehyde	Acrolein	Formaldehyde	benzene	1,3-butadiene	Acetaldehyde	Acrolein	Formaldehyde
peak	0.013483	0.001280	0.049547	n/a	0.099147	0.006370	0.001480	0.001236	0.000344	0.004802	0.000829	0.000006	n/a	n/a	n/a
off-peak	0.019987	0.001890	0.073153	n/a	0.146385	0.008420	0.001957	0.001633	0.000454	0.006348	0.000829	0.000006	n/a	n/a	n/a

1. The upper big table in worksheet "Table 2" includes speciation factors for different air toxics provided by CARB (see **Appendix D** for a description of the methodology used to composite MSAT speciation factors). Based on the analysis year (2004 in this example), copy the respective row of data (line 8 for year 2004 in this example) to the designated line 36 in this worksheet.
2. After copying the speciation factors, the MSAT factors will be automatically calculated in the bottom table of worksheet "Table 2" with blue background. The emission factors for diesel exhaust acrolein and non-diesel evaporative running loss acetaldehyde, acrolein and formaldehyde are not provided because the respective speciation factors are not applicable or are currently unavailable based on CARB data.

Step 8: Calculate total project DPM and MSAT – worksheet "Project Emissions"



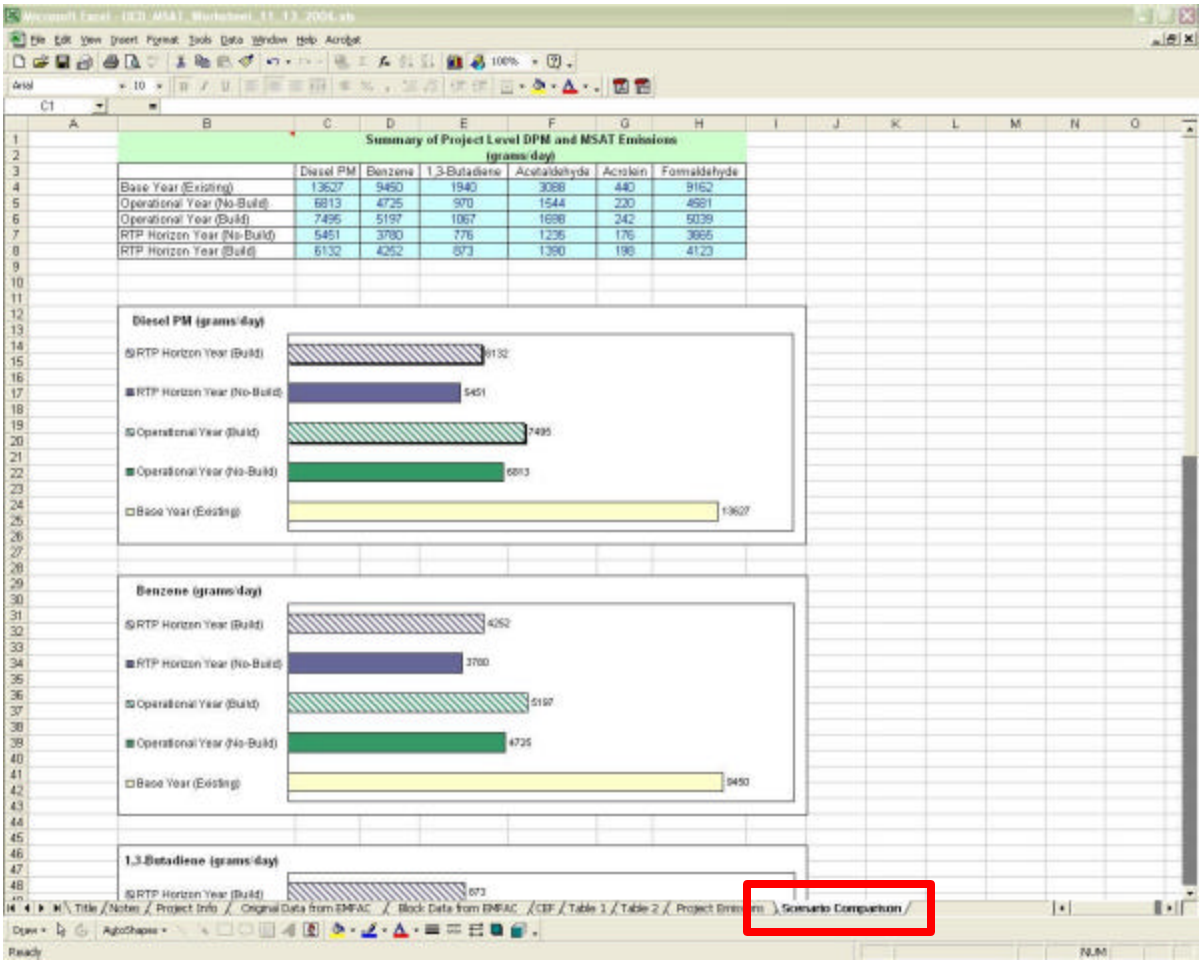
		Traffic Activity					Emissions					
		Diesel volume (veh per day)	Non-Diesel volume (veh per day)	Diesel VMT (daily miles)	Non-Diesel VMT (daily miles)		Diesel PM (grams/day)	Benzene (grams/day)	1,3-Butadiene (grams/day)	Acetaldehyde (grams/day)	Acrolein (grams/day)	Formaldehyde (grams/day)
Current Scenario:	2004											
Caltrans I-5 Improvement (Base Year)												
	Peak	926	42274	7693	351299		3726	2691	532	815	121	2450
	Off-peak	1851	84549	15385	702599		9900	6759	1407	2273	319	6712
Base Year												
Existing	Peak	926	42274	7693	351299		3726	2691	532	815	121	2450
	Off-peak	1851	84549	15385	702599		9900	6759	1407	2273	319	6712
	Sum	2777	126823	23078	1053898	Sum	13627	9450	1940	3088	440	9162
Operational Year												
No-Build	Peak											
	Off-peak											
	Sum	0	0	0	0	Sum	0	0	0	0	0	0
Operational Year												
Build	Peak											
	Off-peak											
	Sum	0	0	0	0	Sum	0	0	0	0	0	0
RTP Horizon Year												
No-Build	Peak											
	Off-peak											
	Sum	0	0	0	0	Sum	0	0	0	0	0	0
RTP Horizon Year												
Build	Peak											
	Off-peak											
	Sum	0	0	0	0	Sum	0	0	0	0	0	0

1. The data in worksheet "Project Emissions" will be automatically updated when the worksheets "Project Info", "Table 1" and "Table 2" are complete. Both the traffic activity and project emissions are specified for peak and off-peak, respectively.
2. The "Traffic Activity" part includes traffic volume and VMT for diesel and non-diesel vehicles, calculated based on project information specified in worksheet "Project Info".
3. The "Emissions" part includes total project emissions for diesel PM and 5 mobile source air toxics: benzene, 1,3-butadiene, acetaldehyde, acrolein and formaldehyde. The formulas used for the emissions calculation are presented in **Appendix E**.
4. Users need to repeat the above 7 steps and update respective data (project information and EMFAC emission factors) for different scenarios. The scenarios may include but are not limited to the following:

- Scenario 1: Base year
- Scenario 2: Operational year (No-build)
- Scenario 3: Operational year (Build)
- Scenario 4: RTP Horizon year (No-build)
- Scenario 5: RTP Horizon year (Build)

5. After each scenario run of the spreadsheet tool, users may copy the emission results shown in the "Current Scenario" table (with blue background) in the worksheet "Project Emissions" to the respective scenario table in the same worksheet. Again, copy only the values of the emission results; DO NOT copy formulas integrated with the data in the "current scenario" table.

Step 9: Summarize total project DPM and MSAT – worksheet "Scenario Comparison"



1. After the MSAT emissions for all possible project scenarios are prepared in the worksheet "Project Emissions", the data in worksheet "Scenario Comparison" will be automatically updated. Users can use these emissions results to conduct further analysis.
2. A summary table is prepared in the worksheet "Scenario Comparison", which summarizes the total daily project MSAT emissions for five possible scenarios. Respective comparison figures are also presented in this worksheet. Users can modify the figures to illustrate project MSAT scenario comparisons.

Conclusion

The methodology described here enables analysts to compare build and no-build project alternatives and estimate how the alternatives affect MSAT emissions. Users should understand that information concerning MSAT emissions is still evolving, and there is uncertainty embedded in both the methodology and the emission factors used. When summarizing and presenting emission analysis results, project analysts are encouraged to emphasize the relative differences among the scenarios analyzed, rather than the absolute value of the emissions estimates. In other words, the methodology is best able to help discern whether implementation of a project alternative results in greater or less emissions compared with other alternatives, rather than in estimating an absolute value for the MSAT emissions themselves.

References

Bai S., Eisinger, D., Niemeier, D. (2006) Project-Level Mobile Source Air Toxics Analysis Spreadsheet Tool. Prepared by the U.C. Davis-Caltrans Air Quality Project. Prepared for the California Department of Transportation. Version 1.2. November 13.

U.S. Environmental Protection Agency (2001) Control of Emissions of Hazardous Air Pollutants from Mobile Sources; Final Rule. *Federal Register*, Vol. 66, No. 61, pp. 17229-17273. March 29. Available on the Internet at <http://www.epa.gov/EPA-AIR/2001/March/Day-29/a37.htm>, last accessed September 29, 2006.

Appendix A: Calculation of composite emission factors

The composite emission factors are specified for four vehicle-pollutant categories and calculated based on the weighted average of basic emission factors for different vehicle classes from EMFAC model.

1. Diesel vehicle hot stabilized exhaust PM, in grams/mile. Composite emission factors are a weighted average of emission factors for 9 vehicle classes: Diesel MDV, Diesel LHD1, Diesel LHD2, Diesel MHD, Diesel HHD, Diesel OBUS, Diesel UBUS, Diesel SBUS and Diesel MH; using VMT proportions of these 9 vehicle classes as the weights.
2. Diesel vehicle hot stabilized exhaust TOG, in grams/mile. Composite emission factors are a weighted average of emission factors for 9 vehicle classes: Diesel MDV, Diesel LHD1, Diesel LHD2, Diesel MHD, Diesel HHD, Diesel OBUS, Diesel UBUS, Diesel SBUS and Diesel MH; using VMT proportions of these 9 vehicle classes as the weights.
3. Non-diesel vehicle hot stabilized exhaust TOG, in grams/mile. Composite emission factors are a weighted average of emission factors for All Non-CAT and All CAT vehicles; using VMT proportions of All Non-CAT and All CAT vehicles as the weights.
4. Non-diesel vehicle running loss evaporative TOG, in grams/minute. Composite emission factors are a weighted average of emission factors for All Non-CAT and All CAT vehicles; using VMT proportions of All Non-CAT and All CAT vehicles as the weights.

Appendix B: Calculation of diesel translation factors

The diesel translation factor ("Diesel Proportion" in the worksheet "CEF") is the proportion of all diesel vehicle volume (or VMT) in the total traffic volume (or VMT) of 9 vehicle classes (MDV, LHD1, LHD2, MHD, HHD, OBUS, UBUS, SBUS and MH). When computing the project total emissions, the traffic activity and the emission factors will be matched in the following way:

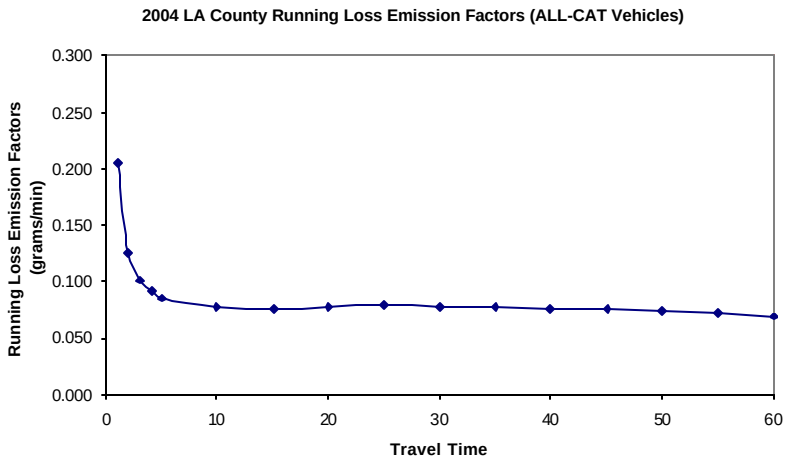
1. For diesel vehicles:
   [Truck VMT × Diesel Proportion] × Diesel composite emission factors
2. For non-diesel vehicles:
   [Truck VMT × (1 – Diesel Proportion) + Non-Truck VMT] × Non-Diesel composite emission factors

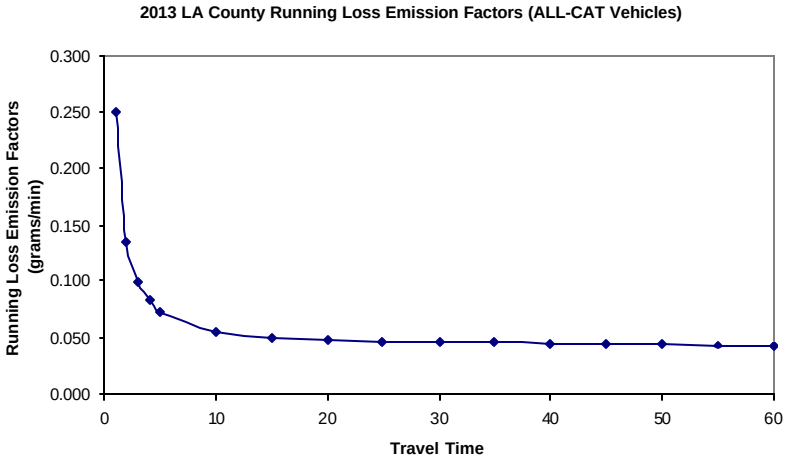
Appendix C: Calculation of running loss emission factors

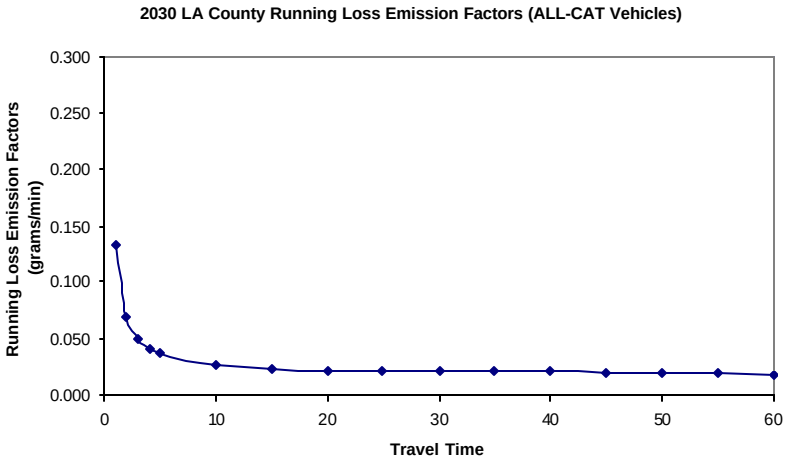
The running loss evaporative TOG factors of non-diesel vehicles are specified for different travel time bins, in the unit of grams/minute, based on EMFAC model output. In the worksheet "CEF", the composite factors for all 16 bins (from 1 minute to 60 minutes with unequal time increment) are the weighted average of running loss emission factors of All Non-CAT and All CAT vehicles (using VMT proportions of All Non-CAT and All CAT vehicles as the weights). For a project-level analysis, the method incorporated in the spreadsheet tool uses a single gram/minute emission factor associated with the 20-minute travel time bin, and that same factor is used for both the build and no-build scenarios.

The approach is determined based on the following considerations:

1. For a project analysis, instead of a complete trip analysis, we are looking at a portion of an overall trip for all vehicles using the target roadway segment; typically, it is expected that travel on a given facility (e.g., an I-5 freeway segment) is likely to take place several minutes after the vehicle is started.
2. The main analysis goal is to get a sense of whether a project alternative increases or lowers emissions, and how it compares to other alternatives; and the analysis of a trip segment should be conservative, meaning it does not over-predict the emission reduction benefits of a proposed project.
3. CARB's existing running loss emission factors are trip-based, meaning they reflect an entire trip of a certain time duration, rather than travel on a specific segment. Given that emissions are higher at the outset of a trip, the running loss factors are higher for shorter trips and lower for longer trips, as the importance of the initial emissions is diluted over a longer trip length. In general, the emission factors flatten out by about the 10 minute mark for year 2004, and by about the 20 minute mark for later analysis years such as 2013 or 2030. The figures shown on the next page illustrate the change of running loss emission factors against travel time based on Los Angeles County EMFAC runs.


2004 LA County Running Loss Emission Factors (ALL-CAT Vehicles)
Running Loss Emission Factors (grams/min)
0.300
0.250
0.200
0.150
0.100
0.050
0.000
0
10
20
30
40
50
60
Travel Time


2013 LA County Running Loss Emission Factors (ALL-CAT Vehicles)
Running Loss Emission Factors (grams/min)
0.300
0.250
0.200
0.150
0.100
0.050
0.000
0
10
20
30
40
50
60
Travel Time


2030 LA County Running Loss Emission Factors (ALL-CAT Vehicles)
Running Loss Emission Factors (grams/min)
0.300
0.250
0.200
0.150
0.100
0.050
0.000
0
10
20
30
40
50
60
Travel Time

4. The approach used here deemphasizes the impact of the initially high emissions that occur in the first few minutes of a vehicle's operation, before it arrives at the project site (e.g., the I-5 freeway), and uses emission factors more representative of travel after a vehicle has been operating for several minutes. This approach better approximates emissions for a portion of a trip.
5. It is also assumed that a project (e.g., adding lanes to the I-5 freeway) will have a greater impact on the travel time, rather than the running loss emission factor, since the travel at that point is from hot stabilized vehicles. Looking at the running loss emission factor curve in the above figures, it is found that after approximately 10 to 20 minutes, the emission factors flatten out, as the impact from the first few minutes of travel is diluted by the rest of the vehicle's trip.
6. Therefore, the approach in the spreadsheet tool is to pick an emission factor that represents the stable part of the curve, and, by 20 min, the factors are relatively stable across many analysis years. This approach is conservative because the emission factors are near their lowest point. So, any improvement in travel, for example, a reduction in travel time of 5 minutes across the affected facility, will be multiplied by a small emission factor. The result will be a modest decrease in emissions.

In summary, the key points of the approach in the spreadsheet tool for handling running loss emission factors are:

- Selecting a single non-diesel running loss emission factor for all analyses – the 20-minute running loss factor.
- Selecting the emission factor based on finding a factor that represents the "stable" part of the emission factor curve, given that project analyses examine a portion of a trip, rather than an entire trip, and one where the vehicle is likely to have been operating for several minutes or more.
- Erring on the side of being conservative in terms of estimating emission reduction benefits from a proposed project.

Appendix D: Determination of air toxic speciation factors

The air toxics speciation factors (for acetaldehyde, 1,3-butadiene, acrolein, benzene and formaldehyde, respectively) provided by CARB include a large range of data from year 1990 to 2020, classified by vehicle class, technology type and fuel type. For a project-level MSAT analysis, the methodology composites speciation factors using an approach that conservatively selects the highest gram/mile emission rate appropriate for the vehicle technology types under consideration. In other words, the speciation factors used in the spreadsheet tool are the worst case (meaning they generate the highest emissions) of the options available. This appendix briefly describes how the composite speciation factors were prepared.

1. Speciation factors for diesel hot stabilized exhaust TOG: CARB speciation information provides a single speciation factor each for benzene, 1,3-butadiene, acetaldehyde and formaldehyde, respectively, for all hot stabilized diesel exhaust emissions (independent of vehicle type). The speciation factors for year 2021 to 2030 are assumed to be the same as that for year 2020. The speciation factors for acrolein are not available based on CARB data.
2. Speciation factors for non-diesel hot stabilized exhaust TOG: three primary vehicle classes are considered (i.e., light-duty auto, light-duty truck 1 and light-duty truck 2); and to be conservative, the worst-case speciation factor identified by CARB (i.e., the factor producing the highest MSAT emissions) is selected for each of the five air toxics, respectively, by calendar year. The speciation factors based on the CARB data are not available for year 2011, 2013, 2014, 2016, 2017, 2019, 2021-2030. The corresponding speciation factors are assumed to be the same as that for their previous year.
3. Speciation factors for non-diesel evaporative running loss TOG: the CARB light-duty automobile (LDA) and light-duty truck (LDT) speciation factors are the same across analysis years of 1997 to 2003, for each of benzene and 1,3-butadiene. These constant speciation factors are assumed unchanged after year 2003. The speciation factors for acetaldehyde, acrolein and formaldehyde are not applicable for this emission category.

Appendix E: Calculation of total project MSAT emissions

The total project MSAT emissions are calculated based on the following formulas:

- **Diesel PM** = Diesel VMT × Diesel exhaust PM factor

- **Benzene** = Diesel VMT × Diesel exhaust factor + Non-diesel VMT × Non-diesel exhaust factor + Non-diesel volume × Vehicle travel time × Non-diesel running loss factor

- **1,3-Butadiene** = Diesel VMT × Diesel exhaust factor + Non-diesel VMT × Non-diesel exhaust factor + Non-diesel volume × Vehicle travel time × Non-diesel running loss factor

- **Acetaldehyde** = Diesel VMT × Diesel exhaust factor + Non-diesel VMT × Non-diesel exhaust factor

- **Acrolein** = Non-diesel VMT × Non-diesel exhaust factor

- **Formaldehyde** = Diesel VMT × Diesel exhaust factor + Non-diesel VMT × Non-diesel exhaust factor