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FINAL REPORT
BASELINE METEOROLOGY AND AIR QUALITY IN THE FOLSOM DISTRICT

PART 3 - CHAPTERS 5-7
BASELINE AIR QUALITY EMISSION LEVELS
AIR QUALITY REGULATIONS
MONITORING RECOMMENDATIONS

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5.0 BASELINE AIR QUALITY EMISSION LEVELS

5.1 FORMATION OF AIR POLLUTANTS

5.1.1 Introduction

Polluted atmospheres generally are associated with man's industrial and domestic activities. However, many of the major gaseous pollutants are also emitted by nature. Taken on a worldwide basis, the total mass of trace gases emitted by nature exceeds those emitted by man by several orders of magnitude. Nonetheless, man's activities do adversely affect the quality of the atmosphere, particularly in dense urban areas and near large emission sources. For many of the pollutants, serious long-term worldwide effects are feared. The effects may be immediate and obvious, such as poor visibility, eye irritation, and objectionable odors; or the effects may be noticeable only through longer periods of observation, such as in corrosion. More subtle effects require sophisticated statistical studies to determine such things as human health effects and changes in the earth's energy balance.

Table 5.1-1 compares typical concentrations of pollutants (Cadle, 1970) with those found in uncontaminated areas. It can be seen that the ratio of concentration of polluted air to clean air ranges from fractional to 1000-fold. Table 5.1-2 by Robinson and Robbins (1972) summarizes the worldwide sources, atmospheric concentrations, residence times, and removal reactions for eight principal gaseous air pollutants. Except for sulfur dioxide, emissions from natural sources exceed those from pollution sources. Figure 5.1-1 and 5.1-2 show the relationship between outdoor and indoor pollution levels for sulfur dioxide and carbon monoxide. Measurements such as these indicate serious penetration into homes near strong pollution sources (Benson, et. al., 1972).

5.1.2 The Gaseous Compounds of Carbon

The gaseous compounds of carbon found in natural and polluted atmospheres comprise a broad spectrum of the compounds of organic chemistry. Because carbon can form bonds with elements such as hydrogen, oxygen, nitrogen, and sulfur and at the same time combine with itself to form a series of straight and branched chain, cyclic, and combined cyclic-chain systems, an almost infinite number of compounds are possible. Many gaseous carbon compounds such as methane (marsh gas), carbon dioxide, carbon monoxide, the terpenes (Table 5.1-3 [Rasmussen, 1972]), and other volatile plant materials are emitted in nature through biological processes, volcanic action, forest fires, natural gas seepage, etc. In areas inhabited by man, the emissions of commerce, industry and transportation are largely concentrated in urban areas and generate high local concentrations of volatile solvents and fossil fuel combustion products.

Table 5.1-1

Comparison of Trace Gas Concentrations (ppm)

	Clean air	*Polluted air*	*Ratio polluted-to-clean*
CO_2	320	400	1.3
CO	0.1	40–70	400–700
CH_4	1.5	2.5	1.3
N_2O	0.25	(?)	—
$NO_2(NO_x)$	0.001	0.2	200
O_3	0.02	0.5	25
SO_2	0.0002	0.2	1000
NH_3	0.01	0.02	2

Table 5.1-2

Summary of Sources, Concentrations, and Major Reactions of Atmospheric Trace Gases

Contaminant	*Major pollution sources*	*Natural sources*	*Estimated emissions (tons)*		*Atmospheric background concentrations*	*Calculated atmospheric residence time*	*Removal reactions and sinks*	*Remarks*
			Pollution	*Natural*				
O_2	Combustion of coal and oil	Volcanoes	146×10^6	No estimate	0.2 ppb	4 days	Oxidation to sulfate by ozone or, after absorption, by solid and liquid aerosols	Photochemical oxidation with NO_2 and HC may be the process needed to give rapid transformation of $SO_2 \rightarrow SO_4$
H_2S	Chemical processes, sewage treatment	Volcanoes, biological action in swamp areas	3×10^6	100×10^6	0.2 ppb	2 days	Oxidation to SO_2	Only one set of background concentrations available
CO	Auto exhaust and other combustion	Forest fires, oceans, terpene reactions	304×10^6	33×10^6	0.1 ppm	<3 years	Probably soil organisms	Ocean contributions to natural source probably low
NO/NO_2	Combustion	Bacterial action in soil (?)	53×10^6	NO: 430×10^6 NO_2: 658×10^6	NO: 0.2–2 ppb NO_2: 0.5–4 ppb	5 days	Oxidation to nitrate after sorption by solid and liquid aerosols, hydrocarbon photochemical reactions	Very little work done on natural processes
NH_3	Waste treatment	Biological decay	4×10^6	1160×10^6	6 ppb to 20 ppb	7 days	Reaction with SO_2 to form $(NH_4)_2SO_4$ oxidation to nitrate	Formation of ammonium salts is major NH_3 sink
N_2O	None	Biological action in soil	None	590×10^6	0.25 ppm	4 years	Photodissociation in stratosphere, biological action in soil	No information on proposed absorption of N_2O by vegetation
Hydrocarbons	Combustion exhaust, chemical processes	Biological processes	88×10^6	CH_4: 1.6×10^9 Terpenes: 200×10^6	CH_4: 1.5 ppm non CH_4: <1 ppb	4 years (CH_4)	Photochemical reaction with NO/NO_2, O_3; large sink necessary for CH_4	"Reactive" hydrocarbon emissions from pollution = 27×10^6 tons
CO_2	Combustion	Biological decay, release from oceans	1.4×10^{10}	10^{12}	320 ppm	2–4 years	Biological adsorption and photosynthesis, absorption in oceans	Atmospheric concentrations increasing by 0.7 ppm/year

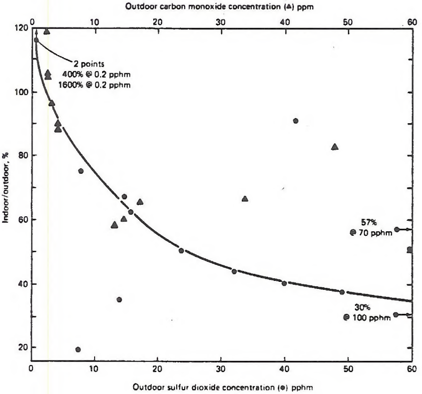

Figure 5.1-1

Indoor concentrations of sulfur dioxide and carbon monoxide as a function of outdoor concentrations.

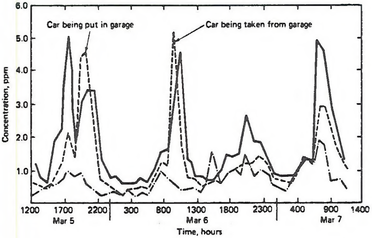

Figure 5.1-2

Carbon monoxide concentrations in house with gas range and furnace and with attached garage. Solid line, kitchen; dashed line, family room; dotdashed line, outside.

Table 5.1-3

Worldwide Terpene Emission Estimates

Investigator	*Method*	*Estimate in tons*
Went[a]	Sum of sagebrush emission and terpenes as percentage of plant tissues	175×10^6
Rasmussen and Went[b]	1. Bagging foliage 1 liter/10 cm^2	23.4×10^{6d}
	2. Enclosure forbs 0.65 m^3/m^2	13.5×10^{6d}
	3. Direct *in situ* ambient conc.	432×10^6
Ripperton, White, and Jeffries[c]	Reaction rate O_3/pinene	2 to 10 × previous estimates

[a] F. W. Went, *Proc. Nat. Acad. Sci.* **46**, 212 (1960).

[b] R. A. Rasmussen and F. W. Went, *Proc. Nat. Acad. Sci.* **53**, 215 (1965).

[c] L. A. Ripperton, O. White, and H. E. Jeffries, "Gas Phase Ozone-Pinene Reactions," pp. 54–56. Div. of Water, Air, and Waste Chemistry, 147th Nat. Meeting Amer. Chem. Soc., Chicago, Illinois, 1967.

[d] Not corrected for vertical foliage area over ground area.

Table 5.1-4

Estimates of Hydrocarbon Emissions, 1940-1970 (10^6 tons/year) (United States)

Source category	*1940*	*1950*	*1960*	*1968*	*1969*	*1970*
Fuel combustion in stationary sources	1.4	1.3	1.0	1.0	0.9	0.6
Transportation	7.5	11.8	18.0	20.2	19.8	19.5
Solid waste disposal	0.7	0.9	1.3	2.0	2.0	2.0
Industrial process losses	3.3	5.2	4.3	4.4	4.7	5.5
Agricultural burning	1.9	2.1	2.5	2.8	2.8	2.8
Miscellaneous	4.5	4.2	4.4	4.9	5.0	4.4
Total	19.1	25.6	31.6	35.2	35.2	34.7
Total controllable[a]	14.7	21.4	27.2	30.3	30.2	30.3

[a] Miscellaneous sources not included.

5.1.2.1 The Hydrocarbons

Table 5.1-4 shows the emissions of hydrocarbons in the United States since 1940 (Cavender et al, 1973). Transportation is by far the principal emitting source, and these data indicate that its emissions seem to have peaked starting in 1968. Table 5.1-5 gives the average concentration for about 30 hydrocarbon compounds identified and measured in Los Angeles, California air (LAAPCD, 1970-72). More than 60 hydrocarbons have been identified, but the total number possible is very large and is limited only by the sensitivity and selectivity of the analytical method used (USEPA, 1970). The compounds are classified into four major functional types: alkanes (paraffins), alkenes (olefins), acetylenes, and aromatics. The concentrations are expressed in both parts per million (ppm) and parts per million as carbon (ppm C). The latter is calculated by multiplying the former by the number of carbon atoms in the respective compound. Parts per million as carbon is considered to be more representative of the hydrocarbon burden of the air.

In themselves, the hydrocarbons in air have relatively low toxicity. They are of concern because of their photochemical activity in the presence of sunlight and nitrogen oxides (Tuesday, 1971; Gordon et al, 1968). They react to form photochemical oxidants of which ozone is predominant (Table 5.1-6). Oxidants, including peroxyacyl nitrate (PAN), are responsible for much of the plant damage and eye irritation associated with smog. Methane has very low photochemical activity. As a consequence, hydrocarbon concentrations are often measured separately as methane on the one hand and non-methane hydrocarbons on the other (Figure 5.1-3). Methane will vary from 40% to 80% of the total hydrocarbons in an urban atmosphere (Figure 5.1-4 (Altshuller et al, 1973).

Strictly speaking, hydrocarbons are the compounds of hydrogen and carbon. At least two of the techniques used for measuring "total" hydrocarbons in air include many other classes of organic compounds. The nondispersive infrared method (NDIR), for example, measures compounds containing carbon-hydrogen bonds. This includes most organic compounds. The flame ionization method measures anything that reacts to form ions in a hydrogen flame. Pure hydrocarbons give higher specific responses, but without prior separation; the longer chain alcohols, aldehydes, esters, acids, etc., also give responses.

5.1.2.2 The Oxygenated Hydrocarbons

The oxygenated hydrocarbons, like the hydrocarbons, include an almost infinite number of compounds. They are classified as alcohols, phenols, ethers, aldehydes, ketones, esters, peroxides, and organic acids (Roberts and Caserio, 1967).

Some minor amounts of oxygenated hydrocarbons are emitted as solvent vapors from the chemical, paint and plastics

Table 5.1-5

Average Hydrocarbon Composition from 218 Ambient Air Samples Taken in Los Angeles, California

Compound	*Concentration*	
	ppm	*ppm (as carbon)*
Methane	3.22	3.22
Ethane	0.098	0.20
Propane	0.049	0.15
Isobutane	0.013	0.05
n-Butane	0.064	0.26
Isopentane	0.043	0.21
n-Pentane	0.035	0.18
2,2-Dimethylbutane	0.0012	0.01
2,3-Dimethylbutane	0.014	0.08
Cyclopentane	0.004	0.02
3-Methylpentane	0.008	0.05
n-Hexane	0.012	0.07
Total alkanes (excluding methane)	0.3412	1.28
Ethylene	0.060	0.12
Propene	0.018	0.05
1-Butane + isobutylene	0.007	0.03
trans-2-Butene	0.0014	0.01
cis-2-Butene	0.0012	Negligible
1-Pentene	0.002	0.01
2-Methyl-1-butene	0.002	0.01
trans-2-Pentene	0.003	0.02
cis-2-Pentene	0.0013	0.01
2-Methyl-2-butene	0.004	0.02
Propadiene	0.0001	Negligible
1,3-Butadiene	0.002	0.01
Total alkenes	0.1020	0.29
Acetylene	0.039	0.08
Methylacetylene	0.0014	Negligible
Total acetylenes	0.0404	0.08
Benzene	0.032	0.19
Toluene	0.053	0.37
Total aromatics	0.085	0.56
Total	3.7886	5.43

Table 5.1-6

Ozone Levels Generated in Photooxidation of Various Hydrocarbons with Oxides of Nitrogen

Hydrocarbon	*Ozone level, ppm*	*Time, min*
Isobutene [a]	1.00	28
2-Methyl-1,3-butadiene	0.80	45
trans-2-Butene	0.73	35
3-Heptene	0.72	60
2-Ethyl-1-butene	0.72	80
1,3-Pentadiene	0.70	45
Propylene	0.68	75
1,3-Butadiene	0.65	45
2,3-Dimethyl-1,3-butadiene	0.65	45
2,3-Dimethyl-2-butene	0.64	70
1-Pentene	0.62	45
1-Butene	0.58	45
cis-2-Butene	0.55	35
2,4,4-Trimethyl-2-pentene	0.55	50
1,5-Hexadiene	0.52	85
2-Methylpentane	0.50	170
1,5-Cyclooctadiene	0.48	65
Cyclohexene	0.45	35
2-Methylheptane	0.45	180
2-Methyl-2-butene	0.45	38
2,2,4-Trimethylpentane	0.26	80
3-Methylpentane	0.22	100
1,2-Butadiene	0.20	60
Cyclohexane	0.20	80
Pentane	0.18	100
Methane	0.0	—

[a] Hydrocarbon concentration (initial) 3 ppm; oxide of nitrogen (NO or NO_2, initial) 1 ppm.

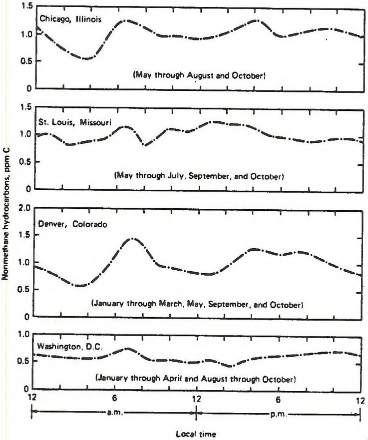

Figure 5.1-3

Nonmethane hydrocarbons as measured by a flame ionization analyzer, averaged by hour of day over several months for various cities.

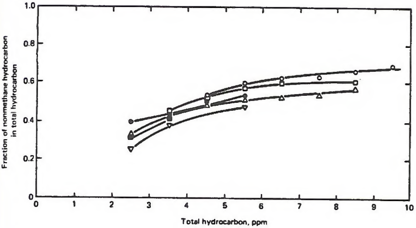

Figure 5.1-4

Nonmethane hydrocarbon fraction to total hydrocarbon for selected locations. ○: Los Angeles, California, 1967; □: Azusa, California, 1967; △: Los Angeles, California, 1968; ▽: Los Angeles, California, 1968---Sundays; ◆: Brooklyn, New York, 1069; ■: Bayonne, New Jersey, 1968 industries. The greater quantities of primary emissions are more usually associated with the automobile. Table 5.1-7 (Seizinger and Dimitriades, 1972) lists some typical oxygenates found in automobile exhaust. The aldehydes are the preponderant oxygenates in emissions but are emitted in minor amounts when compared to hydrocarbon, carbon dioxide, carbon monoxide and nitrogen oxide emissions. Many oxygenated compounds are formed as secondary products from photochemical reactions (Tuesday, 1971).

5.1.2.3 The Oxides of Carbon

Carbon Dioxide

Carbon dioxide is not generally considered an air pollutant. It is non-toxic, and immense quantities of it (10^{12} tons) are cycled through the biosphere annually (Robinson and Robbins, 1972). It is an essential ingredient of plant and animal life cycles. Through photosynthesis, it is converted to plant tissues; oxygen is produced as a by-product. Without photosynthesis, the world's supply of oxygen would reduce drastically to that formed by lightning and photolytic processes acting on water (Mason, 1966; Riehl, 1972).

The concentration of carbon dioxide in air is variable and depends upon whatever sources or sinks are present and such factors as the growing season when plants tend to deplete the amounts present. Callendar (1958) studied carbon dioxide measurements from 1870 to 1955 (Figure 5.1-5). A nineteenth century base value of 290 ppm was established and is generally accepted. Present day values have been set at 320 ppm with an annual growth rate of about 0.7 ppm (Robinson and Robbins, 1972).

Worldwide combustion of fossil fuel is a primary cause of the relatively rapid increase in carbon dioxide in the atmosphere. Robinson and Robbins (1972) have reviewed the sources, sinks and effects of carbon dioxide. Table 5.1-8 shows carbon dioxide emissions projected to the year 2000. A relative increase of nearly 300% in emissions over those of 1965 is predicted. Robinson and Robbins (1972) assume that half the carbon dioxide emitted remains in the atmosphere. This would result in an increase to about 370 ppm.

Carbon dioxide contributes to what is called a "greenhouse" effect in the atmosphere. As in a greenhouse, radiation penetrates the atmosphere and is absorbed by the earth. The earth also radiates energy into space at a reduced level and at longer wavelengths; otherwise, the earths temperature would continue to increase in temperature indefinitely. A balance is maintained between the incoming and outgoing energy. Figure 5.1-6 (Sellers, 1965) shows two radiation envelopes: one at 6000°K to indicate the radiation coming in from the sun; the other at 300°K to indicate the energy radiating from the earth at longer wavelengths. Carbon dioxide absorbs radiation strongly from this envelope and consequently contributes to a warming, or

Table 5.1-7

Oxygenates in Exhaust from Simple Hydrocarbon Fuels

Oxygenate	*Concentration range, ppm*[a]
Acetaldehyde	0.8–4.9
Propionaldehyde (+ acetone)[b]	2.3–14.0
Acrolein	0.2–5.3
Crotonaldehyde (+ toluene)[c]	0.1–7.0
Tiglaldehyde	<0.1–0.7
Benzaldehyde	<0.1–13.5
Tolualdehyde	<0.1–2.6
Ethylbenzaldehyde	<0.1–0.2
o-Hydroxybenzaldehyde (+ C_{10} aromatic)[d]	<0.1–3.5
Acetone (+ propionaldehyde)[b]	2.3–14.0
Methyl ethyl ketone	<0.1–1.0
Methyl vinyl ketone (+ benzene)[e]	0.1–42.6
Methyl propyl (or isopropyl) ketone	<0.1–0.8
3-Methyl-3-buten-2-one	<0.1–0.8
4-Methyl-3-penten-2-one	<0.1–1.5
Acetophenone	<0.1–0.4
Methanol	0.1–0.6
Ethanol	<0.1–0.6
C_6 alcohol (+ C_8 aromatic)[f]	<0.1–1.1
2-Buten-1-ol (+ C_5H_8O)	<0.1–3.6
Benzyl alcohol	<0.1–0.6
Phenol + cresol(s)	<0.1–6.7
2,2,4,4-Tetramethyltetrahydrofuran	<0.1–6.4
Benzofuran	<0.1–2.8
Methyl phenyl ether	<0.1
Methyl formate	<0.1–0.7
Nitromethane	<0.8–5.0
C_4H_8O	<0.1
C_5H_6O	<0.1–0.2
$C_5H_{10}O$	<0.1–0.3

[a] Values represent concentration levels in exhaust from all test fuels.

[b] Data represent unresolved mixture of propionaldehyde + acetone. Chromatographic peak shape suggests acetone to be the predominant component.

[c] Toluene is the predominant component.

[d] The C_{10} aromatic hydrocarbon is the predominant component.

[e] Benzene is the predominant component.

[f] The aromatic hydrocarbon is the predominant component.

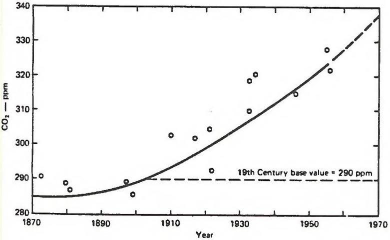

Figure 5.1-5
Average CO_2 concentration in North Atlantic region 1870-1956.

Table 5.1-8

Projected CO_2 Emissions: 1965-2000

	Emissions, 10^9 tons/year				
	1965	*1970*	*1980*	*1990*	*2000*
Coal	7.33	7.40	7.55	7.70	7.85
Petroleum	4.03	5.28	8.57	13.90	22.50
Natural gas	1.19	1.62	2.79	4.80	8.27
Incineration	0.46	0.51	0.61	0.73	0.88
Wood fuel	0.68	0.68	0.68	0.68	0.68
Forest fires	0.39	0.39	0.39	0.39	0.39
Total	14.08	15.88	20.59	28.20	40.57
Relative change	100 %	113 %	146 %	200 %	288 %

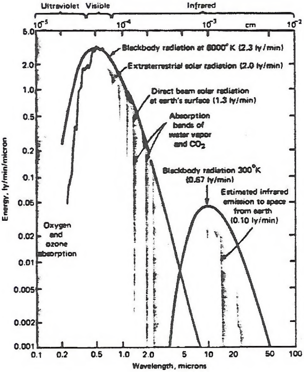

Figure 5.1-6
Spectra of Solar and Earth Radiation

greenhouse, effect. The temperature increase theoretically resulting from an increase of concentration to 370 ppm would be 0.5°C (Manabe and Wetherald, 1967). In reality the earth's energy balance is much more complicated. Water vapor, which absorbs strongly in the infrared, the amount of clouds which reflect sunlight, and global atmospheric circulation patterns all play important roles (Robinson and Robbins, 1972; Sellers, 1965). An increase in the reflectivity of the earth's atmosphere caused by an increase in suspended particulate matter (McCormick and Ludwig, 1967) or an increase in cloud cover could offset the warming tendency of carbon dioxide.

Carbon Monoxide

Carbon monoxide is a colorless, odorless, and tasteless gas which is slightly lighter than air. It is considered a dangerous asphyxiant because it combines strongly with the hemoglobin of the blood and reduces the blood's ability to carry oxygen to cell tissues. Untold numbers of deaths have been caused by carbon monoxide in coal mines, fires and non-ventilated places. A healthy working person can work eight hours a day, 40 hours a week, without noticeable adverse effects at carbon monoxide concentrations of 25 ppm (the threshold limit value).

Carbon monoxide is a product of incomplete combustion of carbon and its compounds. It is emitted by fossil fuel combustion sources in greater quantities than all other pollutant sources combined. Table 5.1-9 summarizes the estimates of emissions in the United States (Cavender et al, 1973). The automobile is by far the largest single pollution emission source. Figure 5.1-7 shows that maximum carbon monoxide concentrations found at eight Continuous Air Monitoring Program (CAMP) stations in the United States (Chang and Weinstock, 1973).

Recent carbon isotope studies conducted at the Argonne National Laboratory (Stevens et al, 1972) showed that nature produces huge quantities of carbon monoxide: from 3 to 640 X 10^9 tons/year as compared to 0.275 x 10^9 tons/year from worldwide pollution sources (Table 5.1-2). The principal natural source is believed to be the result of the photochemical oxidation of methane through an OH radical mechanism (Stevens et al, 1972; Weinstock, 1972). Other natural sources include the decomposition of chlorophyll to give relatively high concentrations of carbon monoxide particularly in the fall (0.2 to 0.5 X 10^9 tons/-year). Volcanoes, natural gas, forest fires, bacterial action in the oceans (0.15 X 10^9 tons/year) are other sources. The estimated total amount of carbon monoxide emissions from natural sources, given in Table 5.1-2, are, consequently, low by 30- to 50-fold, and the residence time of carbon monoxide in air needs to be reduced by a factor of 0.1 to 0.3 per year (Weinstock, 1972; Maugh, 1972).

The background concentration of carbon monoxide is estimated from data gathered in the Pacific (Robinson and Robbins, 1972; 1970) to be approximately 0.1 ppm. Table 5.1-10

Table 5.1-9

Estimates of Carbon Monoxide Emissions (United States) 1940-1970 (10^6 tons/year)

Source category	*1940*	*1950*	*1960*	*1968*	*1969*	*1970*
Fuel combustion in stationary sources	6.2	5.6	2.6	2.0	1.8	0.8
Transportation	34.9	55.4	83.5	113.0	112.0	111.0
Solid waste disposal	1.8	2.6	5.1	8.0	7.9	7.2
Industrial process losses	14.4	18.9	17.7	8.5	12.0	11.4
Agricultural burning	9.1	10.4	12.4	13.9	13.8	13.8
Miscellaneous	19.0	10.0	6.4	5.0	6.3	3.0
Total	85.4	103.0	128.0	150.0	154.0	147.0
Total controllable[a]	66.4	92.9	121.0	145.0	148.0	144.0

[a] Miscellaneous sources not included.

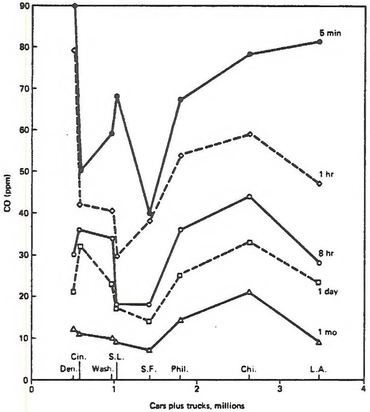

Figure 5.1-7

Maximum CO concentrations at Continuous Air Monitoring Program (CAMP) stations. 1962-1968 maxima vs cars plus trucks. Denver (Den.), Colorado; Cincinnati (Cin.), Ohio; Washington (Wash.), D.C.; St. Louis (S.L.), Missouri; San Francisco (S.F.), California; Philadelphia (Phil.), Pennsylvania; Chicago (Chi.), Illinois; Los Angeles (L.A.), California.

Table 5.1-10

Carbon Monoxide Concentrations in Representative United States Cities. Hourly Maxima in ppm. 1962-1967

	Yearly maxima		*Theoretical geometric mean (17, 51)*
	Highest	*Lowest*	
Chicago, Illinois	59	28	13.2
Cincinnati, Ohio	34	20	4.8
Denver, Colorado	55	40	6.7
Los Angeles, California	47	35	9.7
Philadelphia, Pennsylvania	54	37	6.9
St. Louis, Missouri	29	25	5.5
San Francisco, California	38	22	4.8
Washington, D.C.	41	25	3.5

shows the range of maximum hourly average values for the years of 1962-1967 for eight major United States cities (USEPA, 1970; Faith and Atkisson, 1972). The theoretical geometric mean hourly concentrations for the entire period are also shown. CO concentrations are more than ten times the level of concentrations of other major pollutants.

5.1.3 The Gaseous Compounds of Sulfur

5.1.3.1 The Sulfur Oxides

Sulfur forms a number of oxides (SO, SO_2, S_2O_3, SO_3, S_2O_7) but only sulfur dioxide (SO_2) and sulfur trioxide (SO_3) are of any importance as gaseous air pollutants. The peroxide, S_2O_7, has been suggested as existing in the lower stratosphere where a layer of sulfate particles has been found (Bigg et al, 1970; Junge and Manson 1961).

Sulfur trioxide is generally emitted with SO_2 at about 1%-5% of the SO_2 concentration (Cholak et al, 1958; Tice, 1962). A few industries such as sulfuric acid manufacturing, electroplating and phosphate fertilizer manufacturing may emit higher relative amounts (USEPA, 1972). Sulfur trioxide rapidly combines with water in air to form sulfuric acid (H_2SO_4) which has a low dew point. An aerosol or mist is easily formed, and SO_3 or H_2SO_4 is frequently associated with haze and poor visibility in air (Figure 5.1-8). The analysis for SO_3 or H_2SO_4 in air is quite difficult, and the data have to be interpreted with some care (USEPA, 1972).

Sulfur dioxide is a colorless gas with a pungent, irritating odor. Most people can detect it by taste at 0.3 to 1 ppm (780 to 2620 $\mu g/m^3$). It is highly soluble in water: 11.3 gm/100 ml as compared to 0.169 gm/100 ml for carbon dioxide, forming weakly acidic sulfurous acid (H_2SO_3). In clean air, it oxidizes slowly to sulfur trioxide. It is oxidized more readily by atmospheric oxygen in aqueous aerosols. Heavy metal ions in solution catalyze the reaction which stops when aerosols become acidic. Atmospheric ammonia neutralizes the acid to form ammonium sulfate, which is commonly found in atmospheric particles (Johnstone and Coughanowr, 1958, 1960). In moist air and in the presence of nitrogen oxides, hydrocarbons, and particulates, sulfur dioxide reacts much more rapidly (Urone, 1972; Urone and Schroeder, 1969).

Today, sulfur dioxide remains one of the major atmospheric pollutants. Its worldwide emissions have been estimated at 146 megatons/year by Robinson and Robbins (Table 5.1-2) and more recently as 100 (150 as sulfate) megatons per year by Kellogg et al. (1972) who predict emissions of about 275 megatons per year for the year of 2000. Estimated United States sulfur dioxide emissions for 1970 were 33.9 megatons (Table 5.1-11). Fuel combustion and stationary sources and industrial emissions accounted for 70% and 18% of this figure, respectively (Cavender,

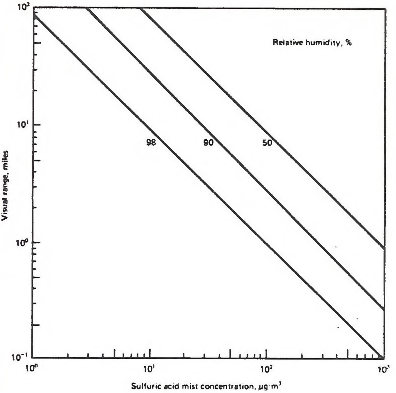

Figure 5.1-8

Calculated visibility (visual range) in miles at various sulfuric acid mist concentrations and different relative humidities.

Table 5.1-11

Estimates of Sulfur Oxide Emissions (United States) 1940-1970 (10^6 tons/year)

Source category	*1940*	*1950*	*1960*	*1968*	*1969*	*1970*
-Fuel combustion in stationary sources	16.8	18.3	17.5	24.7	25.0	26.5
Transportation	0.7	1.0	0.7	1.1	1.1	1.0
Solid waste disposal	Neg[a]	0.1	0.1	0.1	0.2	0.1
Industrial process losses	3.8	4.2	4.7	5.1	5.9	6.0
Agricultural burning	Neg	Neg	Neg	Neg	Neg	Neg
Miscellaneous	0.2	0.2	0.3	0.3	0.2	0.3
Total	21.5	23.8	23.3	31.3	32.4	33.9
Total controllable[b]	21.3	23.6	23.0	31.0	32.2	33.6

[a] Negligible (less than 0.05 × 10^6 tons/year).
[b] Miscellaneous sources not included.

Table 5.1-12

Sulfur Dioxide Concentrations in Representative United States Cities Hourly Maxima, ppm, 1962-1967

	Yearly maxima		*Theoretical geometric mean (17, 51)*
	Highest	*Lowest*	
Chicago, Illinois	1.69	0.86	0.111
Cincinnati, Ohio	0.57	0.41	0.018
Denver, Colorado	0.36	0.17	0.014
Los Angeles, California	0.29	0.13	0.014
Philadelphia, Pennsylvania	1.03	0.66	0.060
St. Louis, Missouri	0.96	0.55	0.031
San Francisco, California	0.26	0.11	0.006
Washington, D.C.	0.62	0.35	0.042

et al, 1973). Intensive efforts are being made to control sulfur dioxide emissions by either removing sulfur from coal and oil or removing sulfur dioxide at the combustion source (USEPA, 1969).

Ambient air concentrations of sulfur dioxide are routinely measured in many cities and have been the subject of a large number of studies. Table 5.1-12 give typical data obtained from the United States Continuous Air Monitoring Program (CAMP). Figure 5.1-9 shows the frequency distribution of sulfur dioxide measurements made in selected United States cities. An approximate log-normal distribution is shown by the straight portions of the lines. This confirms to some extent the model developed by Larsen and others (Larsen, 1969; USEPA, 1969; Larsen, 1971).

5.1.3.2 Reduced Sulfur Compounds

Hydrogen Sulfide

Hydrogen sulfide (H_2S) is a toxic, foul smelling gas well known for its rotten egglike odor. It can be detected at concentrations as low as 0.5 ppb (7 $\mu g/m^3$) (A.D. Little, Inc., 1968). Its natural emission sources include anaerobic biological decay processes on land, in marshes and in the oceans. Volcanoes and natural hot water springs also emit hydrogen sulfide. A total of approximately 100 megatons (268 when expressed as sulfate) is estimated to be emitted in nature (Table 5.1-2) (Kellogg et al, 1972). However this estimate has been made with strong reservations. The analysis of very low concentrations in air is subject to error because some of the hydrogen sulfide is oxidized to sulfur dioxide during the sampling process (Kellogg et al, 1972).

Approximately three megatons of H_2S are estimated to be emitted each year by pollution sources (Robinson and Robbins, 1972) (Table 5.1-2). One of the larger single sources is the kraft pulp industry which uses a sulfide process to extract cellulose from wood (Blosser, 1972). Because of the strong odor of sulfides, such facilities can be detected by their odor 40 miles or more downwind, unless emissions are carefully controlled. Other hydrogen sulfide pollution sources include the rayon industry, coke ovens and the oil refining industry. The processing of "sour" crude oil results in the emission of hydrogen sulfide and other volatile organic sulfides. Hydrogen sulfide emissions from industrial processes are sometimes used as fuel for boilers or are released in burning flares. In either case, they are burned to sulfur dioxide and emitted to the air. Today, many modern refineries recover their sour gasses and process them to form sulfuric acid or elemental sulfur (Faith et al, 1965).

Hydrogen sulfide concentrations in urban air are rarely higher than 0.1 ppm (140 $\mu g/m^3$). Cholak (1952) analyzed Cincinnati air over a period of five years and rarely found hydrogen sulfide to exceed 0.01 ppm (14 $\mu g/m^3$). A survey in Houston,

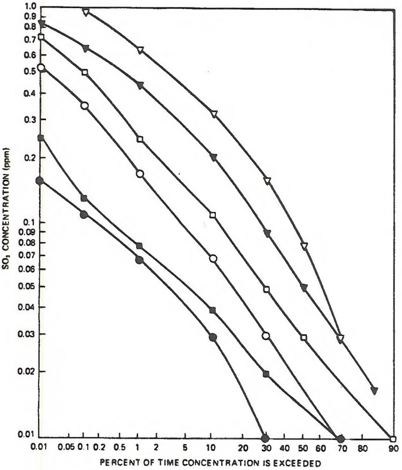

Figure 5.1-9

Frequency distribution of sulfur dioxide levels in selected United States cities, 1962-1967. ▽, Chicago, Illinois; ▼, Philadelphia, Pennsylvania; □, St. Louis, Missouri; ■, Cincinnati, Ohio; ○, Los Angeles, California; ●, San Francisco, California.

Texas showed average values of 0.02 ppm in the most highly polluted section of the city. The highest level measured was 0.28 ppm (390 µg/m^3) (Faith and Atkisson, 1972; SRI, 1957). Katz (1955) found relatively high levels in Windsor, Ontario with a mean concentration of approximately 0.1 ppm and a maximum of 0.6 ppm (835 µg/m^3).

Hydrogen sulfide blackens lead-based paints. A level of 0.1 ppm is said to produce blackening of such paints within 1 hour (Faith and Atkisson, 1972). In air, hydrogen sulfide is oxidized to sulfur dioxide within hours, adding to the ambient sulfur dioxide level (Kellog et al, 1972).

Mercaptans and Sulfides

Other sulfur compounds that are of interest in air pollution, principally because of their strong odors, are methyl mercaptan (CH_3SH), dimethyl sulfide (CH_3SCH_3), dimethyl disulfide (CH_3SSCH_3), and their higher molecular homologs (Blosser, 1972). They have odors similar to those emitted by skunks and rotting cabbage. Total emissions of these compounds are unknown. A number of studies have been concerned with their evaluation (Schmall, 1972) and their measurement in air (Figure 5.1-10 (Rasmussen, 1972).

5.1.4 The Gaseous Compounds of Nitrogen

Nitrogen forms the very stable diatomic gas, N_2, which makes up over 78% of the atmosphere and, fortunately, helps temper the oxidative power of atmospheric oxygen. It also forms a large number of gaseous and nongaseous compounds, many of which are essential to living matter.

They are produced by such natural processes as bacterial fixation, biological growth and decay, lightning, and forest and grassland fires. To a lesser extent, but in higher local urban concentrations, nitrogen compounds are produced by man through a wide number of agricultural, domestic, and industrial activities. In the reduced state, nitrogen forms such compounds as ammonia, amides, amines, amino acids and nitriles. In the oxidized state, it forms seven oxides and a large number of nitro, nitroso, nitrite and nitrate derivatives (Cotton and Wilkinson, 1966).

5.1.4.1 The Oxides of Nitrogen

The oxides of nitrogen include nitrous oxide (N_2O), nitric oxide (NO), nitrogen dioxide (NO_2), nitrogen trioxide (NO_3), nitrogen sesquioxide (N_2O_3), nitrogen tetroxide (N_2O_4), and nitrogen pentoxide (N_2O_5). They and two of their hydrates, nitrous acid (HNO_2) and nitric oxide (NO), and nitrogen dioxide (NO_2) are found in appreciable quantities. The latter two, NO and NO_2, are often analyzed together in air and are referred to as "nitrogen oxides" and given the symbol "NO_x". Nitrous oxide

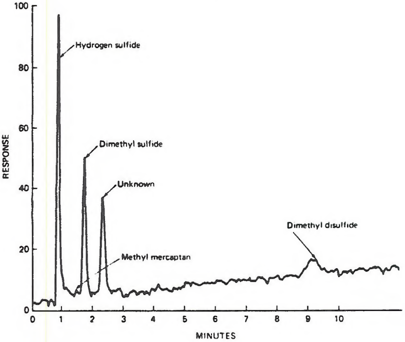

Figure 5.1-10
Sulfur Gases in Ambient Air, In-Situ Analysis

(N_2O) is not included in the "NO_x" measurement, but it is possible for the higher oxides to be included if they happen to be present (APHA, 1972).

Nitrous oxide (N_2O) is a colorless, slightly sweet, nontoxic gas present in the natural environment in relatively large amounts (0.25 ppm) when compared to the concentrations of the other trace gases except carbon dioxide, methane, and the noble gases. It is used as an anesthetic in minor surgery and dentistry. When mixed with air and inhaled it produces a loss of feeling. Its effects are not severe and soon disappear. It is commonly called "laughing gas" because under some conditions it can cause those who inhale it to laugh violently. The major natural source of nitrous oxide is biological activity in the soil and possibly in the oceans. A worldwide production rate of 10^9 tons per year and a residence time of four years has been estimated (Robinson and Robbins, 1972; Craig and Gordon, 1963). Nitrous oxide has been associated with photochemical reactions in the upper atmosphere (Bates and Hays, 1967), but because of its low reactivity in the lower atmosphere it is largely ignored in air pollution studies. There are no known significant pollution sources (Robinson and Robbins, 1972).

Nitric oxide (NO) is a colorless, odorless, and tasteless gas. It is produced in nature by biological action and by combustion processes. It is suspected as being formed and rapidly oxidized in closed silos where dangerous concentrations of nitrogen dioxide have been found (Altshuller, 1958). In air, it is oxidized rapidly by atmospheric ozone and photochemical processes and more slowly by oxygen to form nitrogen dioxide (NO_2). Worldwide natural emissions are estimated by Robinson and Robbins (1972) to be 430 X 10^6 tons per year. Background concentrations are variable and difficult to measure. They are estimated to range from 0.25 to 6 ppb. The residence time in air is about five days (Robinson and Robbins, 1972).

As a pollutant, nitric oxide is produced largely by fuel combustion in both stationary and mobile sources such as the automobile. In the high temperatures of the combustion zone, nitrogen reacts with oxygen to form nitric oxide:

$$N_2 + O_2 \rightleftharpoons 2\ NO \qquad (5.1\text{-}1)$$

The reaction is endothermic and proceeds to the right at high temperatures. At low temperatures, the equilibrium lies almost completely to the left, but the rate of recombination is extremely slow. Consequently, the amount of NO emitted is a function of the flame structure and temperature as well as the rate at which the combustion mixture cools. If the cooling rate is rapid, equilibrium is not maintained and the NO concentration, although thermodynamically unstable, remains high (Trayser and Creswick, 1970; Hall and Blacet, 1952). The proper catalyst can, of course, expedite its decomposition to nitrogen and oxygen. In exhaust gases, where higher concentrations and temperatures prevail, some of the nitric oxide is oxidized to nitrogen dioxide. This generally varies from 0.5% to 10% of the nitric oxide present (USEPA, 1971).

Figure 5.1-11 shows the relative amounts of nitrogen oxides, hydrocarbons, and carbon monoxide in the exhaust of an automobile as a function of the ratio of the air-to-fuel mixture used for the engine. At low air-to-fuel ratios ("rich" mixtures), flame temperatures are low, combustion is incomplete, hydrocarbon and carbon monoxide emissions are high, and nitrogen oxides emissions are low. At higher air-to-fuel ratios ("lean" mixtures) the temperature of the combustion flame becomes hotter, the nitrogen oxides increase until the air-fuel ratio is greater than the stoichiometric point and then decrease rapidly as the excess air cools the flame (Trayser and Creswick, 1970).

Worldwide pollution sources emit approximately 53 X 10^6 tons per year of NO and NO_2 combined (NO_x). Table 5.1-13 gives estimates of NO_x emissions expressed as NO_2 for the United States. Fuel combustion in stationary sources and transportation account for more than 95% of the 22.7 X 10^6 tons emitted per year in the United States. Table 5.1-14 shows maximum and minimum hourly averages of NO_x in several United States cities.

In a polluted atmosphere, nitric oxide is oxidized to nitrogen dioxide primarily through photochemical secondary reactions. Figure 5.1-12 shows the diurnal variations of NO, NO_2 and O_3 in a typical photochemical pollution situation. Nitric oxide reaches a maximum during the early morning traffic rush hours. The rising sun initiates a series of photochemical reactions which convert the nitric oxide to nitrogen dioxide. Within a few hours the nitrogen dioxide reaches a maximum during which it photochemically reacts to form ozone and other oxidants. Both the nitrogen dioxide and the ozone eventually disappear through the formation of nitrated organic compounds, peroxides, aerosols, and other terminal products. The cycle is repeated the following day. If the air mass is not swept away or is brought back by a reversing wind, the residual gases add to the new day's pollutants (Tuesday, 1971).

Nitrogen dioxide is a reddish-brown gas with a pungent, irritating odor. At concentrations higher than those found in the atmosphere, it forms a colorless dimer, nitrogen tetroxide (N_2O_4). Natural emissions are due primarily to biological decay involving nitrates being reduced to nitrites, followed by conversion to nitrous acid (HNO_2), decomposition to nitric oxide and oxidation to nitrogen dioxide. Natural emissions are estimated to be 658 X 10^6 tons per year.

Nitrogen dioxide is one of the more invidious pollutants. It is irritating and corrosive in itself, but more importantly, it serves as an energy trap by absorbing sunlight to form nitric oxide and atomic oxygen:

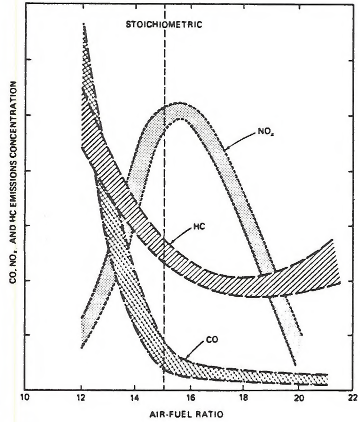

Figure 5.1-11

Effects of air-fuel ratio on exhaust composition (approximate ranges, not to scale).

Table 5.1-13

Estimates of Nitrogen Oxide (NO) Emissions (United States), 1940-1970 (10^6 tons/year)

Source category	*1940*	*1950*	*1960*	*1968*	*1969*	*1970*
Fuel combustion in stationary sources	3.5	4.3	5.2	9.7	10.2	10.0
Transportation	3.2	5.2	8.0	10.6	11.2	11.7
Solid waste disposal	0.1	0.2	0.2	0.4	0.4	0.4
Industrial process losses	Neg[a]	0.1	0.1	0.2	0.2	0.2
Agricultural burning	0.2	0.2	0.3	0.3	0.3	0.3
Miscellaneous	0.8	0.4	0.2	0.2	0.2	0.1
Total	7.9	10.4	14.0	21.3	22.5	22.7
Total controllable[b]	7.1	10.0	13.8	21.1	22.3	22.6

[a] Negligible (less than 0.05 × 10^6 tons/year).

[b] Miscellaneous sources not included.

Table 5.1-14

Nitrogen Oxide (NO) Concentrations in Representative United States Cities Hourly Maxima, ppm, 1962-1968

	Yearly maxima		*Geometric mean*
	Highest	*Lowest*	
Chicago, Illinois	1.06	0.69	0.75
Cincinnati, Ohio	1.42	0.45	0.83
Denver, Colorado[a]	0.72	0.56	0.62
Los Angeles, California	1.35	0.98	1.24
Philadelphia, Pennsylvania	1.79	0.97	1.53
St. Louis, Missouri[b]	0.92	0.44	0.57
Washington, D.C.	1.30	0.68	0.83

[a] 1965–1968

[b] 1964–1968

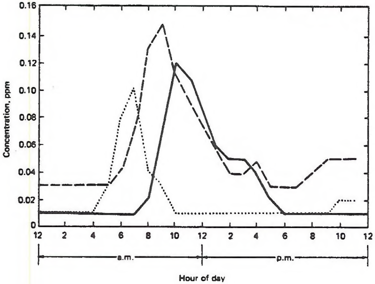

Figure 5.1-12

Typical diurnal variation of NO, NO_2, and O_3 concentrations in Los Angeles, California. Solid line, ozone; long dashed line, nitrogen dioxide; dotted line, nitric oxide.

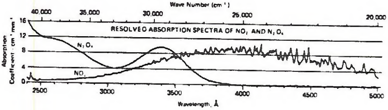

Figure 5.1-13

Absorption coefficients ($1/pl \log_{10} I_0/I$) of NO_2 and N_2O_4 vs wavelength and wave number, measured at 25°C.

$$NO_2 + h\nu \longrightarrow NO + O \qquad (5.1\text{-}2)$$

The atomic oxygen is very reactive, forming ozone with oxygen, and initiating a number of secondary photochemical chain reactions. Nitrogen dioxide absorbs light strongly in the yellow to blue end of the visible spectrum and the near ultraviolet. Figure 5.1-13 (Hall and Blacet, 1952) shows the absorption spectrum of nitrogen dioxide, and Figure 5.1-14 (USEPA, 1971) indicates the amount of light absorbed in terms of parts per million - mile concentrations. A mile thick layer of air containing 0.1 ppm of NO_2 reduces the ultraviolet light reaching the ground by more than 25%. Viewed through a horizontal layer of 10 miles, the same concentration reduces the blue and ultraviolet light more than 90% (Figure 5.1-14). The yellow-brown haze often seen hovering over a city is in a large part due to nitrogen dioxide and the aerosols it helps generate (Carlson and Ahlquist, 1969).

Nitrogen trioxide (NO_3) and nitrogen pentoxide (N_2O_5) have been postulated as intermediates in the photochemical oxidation of hydrocarbons and sulfur dioxide (Urone, 1972; Louw, 1973; Gay and Bufalini, 1971; Schuck et al, 1966). They are not commonly observed; their concentrations are expected to be small and difficult to measure in air in the presence of NO, NO_2 and their various photochemical reaction products. The pentoxide hydrolyzes readily with water vapor in the air to form nitric acid vapor (HNO_3) which has been detected in the stratosphere by spectroscopic means (Cadle and Allen, 1970). Peroxyacetyl nitrate (PAN), an eye-irritating photochemical reaction product from hydrocarbons and nitrogen oxides, has been identified and measured in air (Hall and Blacet, 1952; Hanst, 1971). Atmospheric concentrations as high as 0.1 ppm (500 $\mu g/m^3$) have been reported (USEPA, 1971).

5.1.5 Ozone and Oxidants

Ozone, O_3, is a bluish gas about 1.6 times as heavy as air and highly reactive. It is formed at high altitudes by photochemical reactions involving molecular and atomic oxygen (Cotton and Wilkinson, 1966). Its concentration in the atmosphere depends upon the altitude; being greatest in the stratosphere. At 20 km, its concentration is 0.20 ppm. Its concentration in rural areas, away from pollution sources, is approximately 0.02 ppm (USEPA, 1970). Very minor amounts of ozone are formed during lightning and thunderstorms. Ozone strongly absorbs ultraviolet light in the wavelength region of 2000-3500 A and very weakly at about 6000 A. Its absorption of the energetic portion of the ultraviolet light prevents serious damage to living tissues (USEPA, 1970).

Ozone and other oxidants such as PAN (Stephens, 1961) and hydrogen peroxide (Bufalini et al, 1972) are formed in polluted atmospheres as a result of a rather wide variety of photochemical reactions (Tuesday, 1971; Leighton, 1961). High ozone levels have been found not only in urban areas, where it follows

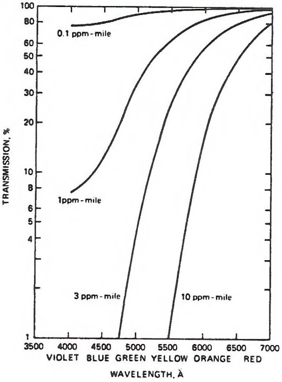

Figure 5.1-14
Transmittance of Visible Light at Different NO_2
Concentrations and Viewing Distances

a trend of build-up during the day and break-down during the night, but also in rural areas. It is believed that ozone or its precursors are being transported long distances or there may may be a nautral source within rural areas.

The overall effect of ozone is a stinging of the eyes and mucous membranes. This reaction was first noticed in Pasadena, California, a suburb of Los Angeles. Shortly thereafter, polluted atmospheres were labeled as "Los Angeles" type because of their general oxidative character. "London"(England) type smogs (i.e., smoke plus fog) were reductive in nature because of their higher concentrations of sulfur dioxide and soot from the burning of coal. Figure 5.1-12 shows the diurnal variation of nitrogen oxides and ozone in a typical Los Angeles type of photochemical pollution. However, since London has cleared its air with a vigorous smoke abatement program, it is experiencing Los Angeles type of pollution as shown by Figure 5.1-15 (Derwent and Stewart, 1973).

To prevent possible serious health effects, an ambient air quality standard maximum 1-hour concentration of 240 g/m^3 (0.12 ppm) has been adopted. Alert levels were set at 200 g/m^3 (0.1 ppm). Figure 5.1-16 shows the number of times that the alert level was exceeded in Los Angeles, California for 1967 thru 1971 (Sagersky, 1973). A study of oxidant levels in the San Francisco, California Bay Area show a trend to smaller annual oxidant levels (Cramer, 1973). However greater efforts are needed to reduce these values. Two studies have shown that indoor air follows outdoor air concentrations rather closely (Mueller, et al, 1973; Thompson et al, 1973).

A number of areas have been measuring total oxidant and ozone concentrations above the alert levels (USEPA). There is reason to believe that the "oxidative" conditions in these instances are not the same as those found in larger cities. Ripperton, et al. (1971), for example, have found evidence for tropospheric photochemical production of ozone.

Chesick (1972) and others (IDA, 1973) have been concerned over the effect that high-flying jet planes would have on the upper atmosphere. Water vapor and nitrogen oxides emitted from the jet exhausts conceivably could react with ozone and reduce its insulating quality for strong ultra-violet rays.

5.1.6 Particulate Matter

The particulate matter commonly found dispersed in the atmosphere is composed of many substances: flourides, beryllium, lead, and asbestos (all toxic), aerosols, dust and other matter such as wood waste generated by forest fires. Combustion also produces particles. Particles larger than 10 m result from many mechanical processes such as wind erosion, grinding and spraying. Trees produce terpenes which can result in organic particles and oceans produce salt particles as well. Only three general classes of physical properties can reasonably be said to apply to all particulate matter. These properties all involve the interface

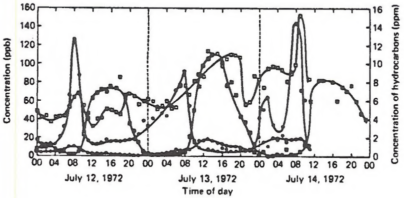

Figure 5.1-15

Diurnal variations of air pollutants measured in London, England from July 12 to July 14, 1972. ■, Ozone, ppb; ●, nitric oxide, ppb; □, nitrogen dioxide, ppb; ○, hydrocarbons, ppm.

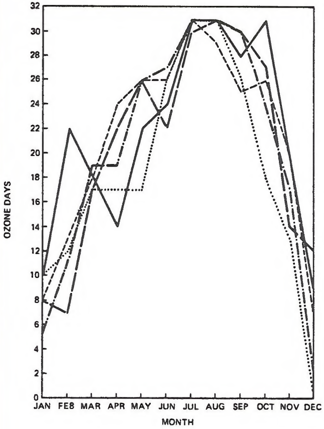

Figure 5.1-16

The number of days each month in Los Angeles County, California during which the ozone concentration has risen to 0.1 ppm or above. Solid line: 1967; short dashed line: 1968; long dashed line: 1969, dashed-dotted line: 1970; dotted line: 1971.

between particles and their surroundings, and include (1) surface properties, (2) motion, and (3) optical properties.

Surface properties include sorption, nucleation and adhesion, among others. Sorption is the deposition of molecules due to collision with an object. If the molecules are in a supersaturated atmosphere, the deposited molecules can attract other molecules causing them to condense out around the original deposit. This is nucleation.

The motion of particulates is generally defined by size. Particles of less than 0.1μm undergo large random motions caused by collisions with individual molecules. Particles larger than 1 μm have significant settling velocities and their motion can vary significantly from the surrounding air. Between 0.1 μm and 1 μm, settling velocities are finite but small compared to air motion. These can, thus, remain suspended in air for long periods (and long travel time). Particles larger than 5-10 μm are generally removed by gravity and other inertial processes.

Optical properties cover the behavior of particles toward light. This affects visiblity, particularly when particles larger than 1 μm are involved. These particles intercept or scatter light in proportion to their cross-sectional area. Smaller particles also scatter light, but according to far more complicated scattering laws.

The concentration of suspended particulate matter which ranges from less than $60 \mu g/m^3$ to $1700 \mu g/m^3$ in various American cities often shows a notable annual variation. Levels are lowest in summer and highest in autumn and winter. Losses of solar radiation occur due to these concentrations, and can run as high as one-third in the summer and two-thirds in the winter. There is also a correlation between particle concentrations and rainfall, and particulates and visibility. The EPA is presently considering a standard for fine particulates which are felt to be the most important in terms of (1) the respirable fraction, (2) the catalytic conversion to secondary contaminants and (3) visibility impairment.

Although raw auto exhaust contains some particulate matter (smoke particles), this is not sufficient to degrade visibility significantly when diluted several thousandfold with air. However, aerosols can be formed by irradiation of dilute auto exhaust or of hydrocarbon/NO_x mixtures. Aerosol formation is much enhanced by the addition of sulfur dioxide to the mixture. This suggests that sulfuric acid plays a role since H_2SO_4 is not only very nonvolatile but it also will absorb water.

5.1.7 Atmospheric Chemistry of Air Pollution

The solution of many air pollution problems involves knowledge of the chemistry of the atmosphere, when it may be termed "clean" and when it is "dirty." Also, the nature of air pollutants as they react as a whole must be determined. In general, the two classes of polluted smogs are called either the London type - a reducing smog where contaminants form nuclei for condensation of water vapor into fogs--or the Los Angeles type - an oxidizing smog where contaminants are photolysed to irritants.

- Solar Radiation

  The sun approaches a perfect black body radiator most closely in the region of 6000°K (12,300°F). Its maximum energy per wavelength occurs at 4500Å, while its maximum photon emission occurs at 6000Å. Photons produce many chemical and energy changes in matter at the molecular level upon absorption, by upsetting vibrational, rotational and electronic balance. Vibrational and rotational changes occur mainly in the infrared region while electronic shifts need the higher energy of the ultraviolet range.

- Photochemical Reactions

  There are four main steps in a photochemical reaction which occur in time sequence: (1) Radiation, (2) Absorption, (3) Primary Reactions, and (4) Secondary reactions. We are mainly interested in substances which absorb photons in the 3000-7000Å spectral region (visible range).

  Absorbers

  O_2
  O_3
  NO_2
  SO_2
  HNO_2 - HNO_3
  RCHO
  RCO
  RCOO
  Particulates

  Non-absorbers

  N_2
  H_2O
  CO
  CO_2
  NO
  SO_3 - H_2SO_4
  RCH
  RCOH
  RCOOH

  (R denotes a radical)

- Oxygen

  The most important photochemical reactions involve the very reactive single oxygen atom.

  $O + O_2 \longrightarrow O_3$

  O + OLEFINS ⟶ Several Fragments

  $O + NO_2 \longrightarrow NO + O_2$

  $O + SO_2 \longrightarrow SO_3$

These atoms are produced by two main reactions:

$$\left.\begin{array}{l} NO_2 + h\nu \rightarrow NO + O \\ O_3 + h\nu \rightarrow O_2 + O \end{array}\right\} \text{Major fragments of photochemical reaction in the atmosphere where } h = \text{Plank's constant and } \nu = \text{the frequency of the radiation.}$$

Oxygen atoms are produced at the rate of 150 pphm hr^{-1}, but because of their reactivity, their stationary concentration in air is usually only 1-2 ppht (parts per hundred thousand).

- Ozone

Ozone is very important as a reactant in photochemical type smog. It is produced through the photolysis of nitrogen dioxide and the reactive oxygen atom.

$$NO_2 + h\nu \rightarrow NO + O$$

$$O + O_2 \rightarrow O_3$$

Ozone is a strong oxidizer and its main atmospheric reactions are:

$$90\% \qquad O_3 + NO \rightarrow NO_2 + O_2$$

$$\text{Equal Rate} \left\{\begin{array}{l} O_3 + NO_2 \rightarrow NO_3 + O_2 \\ O_3 + \text{Olefins} \rightarrow \text{Free radicals, other organic fragments} \end{array}\right.$$

Sulfur Dioxide

Sulfur dioxide is the major sulfur containing compound formed during fuel combustion. Hydrogen sulfide is easily oxidized to sulfur dioxide in air, especially in the presence of sunlight. In sunlight, sulfur dioxide reacts with either atomic or molecular oxygen to form an aerosol, particularly if water vapor is present. This aerosol is dilute sulfuric acid when uncontaminated with particulates, which are found in reducing type smogs. Sulfur dioxide also reacts with organics to form various sulfonic acids which are also irritants. Relative humidity plays a very important role in the photochemical reactions of sulfur dioxide by determining particulate-aerosol formations.

Organic Compound Reactions

The range of classes of organic compounds emitted from various processes and industries is very wide. Most of the higher molecular weight products settle rapidly, but short carbon chain molecules tend to be more reactive as ionic character outweighs the usual covalent nature of organic materials and they are very important as irritant precursors. Absorption of photons often leads to dissociation into free radicals - short fragments with extra electrons which are extremely reactive. Olefins, aldehydes, ketones, peroxides, are classes which easily absorb photons and form free radicals, and are among the usual products of combustion, especially from oil base fuels.

Nitrogen Oxide Reactions

Oxides of nitrogen are formed in practically all combustion processes in air, but the diurnal peaks and valleys of concentration are a matter of concern in air pollution studies due to the high buildup in the morning hours within urban areas as vehicular traffic reaches a peak. The sequence of reactions

$$NO_2 + h\nu \rightarrow NO + O$$

$$O + O_2 \rightarrow O_3$$

$$NO + O_3 \rightarrow NO_2 + O_2$$

is the fastest, most important, and results in the highest concentrations of actual and potential irritant concentrations in air pollution - atmospheric chemistry. Second in importance, photochemically, is olefin photolysis and ozone - organic molecule interaction. Other nitrogen oxide reactions of less importance are:

$$NO_2 + O_3 \rightarrow NO_3 + O_2$$

$$NO + NO_2 + H_2O \rightarrow 2\ HNO_2$$

$$N_2O_5 + H_2O \rightarrow 2HNO_3$$

Non-photochemical Reactions

A secondary reaction following photochemical reaction which is very important is :

$$O_3 + \text{Olefins} \rightarrow \text{free radical fragments}$$

Olefins are the most important beginning class of organic compounds for production of irritants and phytotoxicants.

Reaction with water vapor:

$$NO_x + H_2O \rightarrow HNO_2 - HNO_3$$

$$SO_3 + H_2O \rightarrow H_2SO_4$$

Other inorganic and organic classes of compounds are also emitted to the atmosphere such as flourides which quickly react with various surfaces, ammonia which forms acids, hydrogen sulfide which reacts with organics and forms sulfates, carbon monoxide which slowly oxidizes to carbon dioxide and organic amines which oxidize to acids. The above reactions are generally not of importance except in small localized areas.

Particulate Material Reactions

Particulate matter consists of an entirely different size category than we have examined thus far. As such, it provides reactive surfaces and can act as a third body and catalyst. Interaction with a particulate surface can cause either an energy level change or complete chemical change.

Examples of the former are:

$O\lambda_1 2 + M \rightarrow O\lambda_2 2 + M$ Change in absorption

$CH_3 + M \rightarrow CH_3 + M$ Termination of free radical

Examples of the latter are:

$Zn\,O(M) + H_2O$ vapor $\xrightarrow{h\nu} H_2O_2 + M$

where:

λ = is the wavelength and
M = represents an energy-accepting third body

Catalyzed by photons:

$SO_2 + H_2O$ drop $\rightarrow H_2SO_3$ drop

$H_2SO_4 \bullet H_2O$ drop + $Ca\,CO_3 \rightarrow CaSO_4 + CO_2 + H_2O$ Change in particulate

Kinetics in Atmospheric Chemistry

Without becoming involved in the rigors of kinetic theory, a few elementary definitions should be stated. The basis for determining the importance of any photochemical reaction, stationary concentration, rate of reaction, etc., is the Stark-Einstein Law which states that one photon must be absorbed to initiate photolysis. From this theory is derived the important equation:

$$K_a = \frac{I_a}{jc}$$

Where k_a is the specific absorption rate, I_a is the rate of absorption, j is a conversion factor, and c is the concentration of the absorbing substance. k_a represents the average fraction of absorbing molecules which receive photons per unit time. Primary quantum yield is very important as it tells us what percent of molecules that absorb photons will acutally react to the absorbed energy via a specific process. Absorption of a photon may result either in energy level change, shown by florescence, or chemical change, shown by dissociation or direct reaction. The rate of formation of excited molecules A' is given by:

$$+ \frac{d\ (A')}{dt} = I_a = k_a\ (A) = k_a c \quad \text{where}$$

(A) = c, the concentration of the absorber.

For secondary photochemical reactions rate constant is important. For a bimolecular reaction $A + B \rightarrow C + D$, the decrease in concentration of A will be:

$$- \frac{d\ (A)}{dt} = k_1\ (A)\ (B)$$

where K, is the rate constant of the reaction. In general, the larger the rate constant, the more probable and more important part the reaction plays in the atmosphere.

Thus, a knowledge of what general reactions take place in the atmosphere under different meterological conditions, can help answer questions concerning the relative importance of contaminating substances. From a meteorological point of view, relative humidity and percent possible sunshine are the most important parameters to consider. This is because nitrogen dioxide-olefin photolysis and the reactions which follow are sunshine dependent and the sulfur dioxide-particulate reactions are largely humidity dependent. Further consideration involves precipitation which functions as a removal method, and low wind speed which causes the atmosphere to function as a stable reaction vessel. Extremes of temperature either help catalyze photochemical reactions, as in los Angeles, or enhance fog formation of particulate - SO_2 reactions, as in London.

The state of knowledge of atmospheric chemical reactions and interactions leaves a good bit to be desired as the subject is very complex. Experiments in all the areas discussed are increasing our knowledge and the total picture is slowly emerging.

5.2 AIR POLLUTION EFFECTS ON AIR QUALITY RELATED VALUES

A pollutant can be roughly defined as a harmful chemical or waste material which is discharged into the atmosphere or water. Pollutants add stress to the biosphere, thereby affecting the quantity, quality or diversification of populations. State and local governments have regulated air pollutants for many years, but the first federal legislation was not seen until 1955, with the establishment of an air pollution research program. Public awareness of air pollutant hazards has increased tremendously since that time, and culminated in the enactment of the 1977 Clean Air Act Amendments. As stated in the Act, the purpose of this legislation is "to protect and enhance the quality of the Nation's air resources so as to promote the public health and welfare" (CAAA, 1977). Falling under the umbrella of public health and welfare is not only man, but all air quality related values, including soils, vegetation, wildlife, watersheds, archaeology, and visibility. In general, all aquatic and terrestrial flora and fauna and their habitats must be evaluated to determine threshhold levels, or the point at which a pollutant can no longer be tolerated by a population. Section 5.1 detailed the formation of air pollutants. This section will describe the effect of these pollutants on the environment.

As depicted in Section 2, the majority of BLM lands are situated within the 1500-3000 foot elevation range; however, areas as low as 500 to 1500 feet and as high as 3000 to 6000 feet are also found within the Folsom District. The major vegetation types concentrated in these areas include grass, plains grass, chaparral, woodlands, redwood, pine, Douglas fir and fir. While pollutant effects have been felt severely by California's agricultural crops, these will not be discussed to the extent of the aforementioned vegetation types, as they are not of primary importance to the BLM. Effects on fisheries and native animals will also be discussed to the extent that they have been researched. It is also valuable to note that effects of air pollutants have been seen in archeological sites, such as ancient Grecian ruins, and in geology throughout Europe and the Eastern United States. Although these later effects have not been seen or researched in California, they may become a serious future concern.

Particulates

Within the Folsom district, man-made emission densities for particulates range from 0-10,000 tons per year. Around San Andreas, however, annual emissions fall within the 50,000 to 100,000 ton range. Particulates may be defined as dispersed matter in the liquid or solid phase. A few of the wide variety of chemical constituents of particulate matter are listed in Table 5.2-1. Individual particles range from 0.005 to 500 μm in diameter. While emission control devices can remove up to 99% of stack particulate emissions, their efficiency becomes considerably lower for particles in the size range of 0-5 μm. These particles, therefore, are more readily emitted and can be transported over great distances. Also, this size range is easily passed into the lungs of man and animals, making these smaller particles the most deleterious.

The effect that particulate matter will evoke depends largely on its chemical composition. In general, most trace elements deposited on soil will remain in the surface layers, except in very acidic or sandy soils. While this accumulation serves to protect groundwaters from contamination in the short term, in time, natural processes such as surface runoff, erosion, and windblown dust may serve to contaminate aquatic biota. One of the most important factors in determining potential soil effects is the concentration of naturally occurring endogenous trace elements. Impacts of added particulates will be more severe in areas where endogenous concentrations are currently close to the tolerance limit for any population member. On the other hand, benefit in a deficient area may be gained by the addition of essential trace elements, such as copper, boron, molybdenum, zinc and manganese, (Dvorak, 1978).

Effects on vegetation will vary considerably. Visible effects range from chlorosis, necrosis and discoloration to stunting and deformation. These may be linked to changes in enzymatic reactions or metabolic processes, such as photosynthesis and respiration and will depend not only on the chemical composition of the particulate matter, but also on the exposure concentration, and plant species. In a natural vegetation area, such as the forests of the Folsom District, where the majority of the vegetation is recycled rather than consumed, concentration build-up will exceed that found in agricultural areas.

As trace elements collect in the edible plants the entire food chain will be impacted. Herbivorous wildlife are affected through ingestion and also by the loss of sensitive plant species within their habitat. These factors may contribute to reduced numbers of wildlife species or possibly the elimination of certain species from the affected environment. Ingestion, along with inhalation, are the two modes of entry of trace elements into animals. Several effects of these elements are detailed in Table 5.2-1.

Sulfur Dioxide

All BLM lands within the Folsom District have SO_2 concentrations below two pphm as shown in Figure 5.3-7 and are classified either as attainment areas or unclassified. However, this classificaiton does not preclude effects from being seen within this area. Sources of SO_2 and sulfur compounds include high sulfur fuel combustion (SO_2), anaerobic decompostion of plants material (H_2S), and the industrial production of sulfuric acid. Coal-fired power plants alone account for 40% of total U.S. sulfur-compound emissions. Highest levels of exposure from such plants may be exepcted in the Western U.S., where scrubbers

Table 5.2-1

General Manifestations of Trace Elements in Animals

Element	Target organs or characteristics of toxicity	Comments
Arsenic	Has been associated with increased incidence of lung cancer.	Non-accumulative in animals but has affinity for hair, nails, and skin.
Barium	Has strong stimulating effect on all muscles in acute poisoning.	Poorly absorbed with generally little retention in tissue.
Beryllium	Characteristic granulomatous changes of lung tissue is brought about by long-term exposure.	Via inhalation, beryllium is correlated with an interference in the passage of oxygen.
Cadmium	Is linked with the incidence of hypertension in experimental animals.	Accumulative in all animals and toxic to all systems and functions in humans and animals.
Cobalt	Causes changes in lungs typical of pneumoconiosis. Also causes induction of polycythemia in many species.	With increasing age, the body burden of cobalt diminishes.
Copper	Associated with induction of haemolytic disease, especially in certain species.	In excess, results in some accumulation in the tissue, especially in the liver.
Chromium	Hexavalent compounds extremely toxic to body tissue. Insoluble forms retained in lung tissue.	In particular, the respiratory tract and fat tissue accumulate this metal.
Fluoride	Contributes to dental fluorosis in animals.	Deposits in bone tissue.
Lead	Newly absorbed lead is mostly retained in the body as lead triphosphate, especially in liver, kidneys, pancreas, and aorta.	Has strong affinity to accumulate in bone tissue.
Manganese	Acute intoxication involves changes in the respiratory system, whereas chronic poisoning affects the central nervous system.	Most amounts taken into the body are retained, especially in liver and lymph nodes.
Mercury	Organic forms have effects on brain tissue. The inorganic form is more linked to damage to liver and kidneys.	Can bioaccumulate in tissues of animals.
Molybdenum	Associated with degenerative changes in liver cells.	Can accumulate in tissues.
Nickel	Associated with cancer of lungs.	Very poorly absorbed from gut.
Selenium	Associated with alkali disease in cattle.	Is converted in the body into a volatile compound which is eliminated through breath and sweat.
Vanadium	Is found to inhibit the synthesis of cholesterol and other lipids. Other complications leading to cardiovascular diseases are also prevalent.	Vanadium salts are poorly absorbed from the gastrointestinal tract.
Zinc	Intoxication produces either lung or intestinal tract manifestations.	Absorbed or injected zinc is incorporated at varying rates into different tissue, indicating varying rates of zinc turnover.

Source: Dvorak, 1978

are not used (Dvorak, 1977). Since many BLM land areas contain major coal reserves, this may be an area of great concern in the future.

The effects of gaseous air pollutants such as SO_2 on plants and animals are typically classified according to the exposure. Acute effects are those related to exposures of short duration (up to one month) and comparatively high concentrations. Chronic effects are evoked when organisms are exposed to low-level concentrations for periods of one month to several years. Long-term effects are the result of exposures lasting for decades or longer. These are characterized by abnormal changes in the ecosystem or subtle physiological changes in the organism. Acute injury to vegetation from SO_2 exposured is characterized by collapsed marginal or intercostal leaf areas, which later become dried and bleached to an ivory color in many species, or brownish red or brown in other species. Chronic injury is seen as leaf yellowing from the margins to intercostal areas. Both acute and chronic injuries can result in death of the plant. Long-term injury may also occur without visible symptoms, but may be implied by subtle changes in the ecosystem (Dvorak, 1976).

Sensitivity to SO_2 will vary according to the plant species and microclimate in which it exists. Several vegetation types native to BLM lands in the Folsom District have been listed in Table 5.2-2, according to the sensitivity level as determined by the reference. Plants may also be affected in the following ways: increased respiration, decreased protein content and metabolism, decreased sugar, vitamin and starch content, decreased glucosidase activity and altered terpene activity.

Studies concerning SO_2 and SO_2 with NO_2 effects on desert-type vegetation of the Southwestern U.S. have been conducted by Hill, et.al. (1974). The area studied included Utah and New Mexico at elevations of 4500 to 6500 feet. Using concentrations of 0.5 to 11 ppm SO_2 + 0.1 to 5 ppm NO_2 for 2-hour fumigation periods, the study ranked sensitivity according to Table 5.2-3. Studies have been ranked together as no synergistic effects were found. Common injuries appeared as leaf necrosis and interveinal patches of necrotic tissue on broad leaves. Color of injured tissue varied from tan, gray brown and yellow to rusty brown depending on the species. With desert plants, often the entire leaf was injured. Results of the study suggested that middle-aged and older leaves were more sensitive than younger, expanding leaves and years with unusually high rainfall could cause more severe injury to desert type vegetation (Hill, 1974).

Caldwell, et al (1976) also studied SO_2 effects on southwestern U.S. desert vegetation. Fumigation studies were conducted in the Catalina Mountains near Tucson at 7700 ft. Results were similar to those by Hill et al; (1974) however, Caldwell noted that SO_2 will injure vegetation to a maximum distance of 30 to 40 miles. Past that point, the plume will be too dilute to cause any effects. The most resistant species

Table 5.2-2

SO_2 Injury to California Native Vegetation

Common Name	Sensitivity	Reference
Pine, Jack & Red	Sensitive	Davis & Wilhour (1976)
Douglas Fir	Intermediate	Davis & Wilhour (1976)
Fir, Basalm & Grand	Intermediate	Davis & Wilhour (1976)
Pine, Lodgepole	Intermediate	Davis & Wilhour (1976)
Pine, Ponderosa	Intermediate	Davis & Wilhour (1976)
Pine, Western White	Intermediate	Davis & Wilhour (1976)
Fir, Silver	Resistant	Davis & Wilhour (1976)
Fir, White	Resistant	Davis & Wilhour (1976)
Pine, Limber	Resistant	USDA (1973)
Pine, Mugs	Resistant	Davis & Wilhour (1976)
Pine, Pinton	Resistant	Davis & Wilhour (1976)
Fir, Subalpine	Sensitive	Davis & Wilhour (1976)
Pine, Short Leaf	Intermediate	Treshow (1970)
Sagebrush, Big	Intermediate	Davis & Wilhour (1976)

Source: Dvorak, 1978

Table 5.2-3
Percent of the Total Leaf Area Injured by Different Concentrations of SO_2 in Two-Hour Field Fumigation Studies

Species	Average percent injury						Number of replications					
	SO_2											
	.5 ppm	1 ppm	2 ppm	4 ppm	6 ppm	10 ppm	.5 ppm	1 ppm	2 ppm	4 ppm	6 ppm	10 ppm
Abies concolor (White fir)		0		0	0			1		1	3	
Abies lasiocarpa (Alpine fir)					0	22					5	2
Acer glabrum (Rocky Mountain maple)		0		10	60			1		1	1	
Achillea millefolium (Yarrow)		0	0	0	16	38		1	1	2	5	2
Agoseris glauca (Mountain dandelion)		0	0	10	15			3	2	7	6	
Agropyron caninum (Wheatgrass)			0	0	0	78			1	1	5	2
Agropyron desertorum (Crested wheatgrass)					20						1	
Ambrosia sp. (Ragweed)		0	0	0	1	1		1	3	4	2	1
Amelanchier utahensis (Utah serviceberry)	0	0.2	3	22	33	80	1	3	3	1	3	1
Antennaria sp. (Pussytoes)			0	0					1	1		
Arabis pulchra (Rockcress)				0						1		
Artemisia ludoviciana (Louisiana sage)		0		0	21			2		1	4	
Artemisia tridentata (Big sagebrush)			0	4	9	2			2	5	7	3
Aster chilensis (aster)		0	0	1	5			3	1	6	4	
Astragalus utahensis (Locoweed)		2	0	30	50			1	1	2	2	
Atriplex canescens (Fourwing saltbush)				0	0					1	1	
Atriplex confertifolia (Shadscale)				0	0					1	1	
Betula occidentalis (River birch)				50						1		
Bouteloua barbata (Six-weeks grama grass)		0	0	0	0			3	2	7	9	
Bouteloua gracilis (Blue grama grass)					0						1	
Bromus ciliatus (Fringed brome)		0	0	0	13	96		2	3	5	2	1
Bromus inermis (Smooth brome)						0.6						1
Bromus tectorum (Cheatgrass)			0	0	0	10			1	3	3	1
Cercocarpus ledifolius (Curl-leaf mountain mahogany)					0.4	25					5	1
Cercocarpus montanus (Mountain mahogany)				5						2		
Chenopodium fremontii (Goosefoot)		0	2	5	7			5	3	5	6	
Chrysothamnus nauseosus (Big rubber rabbitbrush)				0	1	40				3	3	1
Chrysothamnus stenophyllus (Little-leaf rabbitbrush)				0						1		
Chrysothamnus viscidiflorus (Sticky-flower rabbitbrush)		0		0	5			2		1	2	
Cirsium undulatum (Thistle)		0		6	14			2		4	4	
Clematis ligusticifolia (Western virgin's bower)				0	0.2					1	1	
Cleome sp. (Beeplant)				0						1		
Cowania mexicana (Cliffrose)					0	3					1	1
Cryptantha humilis (Catseye)				0	15	80				1	1	2
Cynoglossum officinalis (Houndstongue)		0	0.4	8	16			5	4	15	7	
Descurainia californica (Tansy mustard)				0		40				1		1
Ephedra viridis (Mormon tea)		0		0	2	95		2		2	4	1
Equisetum sp. (Horsetail)		0	0	0	0			1	1	2	1	
Eriogonum racemosum (Buckwheat)		0		43	19			1		2	3	
Euphorbia serpyllifolia (Spurge)		0	0	12	15			5	2	9	10	
Eurotia lanata (Winterfat)				6	0					1	2	
Geranium richardsonii (White geranium)			3	7	86				2	2	2	
Gilia aggregata (Scarlet gilia)			0.8	3	14				1	2	2	

Source: Hill, 1974

Table 5.2-3 (cont.)

	Average percent injury						Number of replications					
	SO₂											
Species	.5 ppm	1 ppm	2 ppm	4 ppm	6 ppm	10 ppm	.5 ppm	1 ppm	2 ppm	4 ppm	6 ppm	10 ppm
Gutierrezia sarothrae (Snakeweed)			0	0	21	78			4	2	13	3
Hackelia floribunda (Stickseed)		0		0				1		1		
Haplopappus nuttallii (Goldenweed)					0	100					1	1
Hedysarum boreale (Sweet vetch)			0	0	40	75			2	1	1	1
Hilaria jamesii (Galleta)		0	0	0	0	0		3	2	5	9	1
Hymenoxys richardsonii (Hymenoxys)				0						1		
Juniperus osteosperma (Utah juniper)					0	28					1	2
Juniperus scopulorum (Rocky Mountain juniper)		0		0	0	25		1		1	4	1
Lepidium sp. (Peppergrass)		0						1				
Machaeranthera canescens (Spiny-leafed aster)				25						1		
Mahonia repens (Oregon grape)		0		0	0			1		1	2	
Malacothrix sonchoides (Desert dandelion)				0						2		
Munroa squarrosa (False buffalograss)		0	0	0	0			3	2	7	9	
Oenothera sp. (Evening primrose)		6	12	5	3			3	1	3	1	
Opuntia sp. (Prickly pear cactus)					0						1	
Oryzopsis hymenoides (Indian ricegrass)	0.2	2	2.	17	29	90	4	9	8	14	17	1
Oryzopsis micrantha (Ricegrass)				4						1		
Pachystima myrsinites (Mountain lover)					0						1	
Penstemon sp. (Penstemon)				15		70				1		1
Phacelia corrugata (Scorpion weed)				0						2		
Picea pungens (Blue spruce)			0	0	0				1	2	3	
Pinus edulis (Pinyon pine)				0	0.06	2				4	9	4
Pinus ponderosa (Ponderosa pine)				0	0	1				2	3	1
Poa pratensis (Kentucky blue grass)			0	0	7				1	5	3	
Populus angustifolia (Narrowleaf cottonwood)	0	0	2	11	20		3	6	2	5	2	
Populus tremuloides (Quaking aspen)	0	0	0	12	7	0	1	2	3	11	8	1
Pseudotsuga taxifolia (Douglas fir)				0	0.8					5	4	
Quercus gambelii (Gambel oak)					0	8					1	1
Rhus trilobata (Squawbush)					0.3	0					1	1
Rosa woodsii (Wild rose)		0	1	15	90	60		6	3	5	2	1
Salsola kali (Russian thistle)				7	3					3	2	
Senecio streptanthifolius (Groundsel)				0	8					3	1	
Silene menziesii (Catchfly)				0						1		
Sitanion hystrix (Squirreltail)			0						1			
Sphaeralcea sp. (Cutleaf globe mallow)			0	0.03	17	40			2	4	3	1
Sphaeralcea parvifolia (Globe mallow)	20	22	43	38	30		2	7	3	7	2	
Sporobolus cryptandrus (Sand dropseed)		0	0	0	0	0		3	2	8	7	1
Stipa occidentalis (Needlegrass)					0	73					4	2
Symphoricarpos oreophilus (Snowberry)		0.3	6	18	32			4	4	6	3	
Tragopogon dubius (Goatsbeard)			0	4	8				2	2	3	
Trisetum spicatum (Trisetum)						90						1
Viola sp. (Viola)					25						2	
Yucca sp. (Yucca)						0						1
Zygadenus paniculatus (Death camas)			0	0	13				1	1	2	

Source: Hill, 1974

(Douglas Fir, Pinon Pine, and Arizona Ponderosa) all grow in higher elevations and the three most sensitive species, (Goodding's Willow, Cocklebury, and Sunflower), all grow in low, wet areas. Humidity plays a role in determining the threshhold value for SO_2 injury. Higher humidities tend to lower the SO_2 levels needed to create a response. Generally, injury was proportional to new growth and smaller, less developed individuals were more sensitive. Symptoms were visible within one and one-half days after fumigation. High temperature and wind increased symptom maturation (Caldwell, 1976).

Plants, in general, are more sensitive than animals to SO_2 injury; however, animals are impacted indirectly by changes in habitat or food species. Direct effects in animals also occur. Sulfur is known to inactivate enzymes, thus altering protein synthesis. Enzymes such as diastase, peroxidase and catalase are particularly sensitive. In man, the effects may be increased airway resistance, decreased mucus flow rate, increased susceptibility to respiratory infection and chronic respiratory disease. Six to ten exposures of 0.2 ppm for 10 seconds each has produced altered electro-encephalograms. Recent population studies indicate that, at lower concentrations, inhaled sulfuric acid and specific sulfates produce even greater irritability than from SO_2 (Coffin and Knelson 1976).

Studies by Colucci (1976) show deleterious effects to pulmonary function in laboratory animals with acute exposures of 6.75 ppm for two to three hours. Pulmonary dysfunction occurred with chronic concentrations of 4.86 ppm for several months. Epidemiological studies indicate that chronic exposures of 0.04 ppm can adversely affect human populations. It follows that animals with higher ventilation rates or more exposed mucosal tissue per body size would be more sensitive (Dvorak, 1976). Results of Colucci's studies may be reviewed in Table 5.2-4.

Another integral part of SO_2 emissions concerns the combination of SO_2 and nitric oxide as acid precipitation. The acidification of many freshwater lakes and streams has become an area of extreme concern in Northern Europe and Northeastern North America. The acidity of precipitation has been on the rise in this area since the early 1900's because of increased emissions of acid-forming sulfur and nitrogen compounds. This acidic precipitation can lower the pH of soils and natural waters causing mineral leaching and damage to many aspects of the biosphere.

Studies by Hendrey, et al (1976) show that the acidification of freshwaters produces many changes in the aquatic environment. In six Swedish lakes, where pH had decreased by 1.4 to 1.7 units during a forty-year period, bacterial activity had apparently decreased, leaving dense amounts of fungal hyphai on sediment surfaces. Decreased pH was believed to be the cause for the shift in dominance of organisms from bacteria to fungi, with the consequent decrease in oxygen consumption and interference with nutrient recycling by microdecomposers (Hendry, 1976).

Table 5.2-4

Summary of Toxicological Experiments with Sulfur Dioxide (SO_2)[a]

Species	Concentration (10^5 μg/m^3)	Duration	Effects
Monkey	<0.034	78 weeks	None
Donkey	<0.078		None
	<0.78		Impaired bronchial clearance
Dog	0.13	21 hours/day for 620 days	None
Monkey	0.13	78 weeks	None
Guinea pig	<0.13	22 hours/day for 365 days	None
Dog	0.13	21 hours/day for 225 days	Increased pulmonary resistance
Rat	0.026-0.079	12 hours/day for 4 months	None
Mouse	0.18 -0.26	7 days	Increased sensitivity to pneumonia infection
Rabbit	0.26	3-10 days	Increased S-sulfonate clearance
Mouse	0.26	Up to 72 hours	Lesions in respiratory tract
Rat	0.26	6 hours/day, 5 days/week for 113 days	None
	2.6	6 hours/day, 5 days/week, for 22 days	40% mortality
	∿15	6 hours/day, 5 days/week, for 12 days	∿90% mortality
Guinea pig	0.26	6 hours/day for 20 days	None
Cat	0.52		Increase in pulmonary flow resistance
Rabbit	∿0.52	14 and 62 hours	Formation of S-sulfonate
Mouse	13	5 min/day, 5 days/week for 300 days	Accelerated onset of neoplasia
Hamster	14	3 hours/day for 75 days	Increased pulmonary infection
Dog	13-14	2 hours/2 times/week for 4 to 5 months	Change in goblet cells of bronchi and bronchioles
Rat	13-78		Change in goblet cell release
Rat	26	Up to 6 weeks	None
	52	Up to 6 weeks	Bronchial damage
	104	Up to 6 weeks	Death within 22 days
Rat	78	6 hours/day for 10 days	Increased acid phosphatase activity
Rat	78	2 hours	Gastric inhibition
Mouse	≤78	10 exposures of 10 minutes, with 3 or 7 minutes recovery between exposures	Initial decrease in respiratory rate, then progressive return to preexposure rate; desensitization to successive exposures.
Mouse	Various		Sensitized mice to pneumonia infection

[a] Data extracted from summary of Colluci (1976) and presented in order of increasing concentration, except where there is more than one entry for a single experiment.

Source: Dvorak, 1978

The interference with microdecomposer activities impacts on invertabrates, as food availability and variety is decreased (Hendrey, 1976). Devastating effects have been seen in fish species. In Norway, huge amounts of adult salmon and trout have been killed in connection with spring snow melt or heavy autumn rains. Sweden has reported the extinction of the salmonid population, and severe effects in the roach, perch, and pike communities. Metal smelters in Sudbury, Canada, which emit 2.64 million tons of SO_2 annually, have been thought to be the cause of the rapid disappearance of lake trout, lake herring, white suckers, and other species in the La Coche mountain region during the 1960's. PH values as low as 4.5 were not uncommon in this region. In the Adirondack Mountains of New York State, intensive studies revealed pH levels less than five to be present in 51% of the higher elevation lakes, and 90% of these lakes were devoid of fish life. Species such as brook trout, lake trout, white sucker, brown bullhead and several cyprinid species were completely eliminated over a period of forty years. Cause of death at pH levels less than three may be the result of a coagulation of mucous on gill surfaces and subsequent anoxia. At pH levels of four to five, the cause may be a disturbance of the normal ion and acid-base balance. It appears that small fish are more sensitive than larger members of the same species. Smaller fish have a larger gill surface area per unit weight, which hastens ion fluxes. Age-specific mortality has not been clearly defined although there are indications that age may play a role in some species (Schofield, 1976).

The effect of acid precipitation on soils may be beneficial as well as harmful. Because it increases the amounts of sulfur and nitrogen, the added nutrient benefit may outweigh any deleterious effects. However, leaching of valuable soil minerals, such as Calcium and Manganese, and other cations, has been linked to acid precipitation. Inasmuch as soil structure, texture, and cation exchange capacity vary so widely, it is difficult to determine completely the effect that increased acid will create without first classifying the soil type. Susceptibility, as discussed by Malmer (1976), varies as follows. Natural soils with high pH and base saturation are usually highly resistant, along with soils rich in clay and organic colloids. On the other hand, acid and sandy soils and soil types that are transitional between brown earths and podsals will be more seriously affected by increased acidity. It is relevant also to bear in mind that acid precipitation may carry many other pollutants to the soil, which may increase or counteract expected effects (Malmer, 1976).

As soils are affected, biological effects will be seen on forest vegetation. Some species of lichens, which have the capacity to fix molecular nitrogen from the air, are quite sensitive to SO_2 and lose their nitrogen-fixing ability when subjected to acid precipitation. However, this may not be harmful to forest trees as they are not obligate nitrate plants. The addition of acid rain is also expected to cause the release of aluminum and heavy metal ions from the soil, which are toxic to many plants. It is also felt that nitrogen is accumulating in forest soil, and this accumulated nitrogen is expected to be transformed to nitrate and leached after clearfelling or forest fires. The results of this net acidification during a short period of time is not clearly known. However, it is expected that this condition will contribute to a decreased growth rate of trees (Tamm, 1976). Although effects of acid precipitation have not been established in California, it is being monitored presently in the Ukiah District in order to evaluate trends for future consideration.

Nitrogen Oxides

Like SO_2, coal-fired power plants are a major source of nitrogen oxides. These plants are responsible for 11% of the total nitrogen oxide emissions in the U.S. Other sources of atmospheric nitrogen include ammonia (NH_4) from biodecay and fertilizers, nitrogen oxides (chiefly NO and NO_2) from biochemical reactions within the soil, and also high-temperature combustion processes. Taken on a global scale, most NO_x is produced by bacteria, about 50 x 10^7 tons per year as compared to man-made sources which account for 5 x 10^7 tons per year. In the Folsom District, typical emissions densities for oxides of nitrogen are within the range of 1000 to 5000 tons per year (TPY). In Stanislaus County, higher density levels exist (10,000-50,000 TPY) while Santa Clara County exhibits the highest level of BLM land areas (50,000-70,000 TPY) while these values have not resulted in any violations of the California one-hour standard, effects can be seen in the biosphere.

Soils and plant life have not shown any detrimental effects of increased atmospheric nitrates at their present level (Noggle et al, 1978). In fact, atmospheric nitrate is beneficial because it restores the small quantities of nitrates lost in a mature ecosystem.

Animals and man, however, can be adversely affected by nitrous oxides as they are quite destructive to lung tissue. NO_2 is relatively insoluble in water and therefore is not scrubbed by tracheal and bronchial linings. This results in greater penetration into the lungs, interference with bacterial activity of macrophages, increased susceptibility to infection, bronchial inflammation, and loss of cilia. Long-term, low-level doses may result in an emphysema-type injury, decreased pulmonary compliance, and increased lung weight (Kavet and Brown).

Predicted worst-case NO_x emissions from a 2100 MWe generating station within about a one-half mile radius exceed 5.3 ppm for a short time period. Table 5.2-5 gives an indication of the adverse effects possible even at this level. Epidemiological studies indicate that humans may be adversely affected by chronic exposures to 0.53 ppm of NO_2. The effectiveness of extrapolating these data to wildlife in the region is uncertain (Dvorak, 1978).

Table 5.2-5

Summary of Toxicological Experiments with Nitrogen Oxides (NO_x)[a]

Species	Concentration (10^5 µg/m^3)	Duration	Effects
		Acute exposures	
Guinea pig	0.01-0.20	4 to 24 hours/day for up to 14 days	Elevated protein in urine
Guinea pig	0.04	Up to 21 days	Increased average area per alveolar wall cell
Mouse	0.02-0.30	Up to 17 hours	Impaired bacterial defense
Monkey	0.2 -1.0	2 hours	Decreased tidal volume, progressive histopathological damage
Rat	0.30-0.34	48 hours	Increase in Type II pneumocytes
Rabbit	0.16-1.2	3 hours	Impaired bacterial defense at all levels of exposure
Hamster	0.60-0.70	7 to 10 days	Bronchiolitic lesions
		Chronic exposures	
Mouse	0.01	Up to 12 months	Reduction of functional lung tissue
Monkey	0.02	493 days	Slight to moderate emphysema
Monkey	0.04	14 months	Hypertrophy of bronchiolar epithelium in bronchiole
Rat	0.02	14 months	Marginal changes in epithelium
Guinea pig	0.02	6 months	Higher mortality
Rat	∿0.06	9 months	Decrease in lung compliance
Rat	0.04	Lifetime	"Emphysema-like" injury suggested
Rat	0.04 0.34	Up to 360 days Up to 7 days	Increase in number of cells preparing to divide
Rat	0.12	6 weeks	Interstitial edema, vascular congestion
Rat	0.20	90 days	Decreased body size
Rat	0.30	90 days	Decreased body size
Mouse	∿0.80	Up to 8 weeks	Epithelial damage near terminal bronchioles
Hamster	0.9-1.1	10 weeks	Respiratory rate increased, hyperplasia and hypertrophy in terminal and respiratory bronchioles

[a] Data extracted from summary of Ziskind and Hausknecht (1976) and presented in order of increasing concentration, except where there is more than one entry for a single experiment.

Source: Dvorak, 1978

It is known that NO_2 in combination with SO_2 can produce severe effects at levels where SO_2 or NO_2 alone would not produce a visible response. Since coal combustion in power plants accounts for approximately 40% of total sulfur compound emissions and about 11% of total nitrogen oxide emissions in the continental U.S., it is important to look to these immediate areas for pollutant responses.

Carbon Monoxide

Within the Folsom District, carbon monoxide may be considered a serious pollutant problem. BLM lands in Fresno, Santa Clara and Stanislaus Counties are in non-attainment areas. Several other BLM lands are situated in unclassified sections which are quite close to non-attainment areas as shown in Figure 5.3-4. In these areas, carbon monoxide levels should be continuously monitored.

The toxic properties of carbon monoxide have been known to man for quite some time. Unfortunately, studies involving environmental aspects such as soils, wildlife, vegetation and archaelogy have not been published to the same extent as many other air pollutants. For this reason, carbon monoxide effects on man and mammals alone will be discussed.

Ninety-five percent of carbon monoxide emissions may be attributed to automobile exhaust and, because they are released near the ground, these emissions do not undergo substantial diffusion. This fact coupled with CO's lack of involvment in further atmospheric reactions to form secondary pollutants, accounts for the very high levels in urban areas. The situation is complicated further in that CO measurements in urban areas may be critically underestimated. Studies were conducted by Cortese and Spengler (1976) in the Boston area to determine the ability to represent carbon monoxide exposure by fixed monitoring stations. In this experiment, 66 non-smoking individuals carried portable CO samplers at breathing levels for the period October 1974 through February 1975. Results showed that four of the 66 volunteers, who commuted to work daily, were exposed to 37 ppm CO because of faulty automobile exhaust systems. This level is in excess of the National Ambient Air Quality Standard for one-hour 35 ppm. Considering the other volunteers, concentration of 5 to 20 ppm occurred 85% of the time, 5% were greater than 23 ppm and 1% were over 31 ppm. Comparison of these levels to fixed location monitors in the area, show that the mean one-hour personal exposure concentration (25.3 ppm) was 1.6 times greater than the fixed monitoring concentration (15.6 ppm) for all area stations. This difference may be due to the fact that CO concentrations at breathing level may diminish by 5 to 15% by the time they reach the usual monitoring height of 15 feet (Cortese, et al, 1976). This study would indicate that CO concentrations, as monitored, may actually be significantly higher in urban areas or on heavily traveled roadways.

Effects on small mammals may be derived through studies by Mordelet-Dambrine (1978) and Finelli, et al (1976). Mordelet-Dambrini ventilated guinea pigs and rats with 2.84% CO. After two minutes, tracheal pressure variations were seen and blood pressure and heart rate decreased within one to two minutes, respectively. Rats appeared to be more sensitive than guinea pigs to CO-inhalation. It was postulated that their higher heart rate could trigger the higher sensitivity level (Mordelet-Dambrini, 1978).

Finelli, et al (1976) studied the effects of clean air, exhaust emissions with a catalytic converter, and carbon monoxide emissions on 20 male rats for a period of four weeks. CO levels of 57.5, 172.5 and 517.7 mg/m^3 were used. During the exposure period, 18 animals were killed, and there was a dramatic loss in heart, spleen and body weight. A trend of lower serum cholesterol levels was significant in the rats exposed to the highest CO levels. These effects were not seen in the group exposed to the exhaust equipped with the catalytic converter as CO amounts had been greatly reduced (Finelli, 1976).

Parallel studies have shown that adult rats exposed to automobile exhaust without catalytic converters may also exhibit elevated hematocrit and hemoglobin, cardiac hypertrophy, loss in body weight and increased levels of serum lactate dehydrogenase. Low levels have also caused increased serum and aortic cholesterol in rabbits. This may be a factor in the development of arteriosclerosis in humans (Finelli, 1976). Also in humans, it is known to affect the heart, brain and muscle tissue most seriously because CO has a high affinity for hemoglobin and thus limits the amount of oxygen available to all body tissues, these three being extremely sensitive to oxygen deficiencies. CO has also been associated with reduced ability to perform vigilance tasks and reduced exercise tolerance (Cortese, 1976).

Any of these symptoms may also be seen in species native to the Folsom District. Possibly, symptoms may be more severe in animals with higher heart rates and more lung tissue relative to body weight. However, care should be taken in extrapolation of data.

Hydrocarbons

Hydrocarbon emissions are relatively high in the Folsom district. In San Jose County, emissions exceed 80,000 tons per year. As in the case of carbon monoxide, studies involving hydrocarbons as an air pollutant are not as numerous as those concerning many other air pollutants.

There are three basic sources of hydrocarbons: animal, mineral and vegetable, such as municipally operated sewage treatment systems, industrial discharges from oil-dependent industries and decaying vegetation. Over 90% of major discharges of petroleum hydrocarbons escape from pipelines, tank ships, tank barges, marine facilities and onshore production storage facilities (Boyd, 1976).

At the 1977 American Petroleum Oil Spill Conference, it was reported that in California, concentrations of petroleum hydrocarbons were found in almost all benthic and sandy intertidal sediment samples collected in the Southern California borderland (Reed, 1977). As hydrocarbons collect in soils and water, an effect will be seen on algae and photoplankton. Retardation of algae growth and inhibition of photosynthesis has been linked to the presence of petroleum hydrocarbons. A reported growth stimulation in photoplankton may be due to the slight carcinogenic stimulatory activity of low HC levels (Vandermuelen, 1976).

Effects of hydrocarbons on fish have been well documented by Adams (1975). Studies indicate that recreational vehicles, such as snowmobiles and motor boats, add dangerously high amounts of hydrocarbons to lakes. Death of fish may occur at levels of a few ppm and feeding, homing and reproduction are disrupted at levels of 10 to 100 ppb. These exhaust hydrocarbons concentrate in fatty tissue such as lateral line muscle and visceral fat. These compounds remain in the tissues and are passed to higher animals through the food chain (Adams, 1975). Further discussion of hydrocarbon effects on fish will be included in a subsequent section as this experiment also involved lead values.

Ozone

Hydrocarbons and nitric oxides in the presence of sunlight are known to produce ozone. Automobile exhaust, therefore, may be considered as a primary source of the precursors which give rise to oxidant. High ozone levels have been found not only in the urban environment but also in rural areas, on mountain tops, and at night. The reason for this ozone build-up is not fully known; however, it is believed that ozone or its precursors are being transported long distances or there may be a natural source of hydrocarbons and nitric oxides within forests and swamps, such as terpenes and methane. Within the Folsom District, several areas have been in violation of the federal one-hour standard for oxidant levels as seen in Figure 5.3-11. Areas within Fresno, Madera, Merced, and Stanislaus Counties have recorded five such violations per year.

Ozone is known to reduce photosynthesis in plants, thereby reducing the nutrient value of the plant. Studies of air pollution damage to the forests of the Sierra Nevada Mountains by Williams et al (1974), indicated widespread oxidant-caused injury to conifers. Especially susceptible were the ponderosa and Jeffery pine as measured by the extent and intensity of chloratic mottle on current year needles. Since ozone is dose-accumulative for a variety of sensitive plants, a concentration of 0.06 ppm over a five-month growing season would produce chlorotic mottle on current year needles of the ponderosa pine. It should be noted that this quoted level is within the federal standard of 0.12 ppm (Williams, 1977).

Results of the 1974 Sierra Nevada field survey showed ozone injury to be most abundant in the mixed conifer forest types located from 6000-8000 ft. in elevation. However, injuries at mid-elevation, (4000-6000 feet), where many BLM lands are located, tended to be more severe. These studies indicate that ozone injury is dependent on elevation. At mid elevations, where inversion levels are often found, injuries will be most severe. At higher levels, where ozone is quite abundant, injuries are more prevalent (Williams, 1977). Injuries to other species are detailed in Table 5.2-6.

The California Department of Agriculture yearly assesses damage to vegetation as caused by air pollution. In their 1970 summary, Millecan (1971) details the history of ozone damage to California forests. In the early 1950's in the San Bernardino National Forest, several pines began to turn chloratic and drop needles. Ponderosa and Jeffery pine were particularly involved. In 1963, it was first suggested that ozone might be the cause. Later, in 1969, aerial surveys by the Forest Service and University of California at Riverside revealed the extent of ozone damage. More than 161,000 acres of the ponderosa and Jeffery pines in the San Bernardino National Forest, an estimated two-thirds of the trees, were damaged by ozone. Of these, 3% were dead, another 15% were severely affected, and 82% were moderately or lightly affected. Severe damage potential exists along the entire western slopes of the Sierra Nevada because of the dense ponderosa and Jeffery pine forests. The Sacramento area is another region of great concern as the oxidant index (days with oxidant levels above 0.1 ppm) in Sacramento is 70 as assigned by the Department of the Interior, 1970. This was the highest index in the nation at the time of publication (Millecan, 1971).

In subsequent reports by the Department of Agriculture, it is emphasized that severe pine damage potential exists for the forests of Central and Northern California. Slight ozone damage has been seen in Sequoia National Forest and the Shaver Lake Area in Fresno County. Individual cases of ozone damage have been seen as far north as El Dorado and Nevada Counties (Millecan, 1976).

The Forest Service has been assessing ozone injury since 1974. A recent survey by Pronos et al (1978) revealed the extent of ozone injury in the Sierra and Sequoia National Forests as depicted in Figure 5.2-1. The worst injuries found were considered to be moderate and these were generally found at elevations of 4000 to 7000 feet on the Front Range mountains west of the San Joaquin Valley and along major river drainages. Four sites were also monitored for hourly ozone concentrations. The Federal standard at that time (8pphm) was exceeded almost daily at each site. Maximum and mean hourly concentrations are shown in Table 5.2-7 (Pronos, 1978).

Table 5.2-6

Site Characteristics and Extent of Ozone Injury

Location	Elevation (meters)	Topography	Site	Species with symptoms	Land use
Delilah LO	1564	Ridge	Flat, Dry	Ponderosa (PP)	National Forest (NF)
Mt. Sampson	1623	Ridge	Steep Dry	PP Black Oak (BO)	NF, Private
McKensie Ridge	1600	Ridge	Flat, Dry	PP, BO	NF
Converse Basin	1577	Basin	Mesic	PP, Sugar Pine (SP) Giant Sequoia (GS)	NF
Hume Lake	1577	Basin	Mesic	PP, SP, Jeffery Pine (JP)	NF
Boyden Cave	970	Canyon Bottom	Dry, Steep	PP	NF, National Park (NP)
Park Ridge	2199	Ridge	Steep, Rocky, Moist	PP, JP, SP White Fir (WF)	NP
Buck Rock	2578	Ridge	Steep, Rocky	JP Lodgepole Pine?	NF
Weaver Lake	2669	Flat	Dry	JP, Lodgepole Pine?	NF
Whitaker Expt. Forest	1638	West Slope	Moist	PP, BO, WF, SP, GS	Univ. of Calif.
Pinehurst	1095	West Slope	Dry	PP, BO, WF	NF, Private
Badger F.S.	1000	Flat	Dry	PP, BO	NF, County, Private
Sierra Glenn	970	Flat	Dry	PP	Private, County, State
Eshom Creek	1517	Variable	Moist	PP, BO	NF
Eshom Point	1517	Ridge	Dry	PP, BO	NF
Skagway Grove, Muir Grove	1517	Flat	Moist, Rocky	JP	NP
Lodgepole RS	2038	Flat	Moist, Rocky	JP, LP	NP
Crystal Cave	1456	Flat	Mesic	PP, BO, WF	NP
Giant Forest	1911	Flat	Mesic	JP, BO	NP
Colony Mill RS	1638	Ridge	Dry	PP, WF, BO	NP
Moro Rock	1880	South Slope	Mesic	PP	NP
Cresent Meadow	1914	Meadow	Mesic	JP	NP
Milk Ranch Peak	1897	South Slope	Dry	PP, WF, SP, BO	NP
Mineral King	2254	Canyon Bottom	Mesic	JP	NF

Source: Williams, 1977

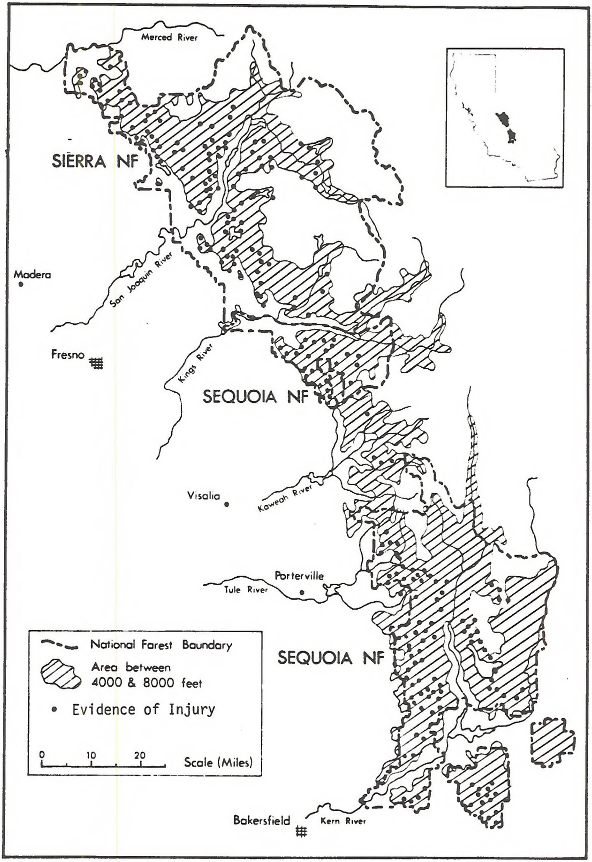
Merced River
SIERRA NF
Madera
San Joaquin River
Fresno
Kings River
SEQUOIA NF
Visalia
Kaweah River
Porterville
Tule River
SEQUOIA NF
Bakersfield
Kern River
National Forest Boundary
Area between 4000 & 8000 feet
Evidence of Injury
0
10
20
Scale (Miles)

Figure 5.2-1

Table 5.2-7

Comparison of Ozone Concentrations at Four Sites in the Southern Sierra Nevada, June-September 1977

LOCATION	JUNE		JULY		AUGUST		SEPTEMBER	
	MAX. HRLY. AVER. (pphm)	MEAN of MAX. HOURS (pphm)	MAX. HRLY. AVER. (pphm)	MEAN of MAX. HOURS (pphm)	MAX. HRLY. AVER. (pphm)	MEAN of MAX. HOURS (pphm)	MAX. HRLY. AVER. (pphm)	MEAN of MAX. HOURS (pphm)
Shaver Lk. Fresno Co.	11	8	13	9	15	11	12	8
Whitaker's Forest	14	10	15	11	14	11	13	9
Park Ridge Lookout	12	9	13	9	13	10	12	8
Mountain Home	--	--	--	--	13	10	12	8

(Concentrations are shown in parts per hundred million; data are not included for those months in which 85 percent or less of the hourly average concentrations were recorded.)

Impacts of ozone on man, animals and other air quality related values have not been studied to the same extent as with vegetation. However, ozone has been found to attack the cell membrane, breaking double bonds and removing hydrogen atoms. In humans, this process acts as a bronchoconstrictor, whereby less air reaches the lungs. There is increased coughing and breathlessness, and lung elasticity is decreased. Also, there is damage to alveolar macrophages in the presence of high concentrations of ozone, increasing the susceptibility to infection and cases of pulmonary edema. With wildlife, we can expect these effects to be seen to an even greater degree, as injury in most cases is more severe in animals with more respiratory tissue per body weight.

Lead

The thirty-day standard for lead is 1.5 ug/m^3. Within Madera, Stanislaus and Santa Clara Counties, violations of this standard may be expected from 10 to 25 times per year. Environmental sources of lead include the petroleum, paint and ceramic industries, and coal combustion.

Lead has become a serious environmental pollutant to the agricultural industry and is a major concern in the vicinity of major roads, as lead collects and accumulates in the soil. To date, plants show no toxic effects, and lead absorbtion by plants is insignificant. Concern, however, stems from the rise in lead content of plants and in animal feed, for these accumulations will affect the entire food chain (Keller, 1977)

As lead accumulates in the soil, long-term changes in productivity, decomposition, nutrient cycling, and insect and mycrobial activities may be seen. In the case of the Hubbard Brook Experimental Forest in Central New Hampshire, lead is accumulating at the rate of 0.67 pounds per half acre per year. Sources of lead measured include precipitation, winter snow and stream water. The soil and especially forest floor humus was found to be the major sink for lead, while lead uptake in vegetation was quite low. The entire system, however, is functioning to remove lead from the atmosphere and hydrologic systems and place it in the soil system. With this current input rate, the doubling time for lead concentration in forest humus would be only 50 years and since lead deposits from the atmosphere have a mean residence time of 5000 years, long-term concentration should be carefully evaluated (Siccama, et al, 1978).

Effects of lead accumulations on fish have been studied by several investigators. Hodsons, et al (1978) has shown that lead uptake in rainbow trout is a function of the pH of the water. Blood lead concentrations increased by a factor of 2.1 as pH decreased by 1.0 unit. Consequently, lead sensitivity increased with low pH levels. The author suggested that low pH increases the permeability of the gills. Sublethal concentration of lead for a period of three to six months may cause spinal deformities. Lead is also known to cause behavioral changes in fish at 70 ppb and death at 0.3 ppm. Therefore, pH should be monitored in streams known to have high lead values (Hodson, 1978).

Badsha and Sainsbury (1977) have studied first year whitings in the Severn Estuary and feel that bioaccumulations are functions of the food chain rather than respiration and gills. Therefore, bottom feeders would be expected to accumulate relatively higher lead amounts than other types of predators. Once ingested, lead is not rejected and slowly increases (Badsha, et al, 1977). Effects on fresh water fish may be quite similar according to experiments by Rehwoldt, et al (1978) in the fresh water stretch of the Hudson River system. In this study several species of fish were caught and lead levels were compared to those of preserved samples. Results are given in Table 5.2-8 and indicate that lead levels are time independent in a relatively clean system such as the Mid-Hudson (Rehwoldt, 1978).

Studies by Adams (1975) involve the effects of lead and hydrocarbons on brook trout. Increasing amounts of these two pollutants are released to the aquatic environment by snowmobiles and outboard motors each year and are attracting much attention. Towle's Pond in Freeport, Maine, served as the site for several experiments. Water samples in November 1971 showed 4.1 ppb lead and no detectable hydrocarbons as a baseline concentration. Through the winter seasons of 1971 and 1972, 56.8 liters of gasoline were burned in snowmobiles operating on the pond. During ice-out, lead levels increased to 88 ppb in 1972 and 135 ppb in 1973. These lead levels decreased rapidly within 72 hours of ice-out and returned to near normal within six days. Lead levels in exposed fish were 15.7 and 8.8 times those of control fish in 1972 and 1973, respectively. Four fish died during the first six hours of the 1973 experiment. Cause of death has been attributed to low oxygen levels in the pond during that period. Hydrocarbon levels ranged from 1 to 10 ppm and an oil slick was visible on the pond for one week after ice-out each year. Levels in exposed fish ranged from 0.1 to 1 ppm. Laboratory study revealed highest lead levels occur in the digestive tract (3.3 times that in control groups) and lowest in the gills, which may further indicate that bottom predators may be seriously affected by increasing lead levels. Elevated lead levels were also found in muscle skin and gills (Adams, 1975).

The pathological effects of lead in small mammals are detailed in reports by Roberts, et al (1978). Two abandoned metaliferous mines in Wales were chosen as the sites for soil, vegetation and mammal tissue measurements to determine lead accumulations. The area was typified by sparse natural vegetation, with a limited range of species, as few populations could survive the heavy metal concentrations in the soil. Table 5.2-9 indicates the lead amounts found in the soil, vegetation and invertebrate populations. Small mammals were caught in the area and examined for lead content. Vegetarian feeders were found to

Table 5.2-8

Average Values (m/g) for Lead in Dry Weight

Common Name	Source*	Pb
Alewife	MC 10 (1976)	0.30
	VC 2 (1953)	0.61
Atlantic Sturgeon	MC (1976)	0.82
	NYS 5 (1924)	0.71
Fundulus	MC 21 (1976)	0.51
	VC 4 (1953)	0.62
	NYS 3 (1936)	0.41
	AMNH (2) (1973)	1.10
Small Mouth Bass	MC 11 (1976)	1.06
	NYS 3 (1936)	0.99
Spottail Shiner	MC 17 (1936)	0.59
	VC 5 (1953)	0.69
	AMNH 2 (1973	0.77
Striped Bass	MC 14 (1976)	0.92
	NYS 2 (1936)	0.40
	AMNH 5 (1973)	0.21
Sunfish	MC 23 (1976)	0.25
White Perch	MC 26 (1976)	1.06
	VC 2 (1953)	1.02
	NYS 1 (1936)	0.80

*	
MC	Marist College
VC	Vassar College
NYS	New York State Museum and Science Service
AMNH	American Museum of Natural History

Number after source is sample size
Number in paranthesis is year caught

Source: Rehwoldt, et.al., (1978)

Table 5.2-9

LEAD CONCENTRATIONS (μg/g dry weight) IN SOIL, VEGETATION AND INVERTEBRATES (mean ± standard error, number of samples in brackets)

	Vegetation Lead	Invertebrates Lead	Surface Soil Lead
Mine A	120 ± 5.40(8)	61.9 ± 14.5(6)	8430 ± 2050(9)
Control	20.8 ± 3.89(8)†	18.4 ± 1.87(6)†	96.3 ± 24.4(10)†
Mine B	249 ± 33.7(9)	81.7 ± 18.6(5)	14010 ± 6160(7)
Control	28.9 ± 2.73(9)†	22.3 ± 4.79(6)†	78.0 ± 10.1(8)†

† Denotes statistical significance at $p < 0.001$ (NS = $p > 0.05$).

Source: Roberts, 1978

have the highest level concentrations and insectivorous mammals the least. In these mammals, bone and kidney tissues had the highest lead concentration, and the liver, brain, and muscle tissues had the least. This supports the generally accepted idea that the skeleton is the main long-term storage site for lead (Roberts, 1978).

Mice were fed lead acetate at levels of 0.1% and 4.0% in experiments by Eyden, et al (1978), to determine toxicity. The animals suffered weight reductions, increased sperm abnormalties, early hair loss, lethargy and reductions in mean survival time. Symptoms were dose-dependent and the authors suggested that death may be attributed to internal organ malfunction resulting from enzyme interference, lack of nervous or hormonal infection from depressed immunological competence (Eyden, 1978).

Lead is also known to accumulate in humans within the blood, bones, urine, aorta, teeth, kidneys and liver. It has been associated with anemia, arterioclerosis, diseases of the central nervous system, bone deterioration, kidney failure, chromosome abberations, and brain damage. It is also known that lead will pass through the placenta in pregnant women. Most serious effects may be seen in young children, ages one to four, as this is the time for normal development of the central nervous system and bone tissue. Yankel et al (1977) observed blood lead levels in young children living near a lead smelter in northern Idaho and found amounts as high as 70 mg Pb/100ml. Ambient air, soil and dust lead levels were attributed to be the major cause for the elevated lead levels. Air exposure alone explained 55% of the variance (Yankel, 1977).

This section has detailed the effects of various pollutants on air quality related values. Whenever possible, environmental concerns typical of the Folsom District were stressed. Where data was lacking, similar species or areas were described. Relating these data to the Folsom District may help to point out critical areas for immediate study or future areas of concern.

5.3 BASELINE AMBIENT AIR QUALITY

The Folsom District encompasses portions of five air basins as described in Section 4.8 - San Francisco Bay Area, San Joaquin Valley, North Central Coast, Central Coastal Mountains and the Mountain Area. Air quality monitoring in the district is concentrated in major cities for most of the pollutants, with an expanded network for the monitoring of total suspended particulates (TSP). The existing monitoring network is shown in subsequent figures in conjunction with the pollutant-specific attainment status for each county.

The California Air Resources Board (CARB), in accordance with the requirements of the Clean Air Act Amendments of 1977, has classified each county in terms of attainment of the National Ambient Air Quality Standards (NAAQS). Air quality regulations are discussed in considerable detail in Section 6; however, a review of the attainment status of counties within the Folsom District provides an excellent means for defining baseline ambient air quality. Figures 5.3-1 through 5.3-5 show the current status for each pollutant as designated for counties in the Folsom District. The figures illustrate which areas have been designated attainment, non-attainment or unclassified. Those counties where insufficient information from the current monitoring network is avilable have been designated as unclassified for a particular pollutant. Since the unclassified areas denote the lack of sufficient baseline air quality data, these maps also indicate which counties require additional monitoring stations to determine their status and thus their problem areas.

Baseline Levels

Ambient air quality values for 1977 for selected stations can be found in Appendix D while long-term baseline data are presented in Appendix E. The values cover all of the major pollutants, although every station does not measure all pollutants of interest. The listings include the number of observations, the yearly high, the arithmetic and geometric means with their standard deviations and the seasonal means and highs. The frequency with which standards are equalled or exceeded is also provided for each station.

Baseline ambient air quality data from Appendix D have been summarized in Figures 5.3-6 and 5.3-7 for total suspended particulates and sulfur dioxide, respectively. These parameters have been selected for graphical presentation and detailed analysis as they comprise the most readily available air quality data. They also provide a good representation of the effects of both industrial and agricultural (or outdoor) sources.

Data are presented as contours of annual average values for these pollutants based upon available data for monitoring stations at locations as depicted in the figures. The reader is

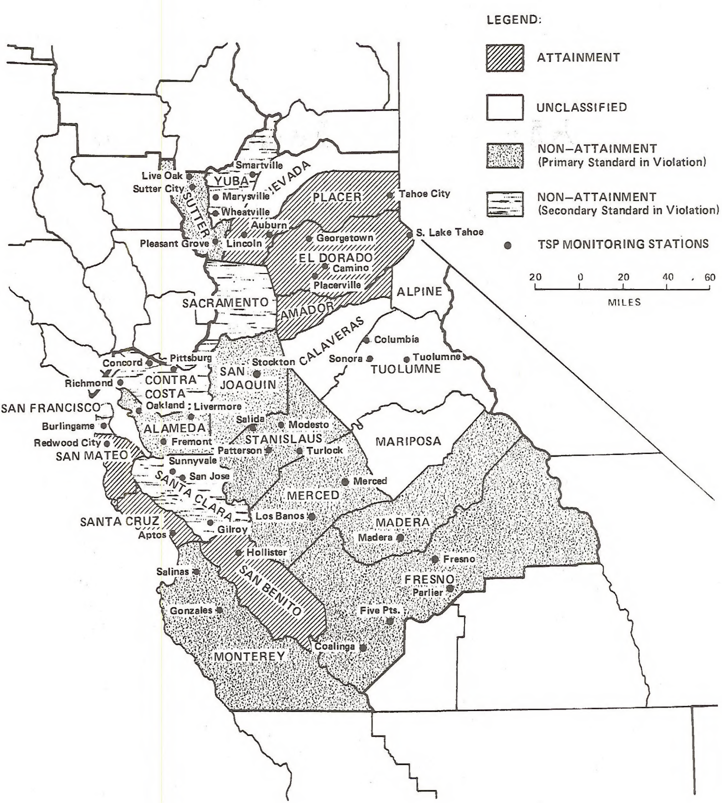

Figure 5.3-1
Folsom District TSP Classifications

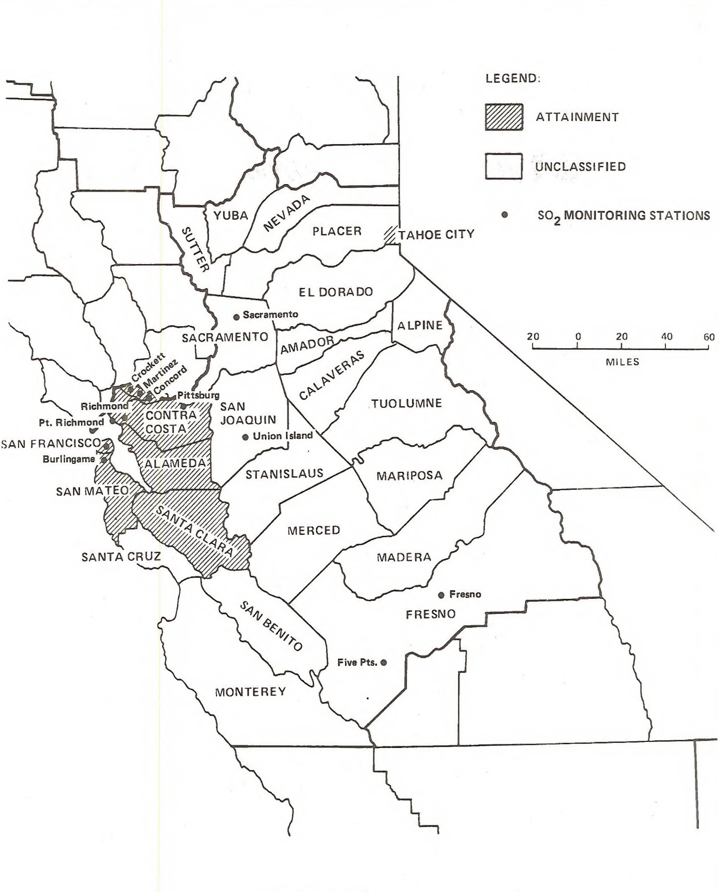

Figure 5.3-2
Folsom District SO_2 Classifications

Figure 5.3-3
Folsom District NO_2 Classifications

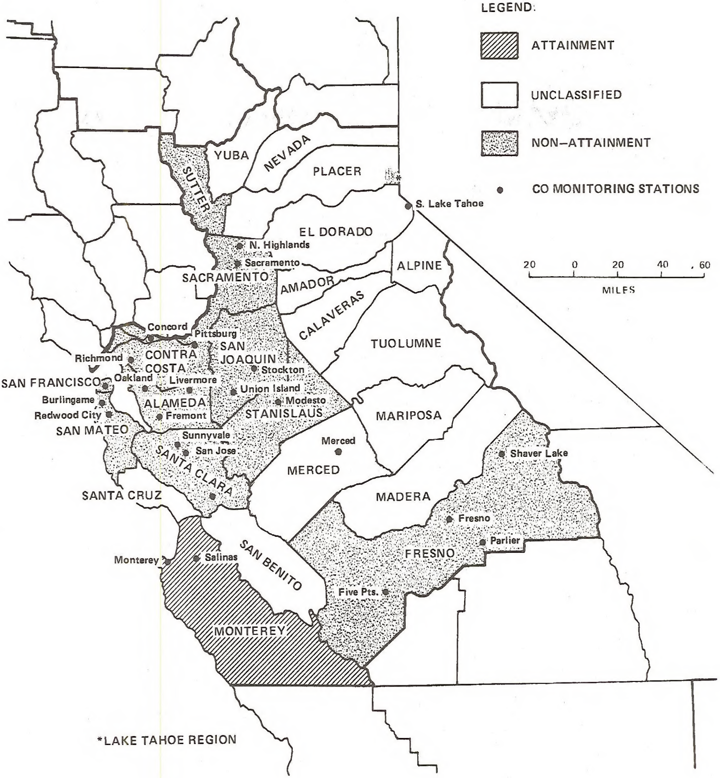

Figure 5.3-4
Folsom District CO Classifications

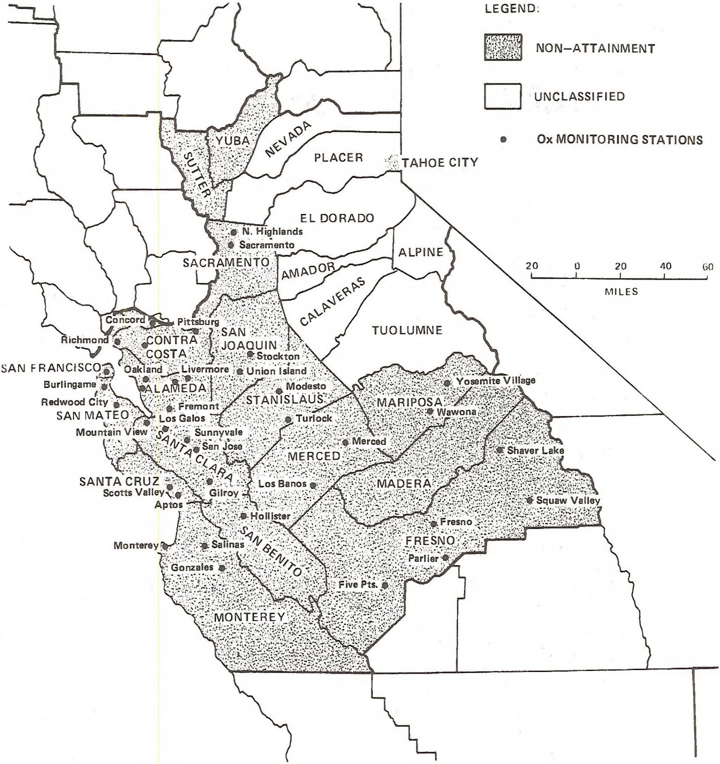

Figure 5.3-5
Folsom District Oxidant Classifications

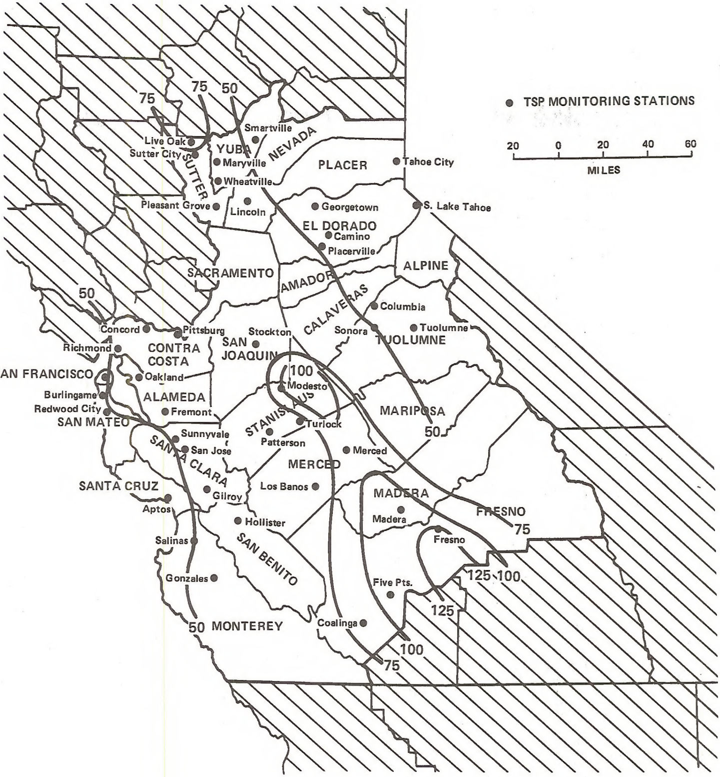

Figure 5.3-6
Annual Geometric Means ($\mu g/m^3$)
For Total Suspended Particulates in the Folsom District

NATIONAL AMBIENT AIR QUALITY STANDARD FOR TSP = 75 $\mu G/M^3$ ANNUAL GEOMETRIC MEAN
CALIFORNIA TSP STANDARD = 60 $\mu G/M^3$ ANNUAL GEOMETRIC MEAN

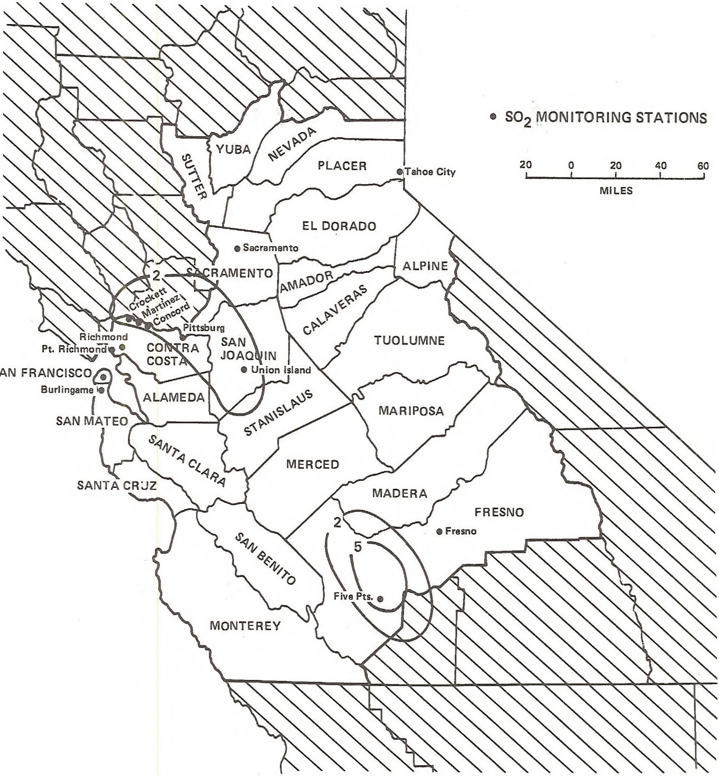

Figure 5.3-7
Annual Average SO_2 Concentrations (pphm)
in the Folsom District

NATIONAL AMBIENT AIR QUALITY STANDARD FOR SO_2 = 0.03 ppm cautioned in the use of these and subsequent figures that contours have been provided based upon a limited amount of available baseline air quality data. The analysis containing the figures can be used with most confidence at locations near monitoring stations. In more remote areas, additional monitoring data would be required to confidently establish baseline levels. Such areas include counties which have not been classified by the CARB under the requirements of the Clean Air Act Amendments of 1977 due to the absence of sufficient monitoring data.

Figure 5.3-6 presents annual geometric means for total suspended particulates in the Folsom District. The figure indicates that total suspended particulate levels are lowest along the immediate coastline and in the higher portions of the Sierra Nevada. Total suspended particulate concentrations are highest in the Central Valley portions of the Folsom District, particularly in the San Joaquin Valley. Annual geometric means range from around 75 micrograms per cubic meter in the Stockton-Sacramento areas to values in excess of 125 micrograms per cubic meter near Fresno. Particulate concentrations increase as one moves either north or south in the Central Valley from the Sacramento-Stockton area. This reflects the increasing distance from the relatively clean maritime air carried into the region through the Carquinez Straits, east of San Francisco. The figure indicates that particulate concentrations are above the California standard in all of the Central Valley. In addition, the federal annual standard for total suspended particulates is violated in the San Joaquin Valley south of Modesto, and in the Sacramento Valley north of Sutter City. Annual particulate levels are below standards along the coast and in the Sierra Nevada.

Annual average sulfur dioxide concentrations in the Folsom District are presented in Figure 5.3-7. These data indicate that annual averages for SO_2 are low throughout the district with maximum values observed east of San Francisco in the Martinez/Pittsburg area and in the southern portion of the district southwest of Fresno near Five Points. Values in excess of the federal annual standard have been noted only at Crockett and Five Points. The higher values noted in portions of Contra Costa County reflect the heavy industrial development in that area, while the higher values noted in the Five Points region of Fresno County reflect the presence of considerable secondary oil recovery operations.

The 1977 data (CARB, 1977) indicate that pollutant levels in the Folsom District are subject to fairly strong seasonal variations. Oxidant readings are highest between April and September while carbon monoxide reaches peak levels from October to March. It should be noted that ozone formation is primarily due to mobile source emissions (autos, trucks, etc.). The formation of ozone has a delay time from initial emissions of NO_2 and HC during which time these pollutants react with the sun and O_2 in the atmosphere to form ozone. Sulfur dioxide, unlike ozone, remains at fairly steady levels throughout the year. This indicates that most SO_2 is attributable to stationary sources while other pollutant levels are affected by seasonal changes in transportation patterns as they are related to the combustion of transportation fuels.

Frequency of Violations

Figures 5.3-8 through 5.3-13 provide the frequency of violations of key standards for total suspended particulates, nitrogen dioxide, carbon monoxide, oxidant, sulfates and lead. A specific figure for sulfur dioxide has not been provided as violations of short-term sulfur dioxide standards are quite rare. Crockett, located in the Carquinez Straits region, has recorded the only violation of the California one-hour standard, the federal three-hour standard, and the California twenty-four-hour standard. This latter standard is only in effect at a location where the state's standard for oxidant and/or suspended particulates have also been violated. The excedence of the SO_2 standard must occur at the same monitor where the TSP and/or ozone standard is violated, in order to be considered a violation. This is the case at Crockett.

Figure 5.3-8 provides the frequency of violations of the California twenty-four-hour standard for total suspended particulates (100 $\mu g/m^3$). The figure indicates that the standard has been violated at all stations except a few on the immediate coastline and those in the high Sierra. The frequency of violations ranges from over 5% of the observations at most stations to 50% of the observations in the Modesto, Merced, Medera, Fresno portion of the Folsom District. This pattern reflects the one described for baseline total suspended particulate levels as described by the annual geometric mean depicted in Figure 5.3-6. The high values in these areas are largely due to wind-blown dust.

Violations of the California one-hour standard for nitrogen dioxide are presented in Figure 5.3-9. Violations of the standard in the Folsom District are quite rare as indicated by these data. Only Sunnyvale recorded a violation during 1977. Annual averages throughout the district are also below the federal standard of 0.05 ppm. The high value in Sunnyvale is most probably due to the high rate of traffic on highways serving the San Jose Metropolitan area.

Figure 5.3-10 provides the frequency of violations of the federal eight-hour standard for carbon monoxide. The figure indicates that violations generally occur only at metropolitan areas. Areas in the Folsom District noting violations include the area near South Lake Tahoe, Fresno, Stockton, Modesto, San Jose and San Francisco. Carbon monoxide concentrations in more rural locations can be expected to be quite modest. As indicated, elevated values for this pollutant are generally due to large emissions associated with heavy vehicular usage.

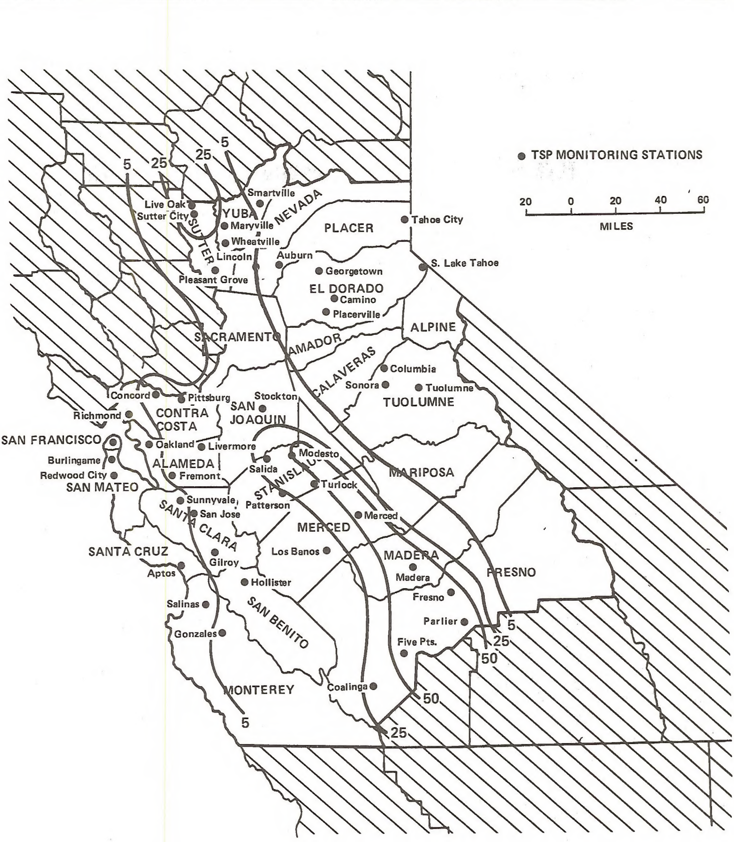

Figure 5.3-8
Frequency (%) of Violations of the California 24-Hour Standard (1) for Total Suspended Particulates

(1) CALIFORNIA 24-HOUR STANDARD FOR TOTAL SUSPENDED PARTICULATES = 100 μG/M^3

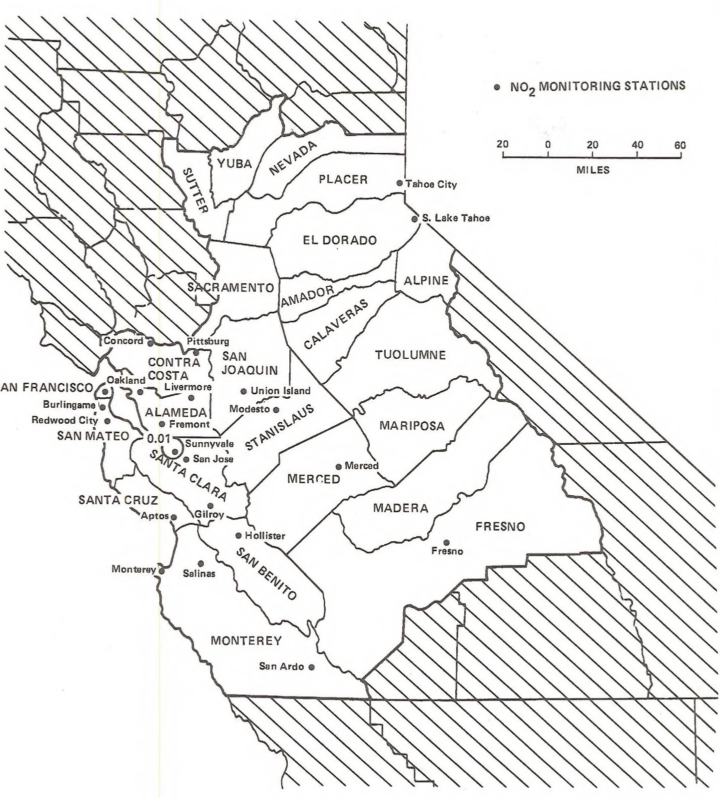

Figure 5.3-9
Frequency (%) of Violations of the
California 1-Hour Standard (1) for Nitrogen Dioxide

(1) CALIFORNIA 1-HOUR STANDARD FOR NITROGEN DIOXIDE = 0.25 ppm

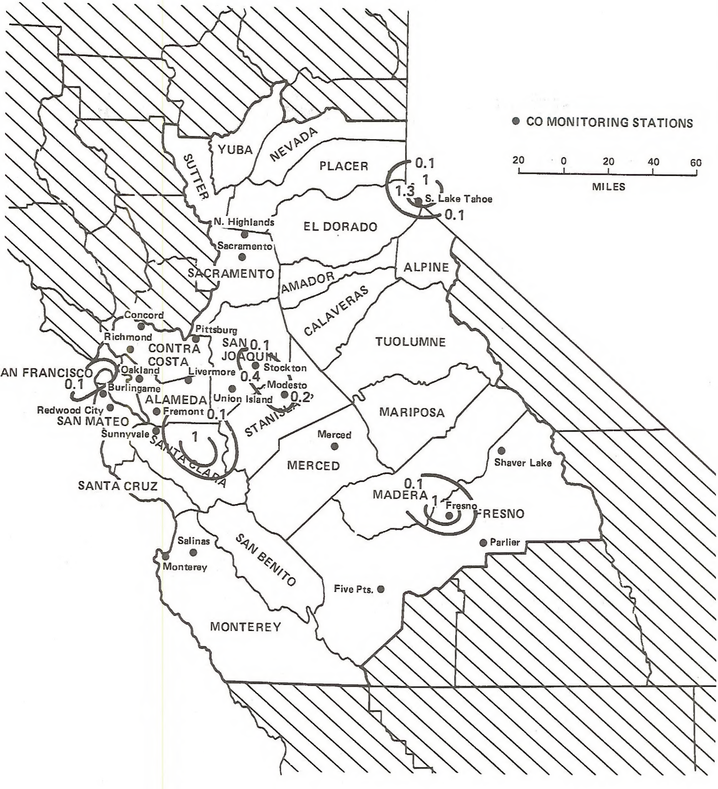

Figure 5.3-10
Frequency (%) of Violations of the Federal
8-Hour Standard (1) for Carbon Monoxide

(1) FEDERAL 8-HOUR STANDARD FOR CARBON MONOXIDE = 9 ppm

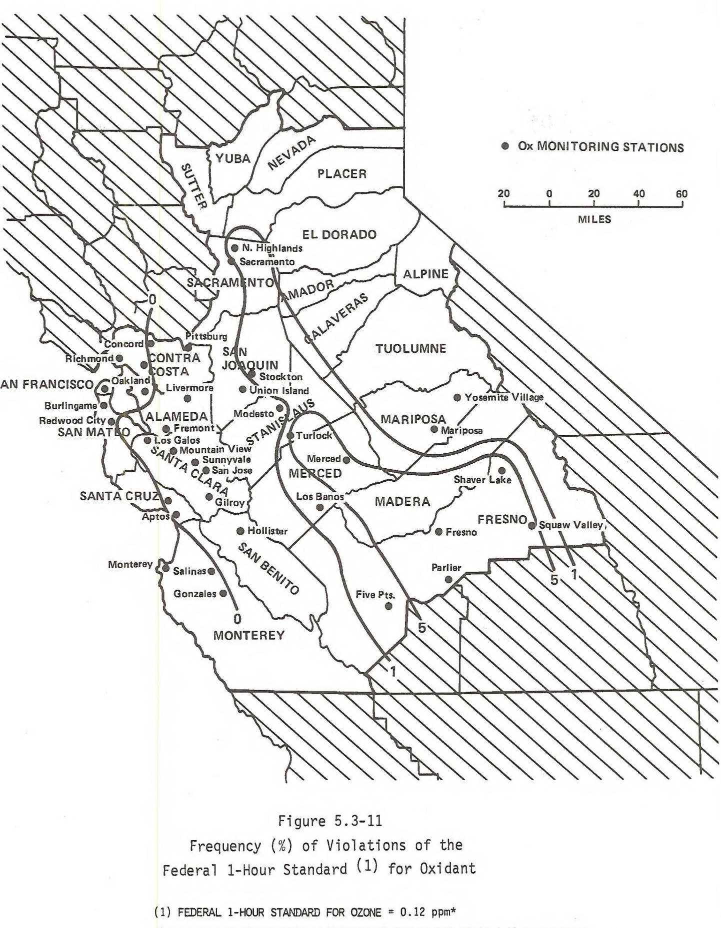

Figure 5.3-11

Frequency (%) of Violations of the Federal 1-Hour Standard (1) for Oxidant

(1) FEDERAL 1-HOUR STANDARD FOR OZONE = 0.12 ppm*

* THE FREQUENCY OF VIOLATIONS WAS DETERMINED WITH RESPECT TO THE 0.08 ppm STANDARD WHICH WAS IN EFFECT IN 1977. THE CARB DATA SHOWS FREQUENCIES WITH RESPECT TO THE OLD STANDARD AND FREQUENCY OF VIOLATIONS WITH RESPECT TO THE 0.12 STANDARD CAN NOT BE DETERMINED FROM THESE DATA.

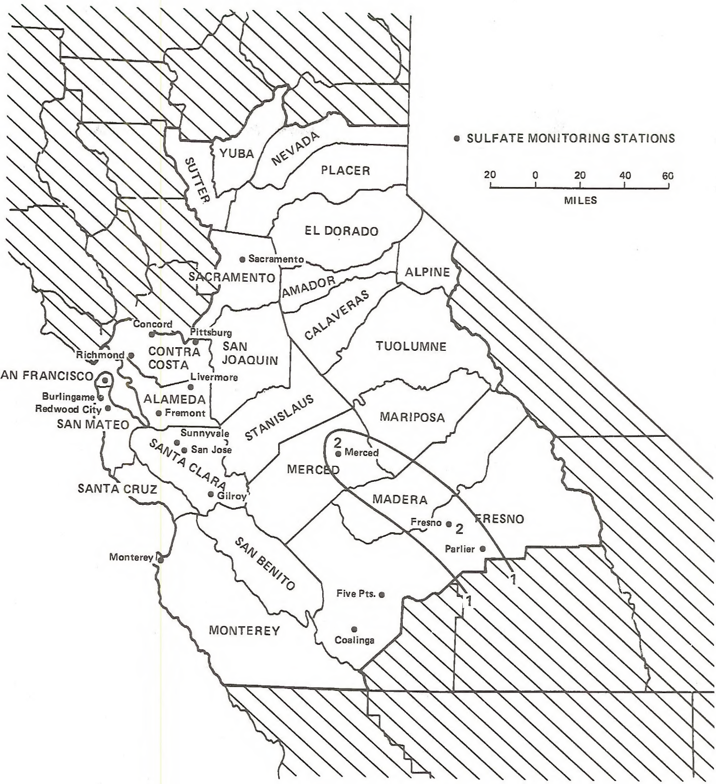

Figure 5.3-12
Frequency (%) of Violations of the
California 24-Hour Standard (1) for Sulfate

(1) CALIFORNIA 24-HOUR STANDARD FOR SULFATE = 25 μG/M^3

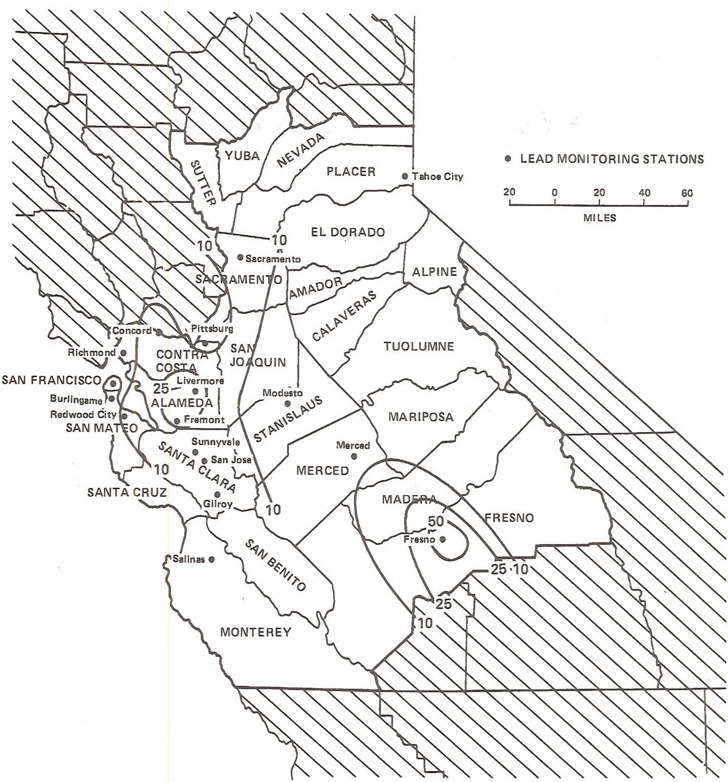

Figure 5.3-13
Frequency (%) of Violations of the
California 30-Day Standard (1) for Lead

(1) CALIFORNIA 30-DAY STANDARD FOR LEAD = 1.5 μG/M^3

A review of the frequency of violations of the federal one-hour standard for photochemical oxidant in the Folsom District is presented in Figure 5.3-11. Most regions in the district do experience violations of the standard during the course of the year with the exception of the immediate coastline. Violations of the standard were not observed during 1977 at such coastal locations as Salinas, Monterey, San Francisco, Oakland and Richmond. All other stations in the District did record violations of the standard including stations in the high Sierra such as Yosemite Village, Shaver Lake and Tahoe City. The frequency of violations of the standard is largest in the Central Valley portion of the district as well as the southern Sierra Nevada. The frequency of violations increases with southward progression through the area. The standard for photochemical oxidant was violated more than 5% of the time at Merced and Fresno, reaching nearly 10% of all observations at this latter location. It is interesting to note the high frequency of violations at Shaver Lake in the high Sierra where the standard was violated 8% of the time. The figure indicates the pervasive nature of violations of the standard not only in heavily industrialized areas, but also in the more remote recreational areas of the Sierra Nevada.

California also maintains a standard for sulfates. The sulfates are viewed as a "secondary pollutant" constituting the sulfate fraction of particulate. As such, they represent the product of the photochemical reaction involving SO_2. Sulfates are very important from the standpoint of health effects and the impairment of visibility. The California twenty-four-hour standard for sulfates was violated only in the San Joaquin Valley portion of the Folsom District as depicted in Figure 5.3-12. The frequency of violations was approximately 2% of the time at both Merced and Fresno. Concentrations tend to be highest in the southwestern portion of Fresno county, and the presence of elevated sulfate levels in the San Joaquin Valley indicates that photochemical processes are occurring resulting in the transformation of SO_2 to sulfates in this portion of the district. This portion of the Folsom District has the highest levels of SO_2 emissions due to the presence of oil-fired steam generators which operate in the oil fields.

Finally, the frequency of violations of the California thirty-day standard for lead are presented in Figure 5.3-13. Once again, violations of the standard for lead occur most frequently in heavily industrial or highly developed areas. These include Contra Costa and Alameda Counties as well as Fresno County in the San Joaquin Valley. The frequency of violations is generally less than 10% at other locations reaching a maximum of 25% at Fremont in Alameda County and a district maximum of over 50% at Fresno.

Long-term Trends

The data presented in Appendix E provide an indication of pollutant trends in the Folsom District. Most of the cities for which monitoring data are available have experienced a moderate decline in maximum oxidant levels. Arithmetic means for oxidant have also shown a gradual decline during recent times. Specific readings for ozone as opposed to oxidant were only begun in 1974 and insufficient data are currently available to make a determination of a trend specifically for ozone.

Carbon monoxide has not shown any discernible trend in terms of peak values. In most cities, CO has stayed in the 16-20 ppm range for the last five years. Sacramento data show an increase in maximum CO values since 1972, as do the Oakland-Jackson and Modesto areas. Average CO concentrations also have not exhibited any significant trend over the past few years.

Nitrogen dioxide has also been fairly constant in recent years. Readings have fallen in the 15-22 pphm (parts per hundred million) range for as many as 12 years in some cities. It is perhaps significant that there has been no change in the range of readings, considering the substantial population and economic growth which has occurred since the early 1960's.

For the other major pollutants, hydrocarbons have exhibited a slight decline. Measurements of total suspended particulates have shown an increase in the COH (coefficient of haze) value for most cities, and high-volume (hi-vol) measurements have not shown any significant decline in maximum readings over the last few years. While maximum recorded values do not provide specific trends, they do indicate changes in maximum exposure levels which can serve as indicators of the general level of pollution to which the populace may be exposed.

5.4 POINT AND AREA SOURCES IN THE FOLSOM DISTRICT

As will be discussed in Section 6 in more detail, the Folsom District includes counties which fall into several Air Quality Control Regions (AQCR). Counties in the Folsom District by AQCR include the San Francisco Bay Area AQCR-Alameda, Contra Costa, San Mateo, San Francisco, Santa Clara counties; The San Joaquin Valley AQCR-Tuolumne, Merced, Fresno, San Joaquin, Stanislaus, Mariposa, Madera, Amador, Calaveras, Sutter counties; The Sacramento Valley AQCR-Nevada, El Dorado, Sacramento, Yuba, Placer counties; The North Central Coast AQCR-San Benito, Monterey, Santa Cruz Counties and the Great Basin Valley AQCR-Alpine County. The area includes a diverse range of agricultural and industrial activities and settlement patterns which are a function of the wide geographical variety. Industrial activities include glass, asphalt, petroleum, gravel, cement, lumber, chemicals and machinery. Food and agricultural-related industries include sugar, salt, cattle, cotton oil, grain, milling and elevator operations (e.g., pellet mills), soup and dairy farms. These industries comprise the bulk of the major emitters (100 tons/years or more) in the District. Other sizable emitters include electrical power stations, ports (e.g., Stockton) and open burning dumps.

A wide range of sources and their associated stack and flow characteristics are noted in the Folsom District. The electrical power plants tend to have multiple (2-10) stacks which are several hundred feet in height. The stacks are typically 11-20 feet in diameter with flow rates from 60,000 to 700,000 actual cubic feet per minute (ACFM). Primary emissions from such plants are CO, NO_x and SO_x (from fuel combustion). Plants of such size typically emit several thousand tons of each pollutant per year.

Other industrial plants (sugar, refractories, glass and so on) usually have only 2-4 stacks which range from 15 to 200 feet in height. These have typical diameters of 2-10 feet and flow rates from 200 to 70,000 cubic feet per minute, an entire order of magnitude smaller than the typical electrical plant. The pollutants most commonly emitted are HC, TSP and CO. Pollutant amounts are generally several hundred (200-800) tons, annually. Chemical plants can emit several thousand tons per year of TSP and SO_x, but this is larger than the average plant.

Other emitters such as lumber companies, open burning dumps and food processing plants generally do not have stacks. Emissions are commonly TSP and CO, in the range of 100-500 tons, annually. (A detailed summary of the District's point sources is provided in Appendix F). Table 5.4-1 provides a summary of typical source exit characteristics for a variety of source types. These data can be used for simplistic or screening level modeling as discussed in more detail in Section 4.9.

Area sources comprise three principle types: solid waste disposal, fuel sources other than factories (such as residences and institutions or transportation) and evaporative losses

Table 5.4-1

Exit Characteristics For
A Cross-Section of Typical Sources

Source	Primary Pollutant(s)	Emission Type	Typical Upward Exit Velocity	Typical Exit Temp.	Typical Exit Height	Typical Exit Diameter
Fugitive Dust	TSP	Ground-level, non-buoyant	Zero	Ambient	4 to 10m (mechanical lift)	N/A
Automobiles	NO_x, CO, HC	Ground-level, slightly buoyant	Zero	150°C to 200°C	0.5m	0.6 to 1.5m
Oil Recovery Operations (Steam Generators)	SO_2, NO_x	Low-level, buoyant	2 to 6 m/s	200°C to 300°C	3 to 7m	1 to 1.5m
Oil Refinery	SO_2, NO_x, CO	Intermediate Level buoyant	6 to 8 m/s	200°C to 400°C	20 to 30m	1 to 2m
Power Plant	SO_2, NO_x, TSP	Elevated, buoyant	8 to 15 m/s	200°C to 500°C	120 to 180m	4 to 10m

N/A = Not Applicable

from solvents and gasses. Major emitters are residential and institutional fuel burning (particularly natural gas), onsite residential incineration, gasoline and diesel fuel used in transportation and depending on the county, solvent evaporative losses. Appendix G provides a complete listing of area source totals on a countywide basis for the Folsom District. Figures 5.4-1 through 5.4-5 indicate the density of emissions for each of the primary pollutants in the Folsom District. The counties of the Folsom District with the highest emission totals include Alameda, Santa Clara, Contra Costa, Monterey, Calaveras and Sacramento.

Figure 5.4-1 indicates that particulate emissions are heaviest in Calaveras County where in excess of 50,000 tons per year are emitted by both point and area sources. Other counties with heavy emissions include Contra Costa, Alameda, San Joaquin and Fresno where emissions range between 10,000 and 50,000 tons per year. As indicated in Appendix F, the bulk of the TSP emissions contributing to the heavy annual totals in Calaveras County are due to the Flint Kote Company located in San Andreas.

Sulfur dioxide emissions are presented in Figure 5.4-2 for the Folsom District. Counties with the heaviest annual emission rates for both point and area sources include Contra Costa, Santa Clara and Monterey where emissions range between 10,000 and 50,000 tons per year. In Santa Clara County, the bulk of these emissions are due to area sources, while in Contra Costa County, point sources such as Phillips Petroleum, Shell Oil and Monsanto in Martinez; Union Oil of California in Rodeo; and Allied Chemical in Richmond are the major contributing sources to SO_2 emissions in this county. Finally, in Monterey County, major sources of SO_2 include Mobile Oil and Texaco in San Orda, and Pacific Gas and Electric's (PGE) Moss Landing Generating Station.

Figure 5.4-3 provides annual emissions densities for oxides of nitrogen in the Folsom District. Once again, emissions are heaviest in Contra Costa, Alameda, and Santa Clara Counties where annual rates run between 50,000 and 70,000 tons. Area sources contribute substantially to NO_x emissions as they generally far outweigh combustion emissions due to major point sources. These include PGE's Pittsburg generating station in Contra Costa County and the Kaiser Cement and Gypsum Company in Permamente.

Annual emissions of carbon monoxide are presented in Figure 5.4-4. Heaviest emissions occur in Alameda, Santa Clara and Sacramento Counties. As with oxides of nitrogen, various sources contribute heavily to carbon monoxide levels. Contributing major point sources include power facilities and other large combustion sources.

Finally, Figure 5.4-5 provides emission densities for hydrocarbons for counties in the Folsom District. Once again heaviest emissions occur in Alameda and Santa Clara Counties due

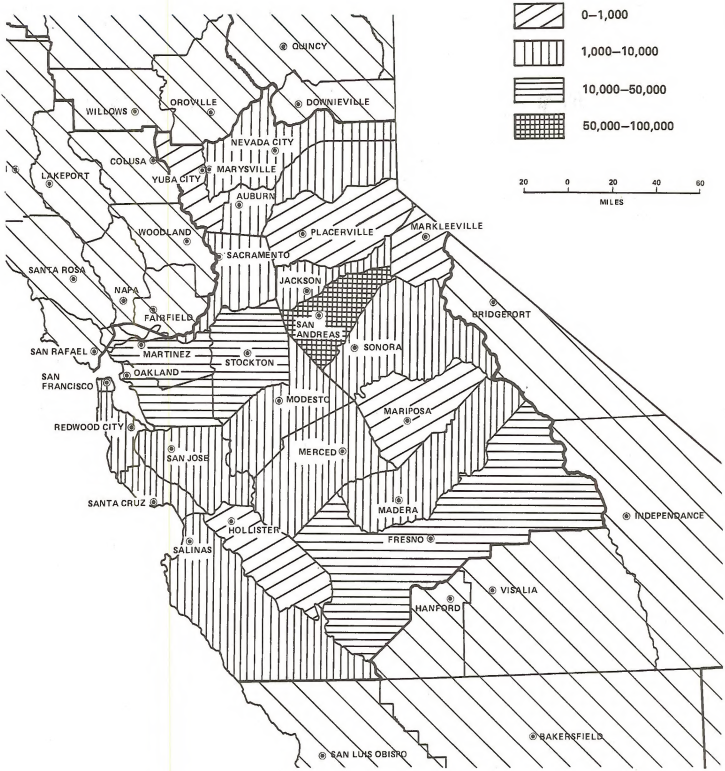

Figure 5.4-1
Emission Density Map for TSP (Tons/Year)
in the Folsom District

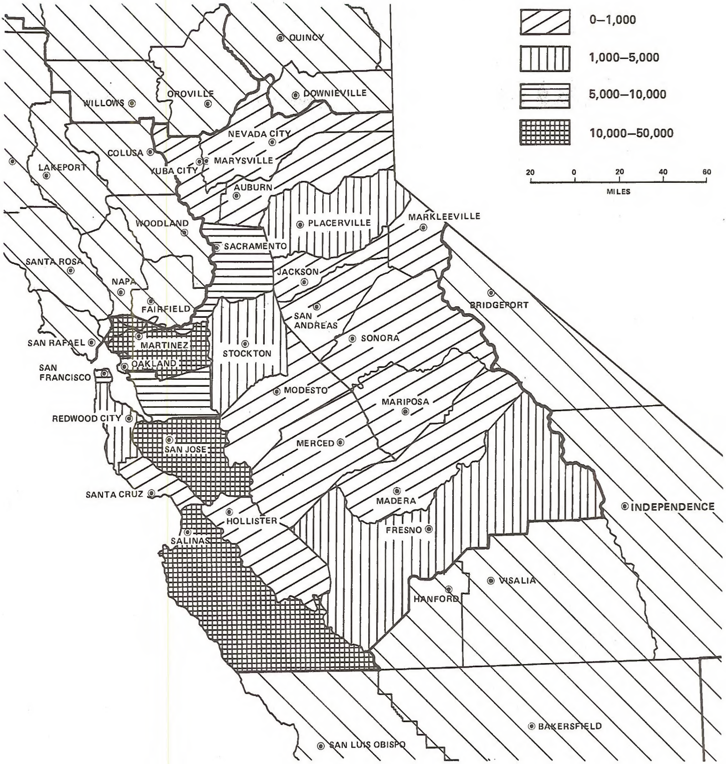

Figure 5.4-2
Emission Density Map for Sulfur Dioxide (Tons/Year)
in the Folsom District

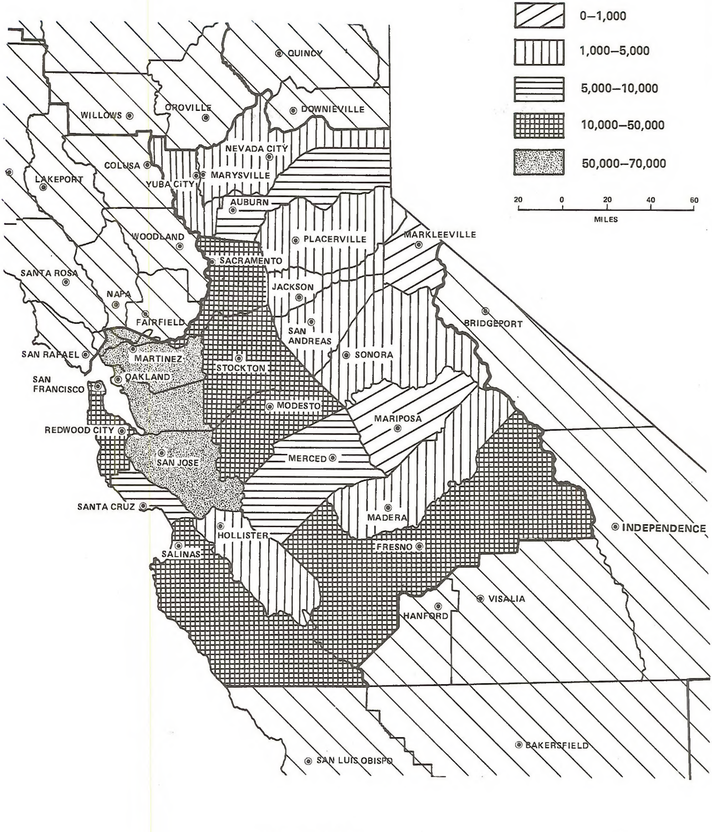

Figure 5.4-3
Emission Density Map for Oxides of Nitrogen (Tons/Year)
in the Folsom District

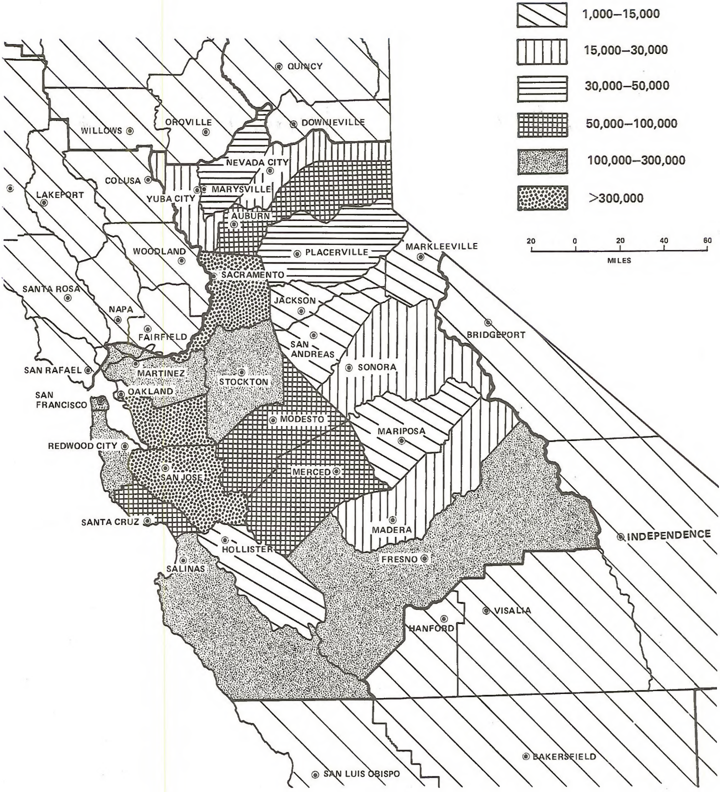

Figure 5.4-4
Emissions Density Map for Carbon Monoxide (Tons/Year)
in the Folsom District

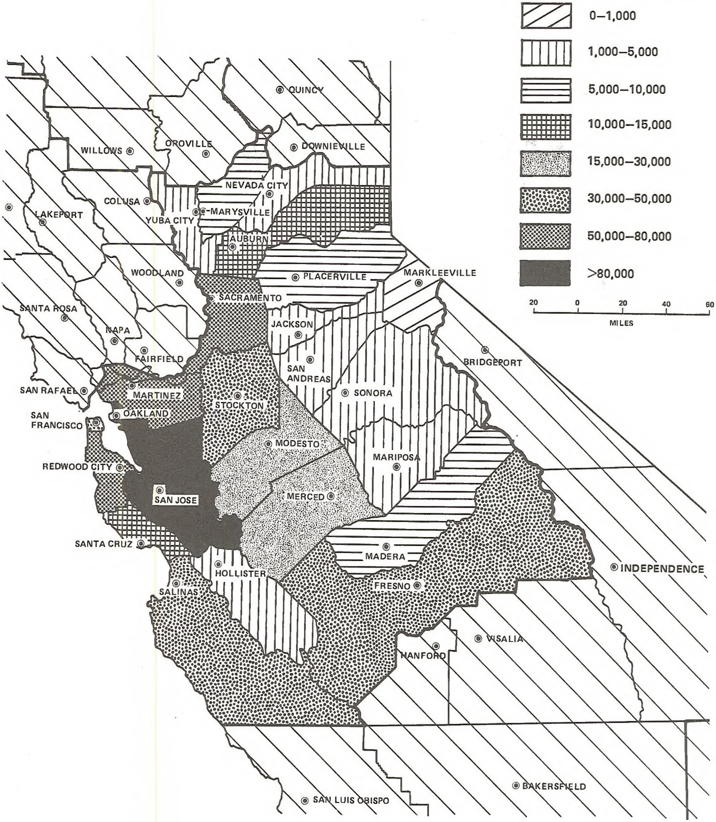

Figure 5.4-5
Emission Density Map (Tons/Year) for Hydrocarbons
in the Folsom District

almost exclusively to evaporative losses of hydrocarbons from petroleum storage facilities and other sources. Totals are greater than 80,000 tons per year in these two counties.

In regard to the National Emissions Standards for Hazardous Air Pollutants (NESHAPS) (see Table 5.4-2), it should be noted that these standards have been promulgated to regulate emissions of EPA designated "hazardous air pollutants" including asbestos, beryllium, mercury and vinyl chloride. (Benzene is currently being proposed). These are emission standards, and no ambient air quality standards have yet been promulgated for these pollutants. The emission standards apply to those pollutants from specified categories of sources. Thus, if there is a high concentration of any of these pollutants in a given area, the EPA <u>cannot</u> declare the area to be "non-attainment" for that pollutant. It can only impose the emission limitations contained in the NESHAPS regulations upon specific point sources.

This comes to light in the case of the Clear Creek area in south San Benito County. In this area, there is a natural source of asbestos: serpentine. The soil in this area is high in asbestos content, and recently the BLM contracted to have a study conducted in this area relating to the concentration of asbestos fibers in the ambient air. During the spring and summer of 1978, a joint study was carried out by the School of Public Health and the Department of Geology and Geophysics of the University of California, Berkeley. The study demonstrated that the Clear Creek area has a great deal of chrysotile asbestos fiber in the roads in the regions used by people in automobiles, and specifically by motorcyclists on "scramble trails" on the barren slopes. This is significant because the contamination is a result of endemic asbestos not related to any industrial activity and, thus, not subject to EPA enforcement. For comparison purposes, measured asbestos levels were compared with Occupational Safety and Health Administration (OSHA) standards promulgated for workers in indoor facilities who are exposed to asbestos. The 8-hr OSHA standard is 2 fibers/ml. In one test, a group of motorcyclists drove for fifteen minutes in the Clear Creek area with collection devices strapped to their bodies. The devices were examined, and found to have collected fibers greatly in excess of the OSHA indoor standard.

The report concludes that, based on other studies, chrysotile asbestos appears less hazardous than amphibole asbestos. In light of this, plus the fact that the recreational users of the area are not exposed to the asbestos for any great length of time, it is not likely that they will show an abnormal pattern of disease.

The report does state, however, that BLM employees who have had longer periods of exposure in this area, should have these facts entered into their records, and should be studied for evidences of pulmonary fibrosis.

Table 5.4-2

NESHAPS Promulgated by EPA as of 1/30/76

Source	Affected Facility	Pollutant	Promulgation Date
Beryllium	Extraction plants, users, disposal rocket testing	Beryllium	04/06/73
Asbestos	Asbestos mills, manufacturing operations, spraying and use	Asbestos	10/14/75
Mercury	Mercury ore processing, Mercury cell chloralkali	Mercury	10/14/75
Vinyl Chloride	Vinyl chloride production	Vinyl Chloride	12/24/75**

** Proposed

The report recommends that the area not be used as a recreation area. BLM has since posted a sign informing the public that the soil in the area has an extremely high asbestos content (Murchio et al, 1978).

Figures 5.4-1 through 5.4-5 indicate that the attainment areas designated by the CARB will become Prevention of Significant Deterioration (PSD) areas (see Section 6.1.2.2) for the pollutants NO_2, SO_2, and TSP, and, for two counties, CO. Most counties in California will be subject to non-attainment rules for oxidant, CO, and TSP. The unclassified areas will also be subject to PSD rules until sufficient monitoring data can be gathered to determine the extent of the pollution problems in those counties. Since many of the counties containing BLM lands are in unclassified areas with regard to pollutants, these counties are subject to the PSD regulations described in Section 6. Depending upon BLM projected usages of these lands, the PSD increments will limit the amount of new construction possible in these areas, the type and size of proposed facilities and abatement equipment to be used to control projected emissions. New Source Performance Standards (NSPS) will have to be considered in conjunction with PSD and NESHAPS to provide a balance between developmental requests to utilize BLM lands and the recreational functions now substantially governing land use.

5.5 ASSISTANCE IN AIR POLLUTION PROBLEMS

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World Meteorlogical Organization-List of Available Publications
WMO Publications Center
UNIPUB Inc.
P.O. Box 433
New York, N.Y. 10016

Professional Meteorological Consultants

Professional meteorologists advertise their services in the Professional Directory section of the Bulletin of the American Meteorological Society. In the May 1979 Bulletin, 83 such firms and individuals were listed. The American Meteorological Society has in the last several years instituted a program of certifying consulting meteorologists. Of the 83 professional services listings in the Bulletin, 40 list Certified Consulting Meteorologists.

Local U.S. National Weather Service Office

The Air Stagnation Advisories are received here by teletype from the National Meteorological Center. Often the public telephones the Weather Service with air pollution complaints which the meteorologists may have traced back to a specific source by examining local wind circulations. Through personal contact with the meteorologist-in-charge (MIC) specific, localized forecasts may be arranged to support a short-term air pollution investigation or sampling program.

USEPA

The USEPA provides a complete information service to all individuals, groups, companies, etc. This includes information on regulations, publications as well as expert advice.

Contract Work

Many universities do contract work for private organizations and for government agencies on meteorlogical problems and also on air pollution surveys.

5.6 GLOSSARY OF TERMS

Acetylenes	A group of unsaturated hydrocarbons whose carbon atoms possess a triple bond.
Acid	A compound that turns blue litmus paper red, generally tastes sour and most often is corrosive; in solution it produces hydrogen ions or protons which can be replaced by metal to form a salt. Acids usually contain hydrogen, neutralized alkalis and form well defined salts.
Adhesion	The force of attraction between unlike molecules, causing adjoining or attachment.
Aerosol	A system of collodial particles dispersed in a gas.
Affinity	A natural liking or reaction; the phylogenetic relationship between two organisms or groups of organisms resulting in a resemblence in general plan or structure; the force by which atoms are held together in chemical compounds.
Alcohol	C_2H_6O or C_2H_5OH, a volatile, colorless pungent liquid; often used as a generic term which includes ethyl alcohol, methol alcohol, amyl alcohol and glycerin.
Aldehyde	Dehydrogenated alcohol.
Alert Levels	A concentration of pollution which dictates the issuance or notification by State Regulatory Agencies to the general public that a threat to human health may occur due to elevated pollution levels.
Algae	Simple aquatic plants without leaves, stems or roots sometimes having brown or reddish pigments.
Alkanes	The group of hydrocarbons in the methane series, also called saturated hydrocarbons or parafins.
Alkenes	A group of hydrocarbons with one double bond; also called olefins or unsaturated hydrocarbons.
Amides	Organic compounds that contain the $CO \bullet NH_2$ radical or an acid radical in replacement for one hydrogen atom of an ammonia molecule.

Amines	Ammonia bases, that is, chemical substances resulting from replacing ammonia hydrogen atoms; amines are products of animal or vegetable decomposition.
Amino Acids	Fundamental structural units of proteins; they are fatty acids in which one hydrogen atom has been replaced by an amino group.
Amphibole	Any of the complex group of the hydrous silicate materials containing chiefly calcium, magnesium, sodium, iron and aluminum, and including hornblend, asbestos, etc.
Anaerobic	Living in the absence of air or free oxygen.
Anoxia	Without oxygen, lack of oxygen for body use.
Aortic	The conveyance of blood from the left ventrical of the heart to all of the body except the lungs.
Aqueous	Water acting as a solvent in a solution; a fluid resembling water.
Aromatics	Any unsaturated hydrocarbon with cyclic molecules resembling benzene, C_6H_6, in chemical behavior, so named because of the fragrant odor of many in the class.
Arteriosclerosis	An arterial disease characterized by an inelasticity and thickening of the vessel walls, with lessened blood flow.
Asbestos	A fibrous amphibole used for making fire-proof articles.
Asphyxiant	An agent or substance which causes death or loss of consciousness by the impairment of normal breathing.
Biosphere	That portion of the world and its atmosphere in which humans, animals and plants can survive.
Bronchoconstrictor	An agent that causes the contraction of the muscles which control the pharynx.
Carcinogenic	Refers to a substnace that tends to produce cancer.

Catalase	The enzyme responsible for the decomposition and oxidation of hydrogen peroxide into water and oxygen.
Catalyst	A substance which accelerates or promotes a chemical action by a reagent which itself remains unchanged.
Catalytic Convertor	A device attached to an automobiles internal combustion engine which chemically alters emissions from the engine prior to release through the exhaust system. The catalytic convertor was introduced on modern-day automobiles in the mid-1970's in an effort to reduce harmful automobile exhaust emissions and promote a cleaner environment.
Cation	Ions of positive charge deposited on the cathode.
Cellulose	The complex carbohydrate substance that forms the material of cell walls of plants.
Chloratic Mottle	Brown or red spots on the surface of a leaf caused by chemical pollution.
Chlorosis	A diseased condition in green plants marked by yellowing or blanching.
Cholestrol	A sterol, $C_{17}H_{45}OH$, occurring in all animal fat and oils, bile, gall stones, nerve tissue, blood, etc.
Chrysotile	A fibrous variety of serpentine; asbestos.
Colloid	A substnace in a state of matter characterized by having small power of diffusion.
Cyprinid	Any fish belonging to the minnow family; carplike in form or structure.
Diastase	The enzyme responsible for starch utilization.
Deformation	The act of marring the natural form or shape of an object; distortion.
Discoloration	The act or fact of changing or spoiling the color of an object; a fade or a stain.
Dissociation	The breaking up of a compound into its simpler constituents by means of heat or electricity.

Ecosystem	A habitable environment existing naturally or created artificially.
Edema	Effusion of serous fluid into the interstices of cells, in tissue spaces or into body cavities.
Emission Density	Emissions per unit area.
Endogenous	Originating or developing internally or within.
Endothermic	Noting or pertaining to a chemical change that is accompanied by an absorption of heat.
Enzyme	A protein substance secreted in animals or by plants whose function is catalytic, promoting chemical reactions for metabolic or physiological processes.
Ester	A compound produced by the reaction between an acid and an alcohol with the elimination of a molecule of water.
Ether	A series of compounds formed by dehydration of alcohols.
Fauna	Collective animal life of any prticular geographical area or time.
Fixation	The act of making stable in consistence or condition; reduction from fluidity or volatility to a more permanent state.
Flora	Collected plant life of any particular area or time.
Flourescence	Emitting radiation (such as light) as a result of, and only during the time of, exposure to radiation from another source.
Glucosidase	The enzyme that catalyzes glucose.
Greenhouse Effect	Most of the infrared radiation emitted by the earth is absorbed by carbon dioxide and water in the atmosphere. Part of the infrared radiaiton absorbed is re-radiated back to earth. This trapping and recycling of terrestrial radiation, which makes the earth warmer than it would be otherwise, is known as Greenhouse Effect, because it was once thought that greenhouses remain warm by the same process.

Heavy Metal	A metal which is made up of elements having large atomic weights.
Hematocrit	A centrifuge for separating the cells of the blood from the plasma.
Hemoglobin	The protein coloring matter of the red blood corpuscles, serving to convey oxygen to the tissues and occurring in reduced form in venous blood and in conbination with oxygen in arterial blood.
Herbivorous	Feeding on plants.
Homolog	An object corredsponding in structure and in origin, but not necessarily in function, to another object; chemicals of the same type, but which differ by a fixed increment in certain constituents.
Humus	The dark organic material in soil produced by the decomposition of vegetable or animal matter.
Hydrate	Compounds with large amounts of water as part of their molecular structure and without rearrangement of the atoms of the H_2O group; hydration is the chemical union of water and any substance.
Hydrolyze	To subject or be subjected to decomposition in which a compound is split into other compounds by taking up the elements of water.
Hypertrophy	An abnormal enlargement of a part or organ.
Hyphai	One of the thread-like elements of the vegetative part of fungi.
Inertial	Matter having the property by which it retains its state of rest or its velocity along a straight line so long as it is not acted upon by an external force.
Insectivorous	Adapted to feeding on insects.
Intercostal Leaf Area	Leaf area between the ribs.
Irradiation	The act of having been heated with radiant energy; the act of having been exposed to radiation.

Irritant	A biological, chemical or physical agent that stimulates a characteristic function or elicits a response, especially an inflammatory response.
Ketones	A group of organic compounds characterized by a carbonyl radical united wih two hydrocarbon radicals; usually colorless, pungent substances.
Leach	A process by which a liquid filters through another substance.
Lichen	A plant composed of an algae and fungi symbiosis.
Macrophage	A large cell that characteristically engulfs a foreign material and consumes debris and foreign bodies.
Marginal Leaf Area	Leaf edges.
Mercaptan	Compound analogous to alcohol containing sulfur in place of oxygen.
Metabolism	The chemical activity that takes place in the cells of living organisms involving two fundamental procedures, catabolism and anabolism, simultaneously at work; the former refers to the breaking up of substances into constituent parts, the latter, building up of the substances from simpler ones.
Microdecomposer	Bacteria which breakdown waste material in soil and in water as a prelude to the initiation of a nutrient recycling process.
Necrosis	Death or decay of tissue.
Nitriles	Any of a class of organic compounds with the general formula RC = N.
Nucleation	Crystal development at one or more points.
Olefins	Members of a hydrocarbon group characterizes by the formula $C_n H_{2n}$ and including ethylene, propoylene and butylene; they are highly reactive and can be formed by destructive distillation of coal petroleum.
Organic Acids	Acids which are usually derived from natural or living sources.

Oxidizer	A substance which causes the conversion of an element into its oxide; a substance which promotes the covering of an element with a coating of oxide or rust.
Pathological	Caused by or involving disease.
Peroxidase	Any of a class of oxidoreductase enzymes that causes the oxidation of a compound by the decomposition of hydrogen peroxide or an organic peroxide.
Peroxides	A class of compounds containing oxygen and other elements, with the O_2 group having a valence of two (-) and acting like a radical.
Phenol	A white crystalline solid obtained from the distillation of tar; it is poisonous and corrosive with a characteristically pungent odor.
Photochemical	Refers to the effects of radiation, visible or ultraviolet, upon chemical reactions.
Photon	A quantum of energy; a fundamental bundle of radiation whose energy is directly proportional to the frequency of the radiation.
Photoplankton	The aggregate of passively floating or drifting organisms in a body of water which derive most of their energy from light.
Photosynthesis	The process by which green plants, containing chlorophyll, with the aid of energy from the sun, manufacture carbohydrates from water and carbon dioxide.
Phototoxicant	A substance that is poisonous to plants.
Podsal	An infertile, acidic forest soil having an ash-colored upper layer depleted of colloids and of iron and aluminum compounds, and a brownish lower layer in which these colloids and compounds have accumulated.
Precursor	A person or object that goes before and indicates the approach or something else.
Primary Pollutant	A pollutant is considered a primary pollutant upon release from its source.
Progenitor	An original or model for later developments; predecessor; precursor.

Pulmonary	Of or pertaining to the lungs.
Pulmonary Fibrosis	A condition marked by an increase of interstitial fibrous tissue in the lungs.
Radical	A combination of atoms that stay together and take part in the chemical reaction as a unit or a group as if it were a single element.
Reactant	Any substance that undergoes a chemical change in a given reaction.
Reactivity	Pertaining to or characterized by reaction.
Secondary Pollutant	A pollutant is considered a secondary pollutant if a chemical change was intitiated subsequent to its release from its source.
Serpentine	A common mineral, hydrous magnesium silicate, usually oily green and sometimes spotted, occurring in many varieties, used for architectural and decorative purposes.
Serum Lactate Dehydrogenase	A class of oxide reductase enzymes that catalyze the removal of hydrogen from the esters or salts of lactic acid.
Sink	A lower state or condition.
Sorption	The binding of one substance by another by any mechanism, such as absorption, adsorption or persorption.
Source	A place from which something comes, arises or is obtained.
Spectroscopy	A procedure for observing the spectrum of light or radiation from any source. Spectroscopy permits the examination and measurement of the spectrum of radiant energy.
Stark-Einstein Law	A law of chemistry which states that one proton must be absorbed by a substance to initiate chemical decomposition.
Stoichiometry	Branch of chemistry dealing with weights and proportions of elements in chemical combination and the methods of determining them.

Stunting	Stopping or slowing down of the growth or development of an object.
Sulfate	Chemical compounds (such as SO_3) created by the photochemical reaction of sulfur dioxide. Sulfates are secondary pollutants with important health and visibility effects.
Sulfide	A binary compound of sulfur with the valence of two (-); also a salt of hydrosulfuric acid.
Synergism	The principal that a cooperative action between two agents - chemical and mechanical for instance - results in an effect greater than the sum of the two effects taken independently.
Terpene	A series of hydrocarbons of the general formula $C_{10}H_{16}$ found in resins.
Thermodynamics	Deals with the principals of conversion of heat into other forms of energy and vice versa.
Toxicity	The quality, relative degree or specific degree of being toxic or poisonous.
Unclassifiable	With respect to air quality, unclassifiable refers to those areas of the country which cannot be a designated attainment or non-attainment area due to insufficient baseline air quality information.
Volatile	Easily vaporized; tending to evaporate at ordinary temperatures and pressure conditions.

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6. AIR QUALITY REGULATIONS

6.1 EXECUTIVE SUMMARY

6.1.1 Background

The Clean Air Act, as amended in 1977, is the primary legislative tool for improving and monitoring air quality in the United States. Many requirements of the act apply to BLM activities, as well as to those of the Fish and Wildlife Service, the Park Service and the Forest Service.

The Clean Air Act was originally passed in 1955. Amendments were passed in succeeding years. Under the 1970 amendments, specific limits for pollutant levels were established including dates for compliance. These pollutant levels are called the National Ambient Air Quality Standards (NAAQS) and are based upon health effects. The Act mandates that the states formulate plans to achieve compliance with these ambient standards. These plans, called State Implementation Plans (SIPs), require transportation control plans, emissions limits for specific categories of sources and permit rules for new or modified sources of air pollution.

Once these plans are adopted by the state and approved by the EPA they are binding as law. The state then has the jurisdictional authority to enforce the regulations under the plan. If a state is found by the EPA to be deficient in its administration of the plan, the EPA can step in and administer it until it feels that the state can once again resume adequate control of the program(s).

Under the 1977 Clean Air Act Amendments, in addition to these SIP requirements, a permit moratorium was imposed requiring Reasonably Available Control Technology (RACT) for existing sources to be determined by the State for all nonattainment areas for which the SIP was not approved by July 1, 1979. A nonattainment area is an area in which the standards for one or more of the criteria pollutants is violated (i.e., SO_2, NO_2, HC, CO, particulate matter). The Act as amended required permit programs to be developed in these nonattainment areas as part of the SIP. These programs will be discussed in further detail below.

6.1.2 Permit Rules for New or Modified Sources

Since 1970, the Clean Air Act has required that any new or modified sources of air pollution must undergo a preconstruction review. The purpose of this review is to ensure that such sources would not violate any ambient standard or contribute to any existing violations of these standards. This review is known as New Source Review.

6.1.2.1 Nonattainment Areas

As mentioned above, in nonattainment areas, states are required to develop permit rules which meet the requirements of the Clean Air Act as amended in 1977. Specifically, these permit rules must require that any new or modified source locating in these areas must obtain a high degree of emission control (called Lowest Achievable Emission Rate or LAER) for the problem pollutant(s) and obtain emission reductions of that pollutant, called emission offsets. Offsets are generally obtained by retrofitting existing sources with air pollution control equipment or by shutting down old units.

Because of the permit moratorium for nonattainment areas, sources wishing to locate in such areas may not receive permits until the nonattainment portion of the SIP for that area has been approved by the EPA.

The counties in California have drafted nonattainment permit rules under the guidelines of a New Source Review "Model Rule" prepared by the California Air Resources Board (CARB). Most of these rules have been adopted by the counties and are either awaiting decisions by the CARB as to whether to submit them to EPA as part of the SIP or have already been submitted. The rules are more stringent than the Clean Air Act requirements for nonattainment areas, and they require control technology for the problem pollutants as well as emission reductions for all problem pollutants and their precursors.

6.1.2.2 Attainment Areas and Prevention of Significant Deterioration Review

In attainment areas (areas in which the air quality is better than the NAAQS), the Clean Air Act amendments required that SIPs contain a special permit program for new or modified sources locating there. However, unlike the nonattainment areas, this requirement to write such a permit rule did not impose a moratorium sanction if it was not adopted by the state or approved by the EPA (i.e., no permits can be granted in nonattainment areas until the EPA approves the state plan, however, this does not apply in attainment areas).

The attainment area permit program, covered in Part C of the Clean Air Act, is called Prevention of Significant Deterioration of Air Quality. As a result of this part of the Act, the EPA, on June 19, 1978, promulgated the Prevention of Significant Deterioration (PSD) regulations. The basic intent of these regulations is to keep "clean air clean." This is accomplished by placing ambient air quality limitations for SO_2 and particulate matter in addition to the NAAQS which have been established for these pollutants. The increase in ambient concentration of these two pollutants from a given baseline concentration (i.e., the air quality as of August 7, 1977 as "baseline concentration" is defined) is limited by what are called "increments." These increments differ depending on the class designation of the area in which the new or modified source is locating (see Figure 6.1-1).

The Clean Air Act and the PSD regulations established three "classes" of clean air areas. Each class has been assigned numerical increments for particulate matter and sulfur dioxide concentrations and will set increments in the near future for all other criteria pollutants. These increments indicate the limit of ambient concentration increase above baseline concentration which will be allowed in each particular "class" area.

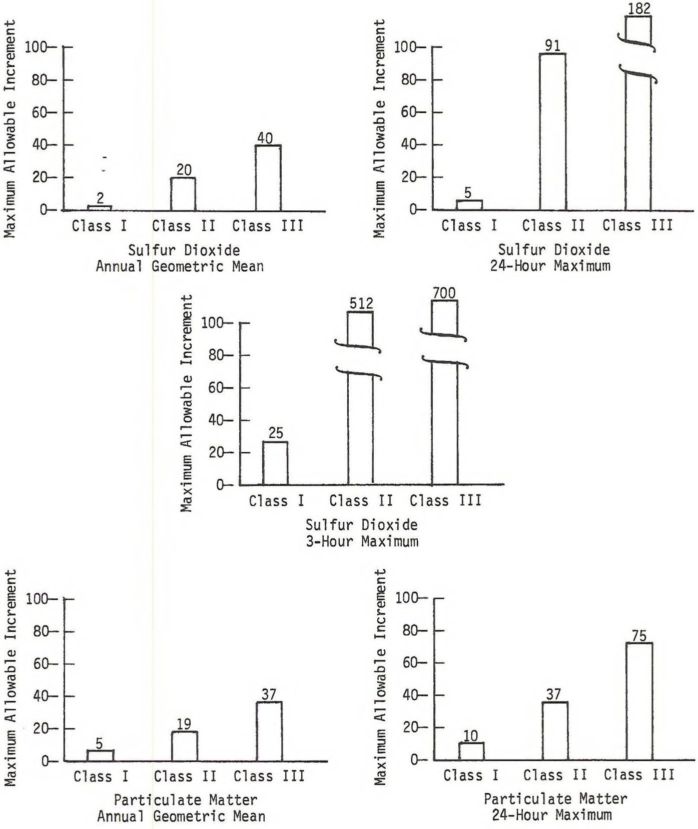
Class I increments allow only minor air quality increases; Class II increments allow a moderate amount of deterioration, and Class III increments allow the most air quality deterioration although violations of the NAAQS are never permitted. Class I areas include national memorials and national wilderness areas exceeding 6,000 acres in size.

Sources subject to PSD must use Best Available Control Technology (BACT) on the proposed new sources or modifications and must also demonstrate that the emissions will not result in concentrations in excess of the PSD increments for SO_2 and particulate matter. The most important aspect of these regulations is that increment consumption is viewed from a cumulative viewpoint. That is, if a source consumes part of the increment, then the next source to apply for permits must work within the remaining increment. Thus, it is possible for the increment to be "used up" in a particular area. Increment consumption is granted on a first-come, first-serve basis.

Presently, the CARB is drafting a Model Rule for attainment areas which is similar to the EPA PSD regulations. The CARB hopes to have the various counties in California adopt this rule, so that it can be submitted to the EPA as part of the SIP. Once the adoption and approval procedure is underway, the CARB plans to write a more comprehensive PSD rule which is more stringent and tailored to the needs of the State of California.

6.1.2.3 Role of the Federal Land Manager in the Permit Review Process

Federal Land Managers (FLM) have input to the PSD permitting process if a project will have an impact on a Class I area. Once a source makes an application to the EPA, the EPA must make a determination as to the probable impacts the project will have. As early as possible, the EPA must contact the appropriate FLM if it is thought that the project will have an impact on a Class I area. The FLM may then review all air quality studies performed in conjunction with the EPA permit application within the 60 day review period. If the FLM finds that the facility would have an adverse impact on the "air quality related values" of the land area, a permit cannot be issued. The source



Sulfur Dioxide
Annual Geometric Mean

Sulfur Dioxide
24-Hour Maximum

Sulfur Dioxide
3-Hour Maximum

Particulate Matter
Annual Geometric Mean

Particulate Matter
24-Hour Maximum

Figure 6.1-1

Prevention of Significant Deterioration

Maximum Allowable Increments as a Function of Class Designation

(μg/m^3)

must then demonstrate that no adverse impact would occur. Denial by the FLM may be made even if the Class I increments are demonstrated not to be exceeded by the project.

It is important to note that if the FLM proposes activities over his land, he must be aware not to exceed the available increment. This will put a bind on future land management decisions.

6.1.2.4 Role of the Federal Land Manager in Class Redesignation Procedures

The FLM has a minor role also in the process of redesignating a particular class area to another designation (for example, a Class I area to be redesignated to a Class II area or vice versa). Redesignations may only be proposed by the state or by an Indian Governing Body. If the area to be redesignated contains federal lands, the FLM is to be notified of the proposal to redesignate. The FLM is to be allowed to comment on the proposal, and if he is opposed to it but the state wishes to continue to pursue it, he must be provided with an explanation of the reasons why the state feels it should be redesignated. The FLM may also provide input at the public hearing which is required for all redesignations but the state has the ultimate authority.

6.1.3 Visibility Protection

The 1977 Amendments added to the Clean Air Act a section entitled "Visibility Protection for Federal Class I Areas". This section declares as a national goal "the prevention of any future, and the remedying of any existing, impairment of visibility in mandatory Class I Federal areas" where impairment results from man-made air pollution. Such a list of Mandatory Class I federal areas was published in the November 3, 1977 Federal Register and those areas so designated are presented in Table 6.4-2 and Figure 6.4-1. The Amendments also required that by February 1978, the Secretary of Interior, in consultation with the States and the FLM's, is to identify any mandatory Class I areas where visibility contributes significant values to the area. These areas were published in the February 24, 1978 Federal Register. As such, all Class I areas in California are areas on which visibility is an important value. The EPA, by February 1979, is to complete a study and report to Congress on available methods for implementing the national goal. The EPA is also authorized to promulgate regulations requiring retrofits on specified pieces of equipment. The FLM must be consulted with regard to these regulations.

6.1.4 Emission Standards

The Clean Air Act gave the EPA the authority to promulgate emission standards for specific categories of equipment. It also gave the EPA the authority to designate certain pollutants as "hazardous", and to set emission standards for such hazardous pollutants for specific categories of equipment.

The EPA has promulgated New Source Performance Standards (NSPS) and National Emission Standards for Hazardous Air Pollutants (NESHAPS). The NSPS standards presently consist of emission limits of pollutants for 28 categories of sources. The NESHAPS have been established for mercury, beryllium, asbestos, vinyl chloride and benzene (proposed only).

6.1.5 State Regulations

6.1.5.1 Permit Rules

As mentioned above, the intent of the Clean Air Act in establishing procedures for permit rules is to require the states to write and adopt such permit rules into their individual SIPs. Until such time as these rules are approved by the EPA and incorporated in the SIP, the EPA still retains the permitting authority. Thus, in California, many applicants required to obtain a PSD permit from the EPA are also required to obtain a New Source Review permit from the county. In nonattainment areas, no permits may be issued until the SIP for these areas is approved by the EPA.

6.1.5.2 Emission Regulations

Each county has a set of emission regulations; some pertain to specific sources of emissions, while others have a general emissions limit emcompassing a broad range of industrial sources. Emission limitations are enforced by the Air Pollution Control District (APCD), and violations of limits may result in fines and/or shut-down. In some situations, a source may be put on a compliance schedule to meet a schedule of emissions limits by specified dates. Such limitations have been adopted for geothermal power plants, for example, in Northern Sonoma and Lake Counties.

6.1.5.3 Burning Regulations

The CARB has promulgated regulations governing the use of outdoor fires for agricultural operations and forest management. The regulations require that burning permits be obtained prior to the use of open outdoor fires. The permits are prepared by the appropriate APCD and/or the designated agency. In most instances the California Department of Forestry is the designated agency for burning and is responsible for the issuance of permits.

The requirements for a burning permit apply to all land areas in the state with the exception of:

- Open burning for agricultural operations or disease or pest prevention above elevations of 3,000 feet MSL (not effective in Tahoe Air Basin).

- Land areas located at an elevation above 6,000 feet MSL (except in Tahoe Air Basin), for agricultural burning, for pest control, forest management, range improvement, improvement of land for wildlife and game habitat and raising of fowl or animals.

BLM land managers will be required to keep a record of the amount of acreage and the tonnage of material burned daily as the APCDs will request this information in preparing their required quarterly reports to the CARB regarding burning permits.

Individual counties have different requirements regarding outdoor burning. In general, all of the counties prohibit outdoor burning unless it is allowed by permit, as discussed above, and if a particular day has been designated a "burn-day." A "burn-day" is any day on which a designated person or agency (i.e., the CARB, APCD, etc.) determines that certain specified burning is allowed.

6.2 THE ROLE OF THE FEDERAL LAND MANAGER

As defined in the 1977 Clean Air Act Amendments, the Federal Land Manager (FLM) for the BLM has the affirmative responsibility to protect the air quality related values which provides for a variety of assignments and programs including protection of visibility, fire management, oil and gas leasing, land use planning of Federal lands, issuance of right-of-way permits, and the preparation of Environmental Impact Statements (EIS's) attendant to such permits. Land management by the BLM is primarily concerned with recreational areas, e.g., wilderness areas, but the concerns of the land manager are not limited to these aspects. For example, oil wells, or gas pipelines, as mentioned above, which are on Federal lands, come under the jurisdiction of the FLM. In order for the Manager to issue a BLM permit for such activities, he must ascertain that the owner or operator of the project has obtained all necessary state, local and federal permits. These include environmental permits in many cases. As another example, a company wishing to construct a geothermal power plant may wish to drill a geothermal well on federal lands. Such a project requires a permit from the local APCD and must be in compliance with the APCD's emission limitations for such sources. In addition, the project may also be required to obtain the EPA's PSD permit. Thus, it is imperative for the FLM to be familiar with the legislative and regulatory aspects of air quality in addition to the baseline meteorology and air quality with which the permit is concerned. An understanding of the rudiments of the air quality review processes in California can be helpful in the preparation of future EIS's, since many applicants are required by law to prepare air quality assessments resulting from their project. Such assessments could be used by the FLM in preparation of an EIS and in making a final decision.

In recent years, the role of the FLM in the protection of air quality has increased. Recent federal legislation, culminating in the 1977 Amendments to the Clean Air Act, has provided increasingly stringent restrictions to protect the clean air resource from further deterioration due to new emitting sources. The 1977 Amendments require the FLM to take an active role in the EPA's PSD permit process. Specifically, the Clean Air Act has given the FLM the authority to comment on projects which impact the air quality in areas designated as Class I (i.e., national parks, monuments or wilderness areas in excess of 6,000 acres, or any other area designated by the State as a Class I Area). In the words of the Act, the FLM must actively protect the "air quality related values including visibility" of such lands and may oppose programs felt to be deleterious to Class I areas.

The Act also authorizes the FLM to take an affirmative role in visibility protection in these areas, as well as taking part in the process of redesignating the Class designation of any area incorporating federal lands.

Because "air quality related values" are one of the concerns of the FLM, it is necessary that the managers be familiar with the implications of clean air legislation as it affects federal lands. Section 6.3 discusses the federal legislative history concerning air pollution, discusses provisions of the 1977 Amendments pertinent to federal land areas and visibility protection, and indicates where the FLM may participate in the implementation of such provisions.

6.3 HISTORY OF AIR QUALITY LEGISLATION

Public concern for the nations air quality and for the effect that polluted air has on human health and welfare led to the passage of National Air Pollution Legislation in 1955. Amendments to this legislation were passed in 1963, 1965, 1967, 1970 and 1977 (Table 6.3-1 is a list of clean air legislation enacted by the Federal Government). Prior to the 1970 amendments, the responsibility for air quality was held by the states with the Federal Government providing little more than financial and technical assistance. Some progress toward cleaner air was achieved; however, in the opinion of a significant portion of the population, this was not good enough. As a result, the 1970 Amendments introduced the Federal Government as a regulatory force. The States remained responsible for developing air quality Implementation Plans but, under the 1970 Amendments, specific limits were set and certain pollutant concentration levels had to be achieved by stipulated dates. These specify concentration levels and are called the National Ambient Air Quality Standards (NAAQS).

Two types of NAAQS were mandated by the Amendments of 1970. Primary standards set levels which allow an adequate margin of safety for public health while Secondary standards specify levels which protect the public welfare from any known or anticipated adverse effects associated with a pollutant's presence in the ambient air. Secondary effects on public welfare refer to impacts on soils, water, crops, visibility, as well as effects on economic values and on personal comfort and well being. Table 6.3-2 shows the standards at current levels. As can be seen, the secondary standards are, in most cases, more stringent, due primarily to the wide range of items included under 'public welfare' which the secondary standards must protect.

The 1977 Amendments attempted to deal with controversies that had developed concerning achievement of the regulations and the overall achievement of the goals of the Clear Air Act. The energy shortage and the cost and development of air quality control equipment on both stationary and mobile sources caused industry to seek delays in achieving mandatory standards. Environmental organizations, through the use of the judicial system, had forced the EPA to promulgate legislation to prevent the significant deterioration of air quality in regions of the country where the air was clearer than established standards. Promulgation of the original PSD regulations brought opposition from persons concerned about such issues as industrial growth, employment, the economy and EPA authority. These and other concerns influenced the Congress to consider amending the Clean Air Act to establish new deadlines for achieving certain standards and to settle the PSD issue.

Table 6.3-1

Clean Air Legislation Enacted by the Federal Government

Date	Public Law	Purpose of Law
6/55	84-159	Provide research and technical assistance relating to air pollution control.
9/59	86-365	Extend the Federal Air Pollution Control Law PL 84-159.
6/60	86-493	Direct the Surgeon General to study and report on health effects of automobile emissions.
12/63	88-206	Improve, strengthen and accelerate programs for the prevention and abatement of air pollution.
10/65	89-272	(Title: Motor Vehicle Air Pollution Control Act). Require standards for automobile emissions and authorize research in solid waste disposal programs.
10/66	89-675	(Title: Clean Air Act Amendments of 1966). Authorize grants to air pollution control agencies for maintenance of control programs.
11/67	90-148	(Title: Air Quality Act of 1967). Authorize planning grants, expand research relating to fuels, and authorize air quality standards.
12/69	91-190	(Title: National Environmental Policy Act). Establish the Council on Environmental Quality, direct Federal agencies to consider environmental quality regulations.
12/70	91-604	(Title: Clean Air Act Amendments of 1970). Provide a more effective program to improve the quality of air.
6/74	93-319	(Title: Energy Supply and Environmental Coordination Act). Provide means of dealing with the energy shortage.
8/77	95-95	(Title: Clean Air Act Amendments of 1977). Requires BACT review on a much expanded basis. Established PSD requirements. Required visibility be considered.

Table 6.3-2
National Primary and Secondary Ambient Air Quality Standards

Air Contaminant	Averaging Time	Federal Primary Standard	Federal Secondary Standard
Nitrogen Dioxide1/	Annual Average	100 μg/m^3 (0.05 ppm)	100 μg/m^3 (0.05 ppm)
Sulfur Dioxide	Annual Average	80 μg/m^3 (0.03 ppm)	- - -
	24-Hour	365 μg/m^3 (0.14 ppm)	- - -
	3-Hour	- - -	1300 μg/m^3 (0.5 ppm)
Suspended Particulate	Annual Geometric Mean	75 μg/m^3	60 μg/m^3
	24-Hour	260 μg/m^3	150 μg/m^3
Hydrocarbons (corrected for Methane)	3-Hour 6-9 a.m.	160 μg/m^3 (0.24 ppm)2/	160 μg/m^3 (0.24 ppm)
Photochemical Ozone (oxidant)	1-Hour	240 μg/m^3 (0.12 ppm)	240 μg/m^3 (0.12 ppm)
Carbon Monoxide	8-Hour	10 mg/m^3 (9 ppm)	10 mg/m^3 (9 ppm)
	1-Hour	40 mg/m^3 (35 ppm)	40 mg/m^3 (35 ppm)
Lead	30-Day	1.5 μg/m^3	- - -

Source: 38 Code of Federal Regulations 25678, September 14, 1973

NOTE: ppm = parts per million
ug/m^3 = micrograms per cubic meter
mg/m^3 = milligrams per cubic meter

1/ Nitrogen dioxide is the only one of the nitrogen oxides considered in the ambient standards.

2/ Maximum 3-hour concentration between 6-9 a.m.

6.4 SUMMARY OF THE CLEAN AIR ACT AMENDMENTS OF 1977, AND RELATED REGULATIONS

President Carter signed the Clean Air Act Amendments of 1977 (PL 95-95) into law on August 7, 1977. The Amendments add to the Clean Air Act Part C, concerning the Prevention of Significant Deterioration (PSD) of air quality and visibility enhancement. Part B adds a section on ozone protection. Part D adds provisions for State Implementation Plan requirements for nonattainment areas. In general, the PSD section establishes a scheme for protecting areas with air quality cleaner than minimum national standards and requires the EPA to promulgate a permit regulation for new or modified sources in such areas. Such regulations were promulgated on June 19, 1978 and will be discussed more fully below. These regulations are generally more comprehensive than those originally promulgated by the EPA in 1974.

The amendments continue the use of two major control schemes designed by the 1970 amendments: National Ambient Air Quality Standards (NAAQS) and New Source Performance Standards (NSPS). In the five year period from January 1971 through January 1976, the EPA promulgated emission limits, or NSPS, for 19 source categories. The amendments of 1977 increased the 19 source categories to 28. The EPA is in the process of promulgating regulations for the additional categories which include stationary internal combustion engines and stationary gas turbines.

6.4.1 National Ambient Air Quality Standards (NAAQS)

As mentioned above, the Clean Air Act amendments of 1970 mandated the EPA to promulgate primary and secondary NAAQS. The 1977 Amendments require that the EPA complete, by December 31, 1980, and at five-year intervals thereafter, a thorough review of air quality criteria, and that National Ambient Air Quality Standards, if appropriate, be revised. The EPA is also mandated to promulgate a NAAQS for NO_2 concentrations over a measurement period of not more than three hours. It was originally due by August, 1978, but the EPA has not as yet made such a promulgation. If the EPA finds that there is not significant evidence that such a standard is needed to protect public health, such a standard will not be required to be promulgated.

6.4.2 Designation of Attainment Status

The Clean Air Act Amendments of 1977 required that by December 6, 1977, every State submit to the EPA a listing of the attainment status of its Air Quality Control Regions (AQCR's) for each of the six pollutants for which a NAAQS has been promulgated. In the March 3, 1978 Federal Register, a listing of all nonattainment areas, by state was published. If an area has air quality better than the NAAQS for SO_2 and TSP, it will be designated as an attainment area; if air quality is worse than the

NAAQS, it will be designated as a nonattainment (NA) area. AQCR's may be subdivided with part designated as attainment and part as nonattainment. Areas for which there is insufficient information to determine whether the standards have been met will be designated as "unable to classify." Attainment/nonattainment designations will be made on a pollutant-specific basis. That is, an area may be an attainment area for one pollutant and a nonattainment area for another pollutant.

6.4.3 State Implementation Plans

The 1977 Amendments retained the use of the State Implementation Plan (SIP) which was originally introduced in the 1970 Amendments. All SIPs will have to be revised to implement the standards and regulations mandated by the Amendments. The SIPs as originally devised in the 1970 Amendments required transportation control plans, emission limits for specific categories of sources, and permit rules for new or modified sources of pollution. The goal of these plans, as stated above, was to ensure that the NAAQS would be met in all areas of the country.

The 1977 Amendments expand upon these requirements, and differentiate between two different types of areas in the country:

- Areas in which the NAAQS are being met (attainment areas)
- Areas in which one or more of the NAAQS are being violated (nonattainment areas)

6.4.3.1 Nonattainment Areas

Under the new Amendments, states containing nonattainment areas must have submitted to the EPA by July 1, 1979, an approvable implementation plan which provides for attainment of primary standards by December 31, 1979. The plan must provide for the implementation of "reasonably available control measures" on existing stationary sources to be determined by the State. If, despite these "reasonable available control measures", a state cannot attain primary standards for carbon monoxide or photochemical oxidant before the deadline, it must submit a second plan revision by December 31, 1987.

The Amendments also made specific requirements regarding permit rules. Since 1970, the Clean Air Act has required that any new or modified source of air pollution must undergo a <u>preconstruction review</u>. The purpose of this review is to ensure that such sources would not violate any ambient standard or contribute to any existing violations of these standards. This review is known as New Source Review.

The Amendments require that in nonattainment areas, the SIP must also contain permit requirements for the review of new or modified sources which would include the requirement for such sources to achieve a "Lowest Achievable Emission Rate" (LAER) for that particular source and pollutant, and to secure emission offsets for that particular pollutant in the locality of the project.

Most importantly, the Amendments impose a permit moratorium. No permits may be issued in a nonattainment area (neither by the State nor the EPA) after July 1, 1979 unless an SIP for that area has been approved by the EPA. Thus, sources wishing to locate in such areas may not receive permits until the nonattainment portion of the SIP for that area has been approved by the EPA.

6.4.3.2 Attainment Areas

- Prevention of Significant Deterioration

  The 1977 Amendments kept active the EPA promulgated regulations for PSD. This is a permit rule which must be incorporated into SIPs for attainment areas. It applies to specific sources which are named in the Clean Air Act and the EPA's subsequent regulation. It is essentially a New Source Review rule for those sources in attainment areas, or in those areas which have been designated as "unable to be classified", according to Section 107 of the Clean Air Act as amended.

  Unlike the nonattainment areas, there is no permit moratorium imposed. The failure of a state to adopt into their SIP a permit rule incorporating the PSD requirements of the Clean Air Act, does not impose a moratorium on permits. Thus, is a SIP is not approved by the EPA in an attainment area, sources will be required to obtain such permits from the EPA, as well as obtaining any permits required by the State. When the State adopts a PSD-type rule which is approved by the EPA, then the State has the jurisdictional authority to administer it, and a source need only obtain the State permit in those cases.

  The basic intent of the PSD regulations is to keep "clean air clean". This is accomplished by placing limitations on the amount that pollutant concentrations can be increased above what is termed "baseline concentration". This will be discussed in further detail below.

- Classification of Attainment Areas under PSD

  The Clean Air Act, and the subsequent PSD regulations designate all attainment areas as either Class I, II or III, depending on the degree of deterioration that is to be allowed. Limits are assigned to increases in pollution concentrations for SO_2 and particulate matter for each classification (See Table 6.4-1). Class I increments allow only minor pollutant concentration increases while Class III increments allow the most concentration increases.

Congress specified that certain areas were automatically to be Class I. These areas include national memorials, parks and wilderness areas exceeding 6,000 acres in size, already in existence by the date of enactment. A list of the Class I areas for California are presented in Table 6.4-2 and illustrated in Figure 6.4-1 (this may be viewed in conjunction with overlay G). These areas may not be redesignated.

Under PSD regulations, the remaining areas are all presently Class II. These areas may be redesignated by the states to either Class I or Class III, following the procedures outlined in the regulations, and which will be discussed in the FLM's role in the Redesignation of Area Classifications. All new Wilderness Areas must be designated as either Class I or II.

- Applicability and Review Requirements

On June 19, 1978, the EPA promulgated the requirements for PSD as required in the Clean Air Act Amendments of 1977. The following discussion is based on the PSD requirements as contained therein. Appendix H contains a summary analysis of the June 18, 1979 decision by the United States Court of Appeals, D.C. Circuit regarding Alabama Power Co., et al. versus USEPA, et al. This case may signigicantly impact PSD regulations as indicated in the Appendix.

The CAAA of 1977 gave detailed requirements to assist states in the modification of their SIP's to conform with the Amendments. Twenty-eight source categories have been specified as subject to the PSD regulations and are listed in Table 6.4-3. A source included in the 28 source categories having potential emissions (i.e. emissions without control equipment) greater than 100 tons/yr for a pollutant <u>is a major PSD source for that pollutant,</u> (provided the area in which the source is locating is attainment for that pollutant; otherwise, it is subject to nonattainment rules).

In addition to the 28 categories specified, there is also a "catch-all" category. Sources having potential (uncontrolled) emissions greater than 250 tons/yr are major PSD sources for that pollutant (provided, once more, that the area in which the source is locating is an attainment area for that pollutant).

Table 6.4-1

Prevention of Significant Deterioration
Maximum Allowable Increments
(In Micrograms Per Cubic Meter)

Pollutant	Class I	Class II	Class III
Particulate Matter			
Annual Geometric Mean	5	19	37
24-Hour Maximum*	10	37	75
Sulfur Dioxide			
Annual Arithmetic Mean	2	20	40
24-Hour Maximum*	5	91	182
3-Hour Maximum*	25	512	700

*May be exceeded once per year

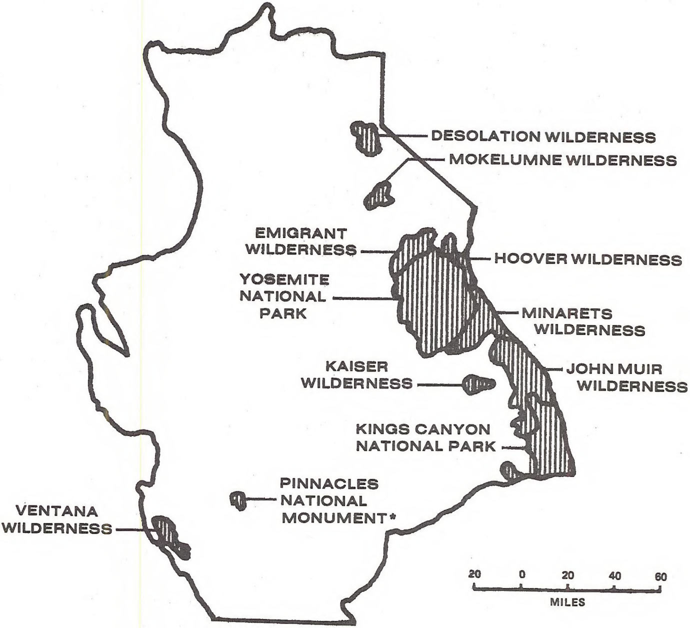
Table 6.4-2
Mandatory Class I Areas Under 1977 Clean Air Act Amendments for California

National Parks

- Kings Canyon
- Lassen Volcanic
- Redwood
- Sequoia
- Yosemite

National Wilderness Areas Over 6,000 Acres

- Agua Tibia
- Caribou
- Cucamonga
- Death Valley
- Desolation
- Dome Land
- Emigrant
- Hoover
- Joshua Tree
- John Muir
- Kaiser
- Lava Beds
- Marble Mountain
- Minarets
- Mokelumne
- Pinnacles
- Point Reyes
- Salmon Trinity Alps
- San Gabriel
- San Jacinto
- San Rafael
- South Warmer
- Thousand Lakes
- Ventana
- Yolla-Bolly Middle Eel



* ONLY THE WILDERNESS PORTIONS ARE DESIGNATED CLASS I.

Figure 6.4-1
Mandatory Class I Areas Under 1977 Clean Air Act Amendments

Table 6.4-3

PSD Major Stationary Sources

Potential Emission of Any Pollutant Greater than 100 tons/yr

Fossil-Fuel Fired Steam Electric Plants
(More than 250 MMBTU/Hr Input)

Coal Cleaning Plants (with Thermal Dryers)

Kraft Pulp Mills

Portland Cement Plants

Primary Zinc Smelters

Iron and Steel Mill Plants

Primary Aluminum Ore Reduction Plants

Primary Copper Smelters

Municipal Incinerators
(Capable of Charging More than 250 Tons Refuse/Day)

Hydrofluoric, Sulfur and Nitric Acid Plants

Petroleum Refineries

Lime Plants

Phosphate Rock Processing Plants

Coke Oven Batteries

Sulfur Recovery Plants

Carbon Black Plants (Furnace Process)

Primary Lead Smelters

Fuel Conversion Plants

Sintering Plants

Secondary Metal Production Plants

Chemical Process Plants

Fossil Fuel Boilers (or Combinations Thereof)
(With Total Storage Capacity Exceeding 300 Thousand BBLS)

Taconite Ore Processing Plants

Glass Fiber Processing Plants

Charcoal Products Plants

and

Notwithstanding the sources above, any source which emits or has potential to emit 250 tons/yr or more of any pollutant regulated under the act.

Major PSD sources must apply Best Available Control Technology (BACT) for each applicable pollutant and undergo an air quality analysis. BACT means an emission limit or control technology representing the maximum degree of reduction with respect to a particular source and pollutant, taking into account: energy, environmental and economic impacts, and technical feasibility. This determination is made by the EPA, but demonstration made by the Applicant will be considered.

If, after application of BACT, the pollutant levels are greater than 50 tons/yr, 1,000 lbs/day or 100 lbs/hr (whichever is the most stringent), an air quality analysis must be performed. The PSD regulations require that a source demonstrate that no violations of NAAQS for NO_2, CO and HC will occur (provided that the area the source poroposes to locate in is attainment for these pollutants). While NO_2, CO and HC concentrations can, in effect, be increased to the NAAQS for these pollutants, for SO_2 and particulate matter, the amount of increase in concentration limited by "increments" above the "baseline concentration". The "increments" are defined by the PSD Class designation for the area in which the source is located.

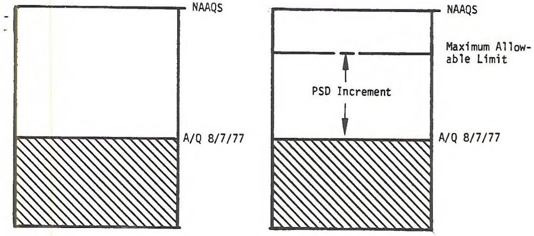
Baseline concentration is essentially the air quality, or concentration level of SO_2 and particulate matter on August 7, 1977. Thus, the emissions from a proposed source are "modeled" via computer simulation modeling, and a concentration prediction is obtained. The SO_2 and/or particulate matter concentration obtained must not exceed the incremental PSD limit for the area in which the source is locating, and the concentration obtained is <u>applied against the increment.</u> This means that increment consumption is viewed from a cumulative view point. That is, if emissions from the source result in SO_2 and particulate concentrations which consume part of the increment allowed from the "baseline concentration", then the next sources to apply for PSD permits must work within the increment which remains (See Figure 6.4-2).

It should be noted that SO_2 and particulate concentrations are prohibited from exceeding the NAAQS. Thus, if a "baseline concentration" is close to the NAAQS, and the additional "increment" defined by the values in Table 6.4-1 would exceed the NAAQS, the NAAQS then becomes the upper limit.

Federal Land Manager's Role in Class I Area Reviews

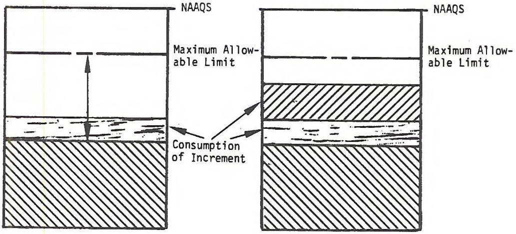
- Denial; impact on air quality related values

FLM's have input to the PSD permitting process if a project will have an impact on a Class I area. Once a source makes an application to the EPA, the EPA must



Baseline Concentration is the Air Quality of Pollutant as of 8/7/77

PSD Increment for SO_2 or Particulate Added to Baseline Establishes Upper Limit Under PSD. The NAAQS is the Upper Limit in All Cases and Cannot be Exceeded



As Sources Are Permitted Under PSD, Their Concentrations of SO_2 or Particulate Consume Increment

Each Succeeding PSD Source to Apply for Permit has Increasingly Less Increment Within Which to Work

Figure 6.4-2
Determination of Maximum Allowable Ambient
Limit Under PSD Increment

contact the appropriate FLM if it is thought that the project will have any air quality impact on a Class I area.

If the FLM finds that emissions from a proposed facility would have an adverse impact on the "air quality related values" (which include visibility) of the land area (even though allowable Class I increments would not be exceeded), he can recommend to the EPA that the permit be denied. If the EPA concurs with the FLM's demonstration, they will not issue the permit.

- Class I variances

Conversely, in a situation where the Class I increments are predicted to be exceeded, the owner of the source may appeal to the FLM. The owner must demonstrate to the FLM that the emissions from the facility will not adversely impact the air quality related values. If the FLM concurs with this demonstration, he must certify this concurrence, and the state may then authorize the EPA to issue a permit which would allow the facility to comply with less stringent air quality increments. In such cases, the maximum increments imposed are the same as the Class II values, except for the three-hour SO_2 increment limit which is not to exceed 325 $\mu g/m^3$ (The Class II three-hour SO_2 increment is 512 $\mu g/m^3$.)

- SO_2 variance by Governor with FLM's concurrence.

In situations where the Class I increments are predicted to be exceeded, and the source would exceed the relaxed SO_2 increments as described above, the owner of the source may appeal to the Governor of the state to receive a variance for <u>sulfur dioxide only.</u> Particulate matter variances cannot be made. In making this appeal, the owner must demonstrate that neither the 24-hour nor 3-hour SO_2 increment limits cannot be met as defined above. The annual SO_2 increment of 20 $\mu g/m^3$ must be met, however. It also must be demonstrated that the project will not adversely affect the air quality related values of the affected area. The FLM, again, has input in this process and is required to make a recommendation to the Governor who can concur or not concur once the FLM approves the demonstration. In addition, a public hearing must be held. Depending on the public input, the Governor, after such hearing, may then grant a variance. The EPA can then issue a permit, and the source would then be permitted to exceed the SO_2 increments presented in Table 6.4-4 for no more than 18 days per year.

- Variance by the Governor with the President's concurrence

  If, in the above process, the FLM does not concur, the permit can not be approved, unless the Governor overrides the FLM's veto. The Governor is authorized to override this veto and recommend a variance. In such a situation, the recommendations of both the FLM and the Governor are sent to the President. The President may approve the Governor's recommendation if he finds the variance to be in the national interest. If the variance is approved, the EPA may issue a permit, and the source would then be permitted to exceed the SO_2 increments presented in Table 6.4-4 for no more than 18 days per year.

  The procedure discussed above is outlined in Figure 6.4-3.

Table 6.4-4

Maximum Allowable Increase ($\mu g/m^3$)

Under Class I SO_2 Variances

Period of Exposure	Terrain Areas Low	Terrain Areas High
24-hour maximum	36	62
3-hour maximum	130	221

- Air Quality Related Values

  The only "air quality related value" specifically cited in the 1977 Amendments is visibility. Other values may include fish and wildlife resources, vegetation, archaelogic sites and soil impacts. The EPA has yet to provide general guidelines regarding the evaluation of impacts of proposed emitting sources on "air quality related values" and until such guidance is available, determinations are to be made on a case-by-case basis. The FLM reviewing the permit can recommend that it be issued with the condition that the facility monitor the impacts of its emissions and reduce their level if adverse effects do occur. Other permit conditions may be recommended to the EPA by the FLM which would ensure protection of air quality related values.

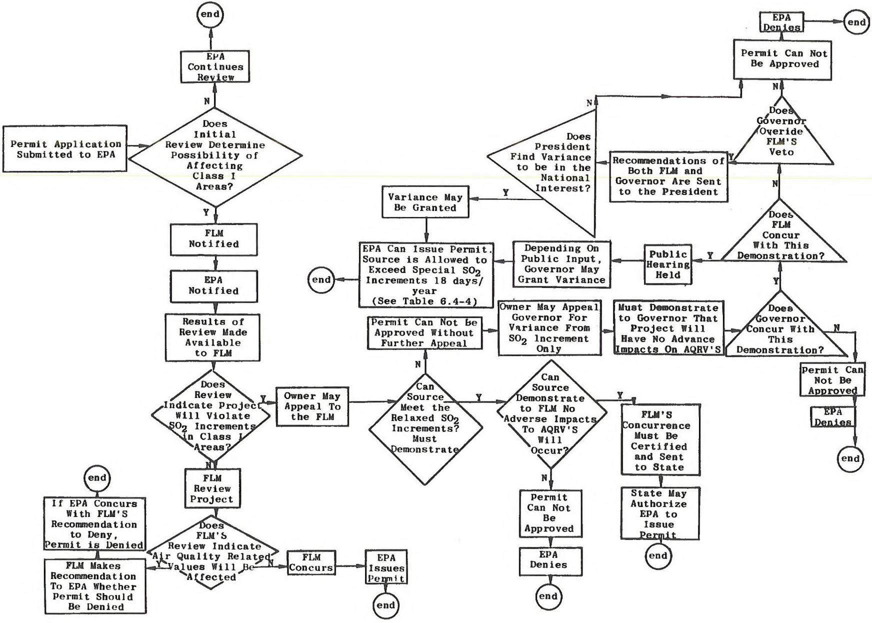


Figure 6.4-3

The PSD Permit Application Process

FLM role in Redesignation of Area Classifications

A state may redesignate any area to Class I. States are also permitted to redesignate certain areas to Class III except the following areas greater than 10,000 acres in size: present national monuments, primitive areas, recreation areas, wild and scenic rivers, wildlife refuges, lakeshores and seashores, and future national parks and wilderness areas. Redesignation of an area to Class III is a complicated process requiring approval by the governor, public notices and hearings, consultation with the state legislature, and approval by a majority of potentially affected local residents.

Detailed analysis is required prior to public hearing including health, environmental, economic, social and energy impacts of the proposal. Redesignation of areas within Indian reservations may only be done by the applicable Indian governing body.

The EPA Administrator may disapprove a proposed redesignation only if the redesignation does not meet the procedural requirements of Part C of the Act. If federal lands are included in the proposed redesignation area, the FLM is to submit recommendations on the proposal, but the state's decision, if it differs, is binding. The EPA may be requested to resolve disputes between states and Indian tribes on proposed redesignations. The redesignation process is summarized in Figure 6.4-4.

6.4.4 Visibility Protection

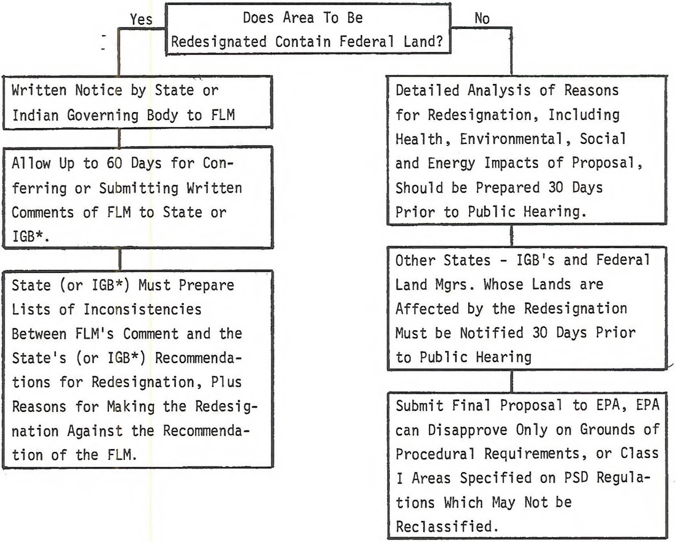
The 1977 Amendments added to the Clean Air Act a section entitled "Visibility Protection for Federal Class I Areas". This section declares as a National goal "the prevention of any future, and the remedying of any existing, impairment of visibility in mandatory Class I Federal areas" where impairment results from man-made air pollution. The Amendments also required that by February 1978, the Secretary of Interior, in consultation with the states and the FLM's, are to identify any mandatory Class I areas where visibility contributes significant values to the area. These areas were published in the February 24, 1978 Federal Register. As such, all Class I areas in California are areas in which visibility is on important value. The EPA was to have conducted a study on visibilty, the report on which was due in February, 1979, and promulgate regulations on visibility by August, 1979.

These regulations, in essence, will provide guidelines to the states on the various techniques and methods to be used to achieve the National goal for visibility. Such a goal would be stated, in all probability, as a "visibility standard".

The regulations would identify "impaired visibility areas" and would require each SIP in such areas to adopt emission limits on sources of pollution, compliance schedules and other

Figure 6.4-4

Redesignation Procedure



* Indian Governing Body

measures necessary to achieve the visibility standard. These measures will include what the Clean Air Act terms "Best Available Retrofit Technology" (BART). Thus, SIPs must impose BART on specific sources named in the Clean Air Act. These sources consist of the sources in the 28 PSD categories, which have potential (uncontrolled) emissions greater than 250 tons/yr of any pollutant, and which have been in operation for longer than 15 years. In addition to these measures, the SIPs must develop long-term strategies for achieving the visibility standard.

The EPA is allowed to exempt sources from BART. Such exemptions can be made if the EPA feels that such sources will not contribute to visibility impairment. The EPA may not give this source-wide exemption on fossil-fuel fired power plants greater than 750 MW. These units would be included in the States' regulations and BART must apply. Exemptions for these units may only be made on a case-by-case basis, where the owner of such units demonstrates to the EPA that the unit of concern would not contribute to impairment of visibility.

Any exemption that the EPA makes regarding these sources and their inclusion in the SIP, must go through the FLM. The Clean Air Act mandates that the FLM's concurrence must be obtained in order for any exemption of this type to be effective. (Section 169A(c)(3) of the Clean Air Act).

The Clean Air Act requires that a public hearing be held on the proposed revision of any SIP relating to the EPA's visibility requirements. The State is also required to consult with the FLM on the proposed revision. Any recommendations and conclusions made by the FLM on this revision are required to be included in the public notice announcing the public hearing.

6.4.5 Ozone Protection

The 1977 Amendments also added a section on ozone protection to the Clean Air Act (Part B). The purpose of this section is to provide for (1) better understanding of the effects of human actions on the stratosphere; (2) better understanding of the effects of changes in the stratosphere; (3) information on progress made in regulating activities which may affect the ozone in the stratosphere in such a way as to cause or contribute to endangerment of the public health and welfare; and (4) information on the need for additional legislation in this area.

The Act authorizes the EPA to conduct a study of the effect of all substances, particularly ozone, as well as practices and activities which may affect the stratosphere. The EPA may use any university of contractor to perform the studies required by the Clean Air Act. In addition to the study to be done by the EPA, the Act mandates that further research and monitoring be done by the following agencies: .

1. National Oceanic and Atmospheric Administration
2. National Aeronautics and Space Administration
3. National Science Foundation
4. United States Department of Agriculture
5. United States Department of Health, Education and Welfare

The EPA was to provide an interim report to the Congress on January 1, 1978 on the progress of the stratosphere study. The Act mandates that a final report is to be completed before August, 1979. Authorization is given to the EPA to write regulations to control any substance which the EPA believes, based on their studies, would affect the stratosphere, particularly in the formation of the ozone. This would include chlorofluorocarbon emissions from aerosol cans and emissions from airplanes, cars, etc. These regulations must take into account the feasibility and the costs of achieving these controls. However, such regulations may exempt medical use products for which the EPA determines there is no suitable substitute.

6.5 STATE AND COUNTY REGULATIONS

6.5.1 State Ambient Air Quality Standards

California began setting Air Quality Standards in 1969 under the provisions of the Mulford-Carrell Act. With the passage of the Clean Air Act Amendments in 1970, the Federal Government began adopting such standards for the entire country. Wherever there is some variation between state and federal Air Quality Standards, the most stringent or limiting standard applies. Table 6.5-1 compares the Federal and California standards. It should be noted that the 1977 Amendments were recently passed and may eventually have a significant effect on state standards and county regulations-particularly in those regions containing Class I areas.

6.5.2 County Regulations

Within the Folson District, the counties and their regulatory agencies are as follows:

- Bay Area Air Quality Management District (BAAQMD)
    - Alameda
    - Contra Costa
    - San Francisco
    - San Mateo
    - Santa Clara
- Great Basin Unified Air Pollution Control District (GBUAPCD)
    - Alpine
    - Mono
- Monterey Bay Unified Air Pollution Control District (MBUAPCD)
    - Monterey
    - Santa Cruz
    - San Benito
- Mountain Counties Air Basin (MCAB)
    - Amador Air Pollution Control District
    - El Dorado Air Pollution Control District
    - Mariposa Air Pollution Control District
    - Calaveras Air Pollution Control District
    - Nevada Air Pollution Control District
    - Placer Air Pollution Control District
    - Tuolumne Air Pollution Control District

6.5.3 Permit Rules

As mentioned previously, the intent of the Clean Air Act in establishing procedures for permit rules is to require the states to write and adopt such permit rules into their individual SIPs. Until such time as these rules are approved by the EPA and incorporated in the SIP, the EPA still remains the permitting authority. Thus, in California, many Applicants who are required

Table 6.5-1
Ambient Air Quality Standards

Pollutant	Averaging Time	California Standards[1]		National Standards[2]		
		Concentration[3]	Method[4]	Primary[3, 5]	Secondary[3, 6]	Method[7]
Oxidant (Ozone)	1 hour	0.10 ppm (200 ug/m^3)	Ultraviolet Photometry	240 μg/m^3 (0.12 ppm)	Same as Primary Std.	Chemiluminescent Method
Carbon Monoxide	12 hour	10 ppm (11 mg/m^3)	Non-Dispersive Infrared Spectroscopy	—	Same as Primary Standards	Non-Dispersive Infrared Spectroscopy
	8 hour	—		10 mg/m^3 (9 ppm)		
	1 hour	40 ppm (46 mg/m^3)		40 mg/m^3 (35 ppm)		
Nitrogen Dioxide	Annual Average	—	Saltzman Method	100 ug/m^3 (0.05 ppm)	Same as Primary Standards	Proposed: Modified J-H Saltzman (O_3 corr.) Chemiluminescent
	1 hour	0.25 ppm (470 ug/m^3)		—		
Sulfur Dioxide	Annual Average	—	Conductimetric Method	80 ug/m^3 (0.03 ppm)	—	Pararosaniline Method
	24 hour	0.05 ppm (131 ug/m^3)[9]		365 ug/m^3 (0.14 ppm)	—	
	3 hour	—		—	1300 ug/m^3 (0.5 ppm)	
	1 hour	0.5 ppm (1310 ug/m^3)		—	—	
Suspended Particulate Matter	Annual Geometric Mean	60 ug/m^3	High Volume Sampling	75 ug/m^3	60 ug/m^3	High Volume Sampling
	24 hour	100 ug/m^3		260 ug/m^3	150 ug/m^3	
Sulfates	24 hour	25 ug/m^3	AIHL Method No. 61	—	—	—
Lead	30 Day Average	1.5 ug/m^3	AIHL Method No. 54	1.5 μg/m^3	—	High Volume Sampling
Hydrogen Sulfide	1 hour	0.03 ppm (42 ug/m^3)	Cadmium Hydroxide Stractan Method	—	—	—
Hydrocarbons (Corrected for Methane)	3 hour (6-9 a.m.)	—	—	160 ug/m^3 (0.24 ppm)	Same as Primary Standards	Flame Ionization Detection Using Gas Chromatography
Ethylene	8 hour	0.1 ppm	—	—	—	—
	1 hour	0.5 ppm				
Visibility Reducing Particles	1 observation	In sufficient amount to (8) reduce the prevailing visibility to less than 10 miles when the relative humidity is less than 70%		—	—	—
APPLICABLE ONLY IN THE LAKE TAHOE AIR BASIN:						
Carbon Monoxide	8 hour	6 ppm (7 mg/m^3)	NDIR	—	—	—
Visibility Reducing Particles	1 observation	In sufficient amount to (8) reduce the prevailing visibility to less then 30 miles when the relative humidity is less than 70%		—	—	—

Table 6.5-1 (Cont.)

NOTES:

1. California standards are values that are not to be equaled or exceeded.

2. National standards, other than those based on annual averages or annual geometric means, are not to be exceeded more than once per year.

3. Concentration expressed first in units in which it was promulgated. Equivalent units given in parentheses are based upon a reference temperature of 25°C and a reference pressure of 760 mm of mercury. All measurements of air quality are to be corrected to a reference temperature of 25°C and a reference pressure of 760 mm of Hg (1,013.2 millibar); ppm in this table refers to ppm by volume, or micromoles of pollutant per mole of gas.

4. Any equivalent procedure which can be shown to the satisfaction of the Air Resources Board to give equivalent results at or near the level of the air quality standard may be used.

5. National Primary Standards: The levels of air quality necessary, with an adequate margin of safety, to protect the public health. Each state must attain the primary standards no later than three years after that state's implementation plan is approved by the Environmental Protection Agency (EPA).

6. National Secondary Standards: The levels of air quality necessary to protect the public welfare from any known or anticipated adverse effects of a pollutant. Each state must attain the secondary standards within a "reasonable time" after implementation plan is approved by the EPA.

7. Reference method as described by the EPA. An "equivalent method" of measurement may be used but must have a "consistent relationship to the reference method" and must be approved by the EPA.

8. Prevailing visibility is defined as the greatest visibility which is attained or surpassed around at least half of the horizon circle, but not necessarily in continuous sectors.

9. At locations where the state standards for oxidant and/or suspended particulate matter are violated. Federal standards apply elsewhere.

to obtain a PSD permit from the EPA, are also required to obtain a New Source Review permit from the County.

In nonattainment areas, however, no permits may be issued unitl the SIP for these areas is approved by the EPA. Thus, in California, no permits can be issued in these areas. At the present time, many counties have rewritten their permit rules to conform with a model or guideline rule which was drafted by the CARB.

These rules have in large part been adopted by the local Districts who in turn submit them to the CARB. The CARB reviews the local rules to see if they conform with ARB's guideline Model Rule. After the CARB reviews the local rule, and concurs with it, it then submits it to the EPA for review and inclusion in the SIP. A local District may not submit directly to the EPA; only the State may submit individual rules to the EPA for inclusion in the SIP. At this point, no rules have been submitted to the EPA; they are presently either being adopted by the local District for submission to the CARB, or have already been submitted to CARB and are waiting for their review.

6.5.3.1 Description of Model Rule/Districts' Rules

The CARB Model Rule was written to ensure conpliance with the requirements of the Clean Air Act, and to provide the individual APCD's with guidance in writing their rules. By and large, most of the Districts in California have adopted the rule, with some minor changes between Districts. Thus, a description of CARB's Model Rule will suffice to describe the indivudual Districts' rules in California.

The Model Rule/District Rules currently apply in both attainment and nonattainment areas (A state PSD rule will eventually control sources in attainment areas). All sources, regardless of emission levels, must first demonstrate compliance with all District rules and regulations (emission limits, etc.). It must also demonstrate that all company-owned sources in the State are in compliance with all emission limitations and standards which are part of the SIP approved by the EPA.

If the emissions from the source are greater than 250 lbs/day (per the Model Rule; this may differ from District to District), for any pollutant, BACT is required for all pollutants.

If, after application of BACT, emissions of any pollutant are greater than 250 lbs/day, the source must meet specific requirements which differ according to two different scenarios as illustrated below:

- <u>Sources Locating in Nonattainment Areas</u>
  Offsets must be obtained for pollutants, in ratios greater than 1.2:1.

- Sources Locating in Areas which are Attainment or Show Infrequent Violations
  Offsets are required only as much as is needed to prevent a new violation or to prevent the worsening of an existing one.

6.5.3.2 California's Air Conservation Program (ACP)

In 1976, the CARB began writing a proposed guideline permit rule affecting new or modified sources locating in attainment areas of the State. It was the state's version of the EPA's PSD program, and was called the California Air Conservation Program (ACP). The CARB had drafted a rule incorporating a four-level classification system of lands, as opposed to the EPA's three-class increment system.

However, since the Clean Air Act Amendments of 1977 drastically changed the PSD requirements for states, and with the rush of activity associated with nonattainment planning, the ACP for the State was temporarily dropped.

Activity resumed recently on drafting the California version of PSD. However, at this time, the rule is being written to be equivalent to the EPA's present PSD regulations, and will not contain extensive additions, or differences, as in the original version. The CARB's purpose in their actions is to draft a rule that the local Districts can easily adopt and which would be easily approvable by the EPA. The rule would then be part of the SIP, and could be enforced by the local Districts.

Subsequent to inclusion in the SIP, the CARB will then commence work on a new version of the ACP which would eventually replace their PSD regualtion. Thus, their PSD regulation serves only as an interim measure in order to obtain full State jurisdictional authority to administer permit programs in attainment areas. The ACP will, in essence, be a more detailed PSD regulation which is tailored to the air quality concerns and needs of California. It is not known at this time whether the ACP will include the utilization of the national Class I, II, and III increment or another suitable increment standard.

The CARB wishes to have their interim PSD regulation (Model Rule) drafted by October. They wish to have the Districts adopt this regulation by the end of 1979.

6.5.3.3 Emission Regulations

Each county has a set of emission regulations; some pertaining to specific sources of emissions, and others representing a general emission limit encompassing a broad range of industrial sources. Emission limitations are enforced by the APCD's, and violations of limits may result in fines and/or shut-downs. In some situations, a source may be put on a compliance schedule to meet a schedule of emission limits on specified dates.

Particulate Matter

A limit is established as to the amount of particulate matter that can be discharged from a source. The limit for Alpine County is 0.3 grains per standard dry cubic foot (grain/SCF) of exhaust gas. In the Bay Area Air Quality Management District and the Monterey Bay Unified Air Pollution Control District the limit is 0.15 grain/SCF for most sources and 0.2 grain/SCF for incinerators and wood fire boilers. Sutter County has no specific emission limits, and relies solely on the state ambient standards for particulates.

The allowable rate of particulate emissions based on process weight rate is also limited. Charts are provided in the regulations of each individual district.

Sulfur Compounds

The quantity of sulfur compounds emitted from any single source is limited at the point of discharge to the atmosphere. Alpine, Yuba, Sacramento, the counties in the San Joaquin Valley Basin (SJVB) and the MBUAPCD's limit is 0.2 percent by volume as sulfur dioxide. The counties in the SJVB all limit combustion sources of SO_2 emissions to 200 lb/hr. The BAAPCD's limit for sulfur dioxide is 300 ppm at the emission point or 0.5 ppm at ground level for three consecutive minutes or 0.5 ppm averaged over 60 minutes or 0.04 ppm averaged over 24 hours. The BAAPCD also limits sulfur trioxide (SO_3) or sulfuric acid (H_2SO_4) at 0.04 grains per cubic foot of exhaust gas volume for acid plants, and 0.08 grains of either for sulfur plants. Sutter County has no specific emission limits, and relies solely on the State ambient standards for SO_2 and sulfates.

Primarily as a means of controlling odor, the BAAPCD limits the ground concentration of hydrogen sulfide (H_2S) to 0.06 ppm for three minutes or 0.03 ppm averaged over one hour.

Nitrogen Oxides

Nitrogen oxide emissions are limited from stationary sources. The limits for specific areas are as follows:

- Alpine county, the MCAB, and the SJVB: 140 lbs/hour (as NO_2) from any source
- BAAPCD: Sources with heat input $\geq$ 250 million BTU/hour - 125 ppm when burning natural gas and 225 ppm when burning oil. Sources with heat input $\geq$ 1,750 million BTU/hour - 175 ppm when burning natural gas and 300 ppm when burning oil

- MBUAPCD: For new or expanded combustion sources - 140 lbs/hour (as NO_2); for sources with heat input more than 1.5 million BTU/hour - 225 ppm (as NO_2) with all fuels burned at 3 percent oxygen; from other combustion sources - 250 ppm as (NO_2).
- Sutter County: uses the state ambient standard rather than an emission limit

Lead Emissions

Several California counties include in their regulations limitations on lead emissions and/or lead concentrations at ground level. The BAAPCD prohibits any source from emitting more than 15 lbs of lead per day resulting in a ground level concentration of 1.0 $\mu g/m^3$ in excess of the background level. Sutter County adopted the state standard of 1.5 $\mu g/m^3$ averaged over 30 days.

Odors

Two methods have been used by counties to regulate odors in the atmosphere. In most counties, odors are covered under regulations for nuisances (see below). The BAAPCD regulations call for APCD personnel to take a sample (sniff) of a suspected odor if ten citizen complaints are received with 90 days. The sample is then diluted with four parts of odor free air. If it remains odorous after dilution, the source is in violation of the regulation.

Nuisances

This regulation generally prohibits any source from emitting air contaminants or other material which cause injury, detriment, nuisance or annoyance to any considerable number of persons or to the public or which endanger the comfort, repose, health or safety of any persons or the public or which cause or have a tendency to cause injury or damage to business or property. The working of this regulation varies with the overall detail of the county or APCD regulations. In some cases, nuisances such as odors are separated out and dealt with directly.

Fuel Sulfur Content

Counties, primarily those in western California, limit the sulfur content of fuel. The BAAPCD limits the sulfur in fuels to 0.5 percent or the emissions from fuel burning to 300 ppm (as SO_2). The MBUAPCD prohibits the burning of gaseous fuel containing sulfur compounds in excess of 50 grains per 100 cubic feet (as H_2S); or the sulfur content of liquid or solid fuel to 0.5 percent by weight. Most of the other counties, if sulfur content is mentioned, simply place the limit at 0.5 percent. In some counties, exceptions are included and provisions are made for sulfur removal from the flue gas.

Reduction of Animal Matter

Prohibits the reduction of animal matter in a source unless all generated emissions are incinerated at temperatures of not less than 1200 degrees Fahrenheit for a period of not less than 0.3 seconds or processed in a manner determined by the Air Pollution Control Officer to be equally or more effective for the purpose of air pollution control.

Miscellaneous Regulations

Other common regulations usually include prohibitions on emissions from organic solvents, new source performance standards, emission standards for hazardous air pollutants, regulations on organic liquid loading, regulations on loading gasoline into stationary tanks.

6.5.3.4 Burning Regulations

The CARB has promulgated regulations governing the use of open outdoor fires for agricultural operations and forest management. Agricultural burning guidelines and meteorological criteria for the regulation of agricultural burning were promulgated for each air basin on March 17, 1971. The purpose of the regulation was to permit burning on days with good meteorology based upon established meteorologiccal criteria. Regulations were adopted on March 17, 1971 and revised on June 21, 1972, February 20, 1975, with a proposed revision April 27, 1978.

The regulations require that burning permits be obtained prior to the use of open outdoor fires. These permits are to be prepared by the designated agency and/or the appropriate APCD. In most instances, the California Department of Forestry (CDF) serves as the designated agency for burning in forested areas throughout the state and, therefore, is responsible for the issuance of permits.

While the CDF serves as the designated agency for the issuance of burning permits in California, this responsibility can be further delegated to other agencies. In some instances, the BLM has been given authority by the CDF to issue permits for land areas managed by the Department of Interior. These include the Susanville and Bodie Planning Units. In these instances, BLM area managers are directly responsible for the issuance of permits and for coordination with other agencies. However, unless this authority has been properly delegated, BLM area managers are not responsible for permitting for open outdoor burning.

BLM area managers responsible for the administration of Department of Interior lands in California must be cognizant of the procedures necessary prior to any burning activities in these areas. The principal points of contact for the BLM area managers include the local APCD, the CARB, the National Weather Service

(NWS) and the CDF. The latter agency should serve as an initial point of contact for area managers faced with the problem of burning on federal lands for the first time. CDF personnel can explain permit issuance procedures to BLM personnel and it is good practice for BLM managers to become very familiar with this process. Table 6.5-2 provides a list of all CDF contacts within California suitable for use by BLM managers.

The requirements for a burning permit apply to all land areas in the state with a few exceptions. Open burning for agricultural operations in the growing of crops or the raising of fowl or animals, as well as disease or pest prevention are exempt from permitting requirements above an elevation of 3,000 feet MSL. This exception does not apply in the Tahoe Air Basin. Land areas located at an elevation above 6,000 feet MSL, except in the Tahoe Air Basin, are exempt from permitting requirements for all agricultural burning which includes outdoor fires for agriculture, pest control, forest management, range improvement, improvement of land for wildlife and game habitat, as well as in the raising of fowl or animals. Most burning on BLM lands will be for forest management or range improvement activity and therefore would be exempt to permitting requirements above 6,000 feet MSL. Below this level, a permit will probably be required for burning on BLM lands. Other special aspects of permitting requirements include the permission to burn between the period of January through May for range management, even on no-burn days if 50% of the land area has been chemically treated. In addition, BLM can notify the CARB seven days in advance for a major burn at an altitude below 6,000 feet MSL. The agency will then provide a special forecast 48-hours prior to the burn and daily thereafter as a special service.

Once again, the CDF will serve as the designated agency for permitting for most BLM lands in California. Other points of contact for BLM land managers include the CARB for burn/no-burn decisions for land areas at altitudes below 6,000 feet MSL. In addition, close contact must also be maintainted with the NWS relative to fire weather forecasts such that all burning can be strictly controlled during dangerously dry periods. These are the key contacts. It is important to proceed with an attitude of cooperation with all agencies to insure safe outdoor burning as well as to limit the possible impacts on ambient air quality by the resultant smoke. BLM managers will be required to keep a record of the amount of acreage and the tonnage of material burned daily as the APCD's will request this information in preparing their required quarterly reports to the CARB regarding burning permits.

Individual counties will prohibit such burning unless the appropriate permit from CDF or other designated agency has been obtained. In addition, the individual APCD's or county air pollution control officer may designate a particular day as a "burn day" or "no-burn day" dependent upon the meteorological conditions within his jurisdiction and time of year. Persons

Table 6.5-2

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF FORESTRY

DIRECTORY

Administrative Unit	Administrative Officer	Title	Street Address	Post Office	Telephone No.	P.O. Box
State Headquarters	Lewis A. Moran	Director	1416 Ninth Street	Sacramento 95814	916-445-3976	
	Larry E. Richey	Deputy Director	1416 Ninth Street	Sacramento 95814	916-445-2921	
	Frank Torkelson	Deputy Director	1416 Ninth Street	Sacramento 95814	916-445-6650	
I. North Coast Headquarters	George Grogan	Chief	135 Ridgeway Avenue	Santa Rosa 95401	707-542-1331	Box 670
	Richard Day	Assistant Chief	135 Ridgeway Avenue	Santa Rosa 95401	707-542-1331	Box 670
Humboldt-Del Norte	Wm Harrington	State Forest Ranger	118 Fortuna Blvd.	Fortuna 95540	707-725-4413	Box 516
Lake-Napa	Byron Carniglia	State Forest Ranger	1572 Railroad Avenue	St. Helena 94574	707-963-3601	Box 73
Mendocino	Thomas Neil	State Forest Ranger	17501 N. Highway 101	Willits 95490	707-459-5561	
Sonoma	Frank Crossfield	State Forest Ranger	2560 W. College Ave.	Santa Rosa 95401	707-546-1544	
II. Sierra Cascade Headquarters	Gary Todd	Chief	1000 Cypress Street	Redding 96001	916-246-6311	Box 2238
	Ross Dunwoody	Assistant Chief	1000 Cypress Street	Redding 96001	916-246-6311	Box 2238
Butte	Robert Paulus	State Forest Ranger	176 Nelson Avenue	Oroville 95965	916-533-6365	
Lassen-Modoc	Jack Burke	State Forest Ranger	Highway 36	Susanville 96130	916-257-4171	
Nevada-Yuba-Placer	John Odgers	State Forest Ranger	13760 Lincoln Way	Auburn 95603	916-885-3722	
Shasta-Trinity	Howard Bromwell	State Forest Ranger	1050 Parkview Avenue	Redding 96001	916-243-1436	
Siskiyou	Richard Miralles	State Forest Ranger	Fair Lane Road	Yreka 96097	916-842-3516	Box 128
Tehama-Glenn	Robert Kersteins	State Forest Ranger	604 Antelope Blvd.	Red Bluff 96080	916-527-2213	Box 1210
IV. South Sierra Headquarters	Gervice Nash	Chief	1234 East Shaw Avenue	Fresno 93710	209-222-3714	
	Don Petersen	Assistant Chief	1234 East Shaw Avenue	Fresno 93710	209-222-3714	
Amador-El Dorado	Ralph Smith	State Forest Ranger	2840 Mt. Danaher Road	Camino 95709	916-644-2345	
Fresno-Kings	Carl Armstrong	State Forest Ranger	210 So. Academy Ave.	Sanger 93657	209-485-7500	
Madera-Mariposa	John Morrow	State Forest Ranger	5366 N. Highway 49	Mariposa 95338	209-966-3622	
Tulare	Raymond H. Banks	State Forest Ranger	1968 S. Lovers Lane	Visalia 93277	209-732-5954	
Tuolumne-Calaveras	James Taylor	State Forest Ranger	785 El Dorado St.	San Andreas 95249	209-754-3831	Star Rt. 1
V. Central Coast Headquarters	John Hastings	Chief	2221 Garden Road	Monterey 93940	408-372-4536	
	Richard Bawcom	Assistant Chief	2221 Garden Road	Monterey 93940	408-372-4536	
San Benito-Monterey	Thomas Perkins	State Forest Ranger	401 Canal Street	King City 93930	408-385-5412	
San Luis Obispos	Theodore Waddell	State Forest Ranger	Morro Road	San Luis Obispo 93401	805-543-4244	Box 151
San Mateo-Santa Cruz	Robert Voss	State Forest Ranger	6059 Highway 9	Felton 95018	408-335-5355	Drawer F-2
Santa Clara	Leroy Taylor	State Forest Ranger	15670 Monterey St.	Morgan Hill 95037	408-779-2121	
VI. Southern California Headquarters	Joseph C. Springer	Chief	2524 Mulberry Street	Riverside 92501	714-781-4140	Box 1067
	James Chambers	Assistant Chief	2524 Mulberry Street	Riverside 92501	714-781-4140	Box 1067
Orange	Carl Downs	State Forest Ranger	180 S. Water Street	Orange 92666	714-538-3551	Box 86
Owens Valley	Ivan Phillips	State Forest Ranger		Bishop 93514	714-387-2401	Rt. 2, Box 22L
Riverside	David Flake	State Forest Ranger	210 W. San Jacinto	Perris 92370	714-657-3183	Box 248
San Bernardino	Rex Griggs	State Forest Ranger	3800 Sierra Way	San Bernardino 92405	714-882-1227	
San Diego	James Dykes	State Forest Ranger	2249 Jamacha Road	El Cajon 92020	714-442-0874	
California Department of Forestry Fire Academy	James Simmons	State Forest Ranger		Ione 95640	209-274-2426	Rt. 1, Box 69

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with the appropriate permits may commence their outdoor burning subject to the conditions of their permits on days designated "burn days". In addition to these requirements, the Monterey Bay Unified APCD imposes the following criteria to be followed.

- Before a permit may be issued, a plan for the burn shall be submitted by the owner, or his agent, to the District and the CDF.
- The plan shall cover the following: ownership, location, equipment available, manpower available, fireguard locations, proposed date and hours of burn, treatment given to trees and brush, method and plan for ignition, location of populated areas, if any, within 20 miles of the exterior boundaries of the burn, and any other information required by the District or the CDF or other designated agency.
- Where economically and technically feasible, brush shall be treated by chemical or mechanical means at least six months prior to a proposed burn, to kill or uproot the brush in order to insure rapid combustion.
- Unwanted trees over six inches in diameter in the burn area or those not effectively treated at the time of the brush treatment shall be felled at least five months prior to the burn; a longer time may be required where conditions warrant.
- Burning shall not commence when wind direction is toward a populated area which would be adversely affected by the burn.

6.6 GLOSSARY OF TERMS

Air Pollution Control District	In California, the county regulatory body responsible for the administration of air pollution regulations.
Air Quality Related Values	Under the Prevention of Significant Deterioration Regulations for Class I areas, the effect of potential pollutant emissions on such variables of soils, vegetation and, most importantly, visibility must be reviewed.
Attainment Areas	The term attainment area means for any air pollutant an area which is shown by monitored data or which is calculated by air quality modeling to comply with any National Ambient Air Quality Standard for such a pollutant.
Baseline Concentration	The ambient concentration level reflecting actual air quality as of August 7, 1977 minus any contribution from major stationary sources and major modifications on which construction commenced on or after January 6, 1975.
Best Available Control Technology (BACT)	An emission limitation (including a visible emissions standard) based on the maximum degree of reduction for each pollutant subject to regulation under the Act which would be emitted from any proposed major stationary source or major modification which the Administrator, on a case by case basis, taking into account energy, environmental and economic impacts and other costs determined to be achievable for such source or modification through application of production processes or available methods, systems and techniques including fuel cleaning or treatment or innovative fuel combustion techniques for control of such pollutant. BACT must always be at least as stringent as the Applicable New Source Performance Standard.
Best Available Retrofit Technology (BART)	Same as Best Available Control Technology with specific application to existing sources.

Burn Day	A burn day is any day on which a designated person or agency determines that certain specified burning is allowed.
Class Designation	The designation of the country as either Class I, II or III under the rules for the Prevention of Significant Deterioration. Class I areas reflect the most stringent requirements while Class III areas are the most lenient.
Clean Air Act (CAA)	The body of air quality legislation promulgated 1955 in with Amendments in 1963, 1965, 1967, 1970, and 1977, and codified in 42USC740/et seq., which are designed to regulate the nations air quality for the purpose of protecting human health and welfare.
Clean Air Act Amendments of 1977	They represent the latest in a series of expanding regulatory requirements designed to protect the air quality resource in the United States. The Amendments of 1977 (PL95-190) introduced key concepts including the Prevention of Significant Deterioration, the use of Best Available Control Technology and the protection of ambient visibility levels.
Criteria Pollutants	That group of pollutants for which National Ambient Air Quality Standards have been promulgated based upon an analysis of the effects of such pollutants upon human health and welfare. Currently, SO_2, NO_x, CO, HC, TSP, lead and photochemical oxidants are criteria pollutants.
Designated Agency	The governmental agency with final authority relative to air quality regulations.
Federal Land Manager	Federal Land Manager means with respect to any lands in the United States, the Secretary of the Department with authority over such lands.
Increments	The maximum allowable increase in a specific pollutant concentration over and above existing "baseline concentrations" as specified in Section 163 of the CAA or as limited by the difference between Air Quality Standards and baseline concentrations for that pollutant.

Indian Governing Body	The term means the governing body of any tribe, band or group of Indians subject to the jurisdiction of the United States and recognized by the United States as possessing power of self government.
Lowest Achievable Emission Rate (LAER)	The emission control technology applicable to a source located in a nonattainment area is established based upon the term Lowest Achievable Emission Rate. This term means that level of emissions which reflects the most stringent emission limitation that is contained in the Implementation Plan of any state or the most stringent emission limitation which is achieved in practice on such class or category of source which ever is more stringent.
Mandatory Class I Area	The term means Federal areas which may not be designated as other than Class I areas under the Clean Air Act Amendments of 1977. These areas are specified in Section 162(a) of the Act.
Modification	Any physical change in the method of operation or an addition to a stationary source, which increases the potential emission rate of any pollutant regulated under the Act by either 100 tons/year or more for any source category identified by the New Source Performance Standards or by 250 tons/year or more for any stationary source.
National Ambient Air Quality Standards (NAAQS)	The Clean Air Act Amendments of 1970 required that specific pollutant concentration levels be identified for the protection of human health (i.e., Primary Standard) and welfare (i.e., Secondary Standards) for each of the criteria pollutants. These specific pollutant levels comprise the National Ambient Air Quality Standards.

National Emissions Standards for Hazardous Air Pollutants (NESHAPS)	Standards promulgated for air pollutants for which no ambient air quality standard is applicable and which in the judgement of the Administrator cause or contribute to air pollution which may reasonably be anticipated to result in an increase in mortality or an increase in serious irreversible or incapacitating reversible illness.
New Source	Any new structure, building, facility, equipment, installation or operaiton which is located on one or more continuous or adjacent properties and which is owned or operated by the same person.
New Source Performance Standards (NSPS)	National Standards promulgated by the USEPA which set emissions limitations for standards of performance for each of 28 separate categories of stationary sources.
New Source Review	No major emitting facility on which construction is commenced after the date of the enactment of the Clean Air Act Amendments of 1977 may be constructed in any area unless the formal permit application process has been completed in accordance with regulations required by Section 165 of the Clean Air Act Amendments of 1977.
No Burn Day	A no burn day is any day on which a designated person or agency determines that certain specified burning is not permitted.
Nonattainment Areas	The term nonattainment area means, for any air pollutant, an area which is showed by monitored data or, which is calculated by air quality modeling, to exceed any National Ambient Air Quality Standard for such pollutant.
Offsets	Soruces locating in nonattainment areas, must obtain emission reductions form other existing sources in the region that more than offset the increase in emissions from the new source. Such offsets must produce a positive net air quality benefit resulting in reasonable further progress toward attainment of the applicable standard.

Permit Moratorium	The cessation of the air quality permitting process pending the resolultion of mandatory regulatory activity.
Potential Emissions	Potential Emissions refer to the maximum emission of pollutants in the absence of air pollutant control equipment.
Pre-Construction Review	No major emitting facility on which construction is commenced after the date of the enactment of the Clean Air Act Amendments of 1977 may be constructed in any area unless the formal permit application process has been completed in accordance with regulations required by Section 165 of the Clean Air Act Amendments of 1977.
Prevention of Significant Deterioration	Specific requirements contained in the Clean Air Act Amendments of 1977 (i.e. Part C, Sections 160 through 169) designed to protect the air quality resource in regions of the country where present baseline pollutant levels are below the National Ambient Air Quality Standards.
Primary Standards	Standards promulgated as part of the National Ambient Air Quality Standards which set pollutant levels which provide an adequate margin of safety for public health.
Reasonably Available Control Technology (RACT)	The least stringent in the control technology heirarchy applicable to existing sources which require a level of control necessary to insure compliance with existing emissions regulations.
Retrofitting	The installation of additional control technology on existing sources of air pollutants.
Secondary Standards	Standards promulgated as part of the National Ambient Air Quality Standards which specify levels which protect the human welfare from known or anticipated adverse effects associated with a pollutants presence in the ambient air.

State Implementation Plan (SIP)	The concept of State Implementation Plans was introduced in the 1970 Clean Air Act Amendments. There purpose is to insure that the NAAQS are met in all areas of the country and require a transportation control plan, emissions limits for specific categories for sources and permit rules for new or modified sources of pollutants.

7. MONITORING RECOMMENDATIONS

7.1 GENERAL REQUIREMENTS

Possible alternatives for future land development of BLM lands within the Folsom District may require the preparation of extensive environmental research reports and impact analyses. In light of this fact, it is important to isolate areas currently under BLM administration that lack substantial onsite data necessary for the preparation of air quality and meteorological analyses. Additionally, areas within the Folsom District that require enhancement of the current existing data base must be identified so that transport and diffusion analyses can be accurately performed.

The ultimate objective is to be able to define air transport and dispersion characteristics and associated baseline ambient air quality levels within the Folsom District. An accurate and current data base provides the means to achieve this objective and enhances the credibility of regional environmental impact statements. It is of vital importance to all organizations concerned with future land development within the Folsom District, that the most accurate and complete environmental impact statements be developed.

A review of the previous sections describing regional air quality, dispersion meteorology and baseline climatology for the Folsom District indicates that certain areas lack the satisfactory historical data base necessary to provide a definitive characterization of these topical items which are essential in environmental analyses. Climatological data are generally adequate for all portions of the Folsom District. Ambient air quality data are readily available for most areas of the district where there exist substantial population centers. These cities and communities are well distributed along the Pacific Coast, the major coastal valley and hilly areas, and in the Central Valley. Detailed dispersion meteorological data are available at a few select locations throughout the district and represent the least resolved data base of all the major air quality components. Data are available to provide an assessment of <u>regional</u> dispersion for most of the Folsom District; however, the extent of the current data base available for <u>site-specific</u> dispersion analyses on lands under BLM administration is generally not satisfactory.

Lands within the Folsom District currently under BLM jurisdiction entail four basic geographical areas. As depicted in Figure 7.1-1, approximately 60% of the BLM lands in the Folsom District are near the foothills of the Sierra Nevada. Nearly 30% of BLM lands are located in the Coastal and Diablo Ranges in the counties of Monterey, San Benito and Fresno. The remaining 10% of BLM lands in the Folsom Distirct are in the coastal valley regions near San Jose and Salinas as well as within the rugged mountain regions near Markleeville, California.

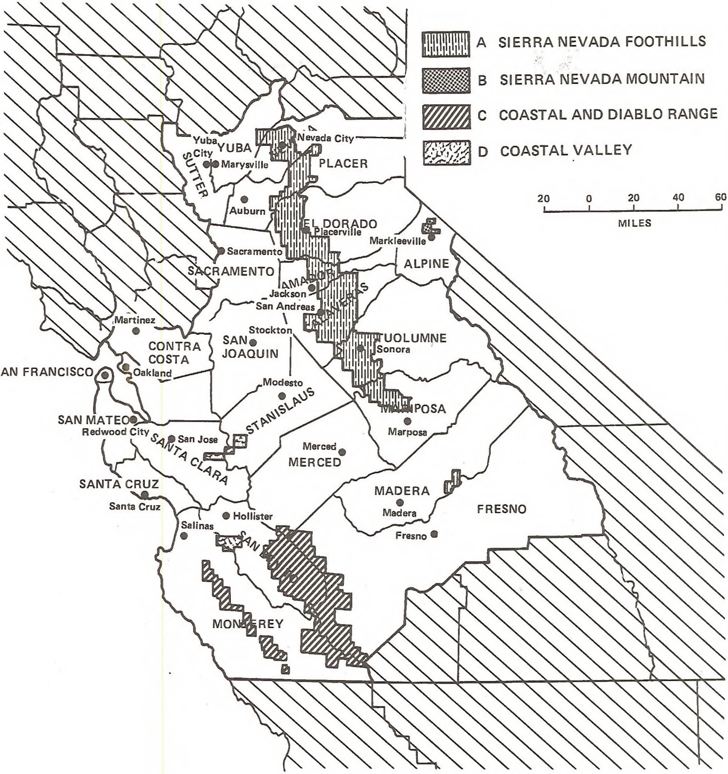


Figure 7.1-1
Categories of BLM Lands
in the Folsom District

Alternative future land uses for these areas may include construction or expansion of energy related facilities, other commerical industrialization, recreation, agriculture, forestry and many others. The development of BLM administered lands for these alternatives may require extensive and elaborate environmental impact assessments including air quality, dispersion meteorology and climatology. The most accurate environmental impact assessment is derived from a highly detailed site-specific data base. Hence, the adequacy of the air quality data base for specific areas of concern must be identified.

The Clean Air Act Amendments of 1977 required continuous monitoring data after August 7, 1978 in support of permit applications for new major sources of air contaminants. The monitoring is required for a period of one year unless (1) the analysis could be accomplished satisfactorily in a shorter period or (2) available offsite data exists which satisfactorily describes onsite conditions.

As discussed in Section 6, the need for monitoring in support of Prevention of Significant Deterioration (PSD) permit applications is based upon a potential to emit 100 tons or more per year of any pollutant regulated under the Clean Air Act for any one of 28 major emitting facilities identified by the Act. For other classes of industry, monitoring requirements are based on a potential emission rate of 250 tons per year. Monitoring is then required for TSP (total suspended particulates), SO_2, CO, O_3 and NO_2, unless it can be established that a source will exceed the emission requirement for only one pollutant, then only that pollutant need be monitored. Meteorological monitoring in support of the program must include (1) hourly average wind speed and direction, (2) hourly averaged atmospheric stability, (3) hourly surface temperature, and (4) hourly precipitation amounts. Monitoring at multiple sites for both air quality and meteorology is usually required in areas of rugged terrain. In most cases, monitoring will be required for a period of one year. This may be shortened, however, if the EPA agrees that worst case conditions will be established during a reduced time period. In the case that baseline conditions have been adequately established, this monitoring requirement may be waived. Further guidance relative to monitoring requirements is contained in the EPA Guideline Series OAQPS No 1.2-096, "Ambient Monitoring Guidelines for Prevention of Significant Deterioration (PSD)."

7.2 INSTRUMENTATION

This section provides a brief review of instrumentation that is commonly used to monitor the various air quality and meteorological parameters. A summary of costs associated with the management and operation of monitoring programs is also provided.

7.2.1 General Requirements

The purchase of an instrument requires the consideration of two classes of requirements:

1. General Instrumentation

2. Specific Objectives

There are many instrumentation requirements that will obviously depend on the specific objectives of the study for which the instrument is needed. There are, however, a number of instrument requirements that should be considered before the purchase of any instrument. The purpose of this section is to describe these general requirements so that a buyer will be able to distinguish between the instrumentation attributes that are important, and those that are only "window dressing". The EPA may be contacted for futher guidance on instrumentation and methods of procedure.

Reliability

Reliability is possibly the most important criterion for an instrument in continous use. Regardless of how accurately an instrument is calibrated and read, it must be reliable to give reproducible results.

Quality Control

Quality control are those activities performed to insure that equipment is maintained and calibrated within specifications.

Quality Assurance

Quality assurance is the method which verifies that quality control activities are performed, e.g., adherence to schedule, documentation, double checks, etc.

Accuracy

Accuracy is defined as the closeness of the instrument output reading to the true value of the parameter. The qualifications of an accurate instrument are as follows:

1. It is properly calibrated under known conditions

2. It has characteristics that are unchanging with time

3. The reactions of the instrument (dynamic response) to changes in the measured parameter are known to within the limits of error requirements.

Precision

Precision is generally defined as the degree of closeness of a series of readings of an unchanging parameter. There often is confusion between the terms accuracy and precision. One way of clarifying their meanings is through the use of the "bulls eye" analogy. Figure 7.2-1 depicts this analogy.

Sensitivity

Sensitivity is defined as the smallest change in the measured variable that causes a detectable change in the output of the instrument.

Simplicity

The lack of instrumentation experience among most observers makes this attribute a must for most meteorological and air quality instrumentation. The qualifications of a simple instrument are as follows:

1. Operational adjustments of the instrument should be simple
2. A simply written Standard Operating Procedures (SOP) manual should accompany the instrument
3. Adjustments that are not intended to be made by the purchaser should require a special tool.

Durability

Obviously, an instrument should be durable enough to survive vibrations and shock encountered in transportation, rough handling, etc. A meteorological or air quality instrument, in addition, should be able to perform reliably in all seasons of the year, and in a smoggy and corrosive atmosphere.

Convenience

Convenience of operation is definitely a must for an operational instrument. As a general rule, an instrument that is simple to operate is also convenient to operate.

Other requirements such as time constants, damping ratio, etc. are objective oriented, and will be covered in a later section.

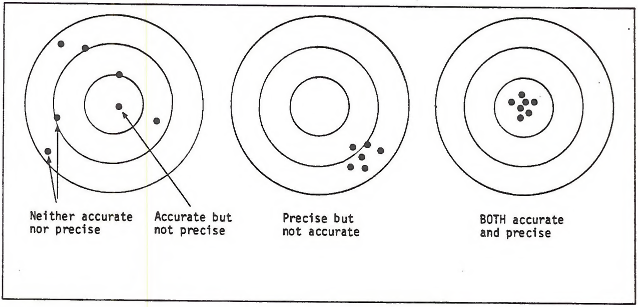


Figure 7.2-1
The Relationship Between
Instrument Accuracy and Precision

7.2.2 Meteorological Instruments

Measurement of atmospheric variables that affect the diffusion and transport of air pollutants is a necessity in nearly every air pollution investigation. Suitable measurements may be available from existing instrumentation at Weather Service city offices, airport stations, or from universities or industries with meteorological installations. Frequently, however, existing instrumentation does not give detailed enough measurements, is not representative of the area in question, or does not measure the variables desired (such as turbulence) and additional instruments must be operated.

Of primary importance in air pollution meteorology is the measurement of wind, including both velocity (direction and speed) and the turbulence. The stability of the lower layers of the atmosphere in which the pollution diffuses is important and may be determined from an analysis of the turbulence characteristics of the atmosphere or the temperature lapse rate.

Of secondary importance is the measurement of humidity (which may affect atmospheric reactions), temperature, precipitation (of importance in washout of pollutants), and solar radiation (which affects photochemical reactions in the atmosphere). Particularly for research studies, it may also be desirable to measure meteorological elements affected by pollutants, such as visibility, solar radiation, and illumination (radiation in the visible range).

Wind Measurements - Surface Instrumentation

- Wind Speed

  Generally, wind speed sensors are broken down into the following categories:

  a. Rotational Anemometers
     1) Vertical Shaft
     2) Horizontal Shaft

  b. Pressure Anemometers
     1) Flat Plate Type Anemometer
     2) Tube Type Anemometer

  c. Bridled Cup Anemometer

  d. Special Types
     1) Hot Wire Anemometer
     2) Sonic Anemometer
     3) Bivane
     4) Vertical/Horizontal (UVW) Anemometer

Pressure anemometers, hot wire and sonic anemometers have enjoyed extensive use in research type operations, but they all have disadvantages which have prohibited their use in operational type situations, such as air pollution surveys. The rotational type anemometers are the most common type of wind speed sensor in use today mainly because they are the only types that satisfy all of the following desirable operational features:

a. Essentially linear relationship between the sensor output and the wind speed;

b. Calibration unaffected by changes in atmospheric temperature, pressure or humidity;

c. Able to measure a wide range of wind speeds (<2 to 200 mph [.9 to 90 m/s]).

d. Long term calibration stability, or calibrations that remain unchanged after 10 years continuous operation;

e. Output of the sensor easily adapted to remote indication;

f. Recording of the wind speed data easily adaptable to either analog or digital form; and

g. Generally an extremely small maintenance requirement.

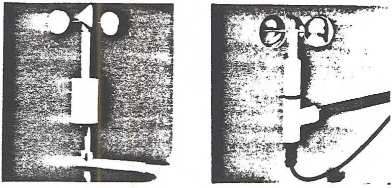
Figure 7.2-2 provides a visual review of routinely available anemometers.

- Wind Direction

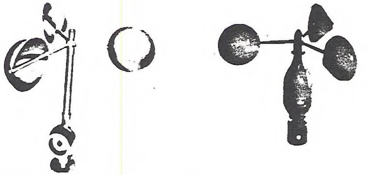
Wind direction sensors are visually presented in Figure 7.2-3 (a-p). They include; (1) flat plate vanes (a, b, c, d, g, i, k, l), (2) splayed vanes (e, f, h, p) and (3) aerodynamic shaped vanes (j, m, n, o).

The splayed vane of Figure 7.2-3 has, mainly because of its durability and reliability, found widespread use in its role as the main wind direction sensor for the National Weather Service. It should be noted that wind direction data obtained from the National Weather Service should be used only as an indication of average wind direction.

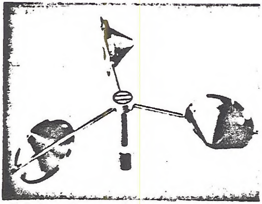
A bi-directional vane is designed to rotate around a vertical axis to measure the azimuth angle of the wind, as does a conventional wind vane. It also can move in the vertical to measure the elevation angle of the wind. Because the vertical motions of the atmosphere are frequently of a different character than the horizontal motions (anisotropic turbulence), measurement of both the horizontal and vertical motions are desirable. This is particularly true under stable conditions when the



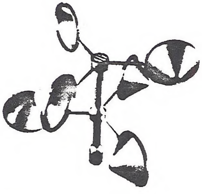
Climet Inst. Co. (a) R.M. Young Co. (b) Belfort Inst. Co. (c)



Henry J. Green Co. (d) Electric Speed Indicator Co. (e) Science Associates Inc. (f)

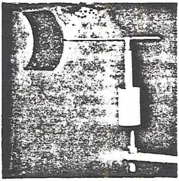


Teledyne-Geotech (Bkmn & Whtly) (g)

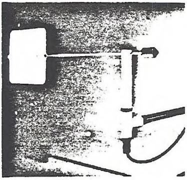


Teledyne-Geotech (Bkmn & Whtly) (h)

Figure 7.2-2
Cup Anemometers

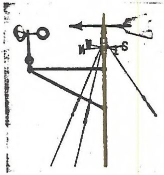


Climet Inst. Co. (a)

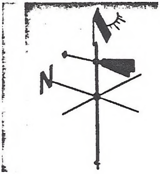


R.M. Young Co. (b)

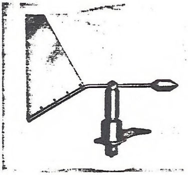
Belfort Inst. Co. (c)



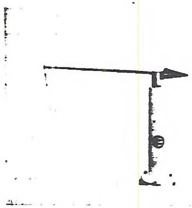
Science Associates Inc. (g)



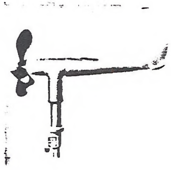
Epic Co. (h)



Epic Co. (i)



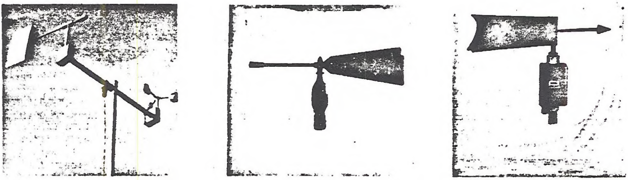
Bendix Co. (m)



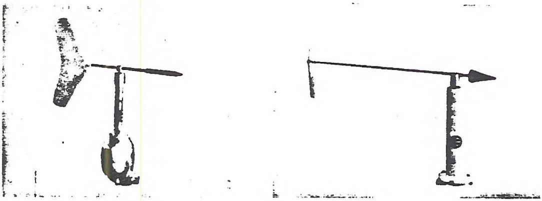
Belfort Inst. Co. (n)

Teledyne-Geotech (l)

Figure 7.2-3
Wind Vanes



Wong Lab. (d) Electric Speed Indicator Co. (e) Science Associates Inc. (f)



Teledyne-Geotech (j) Teledyne-Geotech (k)

Raim Inst. Co. (o) Epic Co. (p)

Figure 7.2-3 (Cont.)
Wind Vanes

vertical motion is almost absent, but horizontal changes in wind direction may be appreciable. Micro-potentiometers are usually used to produce an analog record of both angles. The total wind speed can be measured by replacing the counterweight with a propeller anemometer. Figure 7.2-4 shows two typical anemometer bivanes.

Wind Measurements - Airborne (Winds Aloft)

Fixed location wind velocity sensors measure the wind at a fixed height as it varies with time. Most airborne sensors are used to average wind velocity through a given depth of the atmosphere at a particular time.

- Pilot Balloon (pibal)

  This method of measuring wind velocity uses a gas-filled free balloon (Figure 7.2-5) which is tracked visually through a theodolite. The theodolite is an optical system used to measure the azimuth and elevation angle of the balloon.

  a. Single Theodolite Pibals

     When only one theodolite is used, the balloon is inflated to have a given amount of free lift. The elevation and azimuth angles are used with the assumed ascent rate to compute wind directions and speeds aloft. A theodolite is shown in Figure 7.2-6.

  b. Double Theodolite Pibals

     By this method, the ascent rate of the balloon is not assumed, but calculated from the elevation and azimuth angles of the two theodolite observations taken simultaneously. The two theodolites are set a known distance apart (the baseline). Two types of pilot balloons frequently used reach 3000 ft. within 5 minutes and 8 minutes, respectively, after release. If detailed structure of winds with height is to be determined, readings of azimuth and elevation angle must be read every 15 or 30 seconds.

- Rawinsonde

  This method of measuring wind velocity aloft also uses a gas-filled free balloon, but it is tracked either by radio direction finding apparatus, or by radar. The former method is that most frequently used in the U.S. The radio transmitter carried by the free balloon is usually used to transmit pressure, temperature and humidity information to the ground (radiosonde). The

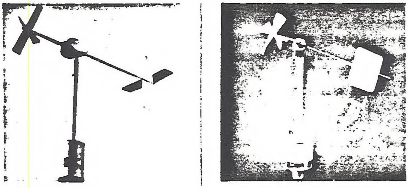


Figure 7.2-4 Anemometer Bivanes

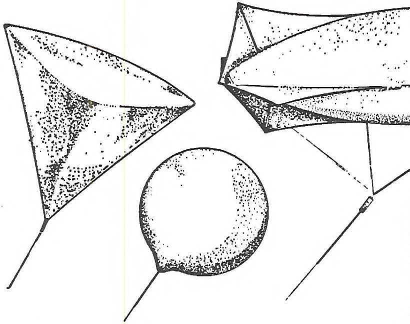


Figure 7.2-5 Meteorological Balloons (L to R - Tetroon, Pilot Balloon, Kytoon)

Figure 7.2-6 Theodolite

radio direction finding equipment determines the elevation angles and azimuth angles of the transmitter. The height is determined by evaluation of the temperature pressure sounding. Using radar, the slant range is available for determining height. Soundings taken with this type of equipment are made on a routine basis for supporting forecasting and aviation activities. The ascent rate of these balloons is on the order of 1000 feet/minute, so they do not yield as much detailed information on winds in the lowest part of the atmosphere as is desired for many air pollution meteorological purposes.

- Rocket Smoke Plumes

  A system using a cold propellant, recoverable rocket to emit a vertical smoke trail to an altitude of 1200 feet has been developed. This smoke trail is photographed simultaneously at short time intervals by two cameras 2000 feet from the launch site, at right angles to each other. The difference in position of the smoke trail from two successive photographs is a measure of one component (north-south for example) of the wind and can be determined at any number of heights from ground level to 1200 feet. Another similar system has been reported by Cooke (1962).

- Constant Level Balloons

  Unlike the previous airborne sensors for wind velocity which obtain average measurements through a vertical layer, constant level balloons are used to determine the trajectory or path of an air parcel during a given time interval. In order to maintain a constant altitude (more accurately to fly along a constant air density surface) the balloon must maintain a constant volume. A tetrahedron shaped balloon (tetroon) of mylar has been used for this purpose (Figure 7.2-5). These have been tracked visually and by radar (Angell and Pack, 1960).

Temperature Lapse Rate

The vertical structure of temperature gives an indication of the stability and turbulence of the atmosphere.

- Temperature Difference Measurements

  One method of estimating the vertical structure of temperature is by measuring the difference in temperature between sensors mounted at different heights. This, of course, gives an average condition between any two particular sensors.

- Balloon-borne Sensors

Temperature sensors may be lifted by either free or captive balloons. By these methods, temperature, not temperature difference, is measured.

1. Radiosonde

The method of radiosonde (radio-soundings) observations is used routinely for temperature, pressure and humidity soundings of the upper air. A free balloon carries the sensors and a radio transmitter aloft. Cycling from sensor to sensor is accomplished by means of an aneroid barometer, and consequently, is a function of pressure. Observations are normally made twice daily at 0000 GMT and 1200 GMT at approximately 70 stations in the contiguous U.S. The ascent rate of the balloon is about 1000 ft/minute. Generally only 4 to 6 temperature readings are recorded within the lower 3000 feet, so the vertical temperature information is not too detailed, but it is still of considerable use when more detailed information is not available.

2. T-Sonde

This system consists of a temperature sensor and radio transmitter which is carried aloft by a free rising balloon. The main difference between this system and the radiosonde system is that only temperature is measured. Ten to twelve measurements are taken within the lower 3000 feet of the atmosphere, thus giving a more detailed structure of temperature with height.

3. Tethered Kite Balloon

Using a captive balloon system to make vertical temperature measurements has the advantages of both a complete recovery of all components of the system, and as detailed a temperature sounding as is desired may be made by controlling the level of the sensor. A balloon having fins is much easier to control and gives greater lift in slight winds than a spherical balloon (see Figure 7.2-5). Most kite balloons can be used in winds less than 15 knots and for air pollution meteorology purposes, these light wind periods are of greatest interest. Because of hazards to aircraft, prior permission from the FAA is required for flights exceeding 500 feet above ground and several methods of relaying the observation to the ground have been used.

- Aircraft Borne Sensors

  In some cases, light aircraft or helicopters have been used for obtaining temperature lapse rate measurements. Although there are complete systems commercially available for this metod of temperature lapse rate measurement, one can use standard temperature sensors (thermisters, resistence thermometers, etc.) and recorders, as long as exposure guidelines are followed.

Precipitation

Because large particles and water soluble gases may be removed from the atmosphere by falling precipitation, measurements of this element may be needed. Chemical or radioactive analysis of rainwater may also be desired.

- Standard Rain Gauge

  The standard rain gauge consists of a metal funnel 8 inches in diameter, a measuring tube having 1/10 the cross-sectional area of the funnel, and a large container 8 inches in diameter (Figure 7.2-7). Normally, precipitation is funneled into the measuring tube and the depth of water in the tube is measured using a dip stick having a special scale (because of the reduction in area). Measurements with this instrument, because they are made manually, yield only accumulated amount since the last measurement.

Humidity

Because of its influence upon certain chemical reactions in the atmosphere and its influence upon visibility, it may be desirable to measure humidity in connection with an air pollution investigation. Also, some air pollutants affect receptors differently with different humidities, so measurement may be important in this respect.

- Hygrothermograph

  This instrument measures both temperature and humidity by activating pen arms to give a continuous record of each element on a strip chart. The chart generally can be used for 7 days. The humidity sensor generally uses human hairs which lengthen as relative humidity increases and shorten with humidity decreases. Temperature measurements are usually made with a bourdon tube which is a curved metal tube containing an organic liquid. The system changes curvature with changes in temperature, activating the pen arm. A hygrothermograph is shown in Figure 7.2-8.

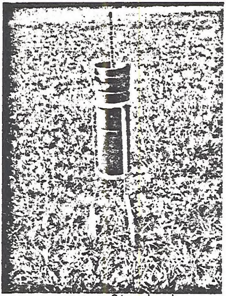


Figure 7.2-7 - Standard Rain Guage

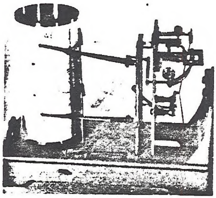


Figure 7.2-8 - Hygrothermograph

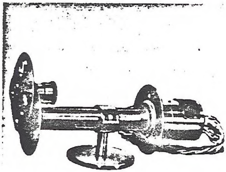


Figure 7.2-10 - Pyrheliometer

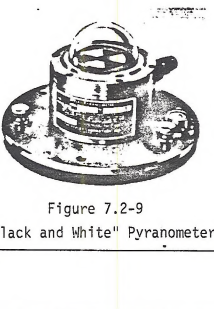


Figure 7.2-9

"Black and White" Pyranometer

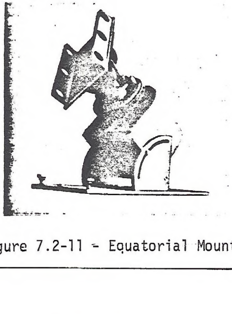


Figure 7.2-11 - Equatorial Mount

- Psychrometers

  Humidity measurement by a psychrometer involves obtaining a dry bulb temperature and a wet bulb temperature from a matched set of thermometers. One thermometer bulb (wet bulb) is covered with a muslin wick moistened with distilled water. There must be enough air motion to cause cooling of the wet bulb due to evaporation of the water on the wick. To obtain this a motor driven fan may be used to draw air at a steady rate past the moistened wick while a reading is taken. A sling psychrometer has both thermometers mounted on a frame which is whirled through the air to cause cooling by evaporation. Relative humidity is then determined from the dry and wet bulb readings through the use of tables. Continuous measurements of humidity, however, can not be obtained using psychrometers.

Radiation

The influence of the sun's radiation upon the turbulence of the atmosphere and upon certain photochemical reactions is sufficient to make measurements of radiation quite important. In addition, radiation may be reduced due to particulate pollution in the atmosphere. Particularly for research purposes, it may be desirable to measure this effect by comparisons between urban and non-urban stations with similar instruments.

- Total Radiation

  The direct radiation from the sun plus the diffuse radiation from the sky may be measured by pyranometers. These instruments are mounted so that the sensor is horizontal and can receive the radiation throughout the hemisphere defined by the horizon. The instrument illustrated in Figure 7.2-9 is of this type.

- Direct Solar Radiation

  The direct solar radiation may be measured continuously by using the pyrheliometer shown in Figure 7.2-10 mounted upon an equatorial mount (Figure 7.2-11) to keep it pointed toward the sun. By using filters, different spectral regions of radiation may be determined.

- Net Radiation

  The difference between the total incoming (solar plus sky) radiation and the outgoing terrestial radiation may be useful in determining the stability, and hence, the turbulent character of the lowest portion of the atmosphere. A net radiometer serves this purpose and is shown in Figure 7.2-12.

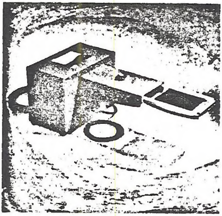


Figure 7.2-12
Net Radiometer

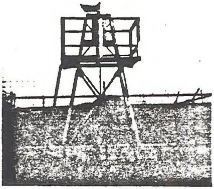


Figure 7.2-13
Transmissometer Detector

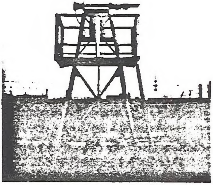


Figure 7.2-14
Transmissometer Receiver

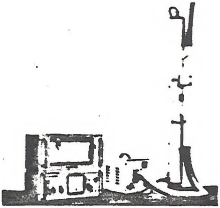


Figure 7.2-15
Integrating Nephelometer

Visibility

Visibility, in addition to being affected by precipitation, is affected by humidity and air pollution. Frequently, visibility is estimated by a human observer. An instrument to measure visibility, called a transmissometer, measures the transmission of light over a fixed baseline, usually on the order of 500 to 700 feet. An intense light source from the projector is focused on a photocell in the detector. The amount of light reaching the photocell over the constant baseline distance is assumed to be proportional to visibility. The transmissometer is restricted to estimating visibility in one direction only.

A transmissometer is also limited in that the light transmission it detects is affected mainly by liquid droplets in the air. It does not detect, to any great efficiency, the particulate matter in the atmosphere. The projector is shown in Figure 7.2-13 and the detector in Figure 7.2-14. A relatively new instrument, called a nephelometer, has been developed which measures the amount of light scattered by impurities, (mainly dust) and thus indicates visibility as it is affected by particulate matter in the atmosphere. It provides for continuous output, operating day or night, rain or shine and is relatively easy to calibrate. It is limited, however, in that measurements may be taken only at the instrument location. An integrating nephelometer is shown in Figure 7.2-15.

Another instrument used to determine visibility is the Vista Ranger (telephotometer), which provides radiance values of a target and the sky, contrast transmittance and data regarding target chromaticity. In other words, it is a telescope type instrument which looks at the sky and a target (such as a mountain peak) and measures the brightness contrast between the two and transmits information on the true color of what is seen. Measurements can be made over long path lengths (tens of Km) and provide quantitative and continuous output. The Vista Ranger, however, can be used only during daytime and readings are more accurate during times of higher sun angle and relatively clear skies.

7.2.3 Air Quality Instruments

The following paragraphs discuss sampling techniques for the measurement of the criteria pollutants TSP, SO_2, NO_2, CO, O_3 and non-methane (unreactive) hydrocarbons (NMHC). Sampling for more sophisticated pollutant species (e.g., sulfates, organic compounds, etc.) is beyond the realm of the discussion and reference is made to the bibliography for a more detailed discussion.

7.2.3.1 Particulates

Particulate pollutants are divided generally into dust that settles in air and dust that remains suspended as an aerosol. The physical consideration determining the class into which a particle falls is the particle diameter.

As a matter of working definition, particles larger than 10 inch diameter are usually thought of as "settleable" while those of a smaller diameter are referred to as "suspended".

Instruments designed to collect either class of particulates are ordinarily chemically passive physical collectors whose function is merely to permit measurement of the collected material without regard to the composition. Generally, the particulates encountered include various mineral dusts (i.e. metallic oxides, sand, carbon particles, flyash fibers and pollen). These particulates can be collected using equipment based on one or more of the following principles.

Dust Sampling by Gravity Settling (Dustfall)

Particles generally larger than 10 in diameter, which are known to settle from air and collect on horizontal surfaces, can be sampled merely by placing an open container in an outdoor area that is free from overhead obstructions. These collectors are ordinarily constructed of polyethylene, glass, or stainless steel, since the inside walls must be inert to atmospheric oxidative flaking, which would contribute to sample weight. In addition, identical dustfall containers should be employed in the same sampling network or where a comparison of results will be made. Figure 7.2-16 presents a simple dustfall collector.

In sampling rather large areas, such as entire communities, it is common to employ at least one dustfall container for every 10 square miles. On the other hand, when dustfall sampling is intended to measure the effect of a given industry or industrial complex, containers may be placed as close as a few hundred feet apart.

This basic working principal is the foundation for the atmospheric deposition station located in the Ukiah District. There are 40 to 60 similar stations nationwide measuring the following elements: SO_4^{-2}, NO_3^{-}, PO_4^{-3}, CO, NH_4, K^+, Na^+, Ca^{++}, Mg^{++}, and pH including total and free acidity and alkalinity and electrical conductivity. The objectives of this program are to measure atmospheric deposition, through precipitation and particulate settling, identifying spatial and temporal trends, to evaluate the importance of natural phenomena (volcanos, soil erosion, etc.) and human activities (power plants, industrial emissions, etc.) as they contribute to the total atmospheric deposition and finally, to research the effect these elements will have on activities such as agricultural, forest, range, fisheries and wildlife management.

Dust Sampling by High-Volume Filtration (The High Volume Sampler)

The high-volume (hi-vol) sampler (see Figure 7.2-17) employs the sloping roof of the shelter as a means for causing air entering the sampler under the eaves of the roof to change

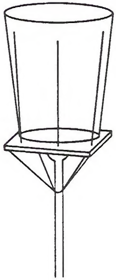


Figure 7.2-16
Simple Dustfall Collector

Figure 7.2-17
High Volume (hi-vol) Air Sampler

direction at least 90° before entering the horizontal filter. Particles that remain entrained in the air sample prior to horizontal filtration have, in so doing, satisfied the definition of truly suspended dust or dust that is not subject to settling under the influence of gravitational force.

The hi-vol is a vacuum cleaner-type motor that is used to draw sample air through a filter area. The filter most frequently employed is the 8 X 10 inch mat, which allows collection of an air sample at a rate from 40 to 60 cubic feet per minute (cfm) over a normal sampling period of 24 hours. These conditions permit the sampling of from 58,000 to 86,000 ft^3 of ambient air, with consequent extraction of about 1/2 gram of suspended particulate (aerosol). This provides quite a substantial weight of sample, which greatly simplifies subsequent chemical or physical analysis.

The motor is usually started and stopped by a simple clock timer, and the duration of sampling is measured by an elapsed time meter that is placed in series with the Hi-Vol motor. Starting and finishing times are at the discretion of the operator, although the EPA recommends starting and finishing from midnight to midnight--24 hours every sixth day. The National Air Sampling Network operates such samplers over the entire country. On the other hand, short-term studies to determine day-to-day variation in particulate levels may require continuous daily 24-hour sampling.

7.2.3.2 Continuous Gas Analyzers

In general, these instruments are based on one of the following principles of operation: colorimetry, atomic or molecular absorption, chemiluminescence, conductivity, coulometry, or combustion.

In the past, colorimetric instructions have been used with varying degrees of success to monitor air by adapting classical color-forming reactions to such plumbing and electronics as were required to produce continuous recorded data. More recently, however, the realm of solid-state physics has produced gas-sensing equipment that respond to physical rather than chemical properties at even the lowest levels of gaseous air contaminants.

Therefore, emphasis is placed on the more recent physical instrumentation for the individual air contaminants. Future development in continuous air monitoring systems will probably be along the lines of physics rather than solution or chemical measurement.

Carbon Monoxide

Automated continuous methods for CO include applications of gas chromatography, nondispersive infrared absorption, catalytic oxidation, and displacement of Hg from HgO to produce mercury vapor.

The most commonly used instruments for CO measurement are those which use the principle of nondispersive infrared, employing either a long path (40 in) or, more recently, a 10 cm (0.39 in) path of infrared radiation.

These analyzers depend on the characteristic energy of absorption of the CO molecule at not only its absorption wavelength maximum of 4.6 but also at a number of equally specific lines ranging from 2 to 15 , which together differentiate CO from such interferences as CO_2, H_2O, SO_2 and NO_2.

As shown in Figure 7.2-18, these instruments employ a heated filament as the source of radiation, a chopper to alternate radiation between the sample and reference cells, a sample cell (usually copper or brass), a reference cell of the same material, and a detector.

Sulfur Dioxide (SO_2)

Among the earliest applications of continuous analyzers to ambient air monitoring were those involving measurement of SO_2. Both continuous and intermittent (sequential) sampling methods have been employed. These often made use of the colorimetric method of West and Gaeke. The West-Gaeke method was first adopted as the approved reference method by the National Air Pollution Control Association (NAPCA, 1969), before being replaced by the EPA colorimetric method.

For the past several years, the monitoring of sources such as kraft paper mills and oil refineries, whose emissions require a continuous total sulfur analyzer, has been accomplished by means of a total combined-sulfur flame photometer.

In this analyzer, sample air is admitted into a hydrogen-rich air flame. Specificity to sulfur arises from the use of a narrowband interference filter that shields the photomultiplier tube detector from all but the 394 mμ emission energy of flame-excited sulfur atoms.

Nitrogen Dioxide (NO_2)

Traditionally, continuous analyzers for NO_2 have employed the Griess-Saltzman modified colorimetric method. Recently, several continuous NO_2-measuring instruments operating on the principle of chemiluminescence have been marketed. Here, a photomultiplier detector is used to measure the luminescence produced in the gas phase reaction between ozone and NO.

This method directly measures NO rather than NO_2. It is mentioned here because it forms the basis for a reliable differential measurement of NO_2 through the use of a reducing medium

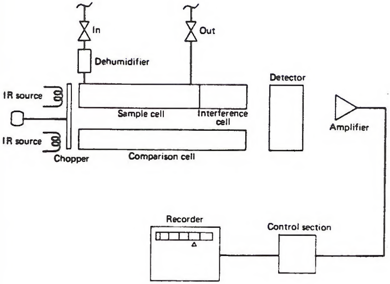


Figure 7.2-18
Diagram of Nondispersive Infrared Analyzer

such as stainless steel at 230°C, to convert NO_2 to NO. Subsequent reaction of NO, thus formed, with ozone produces chemiluminescence equivalent to NO_x, where NO_2 = NO - NO. The sensitivity of this method is reported as 0.01 ppm. To date, sufficient field experience has been obtained to indicate the overall reliability of the instrument over long periods of operation.

Ozone

The first chemiluminescence approach to a specific ozone determination probably was developed by Regener (1960) Regener found that, when air containing ozone contacts the surface of a plate prepared by absorbing rhodamine B on silica gel, a luminescence is produced from the chemical reaction. The intensity of the luminescence is proporational to the concentration of ozone present to concentrations as low as 0.001 ppm.

Regener's detector was found to be subject to a number of interferences, such as NO_2. It was soon followed by the Nederbracht (1965) detector, which employs the chemiluminescence of the ethylene reaction with ozone.

A number of commercially available analyzers have now been marketed. It appears that the ozone-ethylene chemiluminescent reaction, having been adopted by the EPA as a standard method for ozone, will soon become the basis for the common continuous ozone field analyzer. Figure 7.2-19 presents a schematic of a continuous chemiluminescence ozone meter.

Hydrocarbons

Commercial instruments that automatically measure hydrocarbons fall into two main categories:

1. The total hydrocarbon continuous monitor, and
2. The semicontinuous nonmethane hydrocarbon monitor.

Briefly, automatic monitoring of hydrocarbon levels depends on the fact that most organic compounds easily pyrolyze when introduced into an air-hydrogen flame. This pyrolysis produces ions that are collected either by the metal of the flame jet itself (charged negative) or by a cylindrical collecting grid (positively charged) that surrounds the flame. The sensitivity to organic materials varies slightly depending on the number and kind of ions. As a general rule, however, detector response is in proportion to the number of carbon atoms in the chain of the organic molecule. Thus, propane (three carbon atoms) gives roughly three times the intensity of response as does methane, and so on.

This "nonselectivity" is both an advantage and a disadvantage, depending on the information expected from the air analysis. Nonselectivity toward hydrocarbons, but selectiviity

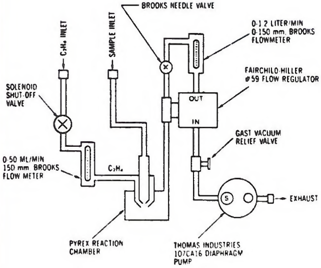


Figure 7.2-19
Diagram of Air-Ethylene System for
Continuous Chemiluminescent Ozone Meter

in the sense that other compounds do not cause response, provides this continuous instrument with the capability of measuring the whole general class of organic compounds without concern for interference. When the instrument response is calibrated using methane, the continuous strip chart readout is then a record of the real-time variation in ambient hydrocarbons as though they were 100% methane.

The Federal ambient air quality standard of 0.24 ppm (6:00 to 9:00 a.m.) average for nonmethane hydrocarbons necessitates the selective measurement of this class of compounds in preference to total hydrocarbons, especially when elevated levels of ozone are either known or suspected.

This analysis is accomplished by a differential measurement using the following procedure. First, small measured volumes of air are delivered intermittently (4 to 12 times/hr) to a flame ionization detector to measure total hydrocarbons. Following this measurement, another similar sample volume is admitted into a stripper column, which removes the relatively heavy non-methane hydrocarbons and water. The effluent from this column, consisting of methane and CO, then enters a gas chromatograph for separation. The methane, which exits first, passes unchanged through a catalytic reduction tube and into the detector, where it is recognized as methane. Carbon monoxide, which exits next, passes through a platinum-hydrogen reducing atmosphere, and emerges as methane. It is thus detectable by the ionizing flame where it is electronically recognized as CO.

Nonmethane levels for these sequential samples results from subtracting the signal of the methane hydrocarbons from the total hydrocarbons where nonmethane HC = total HC - methane HC.

7.2.4 Monitoring Program Operation

Monitoring programs require a diversity of skills for the successful management of a complete program. Key components of a monitoring program include:

- Site Selection
- System Design
- Equipment Selection and Purchase
- Initial Calibration and Installation
- Onsite Surveillance, Maintenance and Repair
- Quarterly Calibration
- Data Handling, Reduction, Summarization and Analysis
- Quality Assurance
- Report Preparation

The costs associated with air quality and meteorological monitoring programs can be enormous. Therefore, it is important to isolate the specific data requirements necessary for a particular study area.

Tables 7.2-1 and 7.2-2 recommend various types of air monitoring and meteorological instrumentation that can provide reliable data necessary for air quality/meteorological analyses. The cost associated with these particular types of instrumentation as presented in the tables include the purchase price only. Table 7.2-3 provides a review of total program costs as a function of the various components as detailed above. The range of cost varies from a simplistic approach (e.g., particulate sampling) to the sophisticated (e.g., full PSD permit support monitoring of gaseous, particulate and meteorological parameters). The prices vary from approximately $10,000 to $200,000 for a year of monitoring. A sophisticated, multiple site program can easily cost over one million dollars.

Figure 7.2-20 presents a schedule for the completion of a one-year monitoring program which indicates a 16 month period from project inception to completion. This schedule assumes that no problems arise. Realistically, it often takes two years to obtain one year of data.

Table 7.2-1

Summary of Air Quality Monitoring Equipment

Parameter	Manufacturer or Source	Model	Cost	Instrument Type and Comments
Total Suspended Particulates	General Metal Works, Inc. 8368 Bridgetown Rd. Cleves, Ohio 45002	Various	$500→$1000	High-Volume Sampler. Options include flow control, timer/ programmer, particle sizing, calibration kit.
TSP	Misco Scientific	Various	$500→$1000	High-Volume Sampler. Similar options. Special designs available.
TSP	Sierra Instruments	#305 & various	$500→$1000	High-Volume Sampler. Similar options.
Lead	Chemical analysis of TSP filters.	Same monitors as above.		
Sulfates	Chemical analysis of TSP filters.	Same monitors as above.		
Ozone	Dasibi Environmental Corp. 616 E. Colorado St. Glendale, CA. 91205	1003-AH	$4000.00	Chemiluminescent Analyzer. Probably the best, UV absorption priniciple.
Ozone	Monitor Labs, Inc. 4202 Sorrento Valley Blvd. San Diego, CA. 92121	8410E	$3025.00	Chemiluminescent Analyzer.
Ozone	Meloy Labs, Inc. 6715 Electronic Dr. Springfield, VA. 22151	OA 325-2R	$3130.00	Chemiluminescent Analyzer.
Ozone	Bendix P. O. Drawer 831 Lewisburg, W. Va. 24901	8002	$3950.00	Chemiluminescent Analyzer.
Ozone	Beckman Instruments, Inc. 2500 Harbor Blvd. Fullerton, CA. 92634	950 A	$3645.00	Chemiluminescent Analyzer.

Table 7.2-1

Summary of Air Quality Monitoring Equipment

(Continued)

Parameter	Manufacturer or Source	Model	Cost	Instrument Type and Comments
SO_2	TECO (Thermo Electron Corp.) 108 South Street Hopkinton, MA. 01748	43	$6850.00	Pulsed Fluorescent Analyzer
SO_2	Monitor Labs	8450E	$4900.00	Flame Photometric Detection (FPD) Analyzer
SO_2	Meloy Labs	SA 285-E	$4950.00	FPD Analyzer (4 linear ranges)
SO_2	Bendix	8300	$5885.00	FPD Analyzer
SO_2	Beckman	953	$6750.00	Chopped Fluorescence Analyzer
SO_2	Philips	PW 9755/02	$6800.00	Coulometric Titration Analyzer
$NO/NO_2/NO_x$	Monitor Labs	8440 E	$5375.00	Chemiluminescent Analyzer
$NO/NO_2/NO_x$	Bendix	8101 C	$5870.00	Chemiluminescent Analyzer
$NO/NO_2/NO_x$	TECO	14 B/E	$5775.00	Chemiluminescent Analyzer
$NO/NO_2/NO_x$	Meloy Labs	NA 530-R	$7500.00	Chemiluminescent Analyzer
$NO/NO_2/NO_x$	Beckman	952 A	$5890.00	Chemiluminescent Analyzer
Methane (CH_4) & total HC (THC)	Bendix	8201, 8202	$5490.00	Flame Ionization Detection (FID) Analyzer
Methane (CH_4) & total HC (THC)	Meloy Labs	HC 500-2C	$3780.00	FID Analyzer

Table 7.2-1

Summary of Air Quality Monitoring Equipment

(Continued)

Parameter	Manufacturer or Source	Model	Cost	Instrument Type and Comments
Methane(CH_4) & total HC (THC)	Mine Safety Appliances (MSA) Co. 400 Penn Center Blvd. Pittsburgh, PA 15235	11-2	$7200.00	Dual FID Analyzer
CO	Bendix	8501-5CA	$6295.00	NDIR Analyzer
CO	MSA	Lira M202S	$4270.00	NDIR Analyzer
CO, CH_y, HC, Ethylene	Beckman	6800 with options	$10→$15K	Out of production. Gas Chromatograph
CO, CH_y, HC Ethylene	Byron	Cannot locate any information.		
CO, CH_y, HC Ethylene	Bendix	Special Order	$9K→$12K	Any combinations available.
H_2S	(1) SO_x scrubber, then convert H_2S to SO_2 for SO_2 specific monitors.			
	(2) Direct measurement using total sulphur analyzers with SO_x scrubbers.			
H_2S	Meloy Labs	SA 285-E	$5100.00	FPD (2) Analyzer
H_2S	TECO	45	$8550.00	FPD (1) Analyzer
H_2S	Philips	PW 9780/00	$7000.00	FPD (2) Analyzer

Table 7.2-2

Summary of Meteorological Monitoring Equipment

Parameter	Manufacturer or Source	Model	Cost	Instrument Type and Comments
Wind Speed/ Wind Direction	Meteorology Research, Inc. (MRI) 464 West Woodbury Rd. Altadena, CA. 91001	1071	$2500.00	Anemometer. Mechanical Station; includes temperature, built-in recorder. Options.
WS/WD	MRI	1074-2	$3000.00	Anemometer. WS/WD sensors in one housing. Options. With signal processors.
WS/WD	MRI	1022	$2800.00	Anemometer. Individual sensors. Options. With signal processors.
WS/WD	MRI	1053	$4800.00	Anemometer. Measures azimuth, elevation, sigmas and WS. With signal processors.
WS/WD	Climatronics Corp. 1324 Motor Parkway Hauppauge, N.Y. 11787	EWS	$2300.00	Anemometer. AC/DC powered. Includes temperature, recorder. Options.
WS/WD	Bendix Corp. Dept. 81 1400 Taylor Ave. Baltimore, MD. 21204	120	$850.00	Anemometer. Aerovane. Translator Model 135 is $900.00.
WS/WD	Met-One, Inc. 154 San Lazaro Sunnyvale, CA. 94086	WS→#010 WD→#020	$1500.00	Anemometer. Micromet quality. With signal processors.
WS/WD	Met-One	WS→#014 WD→#024	$1100.00	Anemometer. AC/DC portable system. With signal processors.
WS/WD	Texas Electronics, Inc. P. O. Box 7225 Dallas, TX. 75209	446A	$1800.00	Anemometer. AC/DC with recorders and signal translator.

Table 7.2-2

Summary of Meteorological Monitoring Equipment

(Continued)

Parameter	Manufacturer or Source	Model	~ Cost	Instrument Type and Comments
WS/WD	Texas Electronics, Inc.	450LC-5	$2500.00	Anemometer. Includes signal translators and recorders.
WS/WD	R. M. Young Company 2801 Aero-Park Drive Traverse City, MI. 49684	12002	$1200.00	Anemometer. Gill microvane/anemometer.* Includes signal translator.
WS/WD	R. M. Young Company	21003	$1800.00	Anemometer. Gill anemometer bivane.* Includes signal translator.
WS/WD	R. M. Young Company	35003	$1500.00	Anemometer. Gill propeller vane.* Includes signal translator.
Temperature	MRI**	840-1	$900.00	Thermometer. Power aspirated. Includes signal translator.
T	MRI	815-1	$650.00	Thermometer. Naturally aspirated. Includes signal translator.
T	Met-One**	Shield→#076 Sensor→#060A	$650.00	Thermometer. Power aspirated. Includes signal translator.
T	Met-One	Shield→#071 Sensor→#063	$550.00	Thermometer. Vane aspirated. Includes signal translator.
T	Texas Electronics	R2-1015	$500.00	Thermometer. Naturally aspirated. Includes signal translator and recorder.

* Fragile - not for rugged environments.

** Also can supply ΔT systems.

Table 7.2-2

Summary of Meteorological Monitoring Equipment

(Continued)

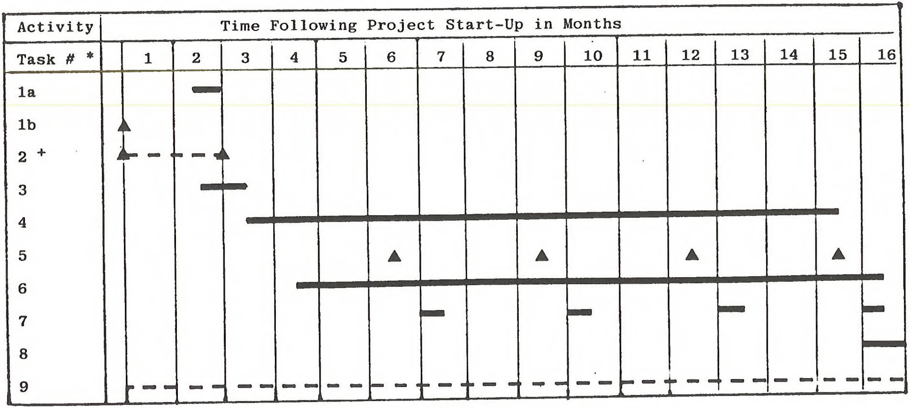
Parameters	Manufacturer or Source	Model	Cost	Instrument Type and Comments
T	R. M. Young Company**	Shield #43103A Sensor #78-0039-0007	$550.00	Thermometer. Naturally aspirated. Includes signal conditioner.
T	R. M. Young Company	Shield #4304A Sensor #78-0039-0007	$750.00	Thermometer. Power aspirated. Includes signal conditioner.
Precipitation	MRI	304	$900.00	Rain gauge. Built-in recorder, battery operated.
Precipitation	MRI	302	$600.00	Rain gauge. Includes signal conditioner. (No recorder.)
Precipitation	Climatronics	100097	$650.00	Rain gauge. Includes signal translator.
Precipitation	Texas Electronics	R2-1014P	$700.00	Rain gauge. Includes signal translator and recorder.
Visibility	MRI	1590	$4000.00 to $4500.00	Integrating nephalometer. Dependent on visual range requirements.
Visibility	MRI	3030	$4300.00	Vista Ranger. Measurer over large path (tens of km). Quantitative & continuous output.

Table 7.2-3
Summary of Monitoring Program Costs

Site Selection	~$1000
System Design	~$ 500 - $3000
Equipment Selection and Purchase	~$2000 - $100,000
Installation and Initial Calibration	~$ 500 - $5000
Onsite Surveillance, Maintenance and Repair	~$5000 - $50,000
Quarterly Calibrations	~$ 500 - $5000
Data Handling, Reduction, Summarization and Analysis	~$1000 - $10,000
Quality Assurance	~$ 500 - $5000
Report Preparation	~$1000 - $10,000

Figure 7.2-20

Proposed Project Schedule



Tasks

*

+

1. Task Organization
    a) Job Procedure (JP) and Quality Assurance (QA) Manuals
    b) Site Visit
2. Equipment Ordering and Initial Calibration
3. Installation and Initial Calibration
4. Onsite Surveillance
5. Quarterly Calibrations
6. Data Reduction
7. Quarterly Reports
8. Final (Annual) Report
9. Task Management

7.3 FOLSOM DISTRICT MONITORING REQUIREMENTS

Specific regions within the Folsom District lack substantial air quality, dispersion meteorology and climatological data necessary for Environmental Impact Statement (EIS) development and would require onsite air quality and/or meteorological monitoring programs to supply supportive data for future analyses. Table 7.3-1 provides an evaluation of the adequacy of the current data base for air quality impact analyses for lands currently under BLM jurisdiction. A satisfactory rating indicates that sufficient data exists within the particular area to provide site-specific information necessary to accurately describe the air quality/meteorological baseline. An unsatisfactory rating indicates that insufficient site-specific data are available for use in future EIS level analyses.

As outlined in Table 7.3-1, climatological data are readily available for all BLM lands in the Folsom District. These data are generally adequate for accurate site-specific assessments. On the other hand, considerable data resolution would be necessary for site-specific dispersion meteorology and air quality assessments for the various BLM land areas in the Folsom District.

Sierra Nevada Foothill Region

For BLM lands along the Sierra Nevada Foothills, insufficient site-specific data are available specifically in terms of atmospheric stability, winds aloft, mixing height and visibility. Additionally, air quality monitoring programs are needed in these foothill regions to more accurately define baseline levels of all the important air pollutant constituents.

High Sierra

The BLM administers relatively few areas in the high Sierra. In the Folsom District, lands near and about Markleeville, California, currently are under the jurisdiction of the BLM. Considerable climatological data are available in this area to adequately quantify temperature, precipitation and the other significant climatological parameters for onsite analyses. However, data supportive of onsite analyses for dispersion meteorology and air quality are currently insufficient for this area.

Coast and Diablo Ranges

The BLM administers lands located in the Coastal and Diablo Ranges of the Folsom District. Data on dispersion meteorology are available for some BLM lands located in Fresno County. Data necessary for the characterization of site-specific winds aloft, mixing heights and visibility are currently insufficient in most of the regions in this area as indicated in Table 7.3-1. Air quality data for these areas are generally sufficient for most of the air pollution constituents, with the exception of

Table 7.3-1

Summary of the Adequacy of Climatological, Dispersion Meteorological and Air Quality Data for BLM Lands in the Folsom District.

Parameters	BLM Land Areas A Sierra Nevada Foothills	 B Sierra Nevada Mountains	 C Coastal and Diablo Ranges	 D Coastal Valleys
Climatology				
Temperature	Satisfactory	Satisfactory	Satisfactory	Satisfactory
Precipitation	Satisfactory	Satisfactory	Satisfactory	Satisfactory
Others	Satisfactory	Satisfactory	Satisfactory	Satisfactory
Dispersion Meteorology				
Wind Speed	Satisfactory[1]	Unsatisfactory	Satisfactory[2]	Satisfactory[3]
Wind Direction	Satisfactory[1]	Unsatisfactory	Satisfactory[2]	Satisfactory[3]
Stability	Unsatisfactory	Unsatisfactory	Satisfactory[2]	Unsatisfactory
Winds Aloft	Unsatisfactory	Unsatisfactory	Unsatisfactory	Unsatisfactory
Mixing Height	Unsatisfactory	Unsatisfactory	Unsatisfactory	Unsatisfactory
Air Quality				
TSP	Satisfactory[4]	Unsatisfactory	Satisfactory	Satisfactory
SO_2	Unsatisfactory	Unsatisfactory	Unsatisfactory	Satisfactory[5]
NO_x	Unsatisfactory	Unsatisfactory	Satisfactory	Satisfactory
O_3	Unsatisfactory[7]	Unsatisfactory	Satisfactory	Satisfactory
CO	Unsatisfactory	Unsatisfactory	Satisfactory[6]	Satisfactory[6]
Visibility	Unsatisfactory	Unsatisfactory	Unsatisfactory	Unsatisfactory

Satisfactory - Sufficient site-specific data to accurately describe a particular parameter for future EIS analyses.

Unsatisfactory - Insufficient site-specific data to accurately describe a particular parameter for future EIS analyses.

[1] In Placer and Calaveras Counties

[2] Only in Fresno County (i.e., Coalinga)

[3] Only at sites near Salinas

[4] Unsatisfactory in Nevada, Calaveras, and Mariposa Counties

[5] Satisfactory only in Santa Clara County

[6] Unsatisfactory in San Benito County

[7] Satisfactory in Mariposa County

sulfur dioxide data. Additionally, a characterization of baseline concentration levels of carbon monoxide in San Benito County would be difficult.

Coastal Valleys

For BLM lands in the coastal valley sufficient site-specific data are not available in order to accurately characterize certain dispersion meteorological parameters. Such parameters as stability, winds aloft, mixing heights, visibility and others require a more extensive data base to support a definitive onsite analysis. Adequate wind speed and wind direction data necessary for onsite analyses are available for BLM lands only in the vicinity of Salinas. In addition, baseline levels of sulfur dioxide are only well characterized in Santa Clara County. Similarly, a satisfactory air quality data base is available for carbon monoxide with the exception of those areas in San Benito County.

Future Monitoring

The monitoring requirements required in support of air quality permit applications are an oblibligation of the Applicant. The data have been presented to inform the Federal Land Manager (FLM) of monitoring requirements, as the role of the FLM in the protection of air quality has increased in recent years. The 1977 Amendments require the FLM To take an active role in EPA's PSD permit process. In addition, the FLM must actively protect the "air quality related values", primarily visibility, of Class I Areas (i.e., national parks, monuments and wilderness areas [See Section 6.4]).

The FLM is charged with ensuring "reasonable progress" toward meeting the national goal of remedying impairment to visibility in Class I Areas. To do this, a visibility baseline must be established. BLM is presently entering into a Cooperative Agreement with the EPA which will begin visibility baseline studies for Class I areas in California. This program will be an expansion of the EPA's Western Fine Particulate Network which includes forty stations uniformly distributed throughout Montana, North Dakota, Wyoming, South Dakota, Utah, Colorado, Arizona and New Mexico. The purpose of this study is to determine the impacts of western energy resource development. Particulate samples are taken twice weekly and undergo mass concentration and trace element analysis.

The visibility monitoring program will include two initial site locations. One site will be located in the Susanville District and one within a desert area of the Riverside District as mandated by the EPA. The objective of the program is to measure visibility, aerosal characteristics and climatology in remote areas influenced by industrial expansion and population growth. The program is also to differentiate between natural and man-made contributions to visibility degradation.

In addition to sophisticated visibility measurements by telephotometers, nephelometers and color photography, size segregated particulate sampling will be conducted with subsequent trace element analysis. The measurement program will be supported by basic meteorological monitoring including wind speed and direction, temperature and relative humidity.

In addition to these two sites, the Folsom District would be an excellent choice for the third station. BLM lands run north-south along the western slopes of the Sierra Nevada from Mariposa northward to Yuba Counties and there are several passes which serve as preferred exit routes for flow out of the Central Valley in this region. Some of these lead into existing Class I areas such as Yosemite National Park. This latter park, located in eastern portions of Tuolumne, Mariposa and Madera Counties, lies just east of BLM administered land areas along the western slopes of the Sierra Nevada. Such an area would serve as an excellent location for the siting of another visibility monitoring station. The actual location would be dependent upon a siting trip to evaluate such factors as accessibility, power availability, security and representativeness.

Baseline visibility is poorly defined in each of the BLM administered land areas located in the Folsom District and shown on Figure 7.1-1. However, monitoring programs should emphasize those areas that incorporate or are adjacent to Class I areas. For this reason, BLM land areas A and B on Figure 7.1-1 should be emphasized in the monitoring program.

7.4 GLOSSARY OF TERMS

Accuracy	The closeness of the instruemnt output to the true value of the parameter.
Anisotropic Turbulence	Turbulence which is directionally dependent.
Bi-Vane	A wind direction instrument designed to rotate around a vertical axis to measure the azimuth and elevation angle of the wind.
Chemiluminescence	The use of a filter multiplier detector to measure the luminescence produced in a gas phase reaction between two species.
Chromatograph	Analyzers used for the separation and measurement of volatile compounds and of compounds that can be quantitatively converted into volatile derivatives.
Colorimetry	The exhaustive quantitative electrolysis of a species being measured by electrolytic generation of a color free agent which reacts quantitatively with the measured species.
Conductivity	The property or power of conducting or transmitting heat, electricity, etc.
Constant Level Balloons	Constant level balloons are used to determine the trajectory of an air parcel at a desired pressure level during a given time interval.
Coulometry	Coulometric analysis is based on exhaustive quantitative electrolysis of the species being measured by electrolytic generation of an agent which reacts quantatively with measured species.
Durabilty	The ability of an instrument to survive vibrations and shock encountered in transportation, rough handling and normal operating conditions.
Dustfall	The simple collection of dust due to gravitational settling.
Dynamic Response	The real time reaction of an instrument.

Flame Ionization	The ionization of gas samples through their introduction into an air hydrogyn flame. Species specific ions are then measured by a detector which measures ion intensity resulting from the flame ionization of any organic compound.
Flame Photometry	The use of a hydrogen rich air flame to induce the emission of excited atoms specific to the pollutant being measured.
Griess-Saltzman Method	A continuous colorimetric method for NO_2 detection.
High-Volume Sampler	The collection of particulate matter on a filter medium through the collection of an air sample at a continuous standard rate.
Hydrothermograph	An instrument for the measurement of temperature and humidity through the use of human hairs which increase or shorten as a function of atmospheric moisture content.
Nephelometer	An instrument which indicates visibility impairment due to the presence of particulate matter in the atmosphere.
Net Radiation	The difference between the total incoming radiation and the outgoing terrestrial radiation.
Net Radiometer	An instrument for the measurement of net radiation.
Nondispersive Infrared Absorption	The use of the principal whereby gaseous compounds absorb infrared radiation at specific wave lengths. In nondispersive absorption, a detector is exposed to a wide wave length band of radiation.
Pilot Balloon	A method for the measurement of wind velocity and wind direction as a function of height using a gas filled free balloon.
Precision	The degree of closeness of a series of readings of an unchanging parameter.
Psychrometer	An instrument which combines a dry bulb and wet bulb thermometer for the subsequent calculation of humidity.

Pyranometer	An instrument used to measure direct radiation.
Pyrheliometer	An instrument used for the continuous measurement of direct solar radiation.
Radiosonde	The use of a free balloon to carry meteorological sensors and a radio transmitter aloft.
Rawinsonde	A method of measuring winds aloft using a gas filled free balloon and radio direction finding apparatus, usually radar.
Reliability	The ability of an air quality or meteorological instrument to provide reproduceable results.
Sensitivity	The smallest change in the measured variable that causes a detectable change in the output of the instrument.
Simplicity	Describes an instrument that can be operated by an individual through the use of Standard Operating Procedures.
T-Sonde	The use of a free balloon to carry a temperature sensor and radio transmitter aloft.
Theodolite	An optical system used to measure the azimuth and elevation angle of a pilot balloon.
Total Radiation	The direct radiation from the sun plus the diffuse radiation from the sky.
Transmissometer	An instrument used for the measurement of visibility through the measurement of the transmission of light over a fixed baseline. Usually on the order of 500 - 700 feet.
UVW Anemometer	An anemometer designed to measure wind speed in the horizontal (x and y directions) and vertical.

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