UNIVERSITY OF CALIFORNIA

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Characterizing Black Carbon Inside Vehicles: Implications for Refined Exposure Assessments for Diesel Exhaust Particulate Matter

A dissertation submitted in partial satisfaction of the

requirements for the degree

Doctor of Environmental Science and Engineering

by

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ABSTRACT OF THE DISSERTATION

Characterizing Black Carbon Inside Vehicles:

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Doctor of Environmental Science and Engineering

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Professor Arthur M. Winer, Chair

Diesel-powered vehicles are now the most important mobile source of particulate matter and oxides of nitrogen. There is also evidence that diesel exhaust particulate matter (DPM) may be carcinogenic. However, accurate assessments of human exposure to DPM have been lacking. One of the most important routes of exposure, time spent in vehicles, has never been quantified. This thesis research fills this gap by analyzing the real-time black carbon (BC) measurements from a recent large study of in-vehicle pollutant concentrations.

Analysis of video tapes made during the study's driving runs was used to make adjustments for atypical driving. The BC measurements were linked with observable driving factors such as following distance and the type of vehicle

followed. The highest BC concentrations occurred almost exclusively while following diesel vehicles, especially those with visible emissions and those with low exhaust locations. Followed-vehicle type explained a large portion of the variability in the in-vehicle BC concentrations. BC data were grouped by the most important predictive factors that could also be linked to typical driving, such as the type and number of axles of the followed vehicles, roadway type, and relative amount of traffic congestion. Realistic driving was then simulated by sampling from the concentration data groupings via a stochastic exposure model. In-vehicle exposures as well as total exposures were calculated for different regions of California, and an extensive analysis of uncertainty was also conducted.

One-third of total exposures was due to time spent in vehicles, making time spent in-vehicles the most important route of DPM exposure on a per time basis. Based on exposures occurring in vehicles and estimated emissions from on-road versus off-road sources, on-road emissions appeared to be about three times more important, on an equal mass basis, at producing DPM exposures. The uncertainty analysis showed almost all uncertainty in the exposures was due to the uncertainty in the fraction of ambient particulate matter due to diesel vehicles, as estimated from the EMFAC mobile source model. The EMFAC model relies on relatively few tests of diesel vehicles compared to gasoline-powered vehicles.