

Development of real-world data for MOVES Development : The Houston Drayage Activity Characterization Study

Carl Fulper, Connie Hart, Jim Warila, John Koupal
OTAQ, US Environmental Protection Agency

Sandeep Kishan, Michael Sabisch, Tim DeFries
Eastern Research Group

TRB
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Houston Drayage Study: Sponsors & Project Team

- U.S. EPA's Office of Transportation & Air Quality (OTAQ)
- Houston-Galveston Area Council (HGAC)
- Texas Commission on Environmental Quality (TCEQ)
- Port of Houston Authority
- Contractors: Eastern Research Group, Sensors Inc., University of Denver



Houston Port Study - Objectives

- **Characterize activity and emissions of HD “drayage” trucks in Houston**
 - Improve Houston inventory/transportation modeling
 - Currently Drayage vehicles are part of MOVES as part of source types: short/long haul single/combo trucks
 - Texas wanted to study the activity around the Ports to characterize the activity/emissions in and around the Ports
 - EPA wants to use data to understand the real world activity/emissions from such trucks for future updates to MOVES
 - Pilot project for users to expand MOVES by creating new “source type”

Customizing MOVES

- **Over 100 database tables store default data**
 - National default emission, fleet & activity data
 - County level fuel & meteorology data
 - Vehicle classes, road types also table driven
- **User encouraged to customize with local data**
 - “Data Managers” allow easy customization of more common inputs (VMT, age distribution, speed distribution etc).
 - Focus of EPA’s current technical guidance
- **User can also make more fundamental changes**
 - E.g., can add vehicle classes and road types with supporting data
 - This study is a pilot on how to do this
 - EPA has not issued any particular guidance on this yet

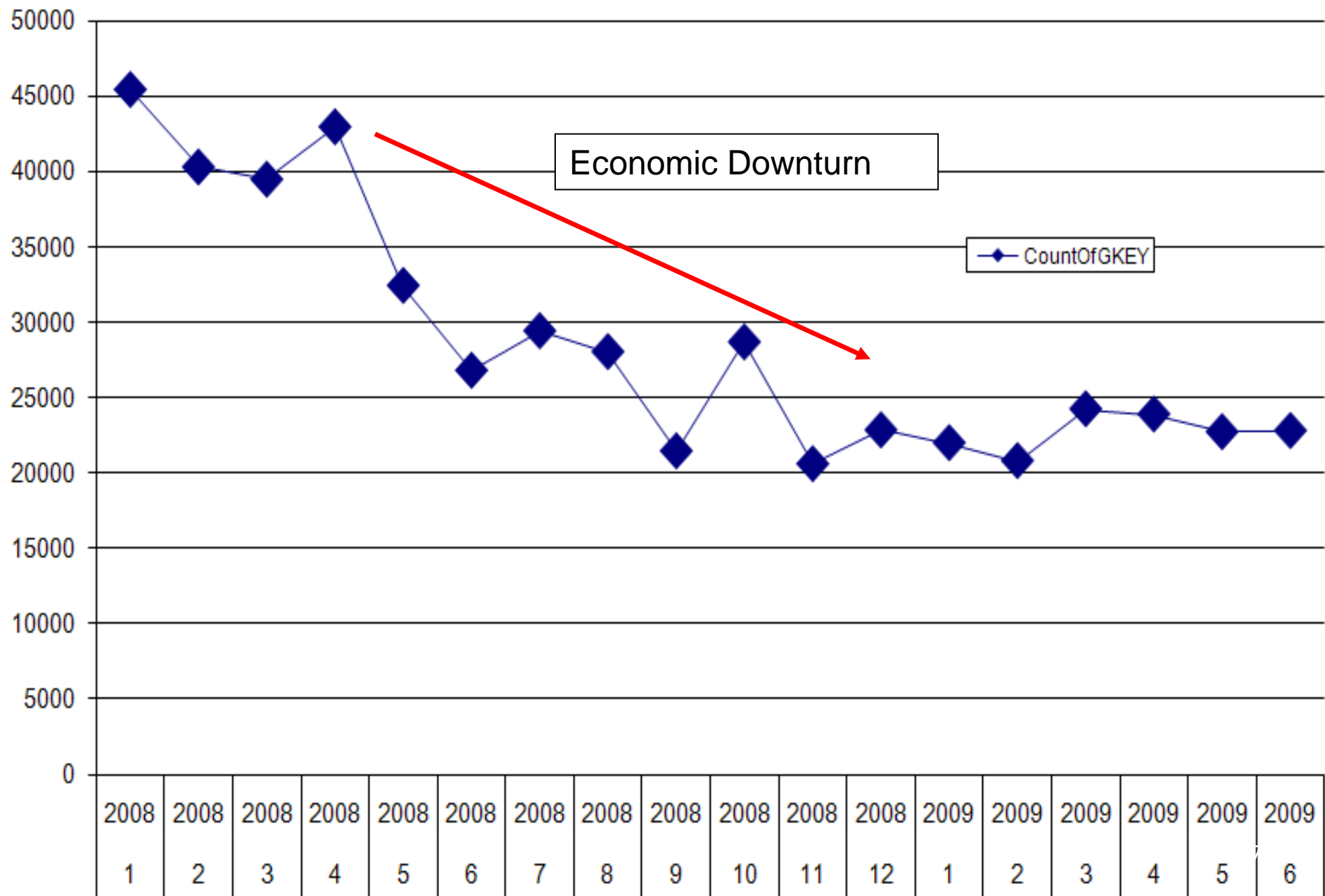
Adding Drayage Trucks to MOVES – Data Required

Data Type	Data Source	Key MOVES MySQL Tables
Population	Port Data, Registration Records	SourceTypeYear, SourceTypeAgeDistribution
Activity	PAMS, PEMS	RoadTypeDistribution
Drive Cycle	PAMS, PEMS	AvgSpeedDistribution, DriveScheduleSecond
Temporal Allocation	PAMS, PEMS	Day/Month/HourVMTFraction
Emissions	PEMS, RSD	EmissionRatebyAge

Major Activities Conducted

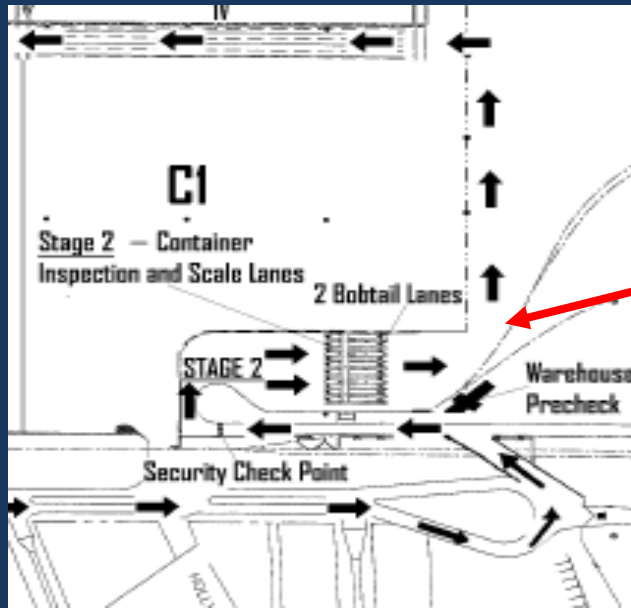
- **Analyzed 18 months of Port Entry data (June '09)**
- **RSD screening study (July '09)**
- **Analysis of RSD data (August - December '09)**
- **Develop Sampling Methodology (Oct '09)**
- **Develop Recruitment Methodology (Oct '09)**
- **Mockups & Develop Testing Procedures (Nov '09)**
- **Recruitment & Preliminary Visits (Nov '09)**
- **Field Testing (December '09 – March '10)**
 - Portable Emissions 1-2 day each vehicle
 - Portable Activity 1 week/vehicle

Number of trucks entering Barbour's Cut Jan 08 – Jun 09



RSD Screening Study

- Conducted by University of Denver
- 2 weeks in July 2009
- Gaseous pollutants (CO₂, CO, THC & NO_x)
- Measured at entry gate of Barbour's Cut port
- Matched license plates to TX DOT database
- RSD readings: 4,032
- Unique vehicles: 1,877

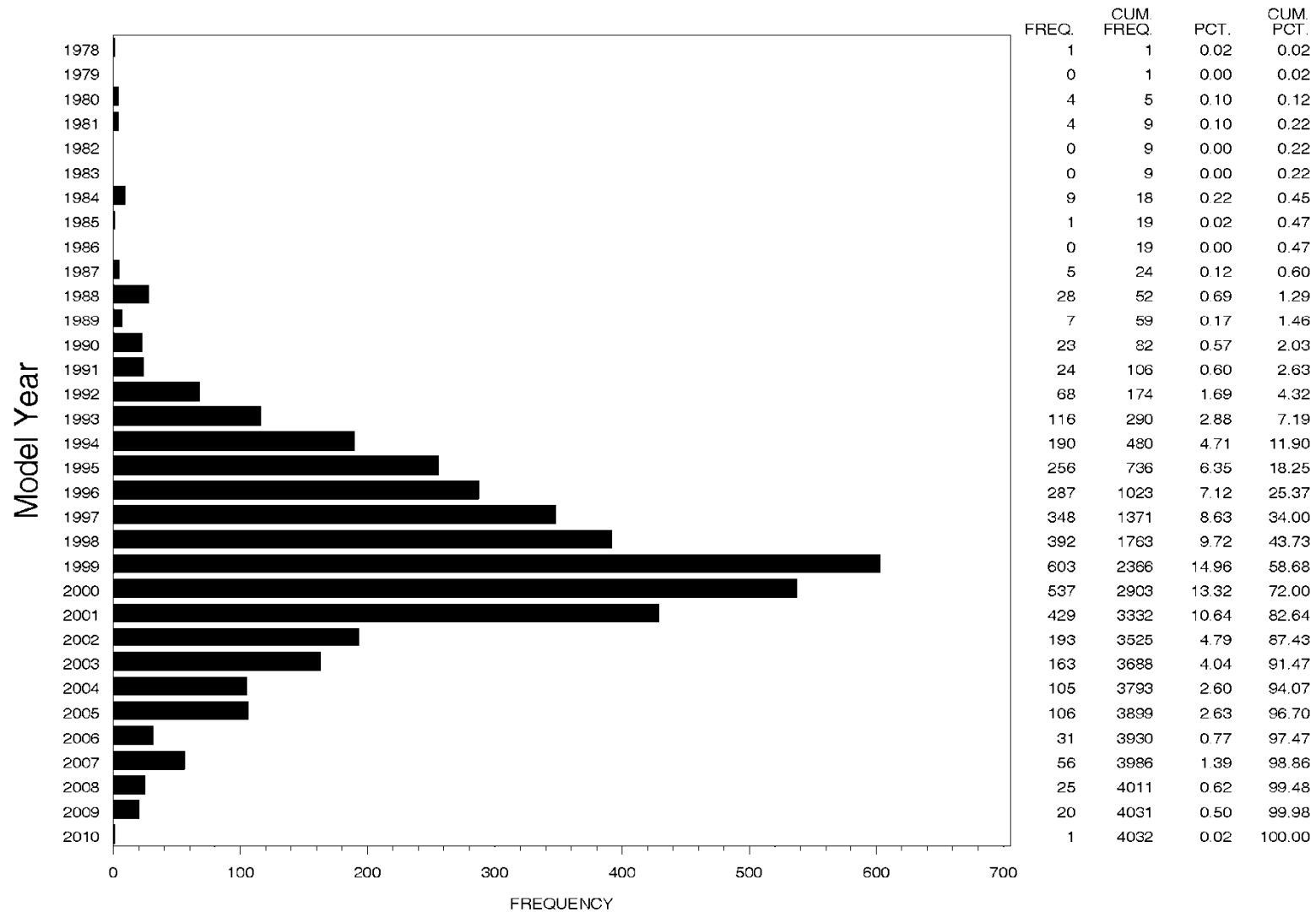


Location of RSD equipment

RSD equipment

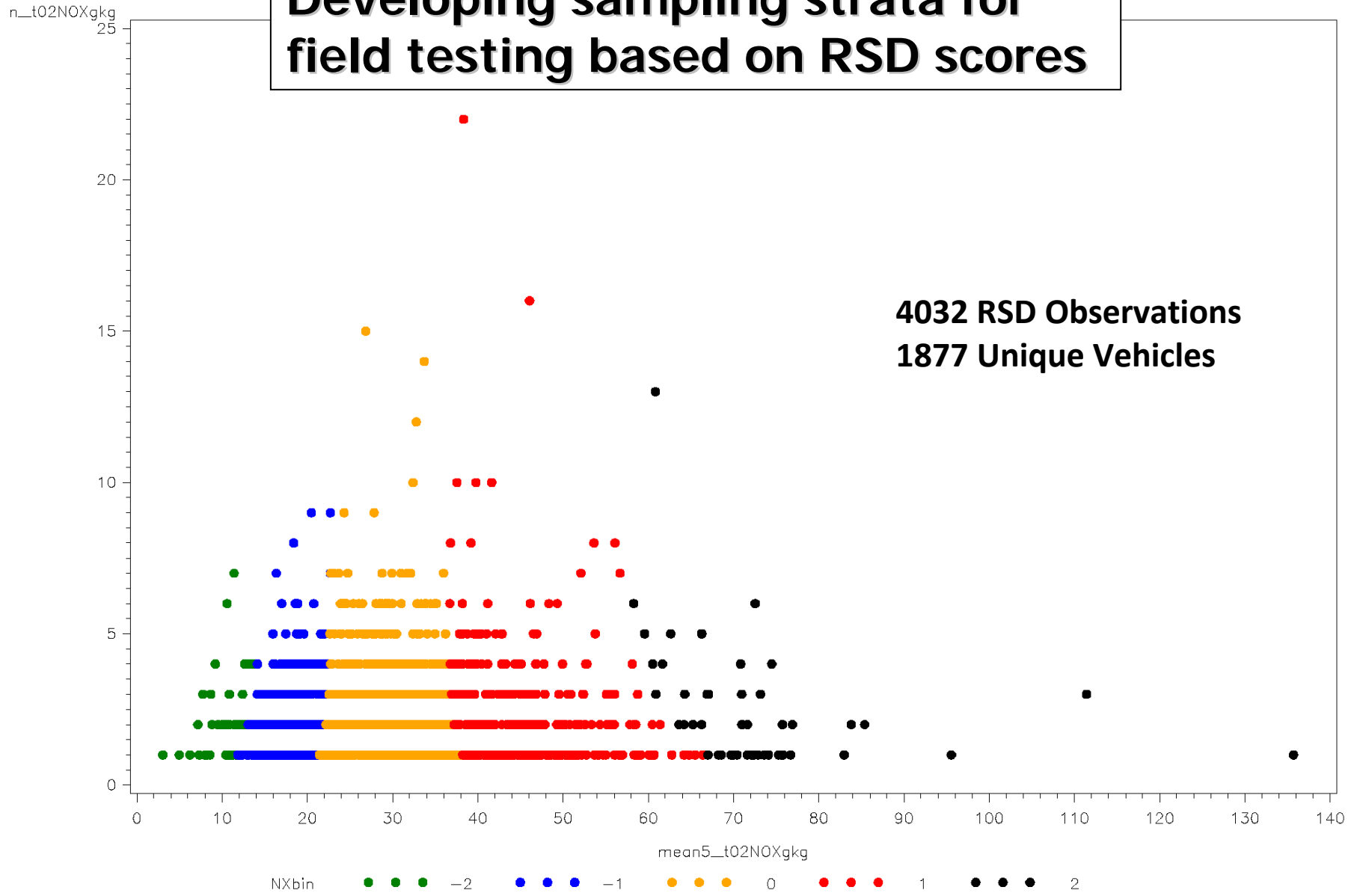


Distribution of Drayage Vehicle Model Years

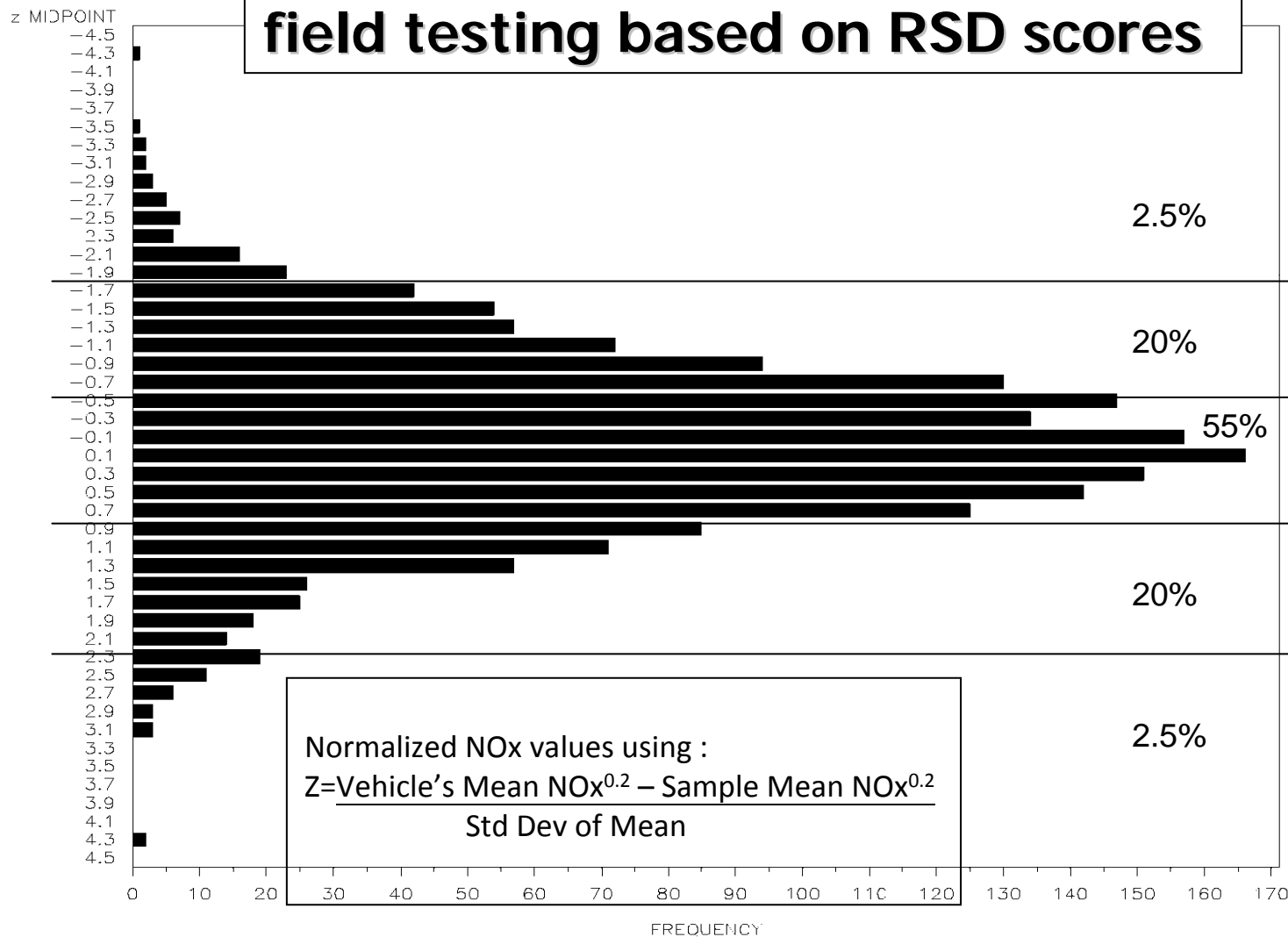


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Developing sampling strata for field testing based on RSD scores



Developed sampling strata for field testing based on RSD scores



FREQ.	CUM. FREQ.	PCT.	CUM. PCT.
0	0	0.00	0.00
1	1	0.05	0.05
0	1	0.00	0.05
0	1	0.00	0.05
0	1	0.00	0.05
1	2	0.05	0.11
2	4	0.11	0.21
2	6	0.11	0.32
3	9	0.16	0.48
5	14	0.27	0.75
7	21	0.37	1.12
6	27	0.32	1.44
16	43	0.85	2.29
23	66	1.23	3.52
42	108	2.24	5.75
54	162	2.88	8.63
57	219	3.04	11.67
72	291	3.84	15.50
94	385	5.01	20.51
130	515	6.93	27.44
147	662	7.83	35.27
134	796	7.14	42.41
157	953	8.36	50.77
166	1119	8.84	59.62
151	1270	8.04	67.66
142	1412	7.57	75.23
125	1537	6.66	81.89
85	1622	4.53	86.41
71	1693	3.78	90.20
57	1750	3.04	93.23
26	1776	1.39	94.62
25	1801	1.33	95.95
18	1819	0.96	96.91
14	1833	0.75	97.66
19	1852	1.01	98.67
11	1863	0.59	99.25
6	1869	0.32	99.57
3	1872	0.16	99.73
3	1875	0.16	99.89
0	1875	0.00	99.89
0	1875	0.00	99.89
0	1875	0.00	99.89
0	1875	0.00	99.89
0	1875	0.00	99.89
0	1875	0.00	99.89
2	1877	0.11	100.00
0	1877	0.00	100.00

Developed Model Year and NOx Bins for Field Set and Desired Stratified Sample

Field Set	NXbin					
	-2	-1	0	1	2	
1978-1993	8	23	69	20	2	122
1994-1997	1	34	259	175	25	494
1998-2003	11	234	636	168	16	1065
2004-2006	11	65	43	8	4	131
2007-2010	15	20	26	4	0	65
	46	376	1033	375	47	1877

Proportional	NXbin					
	-2	-1	0	1	2	
1978-1993	0.1	0.4	1.2	0.3	0.0	2.1
1994-1997	0.0	0.6	4.4	3.0	0.4	8.4
1998-2003	0.2	4.0	10.8	2.9	0.3	18.2
2004-2006	0.2	1.1	0.7	0.1	0.1	2.2
2007-2010	0.3	0.3	0.4	0.1	0.0	1.1
	0.8	6.4	17.6	6.4	0.8	32

Stratified	NXbin					
	-2	-1	0	1	2	
1978-1993	1	1	1	1	1	5
1994-1997	0	1	2	2	2	7
1998-2003	1	2	3	2	2	10
2004-2006	1	2	1	1	1	6
2007-2010	1	1	1	1	0	4
	4	7	8	7	6	32

Measurement Equipment

- **Portable Emissions - SEMTECH DS**
 - Gaseous pollutants (CO₂, CO, THC, NO & NO₂), with exhaust flow
 - Teflon membrane filters (PM) @ 47 C
- **Portable Activity**
 - Isaac data loggers
 - GPS and RPM (older vehicles)
 - GPS & engine parameters (J1708 & J1939)

Testing Summary

- **Portable Emissions Tests (\approx 1 day)**
 - Gaseous & PM: 22 Tests
 - Gaseous-only: 24 Tests
 - Total: 46 Tests on 37 Trucks
- **Portable Activity Tests (\approx 1 week)**
 - Total: 23 Tests on 23 Trucks
 - Some trucks received both PEMS and PAMS

PEMS Vehicle Example

- MY 1994 Freightliner

PM Filters

Semtech_DS

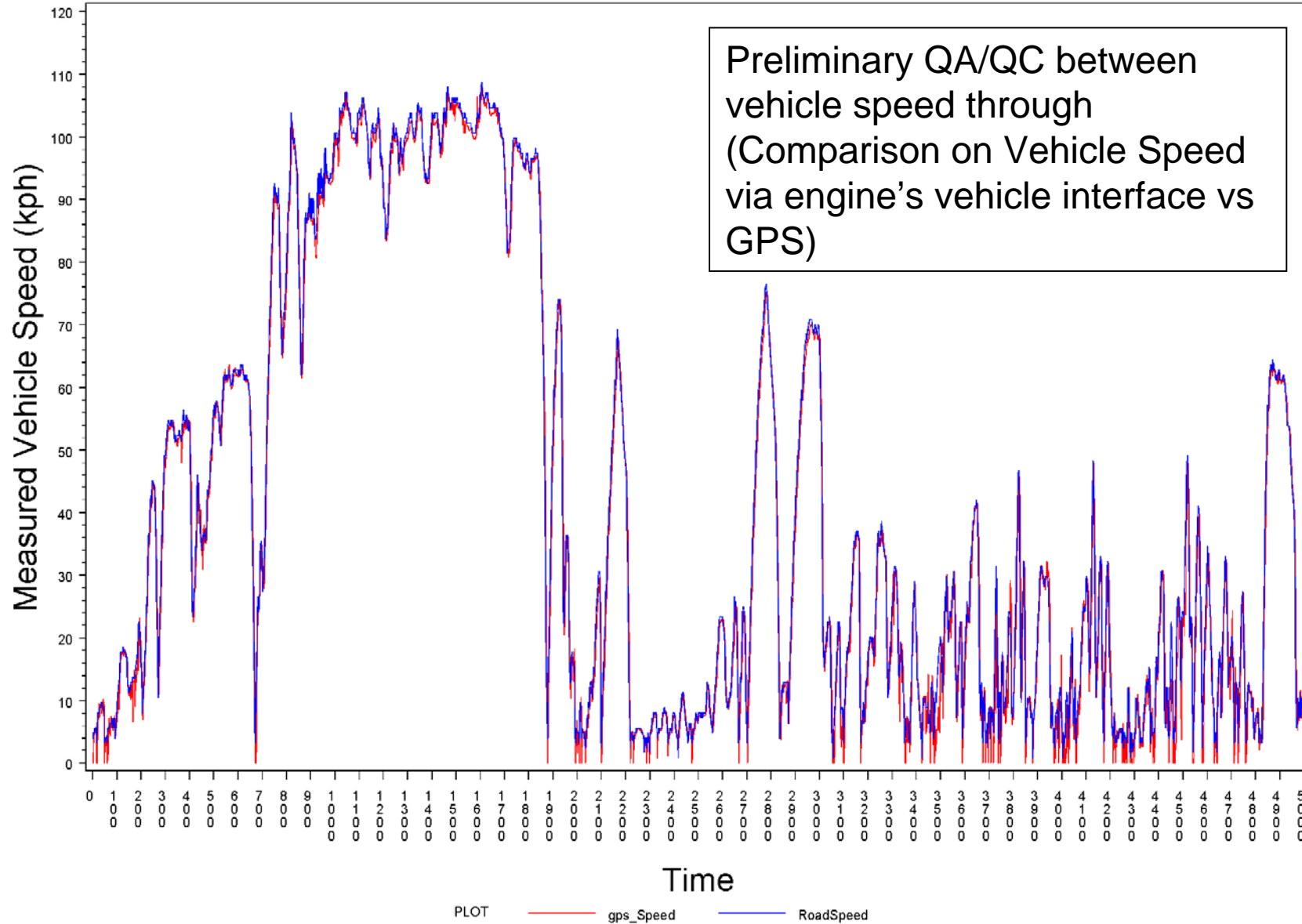


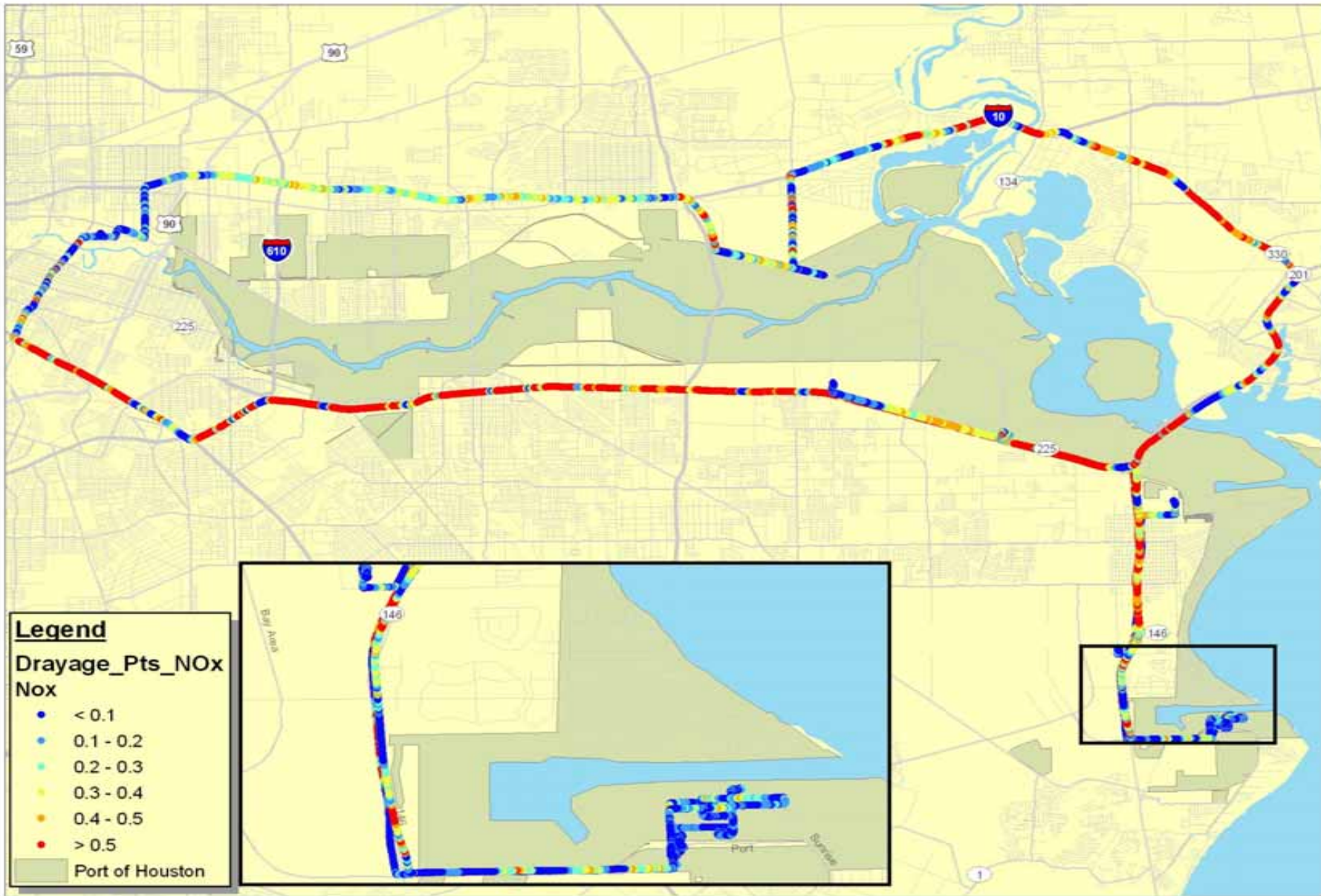
PM Proportional
Sampler System

Exhaust
System

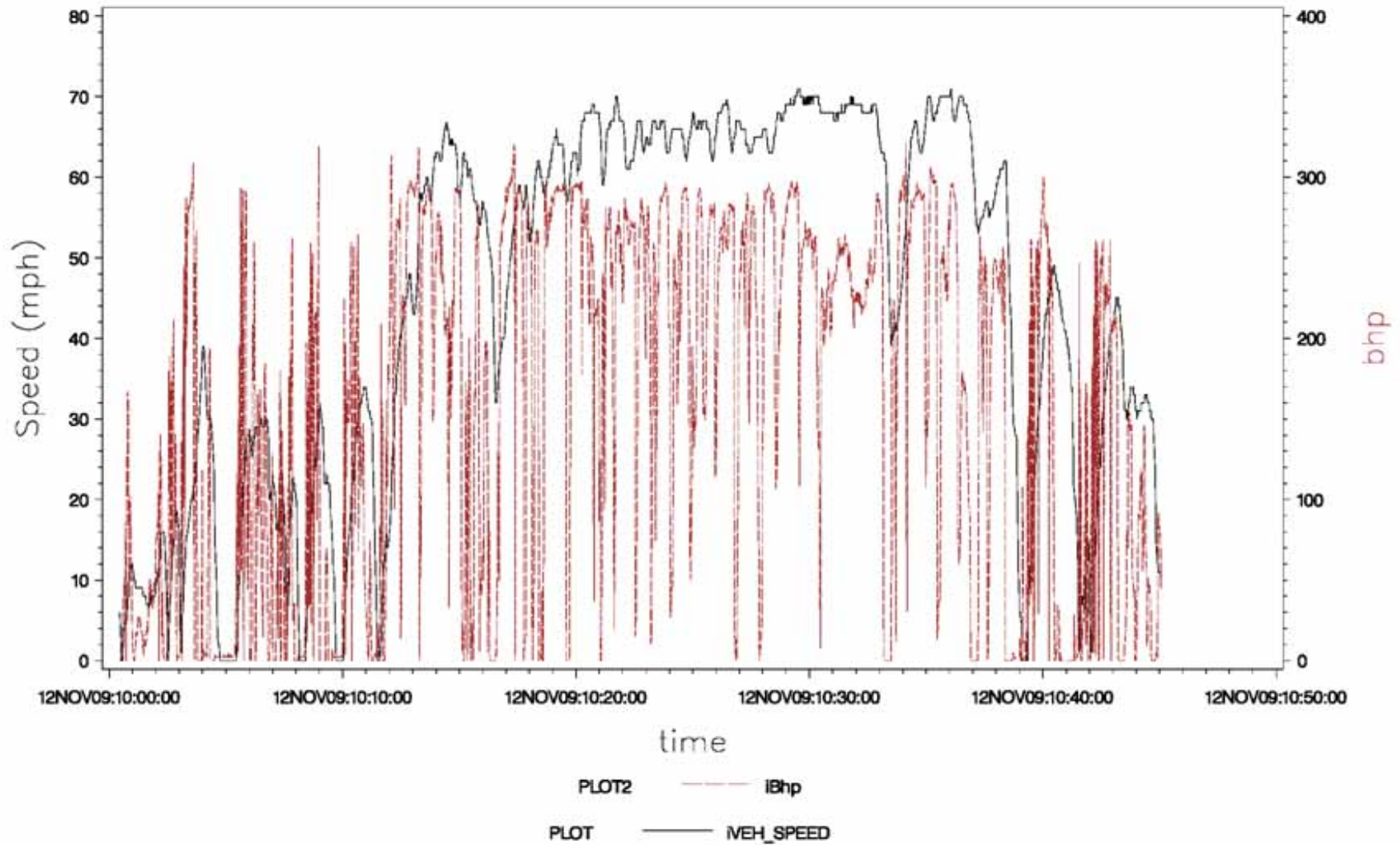


Measures of Vehicle Speed Compared

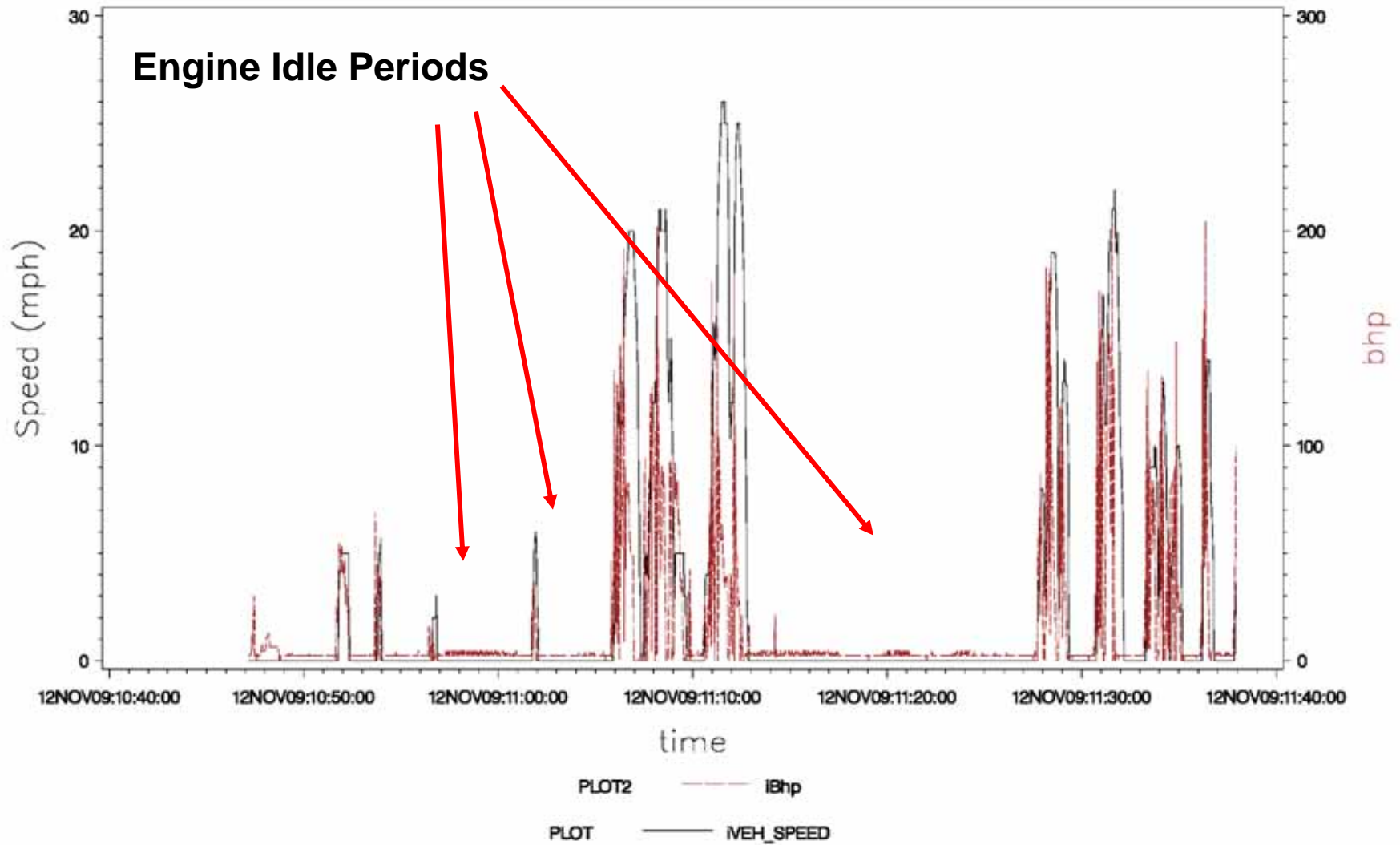




Speed and BHP by Sequence 1994 Freightliner Non Port Activity



Speed and BHP by Sequence 1994 Freightliner Port Activity



Port vs. Non-Port (Onroad) Activity & Emissions (1994 Freightliner)

Contrast of Non Port and Port Activity/Emissions							
	Time (min)	Idle (%)	Distance (miles)	Total PM (g)	Total Nox (g)	Total CO (g)	Total HC (g)
Non Port	155	10.0%	99	31	2517	602	598
Port	104	69.0%	6	14	331	199	288

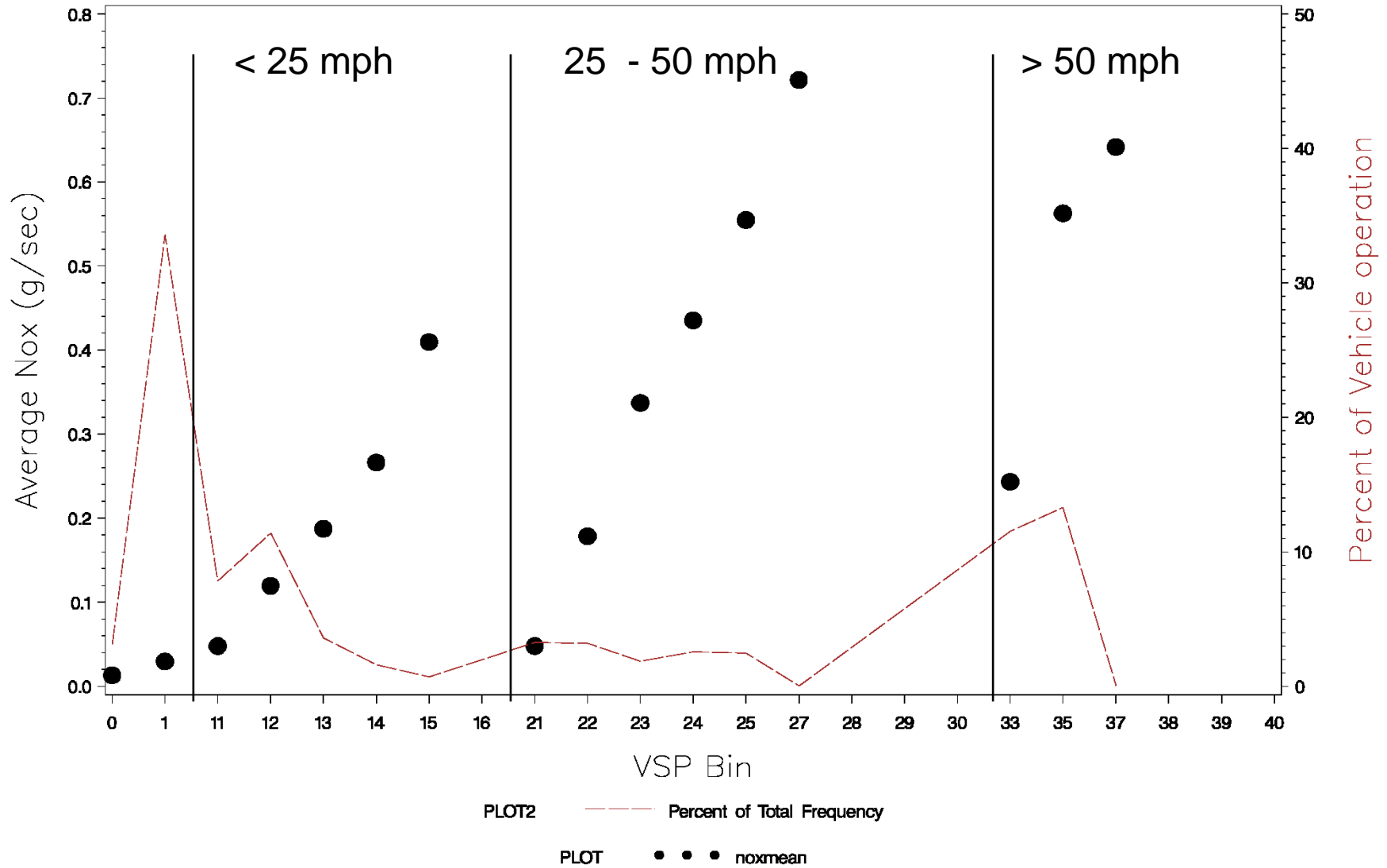
PEMS – Preliminary Data Analyses

- Estimated Vehicle Specific Power (VSP) based on HD MOVES report and in consultation w/ EPA
- $VSP = (\text{efficiency}) * (P_{\text{eng}} - P_{\text{losses}}) / m_{\text{avg}}$
- $VSP = 0.9 * (\text{ibhp} * 0.735 \text{ (kW)} - 8) / 17.1;$
- Used MOVES speed/vsp bins

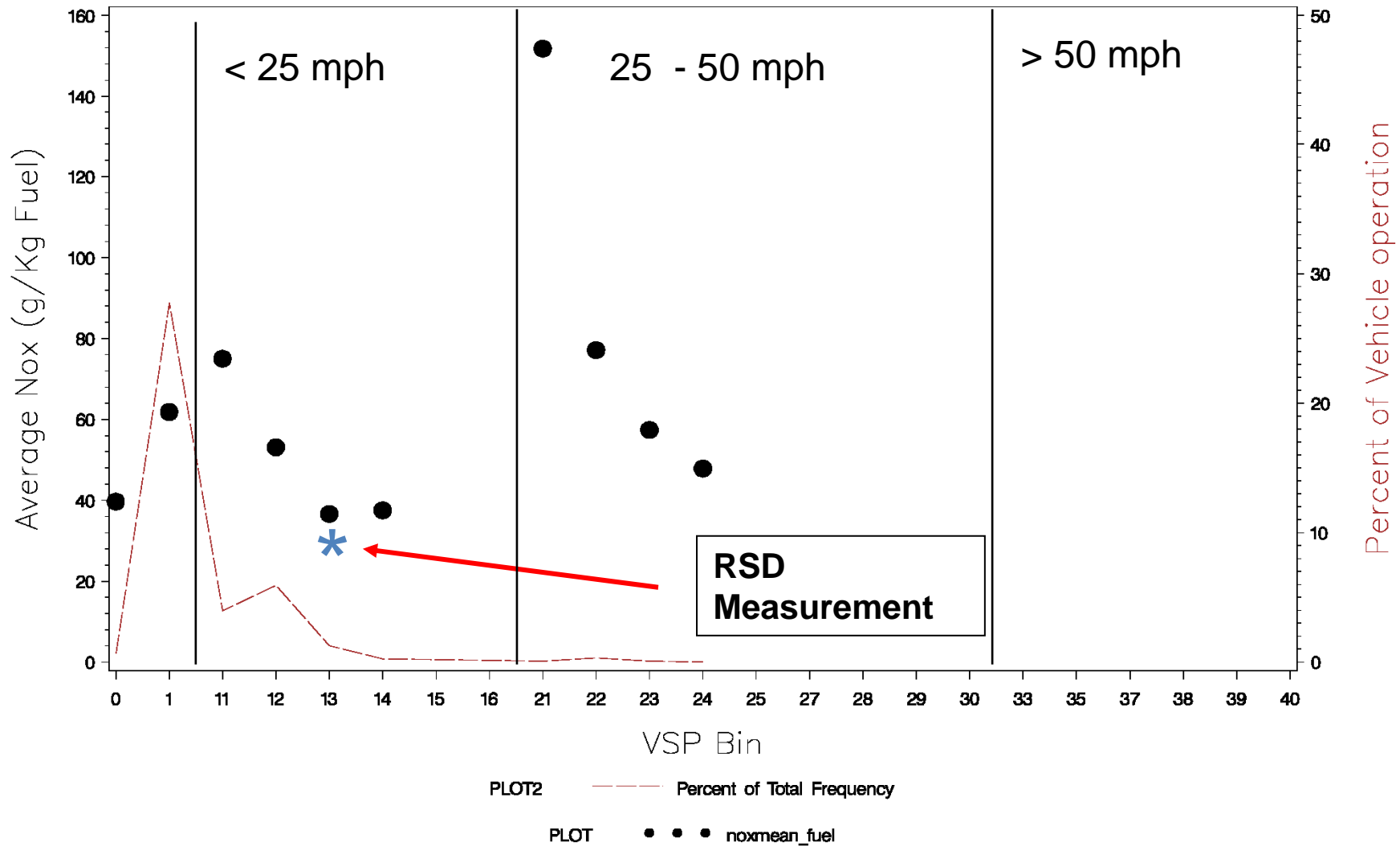
Operating Modes for Running Exhaust Emissions (Used in the following Slides)

		Speed Class (mph)		
		1-25	25-50	50 +
VSP Class (kW/tonne)	30 +	16	30	40
	27-30			
	24-27		29	39
	21-24		28	38
	18-21			
	15-18			37
	12-15		27	
	9-12	15	25	
	6-9	14	24	35
	3-6	13	23	
	0-3	12	22	33
	< 0	11	21	

1994 Freightliner NOx Emissions & Activity by MOVES Vehicle Specific Power (VSP) Bin – Non port

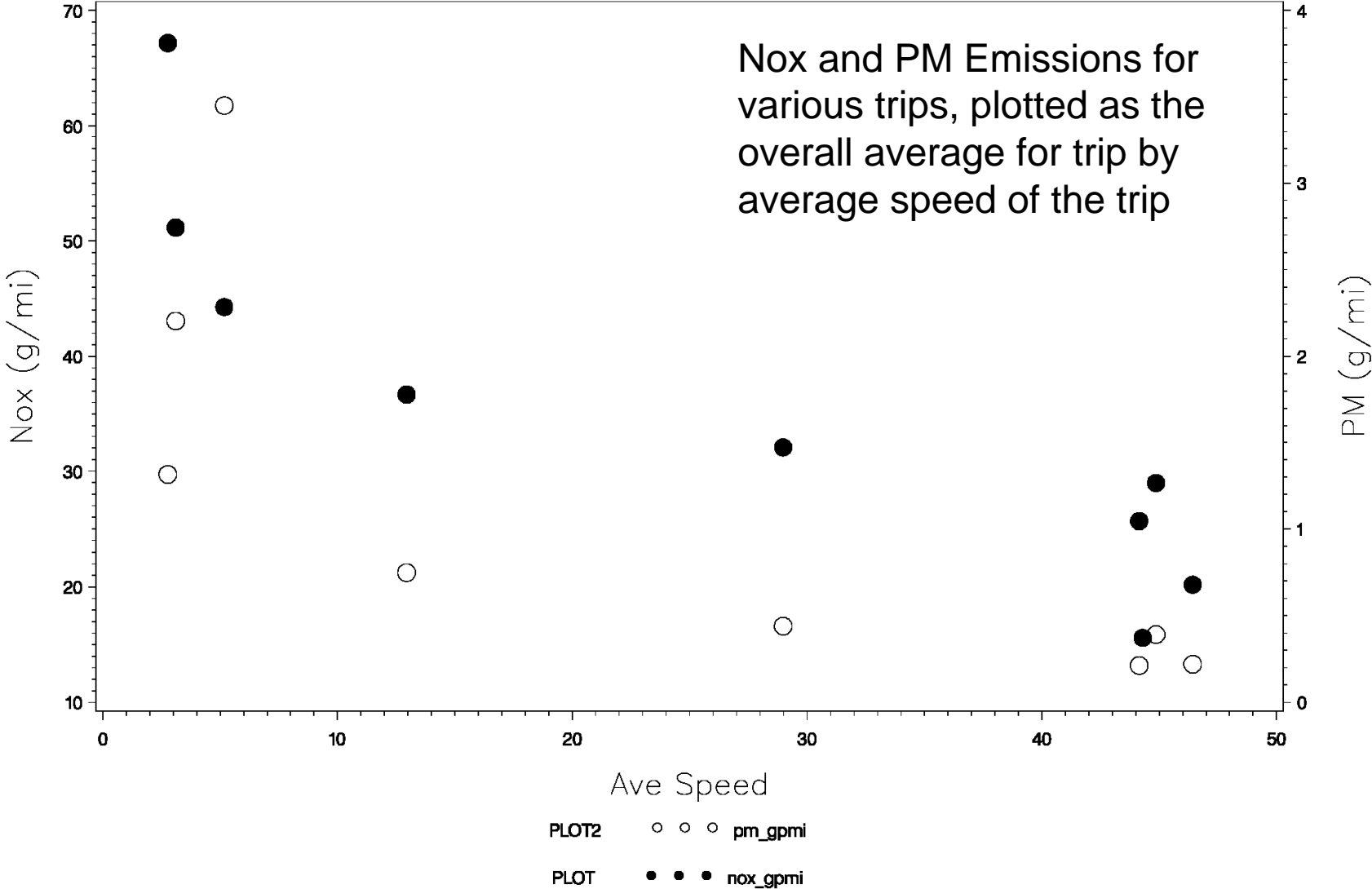


1994 Freightliner NOx / Fuel Ratio by VSP Bin for Port Operation

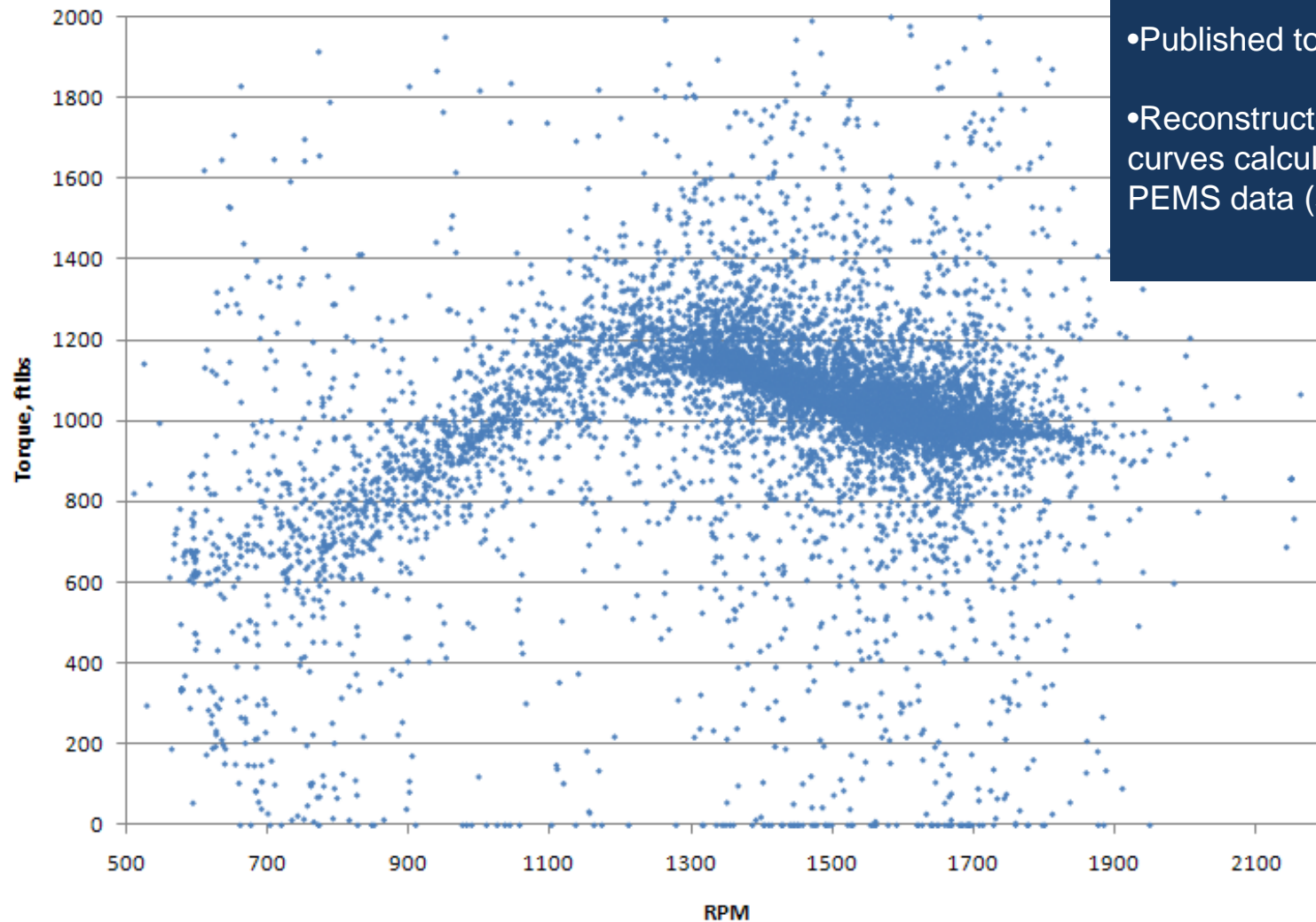


Nox and PM vs Ave Speed

2CF849 1994 Freightliner



Calculated torque curve based on ECU %Load and ECU Torque – 2CF849

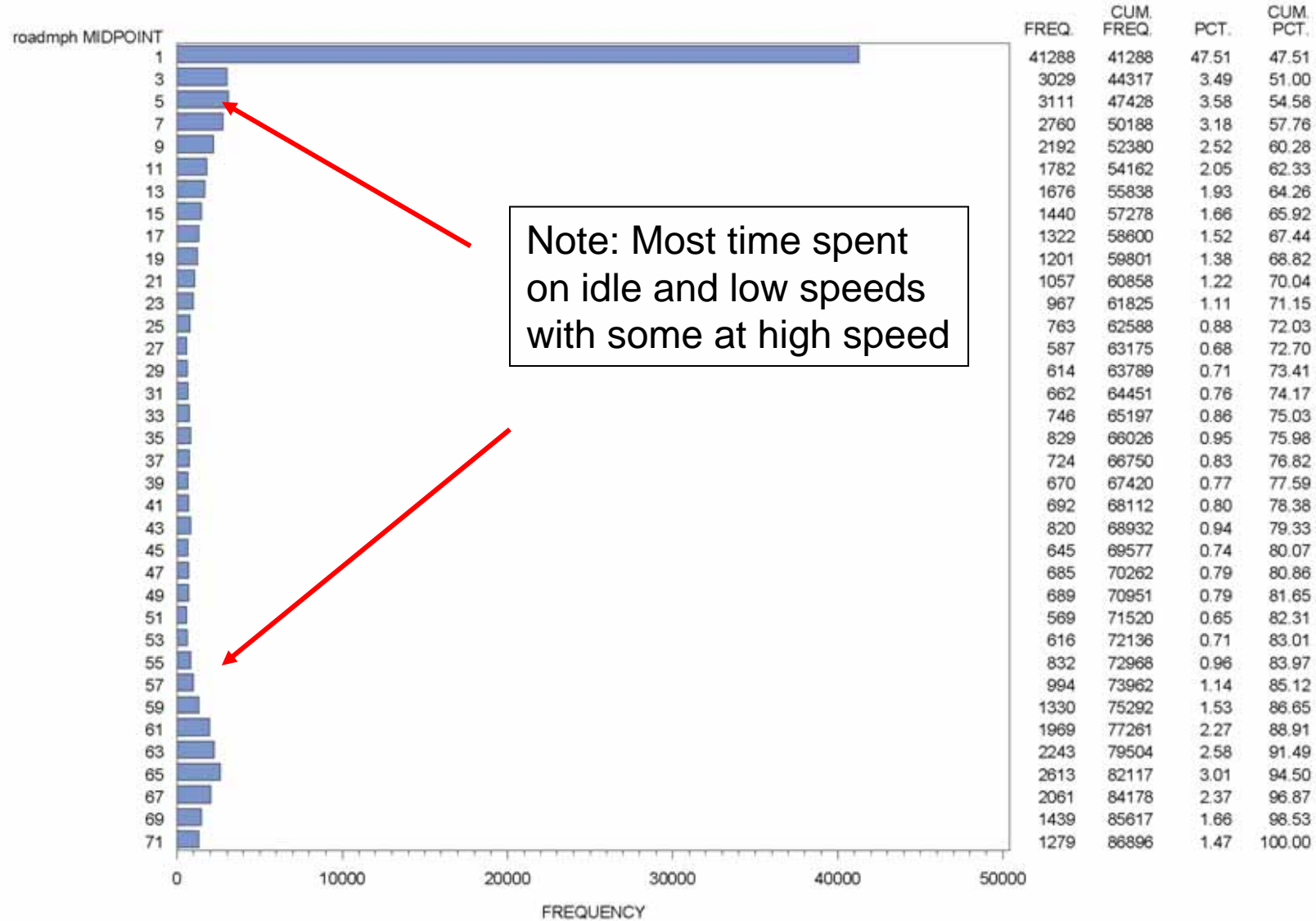


- Can calculate engine power for VSP binning based on:

- Published torque curves

- Reconstructed torque curves calculated based on PEMS data (shown here)

Amount of Operation by vehicle speed (mph)



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Next Steps

- ERG creating a "houston port" input database to reflect port activity/fleet info
- May consider adding new sourcetype (drayage truck) & road type (port) via database too
- EPA will review and consider application in other ports
- EPA will use emissions data to check/update HDD emissions rates in MOVES for next update cycle

Conclusions

- With local data and targeted field work, users can customize MOVES to specialized uses
- EPA plans to develop guidance on this, areas should consult with EPA on such efforts
- RSD screening very useful for improving sampling in portable emissions/activity measurement studies
- Preliminary data shows that in-port emissions are important to quantify
- State, Local and Federal collaboration is key for comprehensive field studies