APPENDIX A

DOCUMENTATION AND ASSUMPTIONS FOR POTENTIAL MEASURES TO MEET HGA ATTAINMENT SHORTFALL

HOUSTON/GALVESTON ATTAINMENT DEMONSTRATION

APRIL 2000 REVISION

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Area Sources

1. Ozone-scavenging catalyst for commercial and residential air conditioning units

   This measure represents equivalent NO_x reductions from the use of catalyst-treated filters in commercial and residential air-conditioning units. As air is drawn through the filter, a catalyzed chemical reaction converts ozone to oxygen. Based on a preliminary calculation performed by EPA Region 6, a credit of 13.0 tpd NO_x from this measure has been placed on the gap closure list.

2. Energy conservation for buildings

   This measure includes implementation of energy-efficient building codes and energy efficiency programs.

3. NO_x limits for water heaters, small boilers, and small process heaters

   This strategy would reduce NO_x emissions from new natural gas-fired water heaters, small boilers, and process heaters sold and installed in Texas beginning in 2002. The strategy would apply to each new water heater, boiler, or process heater with a maximum rated capacity of up to 2.0 MMBtu/hr. Rules of California's Bay Area Management District Regulation 9, Rule 6 and SCAQMD Rules 1121 and 1146.1 could be used as prototypes.

Non-road Mobile Sources

4. Accelerated purchase of Tier 3 non-road heavy-duty diesel equipment

   Under this measure, 50% of the off-road diesel engine fleet >25 hp would meet Tier 2 emission standards, and 50% would meet Tier 3 standards by 2007. To model the emissions benefits for such a measure, an output by model year was generated, using EPA's draft NONROAD emissions model for the following equipment types: construction, commercial, industrial, agricultural, lawn and garden, and logging. Local equipment population and activity files were used for the construction sector assessment, and default values were relied upon for the remainder of the sectors.

   The outputs were sorted by model year for each of these sectors by equipment type and hp grouping, and the total emissions attributable to pre-Tier 2 engines in 2007 were determined. Average Tier 2 and Tier 3 emissions rates were also determined for each grouping on a per unit basis. If Tier 3 engines were available in 2007 for a particular equipment type/hp grouping, 50% of the pre-Tier 2 equipment population was re-assigned to the Tier 2 category, and 50% to the Tier

3 category. "Re-assigned emissions" were calculated by multiplying the pre-Tier equipment populations by the per unit emissions rates for the new standard. For those cases where Tier 3 standards had not yet been adopted, 100% of the pre-Tier 2 population was assigned to the Tier 2 category.

The calculated percentage reductions were then applied to the NEVES-based emissions inventory to obtain final tpd emission reductions for the Gap List. The following table summarizes the results by sector.

Accelerated Tier 2/3 NO_x Benefits, 2007

Category	Baseline Inventory	% Reduction	TPD Benefit
Agricultural	11.95	33.0%	3.94
Construction	63.15*	29.5%	18.63
Commercial	4.79	24.6%	1.18
Industrial	8.51	17.5%	1.49
Lawn and Garden	1.14	13.2%	0.15
Logging	0.49	15.1%	0.07
Total	**90.03**	**28.28%**	**25.46**

* NEVES inventory with LA correction factor applied.

The 25.5 tpd figure is 4.5 tpd higher than the previous gap list estimate of 21.0.

5. NO_x catalyst retrofits for equipment > 175 hp

This calculation was based primarily on data reported by Siemens for their SiNOx SCR system, currently operating in several demonstration projects across the country. Incremental emission controls of 80% were assumed; reported values are 60 to 80% for mobile sources. The upper end of the control potential range may be achieved with the use of clean diesel formulations, as assumed in this analysis. Siemens reported that their system is designed for diesel engines approximately 175 hp and greater. Given that the SiNOx system has been successfully retrofitted in very different applications (e.g., on-road diesel trucks, commercial marine engines, locomotives, and construction equipment), some of which have highly transient operation cycles, this analysis assumed that an aggressive retrofit program could be applied to up to 80% of diesel engines > 175 hp, in the construction, agriculture, commercial, and industrial equipment sectors. All calculations assume that accelerated Tier 3 standards, California diesel, and diesel emulsions are in place before retrofit.

6. Emulsion fuel for diesel equipment

This calculation was based on preliminary test results of Lubrizol Corporation's LubriNOx diesel/water emulsion product, which has obtained up to 20% NOx reductions relative to the base diesel fuel. This percentage is claimed to be independent of baseline fuel properties. Given that use of the PuriNOx product requires no modifications of existing diesel engines or fuel tanks, this analysis assumed a very aggressive penetration rate of 95% of the construction, industrial, commercial, and agricultural equipment in the 8-county HGA area. If widely available, this fuel's

chief limitation is power loss— it is assumed that approximately 5% of the existing fleet applications could not tolerate the loss of power, and could not modify fuel intake to adequately compensate for the loss. All calculations are incremental to the accelerated Tier 3 program, as well as the California diesel program.

7. Electrify airport ground service equipment

   This strategy would affect owners or operators of ground support equipment at airports in the HGA area. The strategy would require owners or operators of the affected ground support equipment to ensure that their ground support equipment fleet be electric-powered by the end of 2007. The listed reduction was quantified by zeroing out the 2007 modeling emissions inventory for this category.

8. California spark ignition standard

   The benefit of the California non-road large spark ignition requirement for engines > 25 hp was calculated using EPA's NONROAD model. The input files to the NONROAD model were adjusted to simulate the introduction of lower emission engines in the area. The fractional benefit for each equipment source classification was then applied to the NEVES emissions inventory to determine the total emission reduction.

9. Ship hotelling (estimate of improved inventory)

   According to the 1993 COAST Study, ship hotelling emissions in 2007 would be 4.88 tons per day NO_x. This estimate is believed to be inflated due to the assumptions made in determining the inventory. The development of a new estimate of ship hotelling emissions has been contracted to a consulting company, and a new inventory will soon be available. According to the consulting company, the new ship hotelling emissions inventory will be approximately 50% less than the 1993 COAST estimate.

10. Economic incentives for construction equipment

11. Low-emission fuel incentives for commercial marine sources

12. Diesel fuel additives (cetane)

13. Regulate activity levels of tug/tow vessels

14. Combustion controls on existing equipment (rich to lean ratio)

15. Preventive maintenance for heavy-duty diesel vehicles

16. Light-duty diesel construction equipment standards

17. Generator standards

18. Restrict start-up/shutdown of ship engines

19. Bunker fuel improvements for commercial marine sources

20. Preventive maintenance for airport equipment

21. Diesel-powered tugs only

22. Low NO_x fuel for local locomotives

23. Restrict landscaping activities (ban from 6–10 a.m.)

24. On-ground airport operational measures

    Implementation of such measures as single engine taxiing to and from airport takeoffs , aircraft towing, minimization of reverse thrust, reduced idling, reduced thrust takeoffs

25. In-air operational measures

    Implementation of such measures as reduced landing flap, optimum flap retraction.

26. Scrappage program for nonroad diesel engines

27. Provide electric power to construction sites

    Install temporary power lines at construction sites, thus reducing use of diesel and gasoline generators.

28. Replacement with electric-powered lawn and garden equipment

29. Commercial fishing engine standards

<u>Onroad Mobile Sources</u>

30. 20% time/area driving restrictions

31. Reduce speed limit to 55 mph

    This calculation utilized link-based data projected for 2007, from H-GAC. The data files contained estimated average speed and total VMT by road classification, for a.m. peak, midday, p.m. peak, and overnight time periods for the 8-county HGA area. To estimate the benefit of this measure, only links with average speeds above 55 mph were considered, regardless of roadway class. For each of these links, a NOx emission factor was estimated in grams per mile, based on the outputs currently being used in the conformity modeling for Houston. For speeds greater than 65 mph (the limit of MOBILE5 outputs), linear extrapolations were used based on the 64 to 65 mph increment. Incremental gram per mile values were then estimated assuming a 55 mph average speed for each of these links, which were in turn multiplied by VMT for the link and summed across all links to obtain a per-day value. This process was repeated for all four time periods to obtain a value of 15.23 tpd. This amount was further adjusted to reflect a 20% decrease in VMT,

resulting in the final 11.42 figure. Note that this approach does not account for the interaction between changing VMT, traffic volumes, and resulting speeds. It is likely that the reductions would be somewhat more than 11.42 tpd, since average link speeds are likely to be higher than those given in the link-based projections, assuming 20% less volume. However, detailed traffic modeling would be needed to account for this interaction.

32. NO_x catalyst retrofits for locally registered heavy-duty diesel trucks

This calculation assumed the use of the Siemens SiNOx SCR technology for on-road heavy diesel applications. As with non-road applications, this system is estimated to obtain 80% NOx reduction levels. Assuming this measure would be mandated through local fleet rules, only those vehicles registered in the 8-county HGA region could be retrofitted. H-GAC staff estimated that approximately 50% of the total HDDV VMT in the region was attributable to locally registered fleets. Therefore, a 50% penetration rate of this technology was assumed. However, this scenario is optimistic since it assumes that drivers and HDDV owners will be able to maintain an adequate supply of reductant on board at all times, although a distribution infrastructure is not currently in place. Note that all estimates are incremental to the adoption of California diesel fuel in the area.

33. 15 ppm sulfur limit in fuel

This calculation utilized California's Predictive Emissions Model (Beta Version 2) to estimate the incremental benefit of moving from 30 to 15 ppm sulfur in gasoline for pre-LEV vehicles, holding all other parameters constant (equal to the default values provided in the model). Such a fuel program follows the proposed modifications to California RFG II, in the wake of the MTBE ban in that state. The benefit for LEV and later vehicles was estimated using EPA's fuel sulfur effect equations, as developed for the upcoming MOBILE6 model. The overall, fleet-average percentage reduction is projected at 3.41%, incremental to California RFG II, with Cal LEV in place starting in 2004.

34. Gasoline detergent additives

This is a conservative estimate of reductions obtainable from gasoline detergent additives. The base fuel is assumed to be California RFG Phase II. In a protocol testing of the product for New Hampshire, the original claimed reduction was 2.31 ton NO_x/million gallons gasoline burned. This figure was reduced to 0.17 ton NO_x/million gallons gasoline by New Hampshire, and is the basis for the placeholder figure included in this current SIP list.

35. California LEV automobile standards

Section 177 of the Federal Clean Air Act allows states to adopt California motor vehicles emission standards, which are more stringent than federal motor vehicle emission standards. This scenario assumes the adoption of the California LEV II program commencing in 2004. Incremental emissions estimates assumed California RFG II, with an NLEV/Tier 2 baseline. Applying the ratio of the certification standards, and accounting for both the Tier 2 and Cal LEV II phase-in schedules, a fleet-average benefit of 1.73% was assumed, resulting in the 2.41 tpd listed.

36. Light rail

37. Vehicle scrappage

This analysis assumed that 13,000 20-year-old (or older) vehicles, tested as "high-NOx" emitters under ASM, would be scrapped per year, from 2005 through 2007. It was also assumed that these vehicles would be replaced by 8-year-old vehicles with "normal-NOx" emission levels. Estimation of high and normal NOx emission rates as a function of vehicle age were taken from the Tier 2/low-sulfur spreadsheet by model-year analysis section. The analysis also used the MOBILE5 default VMT rates for 20-year-old vehicles were used to estimate total tpd values. Note that 13,000 vehicles per year is approximately twice the rate proposed in the initial H-GAC Scrap Demonstration Proposal from 1997. A detailed economic and financial assessment should be undertaken to refine the estimate of likely market potential for this measure.

38. Retrofit of heavy-duty gasoline-powered vehicles with three-way catalysts

This new measure, not previously included on the gap closure list, targets such vehicles as medium-sized school buses and parcel delivery fleets. Since a reliable estimate of the size of these fleets in the 8-county HGA area could not be developed at this time, the total number of heavy-duty gasoline vehicles operating without three-way catalysts in the area was estimated to provide an upper bound of the benefit for this measure.

Local vehicle registration, VMT fraction data, and default mileage accumulation rates from MOBILE5b were used to estimate 2007 engine populations and average miles per day values for the affected fleet (three-way catalysts began to be phased into the fleet in 1988.) In addition, the average NOx grams per mile values for the pre-1988 fleet were estimated using outputs by model year from the MOBILE model, assuming baseline I/M and fuel conditions for the HGA area.

Unfortunately, there is no direct way to model emission factors for old engines operating with new catalysts – the deterioration rates used in MOBILE apply to both engine and catalyst alike. It was assumed that vehicles retrofitted with a new, properly sized catalyst would generate approximately the same emissions as a five-year-old engine/catalyst system. These benefit estimates should be validated using actual test data if available. The table below summarizes the findings of this analysis:

Three-Way Catalyst Retrofit Calculation Summary

HDGV VMT Fraction	0.017
Total 8-County VMT (mi/day)	129,487,934
HDGV VMT (mi/day)	2,201,295
% of Total HDGV VMT for Pre-1988s	8.94%
Total VMT for Pre-1988s (mi/day)	196,846
Average Pre 88 mi/day	4,009
Estimated Pre 88 population	17,921

Pre 88 gpm	7.154
5 Year old gpm	4.005
g/mi delta	3.149
Total reduction, tpd	0.68

Therefore, 0.68 tpd of NOx could be generated if 100% of the pre-1988 fleet were retrofitted with three-way catalysts in 2007. This measure could be effectively implemented through an I/M program with loaded testing of all heavy-duty gasoline engines. Cut points could be set to require all vehicles to have properly functioning three-way catalysts. These standards could be obtained through retrofits or the purchase of a new vehicle. Either way, significant emission reductions would result on a per engine basis.

39. Signalization (RCTSS, light rail)

40. Episodic controls

    Houston Metro estimated that episodic controls would result in 5,000,000 fewer VMT.

41. Ozone Action Days

    Houston Metro estimated that episodic controls would result in 5,000,000 fewer VMT.

42. Bus fare reductions

    Houston Metro used a consultant to evaluate a 50% reduction in bus fares. Given the elasticity of ridership vs. fare, an increase in daily ridership of 22,113 was estimated. This resulted in a net reduction of NOx of 0.08 tons per day.

43. Fleet idling restrictions

    This measure assumes extreme minimization of idling from diesel trucks in the area, as per the NCTCOG proposal for DFW. The idling emission factor for HDDVs from MOBILE5 was used, combined with an estimated 25% idle hours for these vehicles. Using the weighted average speed of 46 mph for the area, and total VMT estimates for these vehicles, benefits were estimated assuming < 1% idle time under the potential rule.

44. Local fleet rules for light-duty commercial vehicles

    This measure assumes that all light-duty commercial vehicles registered in the 8-county HGA area will meet SULEV or better standards by 2007. Numerous simplifications were made to arrive at this estimate. First, all 50,152 vehicles currently registered with the State under the Texas Clean Fleet program (excluding emergency vehicles) were assumed to be passenger cars or light-trucks 1. Next, all vehicles were assumed to be four years old or less, and evenly distributed in age from one to four. Next, all vehicles were assumed to accumulate 15,000 miles per year, and to be driven 6 days per week. All benefits were estimated relative to the proposed Cal LEV II phase-in schedule. In-use baseline gpm emissions levels were estimated from the Tier 2 spreadsheet and multiplied by

the ratio of the certification standards for each model year between 2004 and 2007. Note that this estimate is probably conservative, since LDT2s and HDVs are likely to achieve significantly greater reductions under such a program.

45. Emulsion fuels for heavy-duty diesel trucks

This measure assumed the use of the Lubrizol PuriNOx emulsion, similar to that for non-road sources. It was assumed that only the locally-registered fleet could be expected to use this fuel (50%). A 15% reduction was applied to the post-retrofit emission levels.

46. Expand bikeway network

47. Expand transit service area

48. New or expanded bus service
49. School carpooling programs

50. Expanded RideShare program for transit

51. Flex-time (school)

52. Truck stop idling restrictions

53. New or expanded carpools/vanpools

54. Transit fare incentives on Ozone Action Days

55. Telecommuting

EPA's beta version of its Commuter Model was used, with the following assumptions: 1) total 2007 employment in 8-county region: 2,632,000; 2) employment affected by teleworking program: 2,098,784 (79.7% of total employment); 3) proportion of affected employees actually teleworking: 10%. All other inputs, including estimated mode shares, trip distances, vehicle speeds, emission factors, and the EPA default average of 1.8 days per week for telecommuting, were the held the same as in KM Chng's previous analyses, as previously reported to METRO. The model showed 1,909,646 VMT reduced per day, resulting in a NO_x reduction of 3.00 tons/day.

56. Hybrid buses

57. Flex-time (work)

58. TRANSTAR exansion

59. Drive-through restrictions

60. Local fleet rules for heavy-duty commercial vehicles

61. Transit-oriented development

62. Market-based value (congestion) pricing

    Congestion pricing, also called time-of-use pricing, is designed to discourage driving during peak times by charging a higher price to use the road. The idea is to eliminate or delay low-priority vehicle trips until off-peak hours. The approach is analogous to the pricing of long-distance telephone service, which is higher during weekday business hours.

63. Cetane enhancers in fuels

64. Shuttle for hire (clean-fueled)

65. Emission-based registration fees

66. New sidewalks/crosswalks

67. New or expanded park-and-rides

68. New technology (guided busways)

69. Gas tax increases

70. Parking restrictions/pricing

71. Driving cycle/traffic calming

72. Conserve air conditioning use

73. Vehicle deterioration rate

74. Higher registration fees for ownership of multiple vehicles

75. Higher registration fees for vehicles with more annual VMT

76. Higher registration fees for older vehicles

77. Sustainable development, pedestrian-oriented development

78. Alternative fuels (LNG)

79. Alternative fuels (CNG)

80. Employer on-road vehicle emission reduction program (SCAQMD Rule 2202)

81. Accelerated fleet turnover

82. Operation-based vehicle insurance premiums

This program would set vehicle insurance premiums based on the parameters of when, where, and for how long policyholders operate their vehicles. This innovation is made possible by installing a sensor in the car that logs the referenced parameters in real time. The less time that a policyholder drives, especially during peak commute times, the lower the insurance premium.

83. Pay-at-the-pump liability insurance

A surcharge on gasoline would be instituted as a way to pay for the minimum, state-required liability coverage. under this approach, the total cost of driving (fuel plus liability insurance) for the average driver is unchanged. However, this program would provide a incentive to drive less miles than average because it results in net reduced costs, while driving more miles than average results in a net increased cost. Drivers would still have the option of paying for additional coverage through their own insurance company. This system could be implemented to be revenue-neutral.

84. Vehicle registration fee rebates

Rebates on the annual vehicle registration fee would provide an incentive to purchase low-emitting vehicles and reduce the annual VMT. Under such a system, owners of low-mileage, low-emission vehicles would qualify for a rebate in the form of discounted registration fees, while owners of high-mileage, high-emission vehicles would be subject to a fee or surcharges. This system could be implemented to be revenue-neutral.

85. Parking cash-out

86. Intermodal freight efficiency for heavy-duty diesel vehicles

This strategy encompasses a number of programs for more efficient shipping, including dedicated truck lanes, maintenenace of proper tire pressure and other maintenance measures to promote fuel efficiency, and shortening of truck stop stays.

87. Improved airport access options

88. Intelligent vehicle highway systems

89. Location-efficient mortgages

90. Truck stop electrification for in-truck services

91. Proximate commute programs

92. Station cars

93. Database sharing/traffic management

94. Remote sensing to identify high-emitting vehicles

95. Repair assistance (I/M)

96. Use of alternate fuels or electric power by airport buses

97. Toll reductions for high-occupancy vehicles

98. Car rental service for single tasks

99. Expand I/M beyond 8-county area

100. Suburb to suburb transit service (could include high capacity transit)

101. "Unbundling" of parking from commercial leases (level the playing field for SOV alternatives)

102. Ban on trucks from certain areas

103. Performance standards in contracts
104. Incubator for development of privatization of transit (to grow opportunities for transit in undeserved areas)

105. Removal of speed humps (public and private streets)

106. Improved coordination of off-duty police officers at parking garages/lots to minimize congestion

METRO fleet idling restrictions

METRO-specific emission factors previously developed were used, using MOBILE5a_h and projected METRO fleet data. The modeled HDDV emission factors were used in the calculations, and do not include any adjustment for vehicle weight class/transit bus category. MOBILE5a_h is insensitive to cold starts when calculating HDDV NO_x, so any potential "first-start-of-the-day" effects on emissions are not accounted for. Air conditioning while idling increases the load on the engine, and would be expected to increase NO_x emissions. Neither the EPA MOBILE programs nor the California EMFAC programs can model the use of air conditioning in heavy duty vehicles. Therefore, this emission calculation does not account for air conditioning use, and so may underestimate the actual NO_x reduction. Operational assumptions: bus idling is curtailed for the morning peak period only, and only for buses in revenue service. The size of the affected fleet is 1,349 buses, and the idling reduction is 60 minutes per bus. METRO's factor to annualize daily results, accounting for weekend service levels, is 290 days/year. Calculation: NO_x emission factor for 2007 = 30.770 g/vehicle-hr. Weekday 2007 NO_x emissions = (30.770 g/vehicle-hr) * (1.0 hr/day) * (1,349 buses) = 41,509 g/day = 0.046 tons/day.

Total employment in 8-county region, for 2007: 2,632,000Employment affected by teleworking program: 2,098,784 (79.7% of total employment)Note: The 2,098,784 is the sum of "Office" (842,778), "Retail"

(786,808), "Medical" (195,454), and "Government" 273,744). Inclusion of some sectors, such as retail and medical employment, may cause program benefits to be overestimated because the portion of employees in these sectors who can telecommute may be relatively low. EPA guidance for the model advises against including the Retail and Medical sectors.Proportion of affected employees actually teleworking: 10%All other inputs, including estimated mode shares, trip distances, vehicle speeds, emission factors, and the EPA default average of 1.8 days per week for telecommuting, were the held the same as in KM Chng's previous analyses, as reported to METRO on 3/13/00, 3/17/00, and 3/30/00 4:15 PM EST.ResultsVMT reduction per day: 1,909,646NOx emissions reduction: 2.999 tons/day