APPENDIX A
POLLUTANT CHARACTERISTICS

Oxides of Nitrogen

NOx compounds, such as NO, NO₂, and NO₃ are the result of the combustion process. Nitrogen is often bound to combustion fuels and the ambient air is composed of 79 percent nitrogen, therefore NOx compounds are an unavoidable result of the combustion process. Details of why this occurs are provided in the discussion of combustion in the following section.

Brownish in color with a pungent smell, NO₂ is one of the primary contributors to visible urban haze and brown smog. Relative to other criteria pollutants NO₂ is not considered a health risk, although in high concentrations it can result in damage to cells in the respiratory tract (SCAQMD, 1997). Currently there is not a single area in the US that is in violation of the NO₂ standard (USEPA, 1999). Ninety percent of the NOx compounds resulting from combustion are in the form of nitric oxide (NO). In the presence of sunlight and other combustion byproducts such as volatile organic compounds (VOCs), NO will contribute to the formation of tropospheric ozone. That is, NO and other NOx compounds are not serious pollution problems in and of themselves, but are precursors to more hazardous ozone formation. It is estimated that approximately 50-70 percent of NOx emissions result from motor vehicles, with the residual resulting from electric utilities and industrial boilers.

Oxides of Sulfur

Formed by the oxidation of elemental sulfur in fuel, SOx is a colorless gas with a distinct odor, and is also the result of combustion. SOx is not a serious automobile pollutant since sulfur levels in gasoline and diesel fuels are highly regulated. The primary sources of SOx pollution are from industry and power plants that use coal with a high content of sulfur.

Carbon Monoxide

A colorless and odorless gas, CO is the result of incomplete combustion of hydrocarbons. It is primarily a localized pollution concern or what is referred to as a ‘hot spot’ problem. This is due to the fact that it disperses well and will not typically have time to accumulate at ground level. An exception to this is at high elevation or during cool weather conditions that occur during winter months. Almost all CO air pollution (i.e. 90 percent), is the result of automobile tailpipe emissions (USEPA, 1997).

When CO does accumulate in high concentrations it is a deadly pollutant. When inhaled it interferes with the oxygen carrying capacity of the blood, which results in drowsiness, headaches, and impairment. At high concentrations CO poisoning can be fatal, although such conditions do not typically occur in ambient air (SCAQMD, 1997).
Particulate Matter

Solid or liquid particles composed of smoke, ash, pollen, or chemical droplets, particulate matter becomes an air pollutant when it is small enough to stay suspended for prolonged periods. Particulate matter can be a hazard by itself or act as a carrier for other toxic air contaminants. It also contributes significantly to visibility degradation.

Combustion is the primary source of direct particulate matter, producing particles that range from .01 to 10 microns in diameter. Automobile and other on-road combustion accounts for approximately one quarter of all direct particulate matter with the remainder coming from stationary sources (USEPA, 1997). Particulate matter can also result from fugitive sources such as agricultural activity, construction sites, road dust, and naturally occurring wind erosion.

As can be seen in Table 2-1, there are two standards for particulate matter, one for particles less than 10 microns in diameter (PM$_{10}$) and one for particles less than 2.5 microns in diameter (PM$_{2.5}$). Large particles can cause scaring of lung tissue and aggravate respiratory and heart problems, while fine particles less than 2.5 microns can enter the bloodstream and lead to more serious health problems and premature death. As with most air pollution, health problems are accentuated for the young, elderly, and those with respiratory problems such as asthma (Wilson and Suh, 1997).

Lead

Added to automobile fuel as an anti-knocking compound and performance-enhancing agent, lead is carried on combustion particulates. Lead is a toxic heavy metal that, when inhaled, can enter the lungs and bloodstream and result in brain and nervous system damage. This is particularly a problem for developing individuals. Starting in 1978, lead additives to fuel were phased out and are not allowed in gasoline. As a result, lead air pollution from automobile sources, has been virtually eliminated.

Ozone

Ozone (O$_3$) is a serious air pollution problem when it accumulates at the ground level. Unlike stratospheric O$_3$, which provides protection from ultra-violet rays from the sun, ground level or tropospheric O$_3$, can damage lung tissue and reduce lung capacity. Tropospheric O$_3$ is the primary component of urban smog. When exposed to O$_3$ for six to seven hours, even at relatively low concentrations lung function is significantly reduced in normal, healthy individuals during moderate exercise. The current air quality standard for O$_3$ is 0.12 ppm one-hour maximum concentration over a twenty-four hour period. Many health studies have indicated that negative effect of O$_3$ can occur at lower concentration if exposure is for an extended period of time (USEPA, 1996). In light of this the USEPA has recommended an additional O$_3$ standard of 0.08 ppm maximum 8-hour concentration over a twenty-four hour period (62 CFR 138). This new standard promulgated in 1997 is currently being challenged in court and was not in effect at the time of this research.

Unlike the other five criteria pollutants, O$_3$ is not emitted directly into the air by specific sources. It is formed when NOx compounds and VOCs react with sunlight in the lower layers of the atmosphere. These precursors to O$_3$ can be the product of numerous sources. As discussed NOx
compounds are the result of combustion. VOCs in the form of hydrocarbons can also be the result of combustion as well as other industrial processes and natural sources. Often these precursors will be emitted in one area and transported in the atmosphere for miles before reacting to form O3. As a result, high O3 concentrations can occur over areas that are distant from the precursor source and in areas low in air pollution emissions.

Volatile Organic Compounds

Volatile Organic Compounds (VOCs) are reactive hydrocarbons that contribute to O3 formation. VOCs include many chemical species of hydrocarbons, but do not include methane and other non-reactive compounds. Some of the more reactive and problematic VOCs include ethylene, acetylene, ethane, propylene, and even toxic compounds such as benzene. There are numerous sources of VOCs including solvents and other industrial processes, waste disposal, evaporation and incomplete combustion of motor vehicle fuels, and natural sources. In some areas, forest canopies can contribute up to 50 percent of the VOC emissions in the form of terpenes (from pines) and isoprenes (from various broad-leaf plants).

Ozone forms when VOCs mix in the lower layers of the atmosphere with NOx compounds in the presence of sunlight. The resulting concentration of O3 is a complex function of weather conditions and precursor emissions. As a result, ozone pollution levels are very difficult to predict and control. Ozone pollution is a problem that is wide reaching and difficult to control. Although VOCs are not a criteria pollutant, they are an important player in the formation of ozone. It is therefore just as important to monitor and control VOC emissions as it is other criteria pollutants. This is particularly important in urban areas where motor vehicles can contribute more than 30 percent of the total VOC emissions.