Airport GSE Survey and Emission Modeling

Airports Workshop

Ozone Transport Commission

BWI Airport

December 5, 2001

David Park, NESCAUM

dpark@nescaum.org

NESCAUM
Northeast States for Coordinated Air Use Management

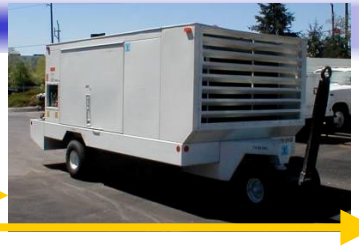
NESCAUM GSE Emission Inventory: Presentataion Overview

- Introduction to GSE
- Goal of the emission inventory
- GSE population and activity inventory development
- GSE model description
  - Input parameters
  - Output parameters
- Modeled Emissions
- Conclusions

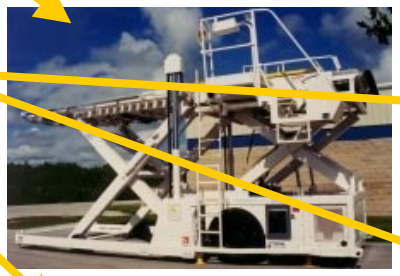
NESCAUM
Northeast States for Coordinated Air Use Management

Ground Support Equipment

- Pushback tractor
- Conditioned air unit
- Air start unit
- Baggage tug
- Belt loader
- Bobtail
- Cargo loader
- Cart
- Deicer
- Forklift
- Fuel truck
- Ground power unit
- Lavatory cart
- Lavatory truck
- Lift
- Maintenance truck
- Service truck
- Water truck





NESCAUM
Northeast States for Coordinated Air Use Management

Goal of the GSE Evaluation

- Evaluate three airports, Boston-Logan, Hartford-Bradley and Manchester, NH.
- Develop specific inventories of GSE population & activity at each.
- Input the populations & activity into the GSE model developed by EEA & compare EPA vs. CARB emission methodology
- Evaluate the EEA GSE Model

NESCAUM
Northeast States for Coordinated Air Use Management

Who Uses GSE?

- Airlines
  - Passenger & Freight
    - Majors, National, Regional
- Airport Authority
  - Maintenance
  - Fire/Rescue
- Fixed Base Operations (FBOs)

NESCAUM
Northeast States for Coordinated Air Use Management

GSE Population & Activity Inventory Development (Past)

- Top Down Method- LTO (Landing/Takeoff)
  - Most inventories rely on this as a default method
  - Regression equation based on aircraft size and GSE activity.
- Less expensive and time consuming.
- Inventory is as accurate as the underlying data used to derive the regression equation.
  - ~~Cold weather vehicles?~~
  - ~~Airport maintenance vehicles?~~

NESCAUM
Northeast States for Coordinated Air Use Management

GSE Population & Activity Inventory Development (NESCAUM)

- Bottom Up- Direct survey of airport populations.
- More time consuming, therefore more costly than the top down method.
- Relies on cooperation of GSE operators and accessibility of airport.
- Has potential to be more accurate than the top down method.

NESCAUM
Northeast States for Coordinated Air Use Management

GSE Population & Activity Inventory Survey

NESCAUM Survey for Airport Ground Service Equipment Fleets									
Your Name:_____					Title:_____				Airport:_LOGAN
Airline/Organization:_____					Telephone Number:_____				Email: _____
Today's Date:_____					Fax:_____				
Vehicle Type	**Included in your fleet? (Circle One)**	**Fuel Type**	**Compression Ignition (Circle One)**	**On Road Certified (Circle One)**	**Number of this type**	**Hours of Operation/ Year**	**Rated Horse-power**	**Fuel Usage/ Year**	**Comments**
		Diesel	Yes / No	Yes / No					
Wide Body		Gasoline	Yes / No	Yes / No					
Aircraft	Yes / No	Electric	Yes / No	Yes / No					
Pushback		LPG/CNG	Yes / No	Yes / No					
Tractor		Jet Fuel	Yes / No	Yes / No					
		(specify) _____	Yes / No	Yes / No					
		Diesel	Yes / No	Yes / No					
Narrow Body		Gasoline	Yes / No	Yes / No					
Aircraft	Yes / No	Electric	Yes / No	Yes / No					
Pushback		LPG/CNG	Yes / No	Yes / No					
Tractor		Jet Fuel	Yes / No	Yes / No					
		(specify) _____	Yes / No	Yes / No					
		Diesel	Yes / No	Yes / No					
Conditioned		Gasoline	Yes / No	Yes / No					
Air	Yes / No	Electric	Yes / No	Yes / No					
Unit		LPG/CNG	Yes / No	Yes / No					
		Jet Fuel	Yes / No	Yes / No					
		(specify)							

Population & Activity Survey Results

- Response Rates
  - Logan:
    - Population: 65% - 82%
    - Usage: 51%
  - Bradley:
    - Population: 80%
    - Usage: 16%
  - Manchester:
    - Population: 98%
    - Usage: 19%
- Data Gaps
  - Logan:
    - Missing data for 3 majors (Northwest, TWA & United)
  - Bradley & Manchester:
    - Survey compliance rate was extremely low but was bolstered by a visual survey
    - Usage information lacking due to population data collection method

NESCAUM
Northeast States for Coordinated Air Use Management

Self Surveying- Does it make sense?

Conditioned Air Unit

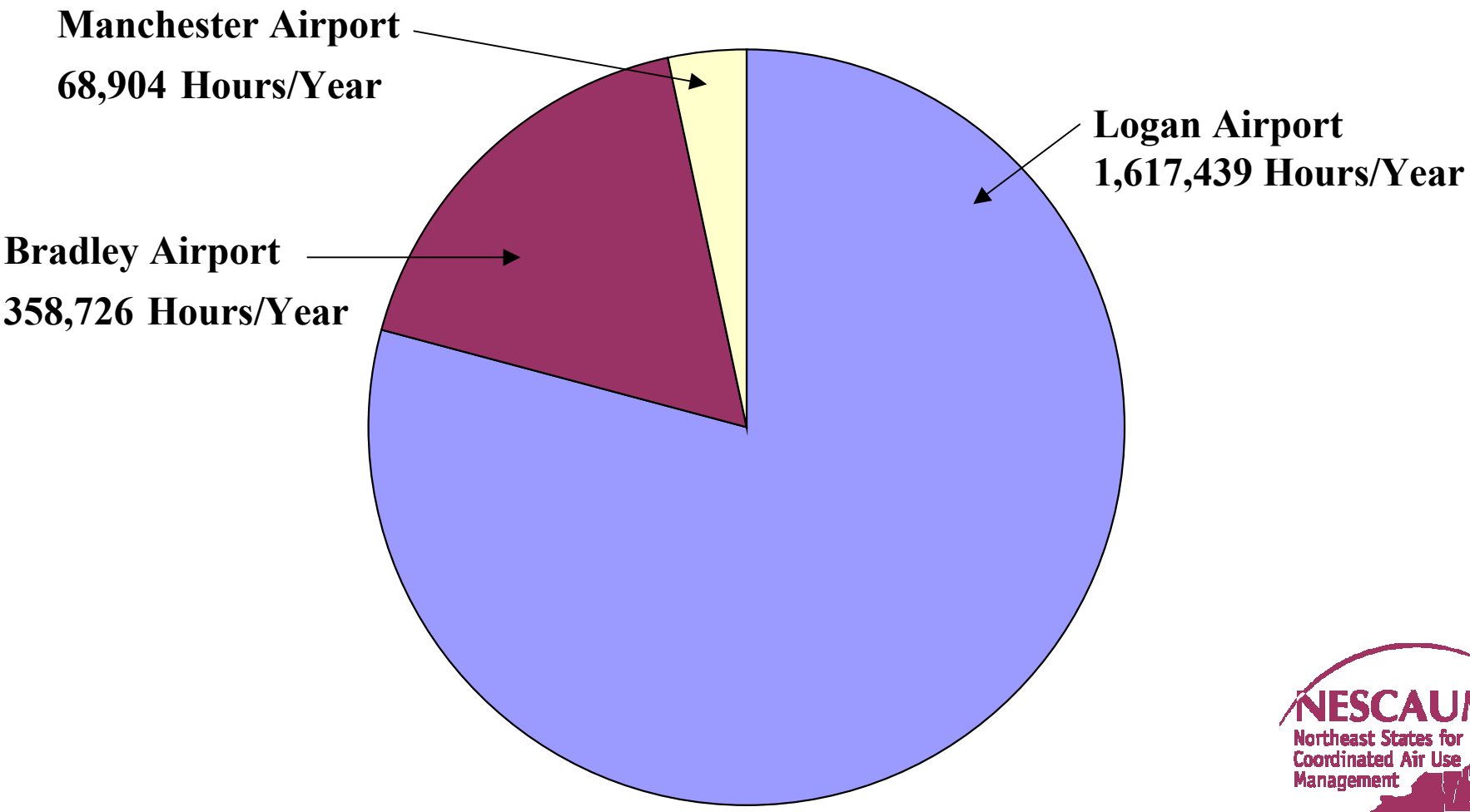
Air Start Unit

Ground Power Unit

- Equipment is difficult to distinguish
- Equipment may be stored elsewhere
- May not capture seasonal usage
- Must rely on default activity data

NESCAUM
Northeast States for Coordinated Air Use Management

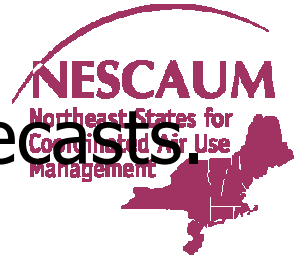
Airport Activity by Hours of GSE Equipment Operation, Year 1999



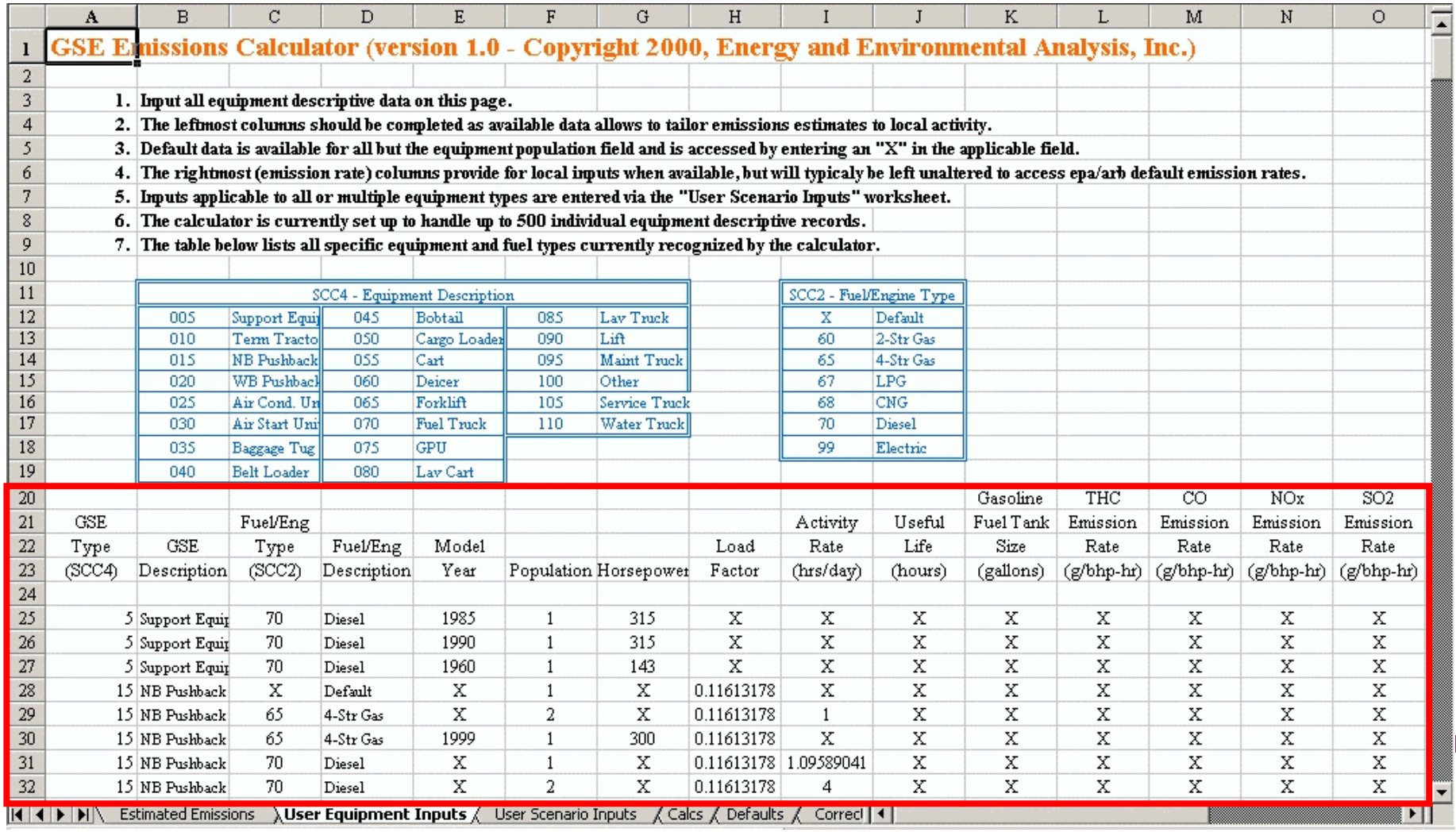
NESCAUM
Northeast States for Coordinated Air Use Management

EEA GSE Emission Calculator, vsn. 1.0 (author Dan Meszler)

- Basis of the Model (Comparison of EPA vs. CARB Estimates)
  - CARB emission rates
  - Default EPA GSE activity
- Improvements to EPA & CARB Methodology
  - Allows the input of specific, user defined values (population, usage, activity, fuel characteristics).
  - Accounts for deterioration
- Future Year Projection Capability? (None)
  - NESCAUM based projections on LTO forecasts.



Data Input: EEA GSE Emission Calculator, vsn. 1.0



GSE Emissions Calculator (version 1.0 - Copyright 2000, Energy and Environmental Analysis, Inc.)

1. **Input all equipment descriptive data on this page.**
2. **The leftmost columns should be completed as available data allows to tailor emissions estimates to local activity.**
3. **Default data is available for all but the equipment population field and is accessed by entering an "X" in the applicable field.**
4. **The rightmost (emission rate) columns provide for local inputs when available, but will typicaly be left unaltered to access epa/arb default emission rates.**
5. **Inputs applicable to all or multiple equipment types are entered via the "User Scenario Inputs" worksheet.**
6. **The calculator is currently set up to handle up to 500 individual equipment descriptive records.**
7. **The table below lists all specific equipment and fuel types currently recognized by the calculator.**

SCC4 - Equipment Description					
005	Support Equi	045	Bobtail	085	Lav Truck
010	Term Tracto	050	Cargo Loader	090	Lift
015	NB Pushback	055	Cart	095	Maint Truck
020	WB Pushback	060	Deicer	100	Other
025	Air Cond. Un	065	Forklift	105	Service Truck
030	Air Start Uni	070	Fuel Truck	110	Water Truck
035	Baggage Tug	075	GPU		
040	Belt Loader	080	Lav Cart		

SCC2 - Fuel/Engine Type	
X	Default
60	2-Str Gas
65	4-Str Gas
67	LPG
68	CNG
70	Diesel
99	Electric

GSE Type (SCC4)	GSE Description	Fuel/Eng Type (SCC2)	Fuel/Eng Description	Model Year	Population	Horsepower	Load Factor	Activity Rate (hrs/day)	Useful Life (hours)	Gasoline Fuel Tank Size (gallons)	THC Emission Rate (g/bhp-hr)	CO Emission Rate (g/bhp-hr)	NOx Emission Rate (g/bhp-hr)	SO2 Emission Rate (g/bhp-hr)
5	Support Equi	70	Diesel	1985	1	315	X	X	X	X	X	X	X	X
5	Support Equi	70	Diesel	1990	1	315	X	X	X	X	X	X	X	X
5	Support Equi	70	Diesel	1960	1	143	X	X	X	X	X	X	X	X
15	NB Pushback	X	Default	X	1	X	0.11613178	X	X	X	X	X	X	X
15	NB Pushback	65	4-Str Gas	X	2	X	0.11613178	1	X	X	X	X	X	X
15	NB Pushback	65	4-Str Gas	1999	1	300	0.11613178	X	X	X	X	X	X	X
15	NB Pushback	70	Diesel	X	1	X	0.11613178	1.09589041	X	X	X	X	X	X
15	NB Pushback	70	Diesel	X	2	X	0.11613178	4	X	X	X	X	X	X

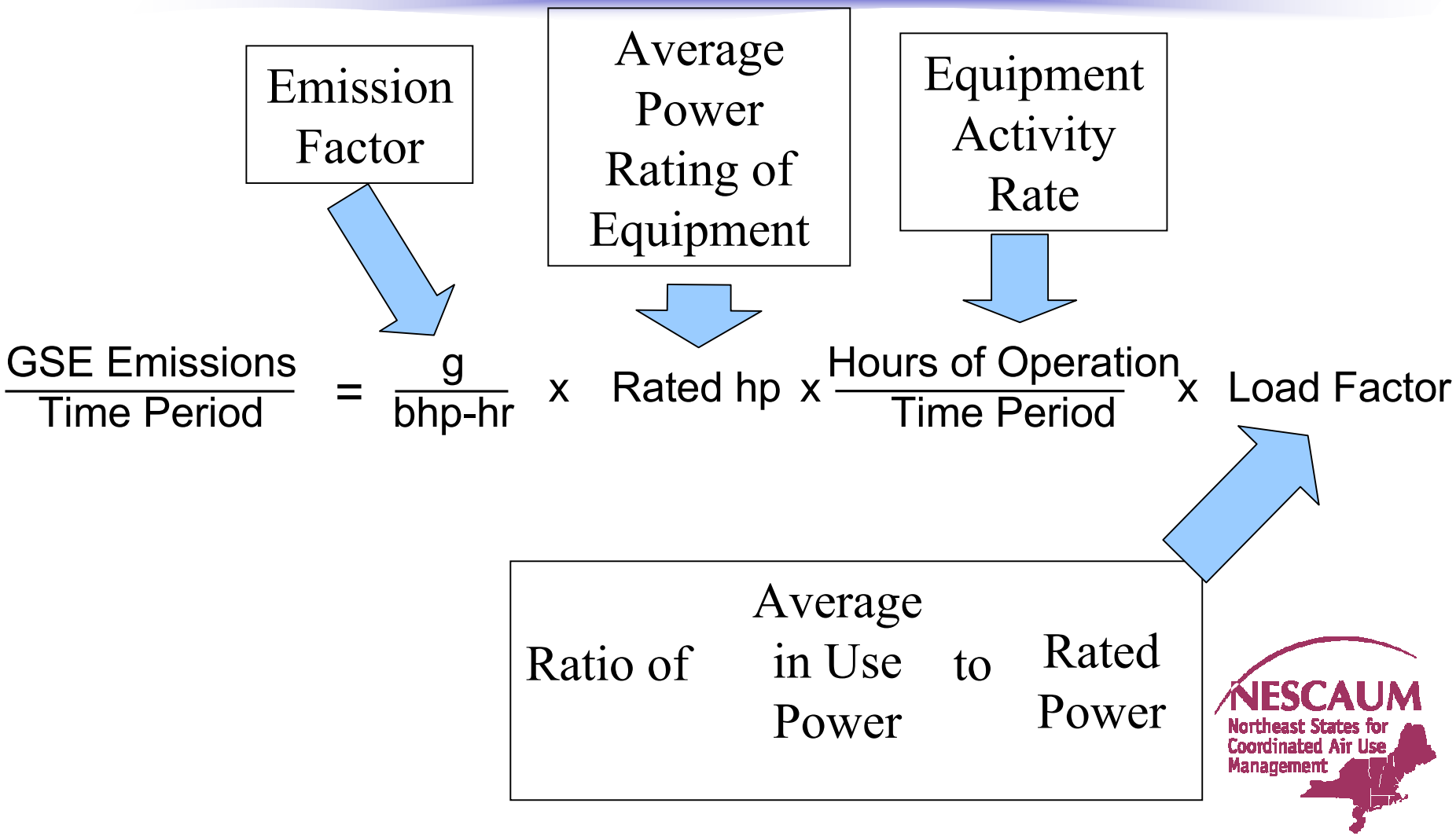
Estimated Emissions | **User Equipment Inputs** | User Scenario Inputs | Calcs | Defaults | Correcl

Data Input: EEA GSE Emission Calculator, vsn. 1.0 (Cont'd)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
20											Gasoline	THC	CO	NOx	SO2
21	GSE		Fuel/Eng						Activity	Useful	Fuel Tank	Emission	Emission	Emission	Emission
22	Type	GSE	Type	Fuel/Eng	Model			Load	Rate	Life	Size	Rate	Rate	Rate	Rate
23	(SCC4)	Description	(SCC2)	Description	Year	Population	Horsepower	Factor	(hrs/day)	(hours)	(gallons)	(g/bhp-hr)	(g/bhp-hr)	(g/bhp-hr)	(g/bhp-hr)
24															
25	5	Support Equip	70	Diesel	1985	1	315	X	X	X	X	X	X	X	X
26	5	Support Equip	70	Diesel	1990	1	315	X	X	X	X	X	X	X	X
27	5	Support Equip	70	Diesel	1960	1	143	X	X	X	X	X	X	X	X
28	15	NB Pushback	X	Default	X	1	X	0.11613178	X	X	X	X	X	X	X
29	15	NB Pushback	65	4-Str Gas	X	2	X	0.11613178	1	X	X	X	X	X	X
30	15	NB Pushback	65	4-Str Gas	1999	1	300	0.11613178	X	X	X	X	X	X	X
31	15	NB Pushback	70	Diesel	X	1	X	0.11613178	1.09589041	X	X	X	X	X	X
32	15	NB Pushback	70	Diesel	X	2	X	0.11613178	4	X	X	X	X	X	X
33	15	NB Pushback	70	Diesel	1996	1	210	X	X	X	X	X	X	X	X
34	15	NB Pushback	70	Diesel	1973	1	93	0.46710526	0.13424658	X	X	X	X	X	X
35	15	NB Pushback	70	Diesel	1993	1	150	0.46710526	0.13424658	X	X	X	X	X	X
36	15	NB Pushback	70	Diesel	1998	1	110	0.46710526	0.13424658	X	X	X	X	X	X
37	15	NB Pushback	70	Diesel	1999	1	300	0.46710526	0.13424658	X	X	X	X	X	X
38	20	WB Pushback	70	Diesel	1978	1	210	0.46710526	0.13424658	X	X	X	X	X	X
39	20	WB Pushback	70	Diesel	1985	2	285	0.46710526	0.13424658	X	X	X	X	X	X
40	20	WB Pushback	70	Diesel	1989	1	270	0.46710526	0.13424658	X	X	X	X	X	X
41	20	WB Pushback	70	Diesel	1990	1	300	0.46710526	0.13424658	X	X	X	X	X	X
42	20	WB Pushback	70	Diesel	1995	1	X	0.46710526	0.13424658	X	X	X	X	X	X
43	20	WB Pushback	70	Diesel	1995	1	300	0.46710526	0.13424658	X	X	X	X	X	X
44	20	WB Pushback	70	Diesel	1999	3	300	0.46710526	0.13424658	X	X	X	X	X	X
45	20	WB Pushback	70	Diesel	X	1	360	X	0.20547945	X	X	X	X	X	X
46	20	WB Pushback	70	Diesel	X	1	210	X	X	X	X	X	X	X	X
47	20	WB Pushback	70	Diesel	1975	1	350	X	X	X	X	X	X	X	X
48	20	WB Pushback	70	Diesel	1982	1	135	X	X	X	X	X	X	X	X
49	20	WB Pushback	70	Diesel	1988	1	210	X	X	X	X	X	X	X	X
50	20	WB Pushback	70	Diesel	1989	2	540	X	X	X	X	X	X	X	X
51	20	WB Pushback	70	Diesel	X	1	342	X	0.20547945	X	X	X	X	X	X

Estimated Emissions | **User Equipment Inputs** | User Scenario Inputs | Calcs | Defaults | Correcl

Algorithm for GSE Emissions Calculation



Load Factor Adjustment: EEA GSE Emission Calculator, vsn. 1.0

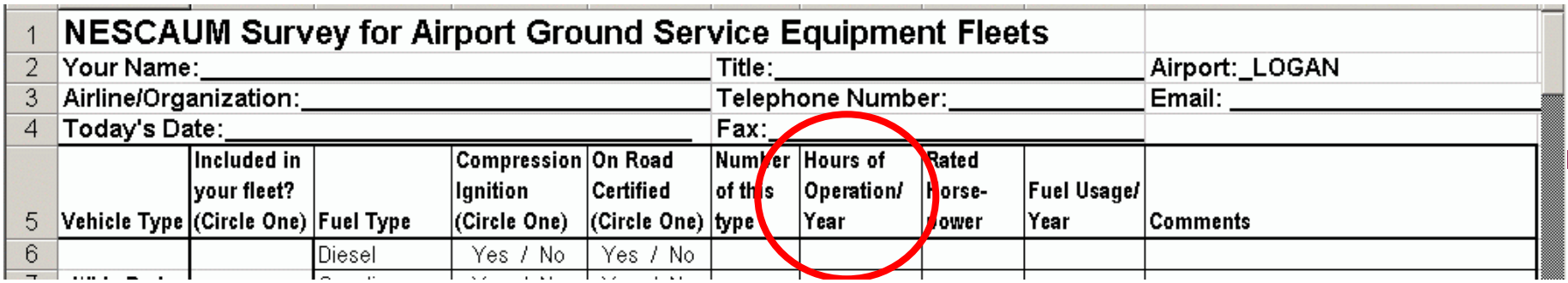
$$\text{Load Factor} = \frac{\text{Average Power In Use}}{\text{Rated Power}}$$

$$= \frac{\dfrac{\text{Brake Specific Fuel Consumption}}{\cancel{\text{Rated Hp/Hr}}}}{\dfrac{\text{Rated Brake Specific Fuel Consumption}}{\cancel{\text{Rated Hp/Hr}}}}$$

NESCAUM
Northeast States for Coordinated Air Use Management

Why Adjust Load Factors Based on Fuel Consumption?

Model Equivalent Name	Equipment Type	Model Load Factor	Corrected Load Factor
NB Pushback	Narrow Body Aircraft Pushback Tractor	0.80	0.12
NB Pushback	FE Loader	0.80	0.47
WB Pushback	Wide Body Aircraft Pushback Tractor	0.80	0.08
WB Pushback	WB Pushback	0.80	0.47
Air Cond. Unit	Conditioned Air Unit	0.75	0.39
Air Start Unit	Air Start Unit	0.90	0.02
Baggage Tug	Baggage Tug	0.55	0.02
Belt Loader	Belt Loader	0.50	0.07



1	NESCAUM Survey for Airport Ground Service Equipment Fleets									
2	Your Name:_____				Title:_____				Airport:_LOGAN	
3	Airline/Organization:_____				Telephone Number:_____				Email: _____	
4	Today's Date:_____				Fax:_____					
5	Vehicle Type	Included in your fleet? (Circle One)	Fuel Type	Compression Ignition (Circle One)	On Road Certified (Circle One)	Number of this type	Hours of Operation/ Year	Rated Horse-power	Fuel Usage/ Year	Comments
6			Diesel	Yes / No	Yes / No					

Pollutants: EEA GSE Emission Calculator, vsn. 1.0

- Hydrocarbon:
  - Model reports evaporative and exhaust portions of HC separately and as a total.
  - User may specify how hydrocarbons should be reported:

    THC, TOG, NMHC, NMOG, VOC

NESCAUM
Northeast States for Coordinated Air Use Management

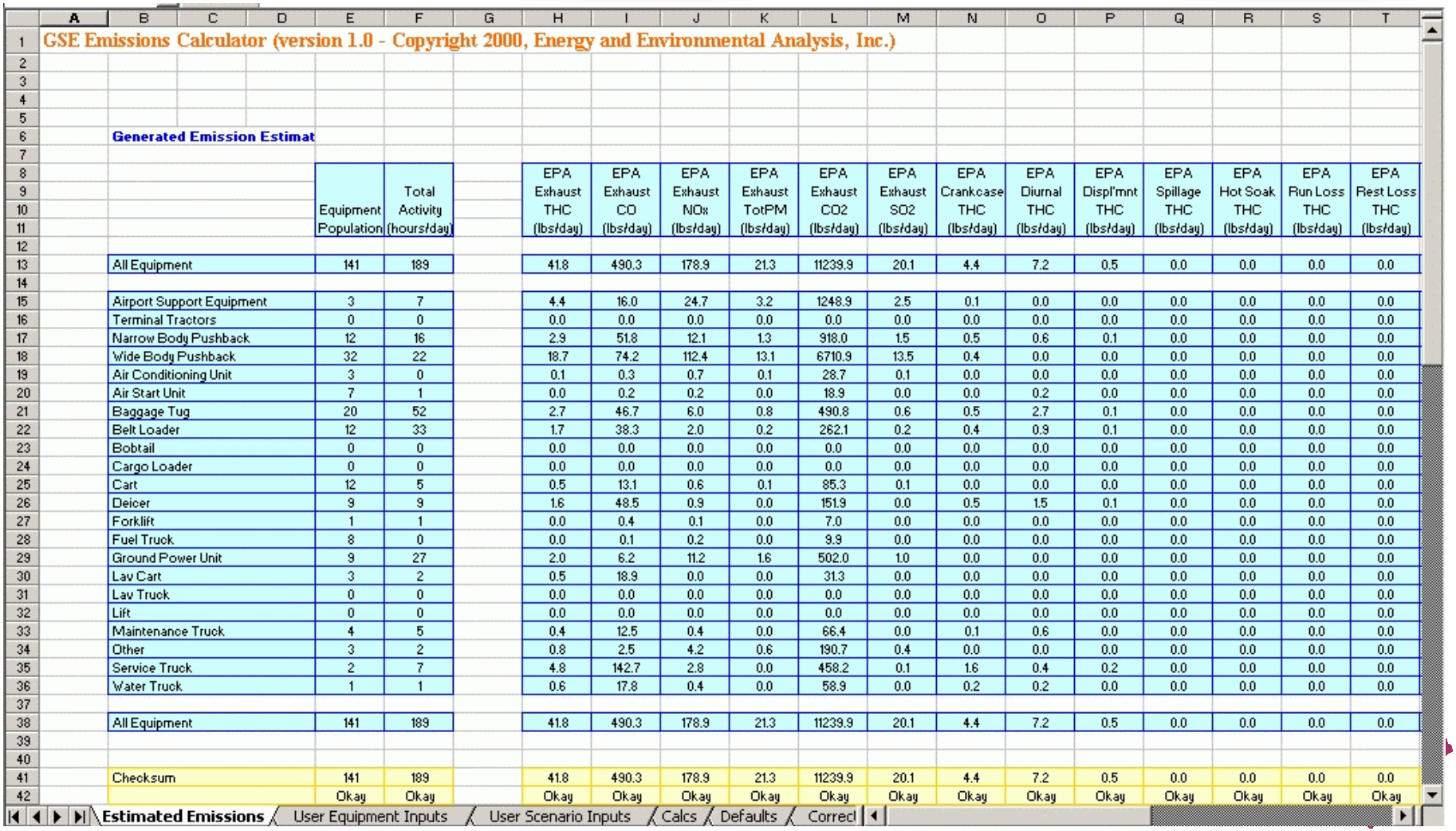
Pollutants: EEA GSE Emission Calculator, vsn. 1.0 (Cont'd)

- Particulate Matter:
  - Model does not currently distinguish between Total PM and PM_{10}
  - User may specify how PM should be reported:

    Total PM, PM_{10}, $PM_{2.5}$
- Other pollutants reported
  - NO_x, CO, CO_2, SO_2

NESCAUM
Northeast States for Coordinated Air Use Management

Output: EEA GSE Emission Calculator, vsn. 1.0



GSE Emissions Calculator (version 1.0 - Copyright 2000, Energy and Environmental Analysis, Inc.)

Generated Emission Estimat

	Equipment Population	Total Activity (hours/day)	EPA Exhaust THC (lbs/day)	EPA Exhaust CO (lbs/day)	EPA Exhaust NOx (lbs/day)	EPA Exhaust TotPM (lbs/day)	EPA Exhaust CO2 (lbs/day)	EPA Exhaust SO2 (lbs/day)	EPA Crankcase THC (lbs/day)	EPA Diurnal THC (lbs/day)	EPA Displ'mnt THC (lbs/day)	EPA Spillage THC (lbs/day)	EPA Hot Soak THC (lbs/day)	EPA Run Loss THC (lbs/day)	EPA Rest Loss THC (lbs/day)
All Equipment	141	189	41.8	490.3	178.9	21.3	11239.9	20.1	4.4	7.2	0.5	0.0	0.0	0.0	0.0
Airport Support Equipment	3	7	4.4	16.0	24.7	3.2	1248.9	2.5	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Terminal Tractors	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Narrow Body Pushback	12	16	2.9	51.8	12.1	1.3	918.0	1.5	0.5	0.6	0.1	0.0	0.0	0.0	0.0
Wide Body Pushback	32	22	18.7	74.2	112.4	13.1	6710.9	13.5	0.4	0.0	0.0	0.0	0.0	0.0	0.0
Air Conditioning Unit	3	0	0.1	0.3	0.7	0.1	28.7	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Air Start Unit	7	1	0.0	0.2	0.2	0.0	18.9	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0
Baggage Tug	20	52	2.7	46.7	6.0	0.8	490.8	0.6	0.5	2.7	0.1	0.0	0.0	0.0	0.0
Belt Loader	12	33	1.7	38.3	2.0	0.2	262.1	0.2	0.4	0.9	0.1	0.0	0.0	0.0	0.0
Bobtail	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cargo Loader	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cart	12	5	0.5	13.1	0.6	0.1	85.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Deicer	9	9	1.6	48.5	0.9	0.0	151.9	0.0	0.5	1.5	0.1	0.0	0.0	0.0	0.0
Forklift	1	1	0.0	0.4	0.1	0.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fuel Truck	8	0	0.0	0.1	0.2	0.0	9.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ground Power Unit	9	27	2.0	6.2	11.2	1.6	502.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lav Cart	3	2	0.5	18.9	0.0	0.0	31.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lav Truck	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lift	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maintenance Truck	4	5	0.4	12.5	0.4	0.0	66.4	0.0	0.1	0.6	0.0	0.0	0.0	0.0	0.0
Other	3	2	0.8	2.5	4.2	0.6	190.7	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Service Truck	2	7	4.8	142.7	2.8	0.0	458.2	0.1	1.6	0.4	0.2	0.0	0.0	0.0	0.0
Water Truck	1	1	0.6	17.8	0.4	0.0	58.9	0.0	0.2	0.2	0.0	0.0	0.0	0.0	0.0
All Equipment	141	189	41.8	490.3	178.9	21.3	11239.9	20.1	4.4	7.2	0.5	0.0	0.0	0.0	0.0
Checksum	141	189	41.8	490.3	178.9	21.3	11239.9	20.1	4.4	7.2	0.5	0.0	0.0	0.0	0.0
	Okay	Okay	Okay	Okay	Okay	Okay	Okay	Okay	Okay	Okay	Okay	Okay	Okay	Okay	Okay

Estimated Emissions | User Equipment Inputs | User Scenario Inputs | Calcs | Defaults | Correcl

Projection Year Emissions, 2010

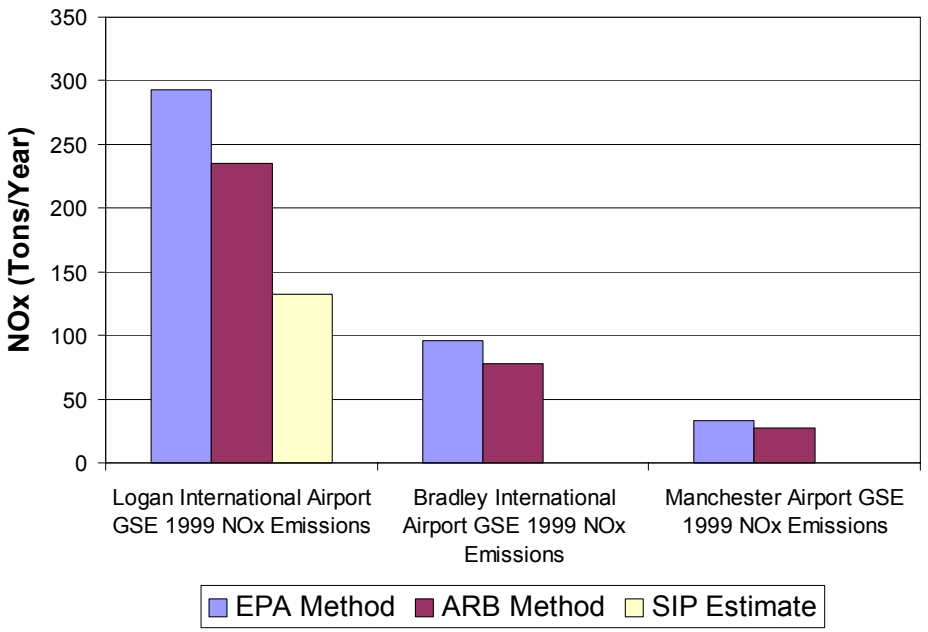
- Airline GSE population and activity projections based on a proportional increase in LTOs
- Airport management fleet growth dependent on airport
  - Logan was not predicted to expand significantly geographically.
  - Bradley and Manchester both expected to expand geographically.

Airport	GSE Population Growth Factor
Logan Airport	110.2%
Bradley International Airport	136.5%
Manchester Airport	140.5%

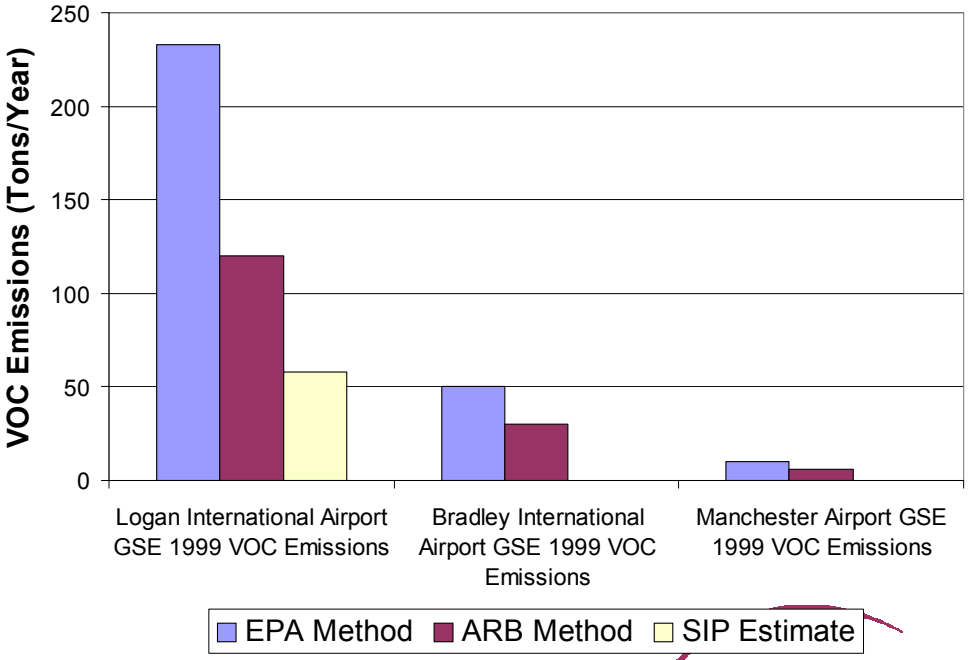
NESCAUM
Northeast States for Coordinated Air Use Management

Modeled GSE NO_x & THC Emissions at Study Airports, 1999

NOx Emissions (TPY)



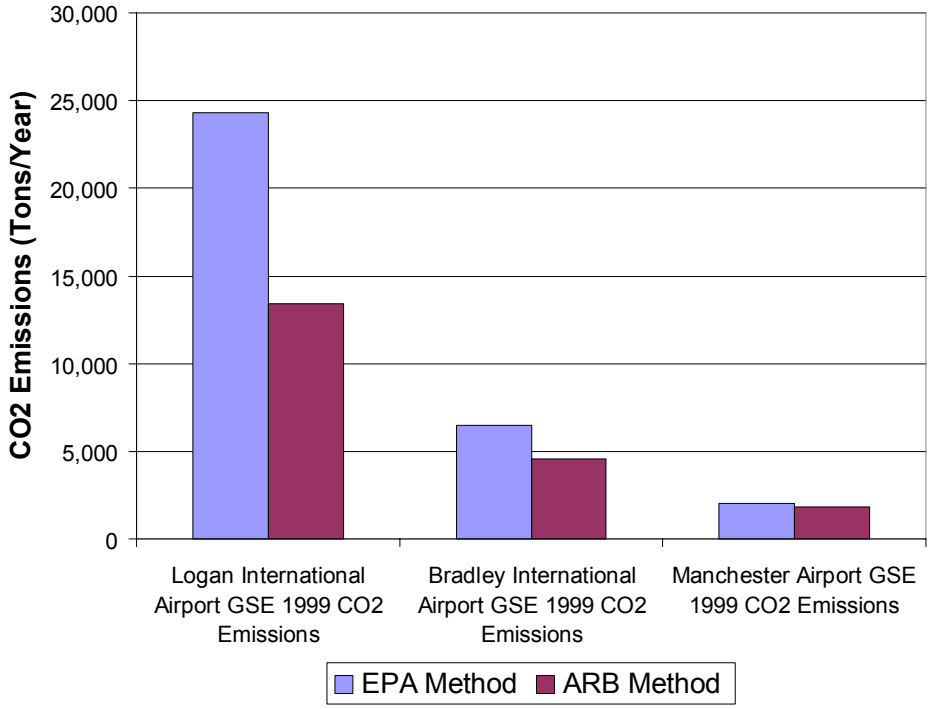
THC Emissions (TPY)



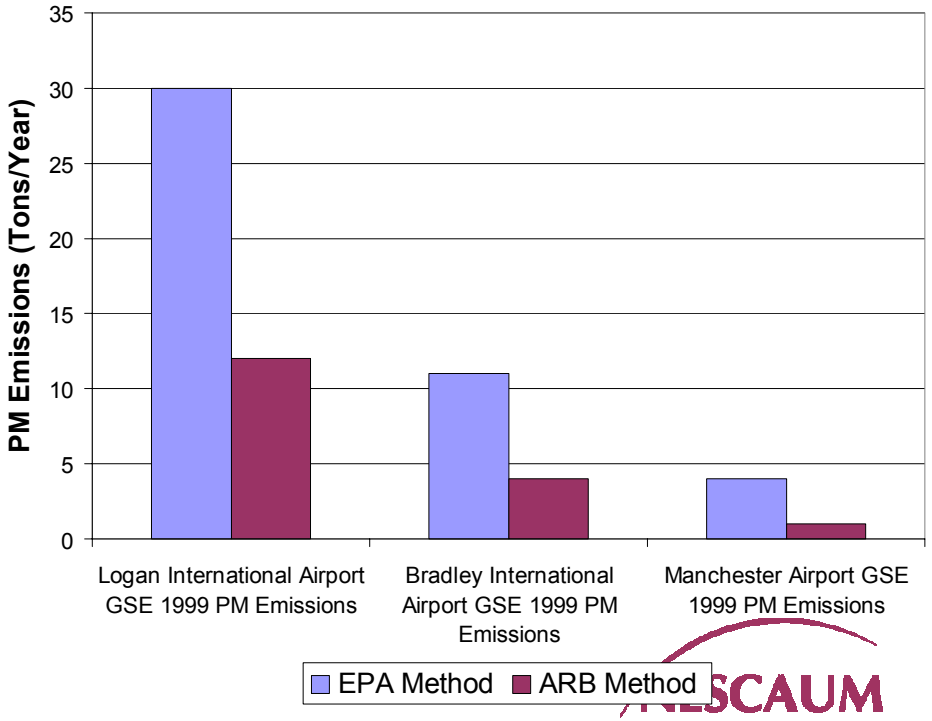
NESCAUM
Northeast States for Coordinated Air Use Management

Modeled GSE CO & PM Emissions at Study Airports, 1999

CO_2 Emissions (TPY)



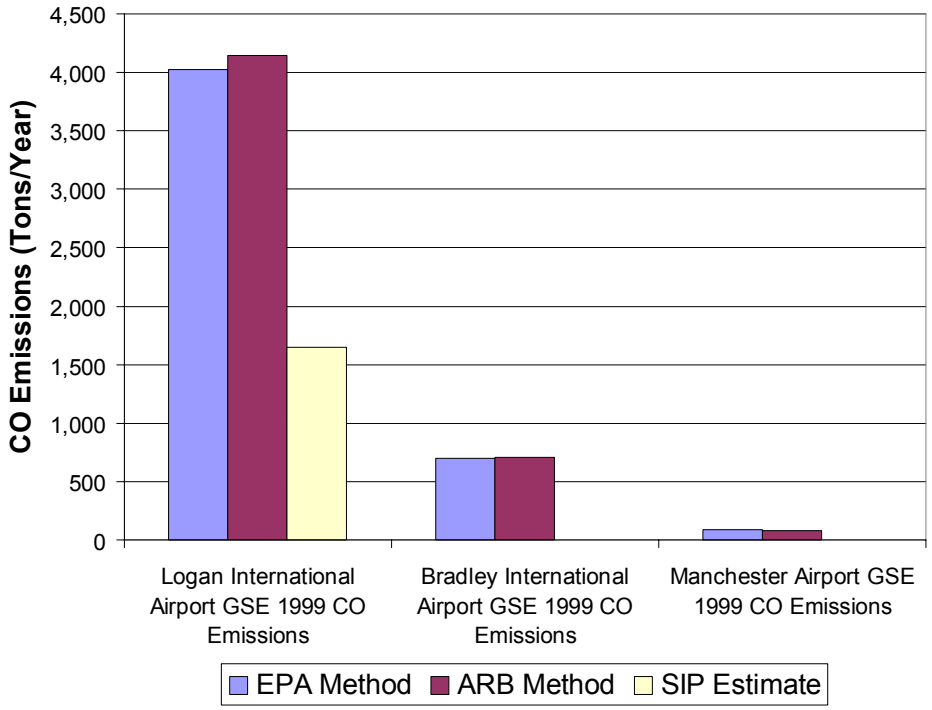
PM Emissions (TPY)



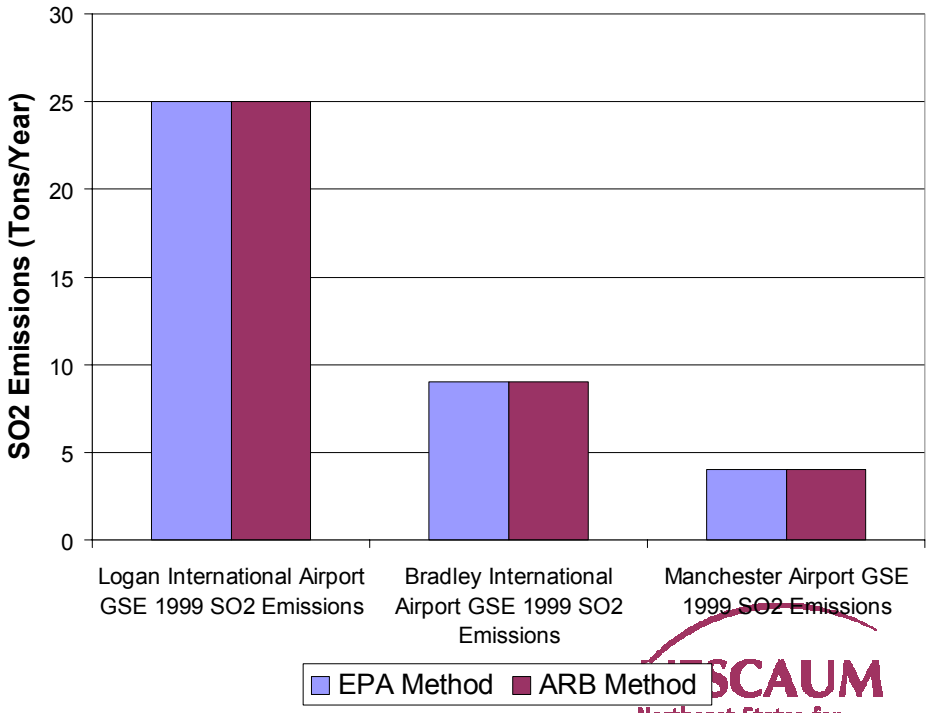
NESCAUM
Northeast States for Coordinated Air Use Management

Modeled GSE CO_2 & SO_2 Emissions at Study Airports, 1999

CO Emissions (TPY)

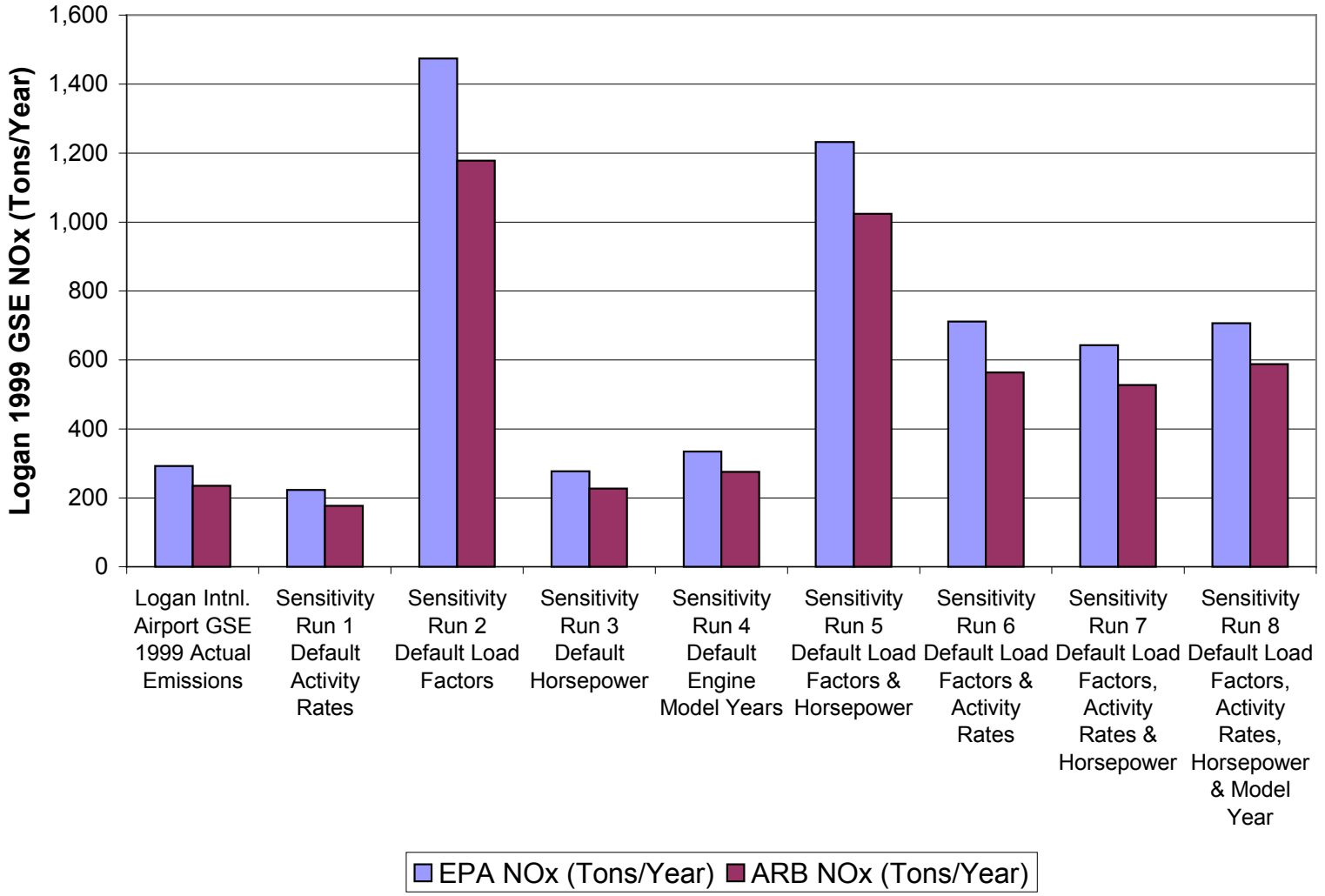


SO_2 Emissions (TPY)



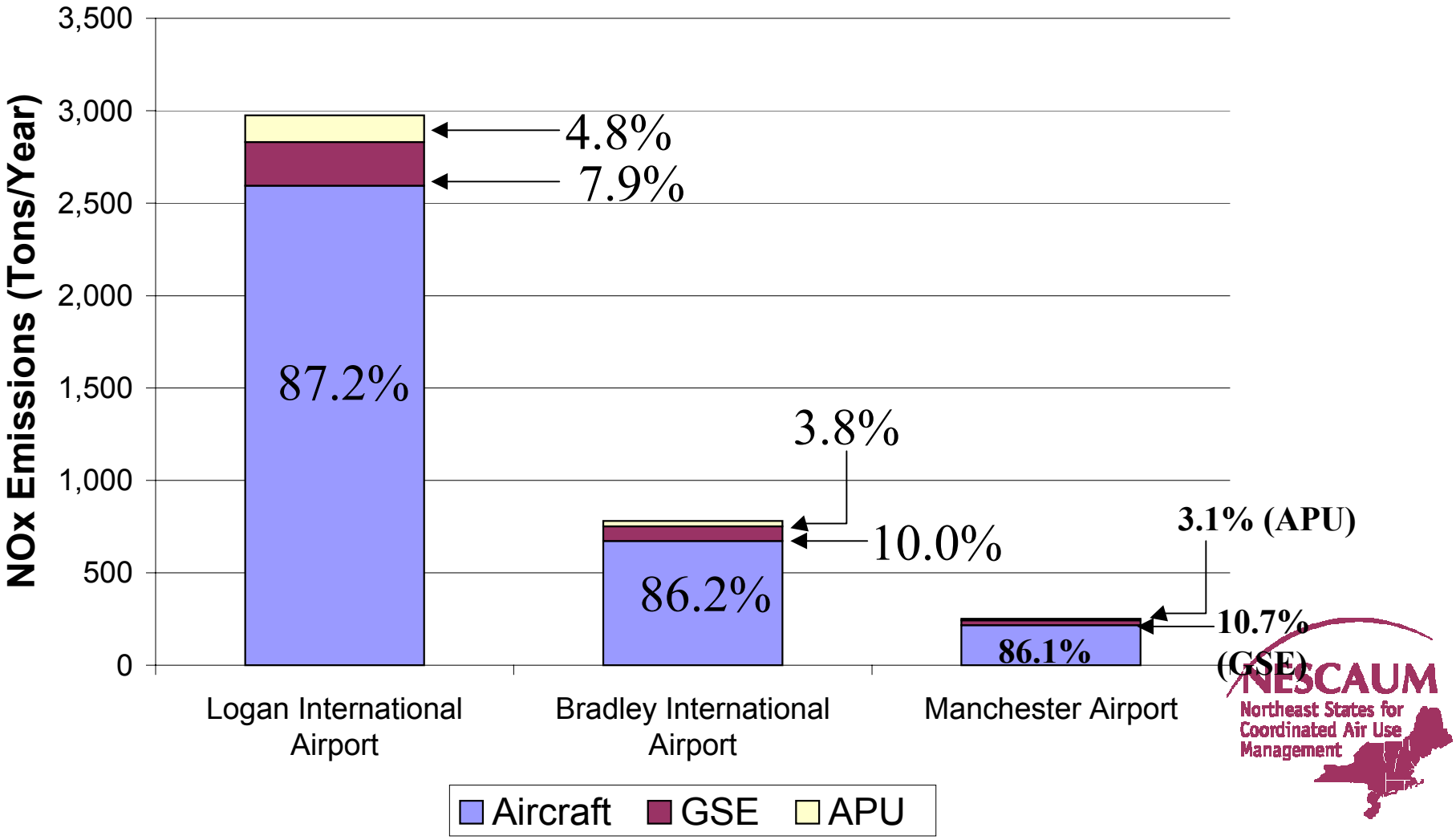
NESCAUM
Northeast States for Coordinated Air Use Management

Model Sensitivity Analysis



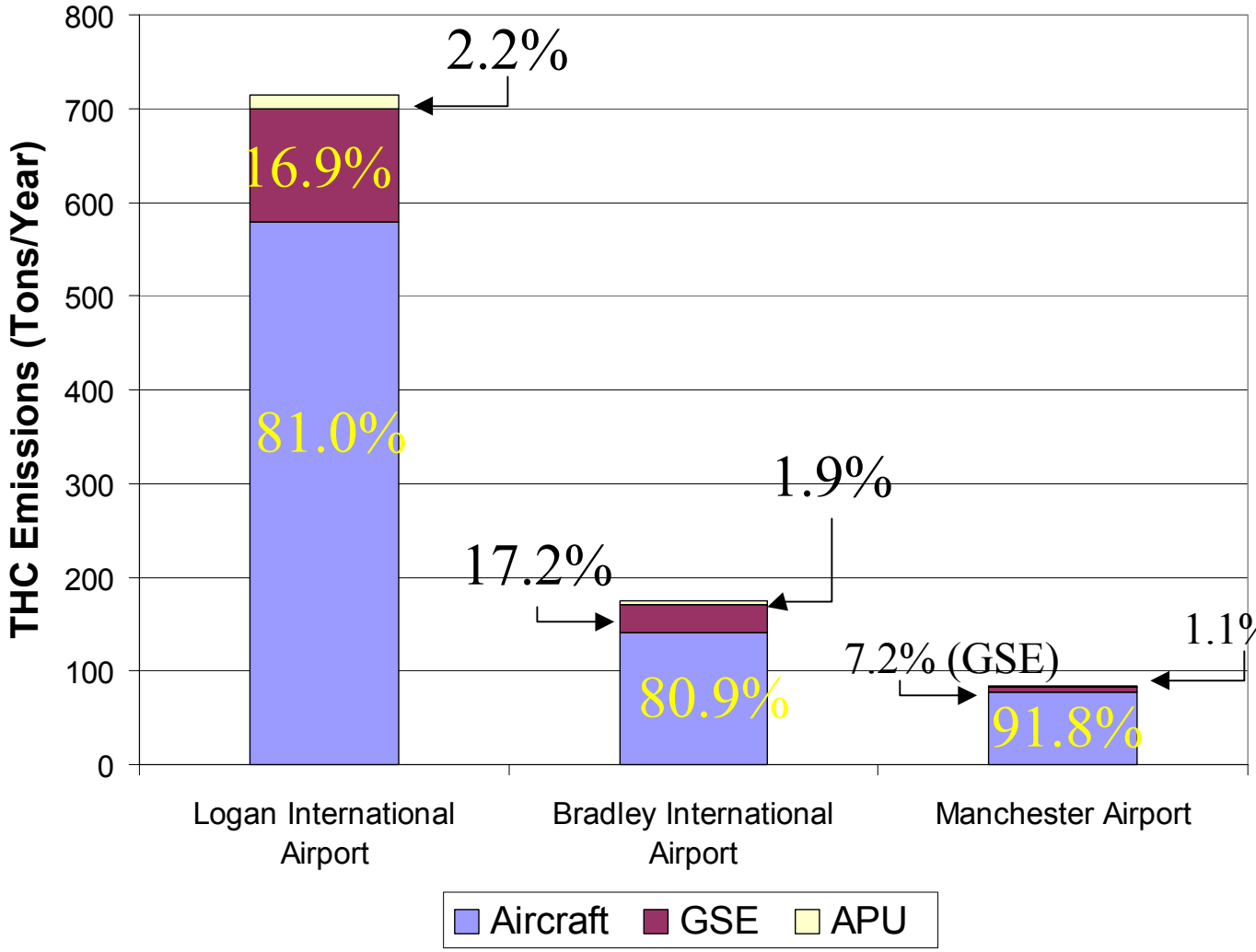
NESCAUM
Northeast States for Coordinated Air Use Management

Total Airport NOx Emissions 1999 (Aircraft, GSE & APU)



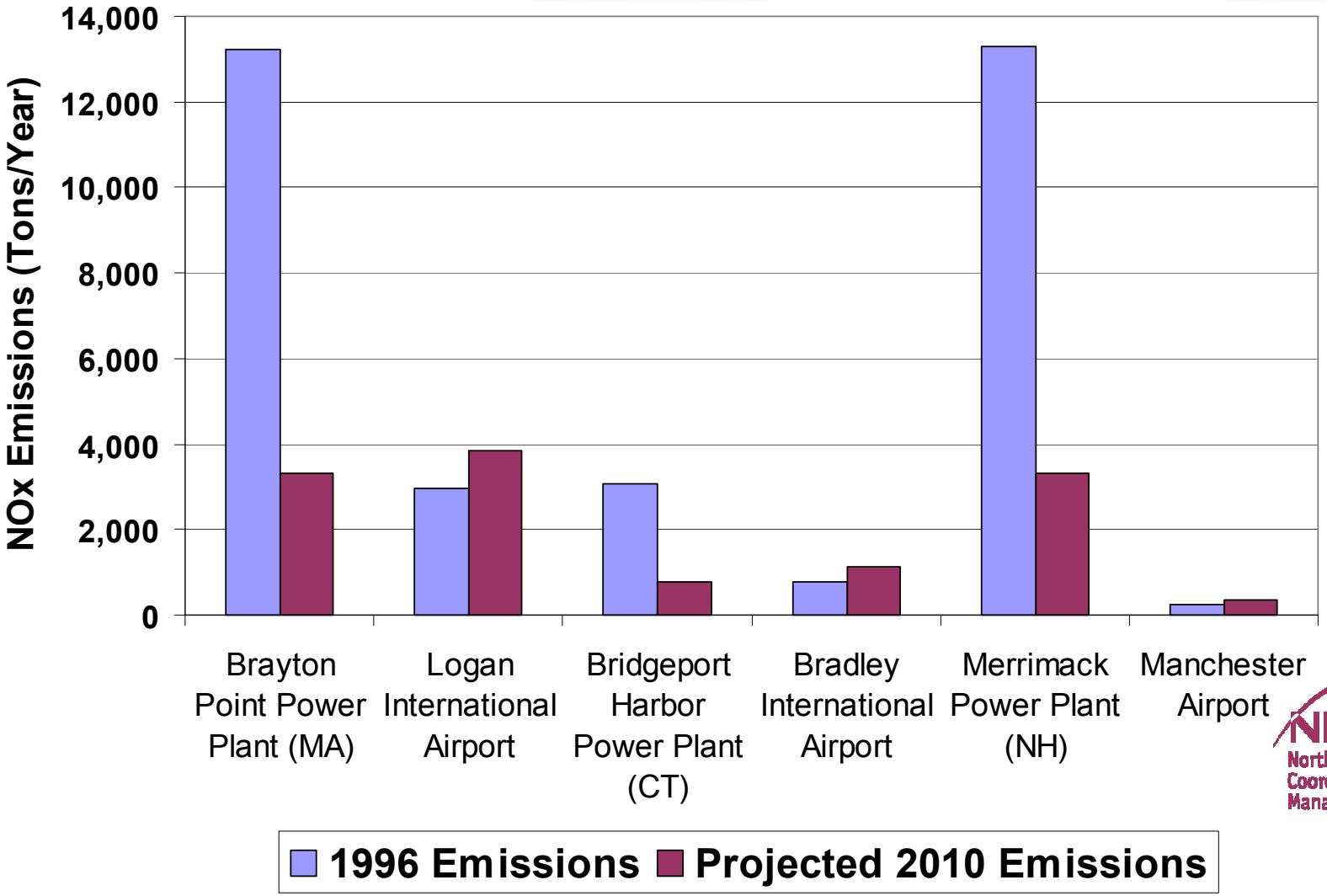
NESCAUM
Northeast States for Coordinated Air Use Management

Total Airport THC Emissions 1999 (Aircraft, GSE & APU)



NESCAUM
Northeast States for Coordinated Air Use Management

Power Plant - Airport NO_x Emissions Comparison, 1996 vs. Projected 2010



NESCAUM
Northeast States for Coordinated Air Use Management