APPENDIX D

Conceptual Model for the HGB Attainment Demonstration SIP Revision for the 2008 Eight-Hour Ozone Standard

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1.1 SUMMARY

Ozone formation conceptual models characterize ozone trends, precursors, formation, and transport in a particular geographic area. This information provides a comprehensive picture of not only where and when ozone forms, but also how and why ozone forms in a geographic area. Conceptual models are required by the U.S. Environmental Protection Agency (EPA) to accompany ozone photochemical modeling performed for State Implementation Plans (SIP). The TCEQ believes that the Conceptual Model from the 2010 Houston-Galveston-Brazoria (HGB) Attainment Demonstration SIP Revision (TCEQ, 2010) adequately explains ozone formation in the HGB area. Recent trends in ozone and its precursors as well as a discussion of recent studies detailing ozone formation, accumulation, background, and transport can be found in Chapter 5: Weight of Evidence. A summary of the previous conceptual model is included below.

The Houston-Galveston-Brazoria (HGB) area has made substantial progress in improving air quality. The area is currently measuring attainment of both the one-hour ozone National Ambient Air Quality Standards (NAAQS) of 0.12 ppm and the 1997 eight-hour ozone NAAQS of 0.08 ppm. Work remains, however, to achieve the more stringent 2008 eight-hour ozone NAAQS of 0.075 ppm.

Local ozone production in the HGB area peaks at the same time of year and for many of the same reasons as in other areas of Texas and the United States. However, the ozone season in Houston lasts longer than in many other areas. The HGB area also has a relatively high frequency of ozone exceedance days compared to the national averages, reflecting the persistent hot, sunny and relatively stagnant conditions associated with high pressure in the Gulf of Mexico during the summer as well as the large number of mobile, area, and industrial sources.

Ozone production is generally associated with relatively clear skies, light winds, abundant sunshine, and warm temperatures. Typically, these meteorological conditions are associated with high-pressure areas that migrate across the U.S. during the summer season. However, the persistent summertime high pressure area in the Gulf of Mexico, and air mass flow reversals associated with the land/sea breeze phenomenon, make the Houston situation unusual, if not unique, among U.S. metropolitan areas. High-pressure areas have two characteristics that encourage ozone formation: light winds and subsidence inversions. Typically, winds circulating around a high-pressure system are too weak to ventilate the urban area well, so local emissions tend to accumulate. Subsidence inversions cap the vertical mixing, further aggravating the situation by concentrating local pollutants near the surface.

Ozone formation in the HGB area has been associated with the daytime/nighttime flow reversal of the land/sea breeze which was identified as a cause during the 1993 Gulf of Mexico Air Quality Study and confirmed by several more recent studies by state and federal researchers. Land/sea breezes are common in coastal areas and have been associated with ozone formation in the Houston area. Land/sea breeze flow reversal requires light synoptic scale forcing associated with high-pressure areas, thereby allowing local phenomena to dominate the local circulations. Light winds and the restricted vertical mixing allow high concentrations of pollutants to accumulate during the night and morning hours, and the nocturnal land breeze carries the pollutants out over Galveston Bay and into the Gulf of Mexico. Then, during the afternoon, the sea breeze flow reversal carries the ozone back into the city. In contrast, on low ozone
days, the precursor emissions are diluted and carried out of the area by the stronger and more persistent winds.

A number of other specific factors add considerably to the complexity of the HGB area situation. For example, the large cluster of petrochemical industries and other sources in the Houston Ship Channel emit nitrogen oxide (NO$_x$) along with a variety of volatile organic compound (VOC) precursors not typically found in other urban areas. Oak forests near the city emit large amounts of isoprene, which reacts strongly with the NO$_x$ emitted from these industries and numerous other anthropogenic sources in the area. When compared to local sources, background concentrations and transport issues appear to play a secondary, though not insignificant, role in the HGB area. However, transport issues are likely to grow in importance in the future as local emissions reductions continue.

Detailed investigation of these factors establishes the following findings:

- The highest ozone concentrations and events in the HGB area appear to be driven by industrial emissions of ozone precursors – NO$_x$ and highly reactive VOC (HRVOC) – as well as by other local sources and meteorological conditions that facilitate ozone accumulation and transport across the city.

- Over time, ozone concentrations in Houston have been decreasing, and, in some cases, substantially. Even when data are adjusted to account for inter-annual variations in meteorology, a downward trend in concentrations is observed.

- The decline in ozone concentrations is substantiated, in part, by sizeable reductions in emissions of NO$_x$ and HRVOC in the HGB area. In spite of measured decreases in industrial emissions, industrial regions of the HGB area continue to appear linked to the highest ozone concentrations observed in the city.

- Finally, background ozone concentrations entering the HGB area are higher when transport winds are very light and when the transported parcels originate from the northeast. In the former case, recirculation of local emissions and ozone is a strong possibility. In the latter case, the northeasterly winds appear to carry higher levels of background ozone into southeast Texas from the Midwest and southeast U.S.

1.2 REFERENCES