

*Use of MOBILE6 to Develop & Quality Assure
"Link-Based" Inventories for the 8-County
Houston/Galveston Nonattainment Area*

*EPA Mobile Source Present and
Future Models Workshop*

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November 7, 2002

On-Road Mobile Sources Emissions Inventory Development

- Emissions inventory is combination of:
 - Level of Activity – Vehicle Miles Traveled (VMT)
 - Emission Rate per Unit of Activity – Grams per Mile (gpm)
- “Macro” or “County-Level” Emissions Inventories:
 - Total county VMT multiplied by composite emission rates
 - Total freeway VMT multiplied by freeway emission rates
 - Total arterial VMT multiplied by arterial emission rates
- “Micro” or “Link-level” Emissions Inventories:
 - Travel demand model segments roadway network into “links”
 - VMT & Average Speed estimated for each link by hour
 - Distribution of VMT by 28 MOBILE6 vehicle types estimated
 - NO_x, VOC, & CO emissions determined for each link by hour
 - Needed for spatial and temporal allocations of emissions

2000 & 2007 Houston/Galveston Area MOBILE6 Link-Based Inventory Development August 22–September 1 Episode Days

- Contracted to Texas Transportation Institute (TTI):
 - 2000 Current Speed Limit Scenario
 - 2007 Current Speed Limit Scenario
 - 2007 55 mph Speed Limit Scenario
- Roadway “link-based” emissions for each:
 - County
 - Hour (Central Daylight Time)
 - Episode Day
- Mobile emissions broken down by:
 - 28 Vehicle Types (LDGV, LDGT1, LDGT2, etc.)
 - 13 Functional Classes (“Roadway Types”)
 - 14 Pollutant Types (NO_x, CO, VOC, Evaporative, etc.)

Harris County
MOBILE6 24-Hour Composite Emissions
Wednesday August 30, 2000 Episode Day

<i>Harris County</i>	<i>NO_x (tpd)</i>	<i>VOC (tpd)</i>	<i>CO (tpd)</i>
<i>TTI Hourly Link Analysis</i>	177.0	107.9	1,459.6
<i>24-Hour Composite Analysis</i>	174.0	107.1	1,450.3
<i>Relative Difference</i>	-1.7%	-0.7%	-0.6%

***Harris County
MOBILE6 24-Hour Composite Emissions
2007 Wednesday August 30th Episode Day***

<i>Harris County</i>	<i>NO_x (tpd)</i>	<i>VOC (tpd)</i>	<i>CO (tpd)</i>
<i>TTI Hourly Link Analysis</i>	101.5	59.7	864.4
<i>24-Hour Composite Analysis</i>	100.4	59.4	861.1
<i>Relative Difference</i>	-1.1%	-0.6%	-0.4%

Harris County
MOBILE6 24-Hour Composite Emissions
2007 55 mph Scenario - Wednesday August 30th

<i>Harris County</i>	<i>NO_x (tpd)</i>	<i>VOC (tpd)</i>	<i>CO (tpd)</i>
<i>TTI Hourly Link Analysis</i>	98.1	60.0	844.5
<i>24-Hour Composite Analysis</i>	96.4	59.8	836.4
<i>Relative Difference</i>	-1.7%	-0.4%	-1.0%

MOBILE6 Activity Commands For Correlation Between Hourly Link & 24-Hour Composite Emission Analyses

- VMT BY FACILITY
 - MOBILE6 User's Guide, Section 2.8.8.2.a, Page 72
 - Hourly distribution of VMT by vehicle class to roadway types
- VMT BY HOUR
 - MOBILE6 User's Guide, Section 2.8.8.2.b, Page 73
 - Hourly distribution of total VMT
- SPEED VMT
 - MOBILE6 User's Guide, Section 2.8.8.2.c, Page 74
 - Hourly distribution of VMT by average speed for arterials and freeways
 - 14 speed "bins" from 2.5-65 mph

***Comparison of MOBILE6 Activity Commands With
Link Inventory Totals for Harris County
Wednesday August 30, 2000 Episode Day***

<i>Command</i>	<i>NO_x (tpd)</i>	<i>VOC (tpd)</i>	<i>CO (tpd)</i>
<i>VMT BY FACILITY</i>	172.9	113.6	1461.9
<i>VMT BY HOUR</i>	169.4	121.6	1418.6
<i>SPEED VMT</i>	170.8	116.0	1394.0
<i>All 3 Off</i>	169.2	120.6	1411.4
<i>All 3 On</i>	174.0	107.1	1450.3
<i>Link Inventory</i>	177.0	107.9	1459.6

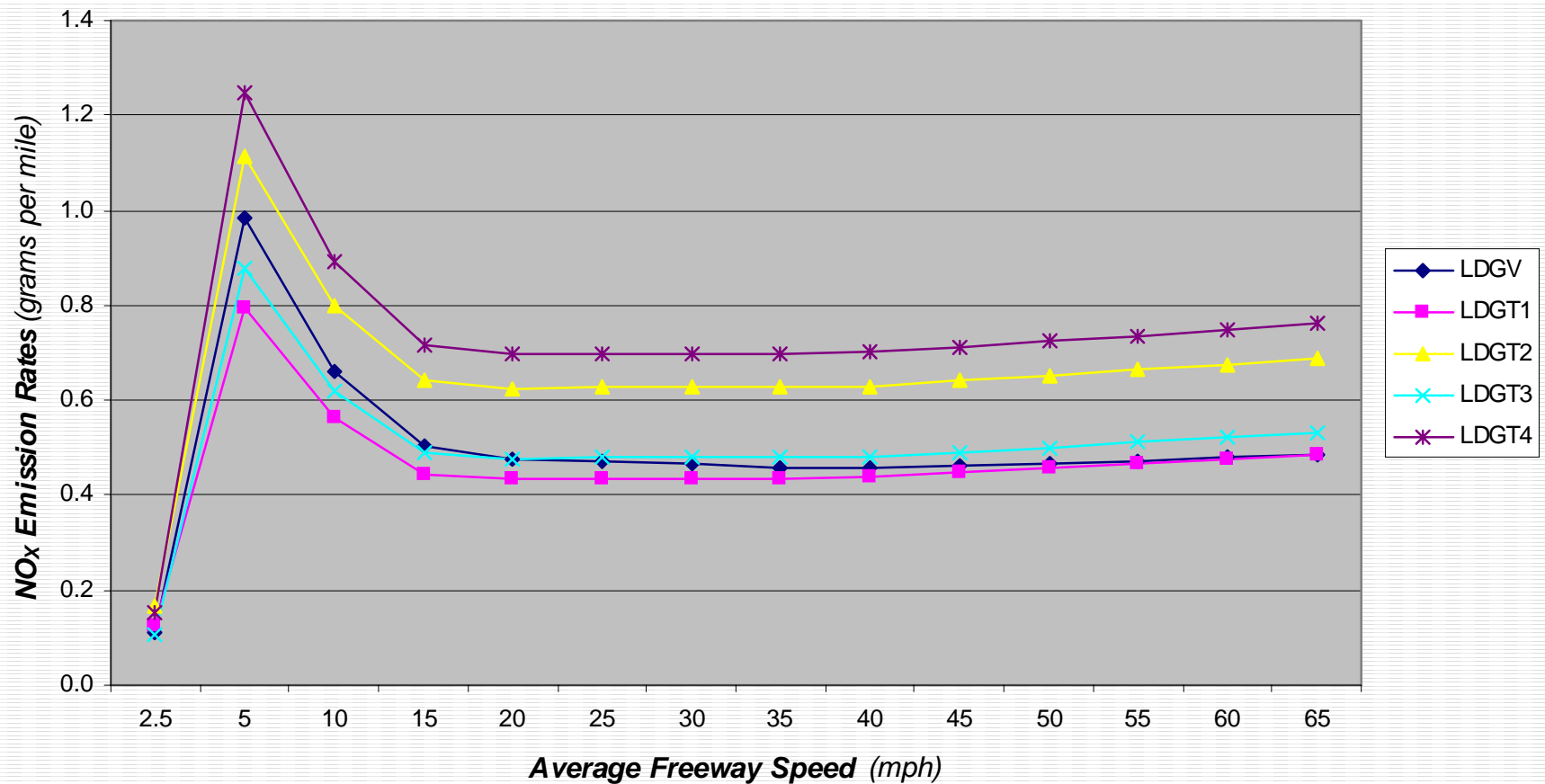
***Comparison of MOBILE6 Activity Commands With
Link Inventory for Harris County
Wednesday August 30, 2000 Episode Day***

<i>Command</i>	<i>NO_x</i>	<i>VOC</i>	<i>CO</i>
<i>VMT BY FACILITY</i>	-2.3%	5.2%	0.2%
<i>VMT BY HOUR</i>	-4.3%	12.7%	-2.8%
<i>SPEED VMT</i>	-3.5%	7.5%	-4.5%
<i>All 3 Off</i>	-4.4%	11.7%	-3.3%
<i>All 3 On</i>	-1.7%	-0.7%	-0.6%
<i>Link Inventory</i>	NA	NA	NA

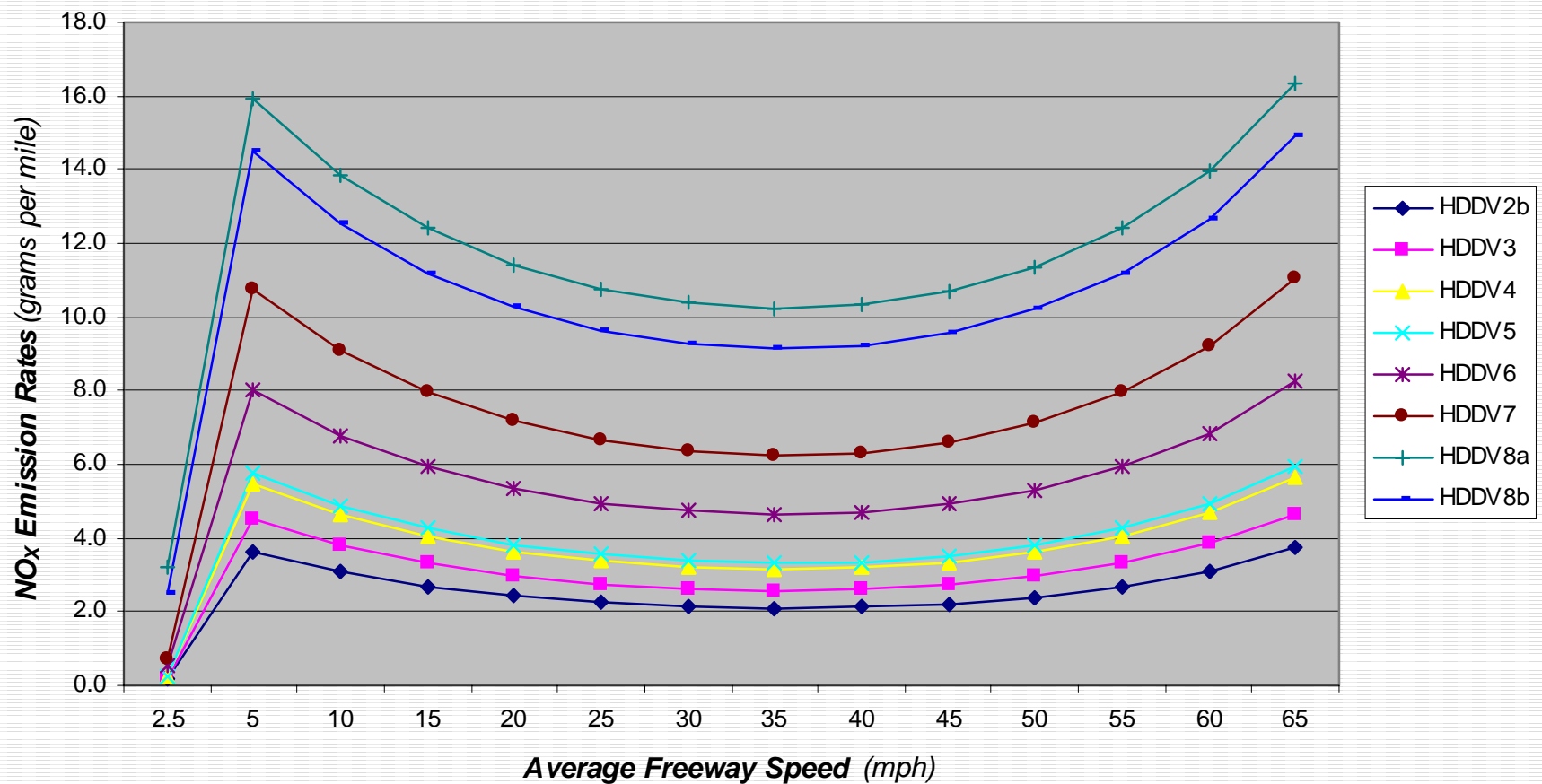
***Comparison of MOBILE6 "All 3 On" Scenario With
Link Inventory by Vehicle Class for Harris County
Wednesday August 30, 2000 Episode Day***

<i>Vehicle Group</i>	<i>NO_x</i>	<i>VOC</i>	<i>CO</i>
<i>LDGV & LDGT1-4</i>	-0.6%	-0.5%	-0.4%
<i>HDGV2b-8b</i>	-0.2%	-3.9%	-5.4%
<i>LDDV & LDDT1-4</i>	-3.7%	-1.3%	-2.1%
<i>HDDV2b-8b</i>	-3.6%	-2.1%	-4.1%
<i>MC</i>	-1.1%	-2.9%	-10.0%
<i>HDGB</i>	0.1%	-2.0%	-4.5%
<i>HDDBT</i>	-2.1%	-5.0%	-5.9%
<i>HDDBS</i>	-2.1%	-5.0%	-5.9%
<i>Total</i>	-1.7%	-0.7%	-0.6%

MOBILE6 Freeway NO_x Emission Rates 2007 Harris County - Wednesday August 30th Episode Day Light-Duty Gasoline Vehicles & Trucks



MOBILE6 Freeway NO_x Emission Rates 2007 Harris County - Wednesday August 30th Episode Day Heavy-Duty Diesel Vehicles



MOBILE6 Sensitivity Runs Harris County Wednesday August 30, 2000

- Total VMT is primary factor affecting overall emissions
 - Based on local travel demand model from Houston-area MPO
 - Adjustments made for time-of-year and day-of-week
- Distribution of VMT by Vehicle Types (“VMT Mix”)
 - Due to relatively high emission rates, NO_x emissions (but not VOC and CO) are sensitive to heavy-duty diesel VMT mix
 - Inventory not very sensitive to VMT distribution among light-duty gasoline vehicles & trucks (cars, pickups, & SUVs)
 - Local vehicle classification data “converted” to 28 MOBILE6 types
 - VMT mix varies by county, roadway type, time-of-day, & day-of-week
 - Urban versus rural VMT mix important for HDDV8a & HDDV8b classes
- Humidity Effects
 - Increased humidity levels reduce NO_x emissions due to “quenching” of combustion chamber temperatures
 - MOBILE6 accepts absolute (not relative) humidity input only

MOBILE5 & MOBILE6

Vehicle Classification Summary








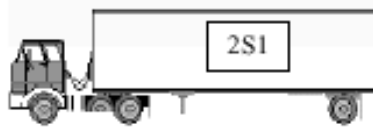
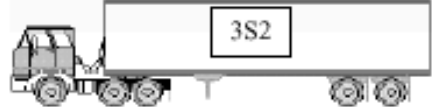
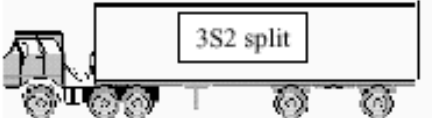





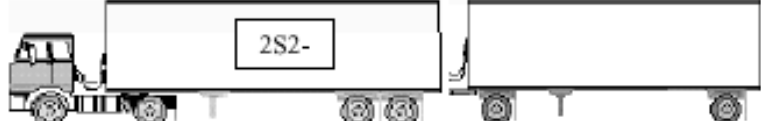


<i>MOBILE5</i>	<i>MOBILE6</i>		<i>MOBILE5</i>	<i>MOBILE6</i>		<i>MOBILE5</i>	<i>MOBILE6</i>
LDGV	LDGV		HDGV	HDGV2b		HDDV	HDDV2b
LDGT1	LDGT1			HDGV3			HDDV3
	LDGT2			HDGV4			HDDV4
LDGT2	LDGT3			HDGV5			HDDV5
	LDGT4			HDGV6			HDDV6
LDDV	LDDV			HDGV7			HDDV7
LDDT	LDDT12			HDGV8a			HDDV8a
	LDDT34			HDGV8b			HDDV8b
MC	MC			HDGB			HDDBT
							HDDBS

Harris County

*MOBILE6 24-Hour Composite NO_x Emission Rates
Wednesday August 30, 2000 Episode Day*

MOBILE6	NO_x (gpm)	MOBILE6	NO_x (gpm)	MOBILE6	NO_x (gpm)
LDGV	0.9756	HDGV2b	4.6860	HDDV2b	4.3304
LDGT1	0.8843	HDGV3	5.2338	HDDV3	5.2177
LDGT2	1.0826	HDGV4	4.8755	HDDV4	6.1550
LDGT3	0.9049	HDGV5	6.7443	HDDV5	6.6584
LDGT4	1.1464	HDGV6	6.5056	HDDV6	10.4246
LDDV	1.7965	HDGV7	6.7879	HDDV7	13.1463
LDDT12	3.0551	HDGV8a	7.5975	HDDV8a	23.4679
LDDT34	1.2921	HDGV8b	10.0526	HDDV8b	25.8863
MC	0.9650	HDGB	7.7840	HDDBT	22.7264
				HDDBS	14.6388

TxDOT On-Road Data Collection FHWA Vehicle Classifications

<p>(1) Motorcycles</p> 	<p>(2) Passenger Cars (w/ 1 or 2 axle trailers)</p> 	<p>(3) Two Axle, 4 Tire Single Units. Pickup or Van w/ 1 or 2 axle trailers</p> 	<p>(4) Buses</p> 	
<p>(5) 2D – Two Axle, Six Tire Single Unit Includes Handicapped Equipped & Mini School Buses.</p> 		<p>(6) 3 Axles Single Unit</p> 	<p>(7) 4, or more, Axles Single Unit</p> 	<p>(8) 3-4 Axles, Single Trailer</p> 
<p>(9) 5 Axles Single Trailer</p>  		<p>(10) 6, or more, Axles Single Trailer</p>  		 
<p>(11) 5, or less, Axles Multi-Trailers</p> 			<p>(12) 6 Axles Multi-Trailers</p> 	
<p>(13) 7, or More, Axles Multi-Trailers</p> 				

1997-98 FHWA Heavy-Duty Truck Activity Study Conducted in California Urban Versus Rural VMT

Table 8. Sample Truck Activity Data (VMT) in Urban and Rural Areas

	Weight Class					
Urban Area Class	T4 8.5-10K	T5 10-14K	T6 14-33K	T7 33-60K	T8 >60K	Totals
Large Urban (200,000+)	24 0%	-- 0%	1 0%	325 0%	119 0%	469 1%
Urbanized (50,000 to 200,000)	953 1%	527 1%	2,459 3%	2,785 3%	1,516 2%	8,240 9%
Small Urban (5,000 to 50,000)	740 1%	847 1%	5,176 6%	18,486 21%	9,649 11%	34,897 40%
Rural	739 1%	110 0%	2,547 3%	23,239 27%	16,544 19%	43,179 50%
Weight Class Total	2,456 3%	1,484 2%	10,182 12%	44,834 52%	27,828 32%	86,784 100%

MOBILE6 Light-Duty Gasoline NO_x Emissions Harris County VMT Mix Effects Wednesday August 30, 2000 Episode Day

- Light-Duty Gasoline Fleet (LDGs)
 - Consists of most passenger cars, pickup trucks, and SUVs
 - MOBILE5 Classes: LDGV, LDGT1, & LDGT2
 - MOBILE6 Classes: LDGV, LDGT1, LDGT2, LDGT3, & LDGT4
 - Comprises roughly 91% of overall VMT
- Inventory not very sensitive to VMT mix among LDGs
 - TTI VMT Mix: 91.2 tpd of NO_x
 - EPA 2000 Default VMT Mix: 91.6 tpd of NO_x
 - ED 60/25/15 VMT Mix: 91.1 tpd of NO_x
- Little difference in NO_x emission rates among LDGs
 - Emission standards among LDGs converging
 - Increased purchases of SUVs in fleet
 - Passenger cars relatively “older” than SUVs

Harris County
MOBILE6 Light-Duty Gasoline VMT Mix Summary
Wednesday August 30, 2000 Episode Day

VMT Mix Scenario	NO_x (tpd)	VOC (tpd)	CO (tpd)
<i>TTI/TxDOT</i>	91.2	100.0	1379.4
<i>MOBILE6 Default</i>	91.6	99.3	1392.3
<i>60/25/15</i>	91.1	97.3	1369.8
<i>TTI/TxDOT</i>	NA	NA	NA
<i>MOBILE6 Default</i>	0.44%	-0.73%	0.94%
<i>60/25/15</i>	-0.04%	-2.72%	-0.69%

MOBILE6

Absolute Humidity Input Calculations

- Option 1: Use lowest hourly absolute humidity
 - Better for “low” humidity areas (e.g., West Texas)
- Option 2: Use highest value that does not result in any hourly relative humidity exceeding 100%
 - Better for “high” humidity areas (e.g., Houston, Beaumont)
- Option 3: Average of Options #1 and #2
 - Better for “moderate” humidity areas (e.g., Austin, Dallas)
 - Not currently included in MOBILE6 guidance document
- TCEQ Approach to Absolute Humidity Inputs
 - Calculate hourly values from temperature & relative humidity
 - Determine 24-hour inputs for Options 1-3
 - Calculate predicted hourly relative humidity for Options 1-3
 - Compare predicted to observed relative humidity values by hour to choose best option
 - Prefer option of inputting observed hourly relative humidity

MOBILE6 Sensitivity to Humidity Input Harris County Wednesday August 30, 2000

- Absolute Humidity Input of 142.4 grains/pound
 - Compared with default:

	<u>142.4</u>	<u>75.0</u>
• NO _x 8% lower	174.0 tpd	189.1 tpd
• VOC 0.8% higher	107.1 tpd	106.3 tpd
• CO 6% higher	1450.3 tpd	1367.6 tpd
- Only LDGV, LDGT1-4, & MC Classes Respond to Humidity
 - NO_x emissions drop ~14.2% for light-duty gasoline classes
 - No response from diesel and heavy-duty gasoline classes
 - 40 CFR Part 86.1342-90 Diesel Emissions Correction Factor
 - $K = 1 / \{1 - [0.0026 * (\text{Absolute Humidity} - 75)]\}$
 - 40 CFR Part 86.1342-90 Gasoline Emissions Correction Factor
 - $K = 1 / \{1 - [0.0047 * (\text{Absolute Humidity} - 75)]\}$

Suggestions for Further Investigation MOBILE6 Inputs & Emission Rate Estimation

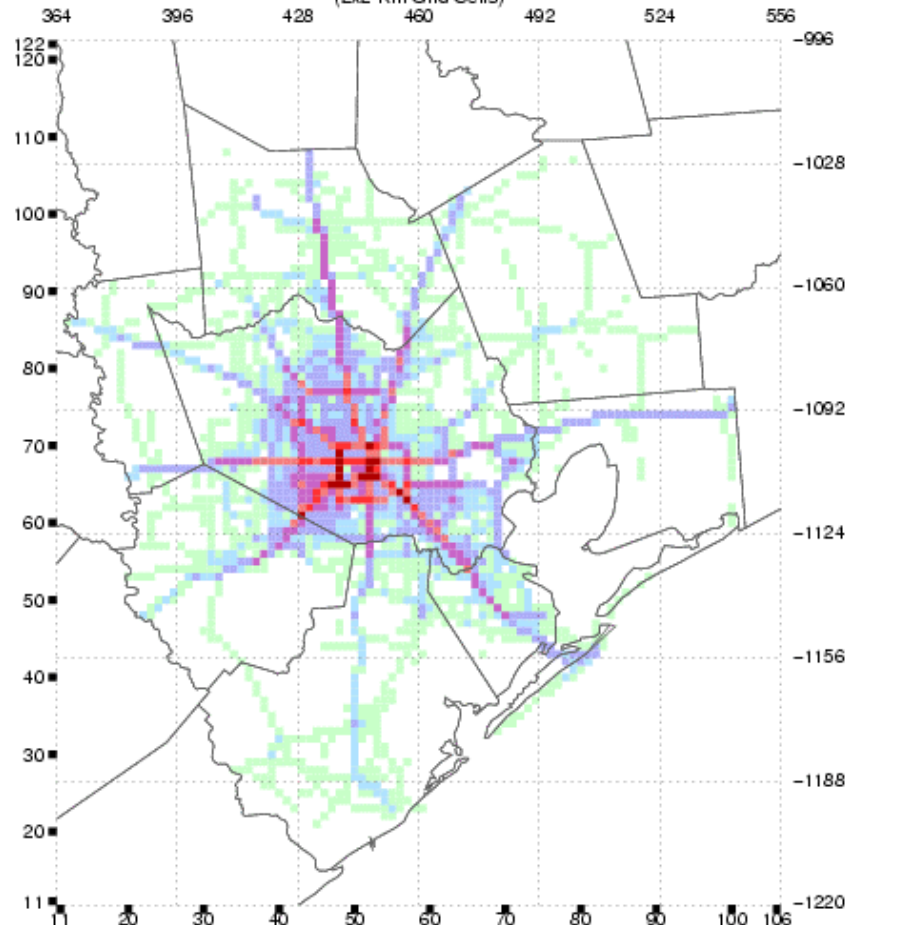
- MOBILE6 VIN decoder
 - Improved local age distribution inputs from registration data
 - Validate and/or refine VMT mix inputs for “lighter-duty” vehicles
 - Cross-reference remote sensing license plate data with VINs
 - Possible application for some heavy-duty classes?
- Heavy-Duty Vehicle Activity Data
 - Validate and/or refine conversion of FHWA-to-MOBILE6 classification categories
 - Other methods for “fine tuning” heavy-duty diesel VMT mix?
- Address correlation of diesel and heavy-duty gasoline emissions to humidity levels

2000 MOBILE6 August 30th NO_x Emissions

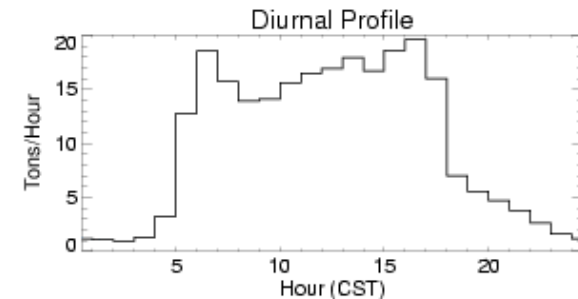
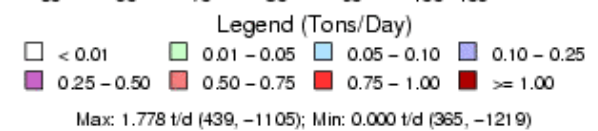
- **8-County Geographic Distribution**
- **County Totals**
- **Temporal Profile**
 - Central Standard Time
 - Rush Hour Peaks
 - Mid-Day Hump From Heavy-Duty Diesel Trucks

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8-County HGA On-Road Mobile Source 24-Hour NO_x Emissions
2000 Base Case, Wednesday August 30th Episode Day
(2x2 Km Grid Cells)



Emissions Plotted	
County	Tons/Day
Brazoria	11.66
Chambers	5.96
Fort Bend	13.46
Galveston	10.99
Harris	177.47
Liberty	4.66
Montgomery	15.69
Waller	4.15
HG SUBTOTAL:	244.06
MAP TOTAL:	245.77

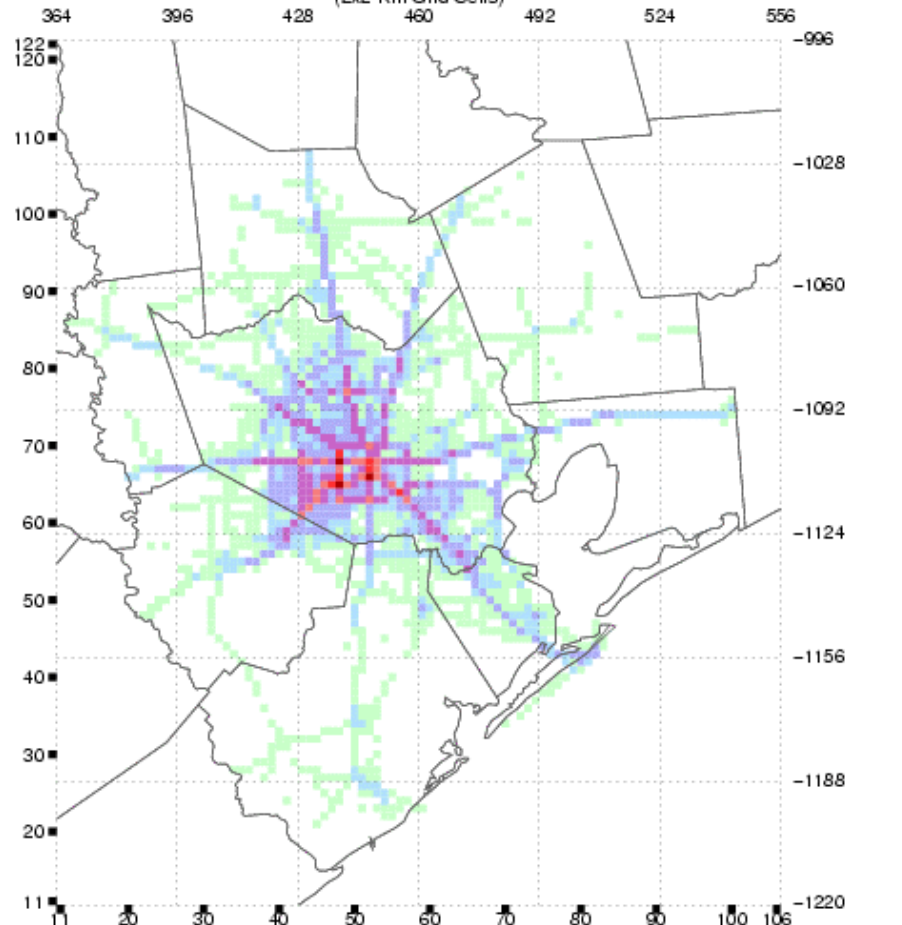


2000 MOBILE6 August 30th VOC Emissions

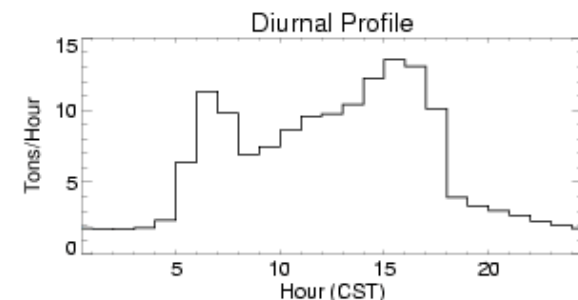
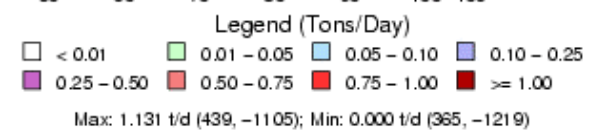
- **8-County Geographic Distribution**
- **County Totals**
- **Temporal Profile**
 - Central Standard Time
 - Rush Hour Peaks
 - Dominated by Gasoline Vehicles

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8-County HGA On-Road Mobile Source 24-Hour VOC Emissions
2000 Base Case, Wednesday August 30th Episode Day
(2x2 Km Grid Cells)



Emissions Plotted	
County	Tons/Day
Brazoria	7.43
Chambers	3.20
Fort Bend	8.37
Galveston	7.38
Harris	113.06
Liberty	3.06
Montgomery	9.59
Waller	2.72
HG SUBTOTAL:	154.81
MAP TOTAL:	155.97



8-County Houston/Galveston Area

On-Road Mobile Inventory Data for 2000 & 2007

- **TNRCC HGA Air Quality Science Evaluation Website**
 - http://www.tnrcc.state.tx.us/air/aqp/airquality_photomod.html#section4
 - Access MOBILE6 data on FTP site through “On-Road Mobile” link
 - Attachment 6 to the Technical Support Document contains On-Road Mobile Source Inventory discussion from pages 5-73
 - 2000 MOBILE5b Inventory Page 9
 - 2000 MOBILE6 Inventory Page 12
 - 2007 MOBILE6 Inventory Page 17
 - 2007 55 mph Speed Limit Benefits Page 20
 - MOBILE6 Humidity Inputs Page 28
 - VMT Mix Discussion Page 33
 - VMT Mix from SUVs Page 36
 - VMT Mix from Heavy-Duty Vehicles Page 42
 - EPS2X Processing of Mobile Inventories Page 45
 - Quality Assurance of Gridded Mobile Inventories Page 61
 - On-Road Mobile Inventory Outside of HGA Page 72
 - Attachments 6-1, 6-2, & 6-3 are TTI reports for 2000 MOBILE5b, 2000 MOBILE6, & 2007 MOBILE6 inventories.