APPENDIX C
AIR QUALITY

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Particulate Matter Terminology

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PARTICULATE MATTER TERMINOLOGY

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Aerosols and Particulate Matter

Most people would interpret the term "aerosol" as indicating some type of liquid droplet or mist sprayed into the air. Similarly, most people would interpret the term "particulate matter" as implying a solid particle (such as dust or fly ash). Air pollution specialists, however, use the terms "aerosol" and "particulate matter" interchangeably; both terms can refer to either liquid or solid material suspended in the air. In many industrial applications the term aerosol implies small particle sizes with low settling rates; a similar connotation is sometimes evident in air pollution discussions.

Suspended particulate matter is sometimes characterized as a "dispersion aerosol" or a "condensation aerosol" according to the mechanism of formation. Dispersion aerosols are formed by mechanical abrasion (for solid particles), atomization (for liquid particles), or mechanical dispersion (for powdery solids). Condensation aerosols are formed by a phase change of gaseous compounds (e.g., by condensation of saturated or supersaturated vapors) or by chemical reactions of gases to form nonvolatile compounds.

Particle Size Terminology

Size, shape, and density are important physical characteristics of suspended particulate matter. Particle dimensions can be discussed using many different units of measure. The most common size unit used in air pollution discussions is the micrometer or micron. There are 1 million microns in a meter and 25,400 microns in an inch; 1 micron is 0.001 milimeters or 0.00003937 inches. Most people cannot distinguish individual particles with a maximum physical dimension smaller than 50 microns.

Most solid particles have fairly complex and irregular shapes, thus complicating any description of physical size. Because many different techniques are used to collect and analyze suspended particulate matter, it is important to distinguish between the various technical terms and descriptions that are commonly used to describe particle size.

Although particle size terminology implies a physical size measurement, most air pollution discussions of particle size are not based on the physical dimensions of suspended particles. In many cases, particle size terminology is merely used as a convenient shorthand for describing the aerodynamic behavior of suspended particles.

Physical particle size is important to many industrial process operations. Pollution control and medical considerations, however, are more easily addressed by considering particle behavior rather than particle size per se. Two considerations of special importance to pollution control and medical evaluations are the rate at which particles settle in still air and the extent to which particles in a moving air stream will be removed by inertial impaction if the air stream follows a bent or curved path. Large, dense particles settle rapidly and are easily removed from an air stream by inertial impaction; small, low density particles settle very slowly and tend to follow a bent or curved air stream pathway.

Approximately 20 different particle diameter definitions can be found in relevant literature from such diverse fields as soil science, geology, geomorphology, health physics, atmospheric sciences, microscopic analysis procedures, and industrial process engineering. Much of the published literature on particle size distributions simply refers to particle diameter or particle radius without clarifying which specific definition is being used. Some of the literature merely refers to particle size without clarifying whether the size value refers to a diameter or a radius.

The use of similar terminology by different disciplines is no assurance of a common definition. Both soil scientists and atmospheric scientists sometimes discuss the particle sizes involved in wind erosion processes by referring to "equivalent diameters". Unfortunately, the technical definitions of "equivalent diameter" used by these two disciplines are very different.

Even closely related disciplines use different definitions. Although both disciplines use quartz as a reference mineral in their particle size definitions, the "equivalent diameter" of soil scientists is not the same as the "equivalent hydraulic diameter" of sedimentologists and geologists. From a mathematical standpoint, the "equivalent hydraulic diameter" of sedimentologists and the "equivalent diameter" of atmospheric scientists are true equivalent diameters while the "equivalent diameter" of soil scientists is not.

The definitions used or implied most frequently in data relevant to ambient air quality discussions are presented below. Allen (1990) and Syvitski (1991) provide additional particle size definitions. A sieve diameter is usually implied when large particles have been mechanically sorted into size categories. Particle size data derived from settling velocity analyses generally will be reported as sedimentation diameters. Particle size determinations based on microscopic examination may reflect any of several definitions, with Feret's diameter, Martin's diameter, and the projected area diameter being common definitions. Particle size information provided by ambient air quality sampling instruments usually refers to the aerodynamic equivalent diameter.

Sieve Diameter. The sieve diameter of a particle is the width of the minimum square aperture through which the particle will pass. Because many particles have complex physical shapes, the sieve diameter will often be larger than the minimum physical dimension and smaller than the maximum physical dimension of the particle.

Martin's Diameter. Martin's diameter is calculated from the image of a particle viewed or photographed through a microscope. Martin's diameter is the length of a line (drawn in some fixed orientation) that bisects the particle image into two portions of equal area. Martin's diameter is determined for many individual particles, with the individual measurements used for statistical summaries.

Feret's Diameter. Feret's diameter is calculated from the two-dimensional image of a particle (generally viewed or photographed through a microscope). Feret's diameter is calculated as the distance between two tangents on opposite sides of the particle parallel to some fixed direction. Feret's diameter is determined for many individual particles, with results of the individual measurements used for statistical summaries.

Long Axis. The long axis of a particle viewed or photographed through a microscope is the maximum Feret's diameter when all possible tangent pair orientations are considered for the individual particle. Some references use the terms "maximum horizontal intercept" or "longest dimension" rather than long axis.

Maximum Chord. The maximum chord for a particle viewed or photographed through a microscope is the maximum length of a line parallel to some fixed orientation and contained entirely within the perimeter outline of the particle. Complex particle outlines may cause the maximum chord to be smaller than the corresponding Feret's diameter.

Perimeter Diameter. The perimeter diameter of a particle is the diameter of a circle having the same circumference as the perimeter of a particle viewed or photographed through a microscope.

Projected Area Diameter. The projected area diameter of a particle is the diameter of a circle having the same enclosed area as the outline of the particle (generally viewed or photographed through a microscope). Two different projected area diameter definitions are in widespread use. One definition is based on particles in a random orientation. The other definition is based on particles resting in a stable orientation. The projected area diameter is generally larger than Martin's diameter and smaller than Feret's diameter. Some references use the term "nominal sectional diameter" instead of projected area diameter.

Equivalent Spherical Diameter Because most suspended particulate matter has an irregular shape, the equivalent spherical diameter (generally referred to simply as the equivalent diameter) is used as a standardized description of physical particle size. The equivalent diameter is calculated by measuring the volume of a particle and computing the diameter of a sphere having the same volume. Some references use the terms "volume diameter" or "true nominal diameter" instead of equivalent spherical diameter.

Sedimentation (Stokes) Diameter. The sedimentation (or Stokes) diameter of a particle is based on the terminal settling velocity of a particle in still air. The sedimentation diameter is the diameter of a sphere having the same terminal settling velocity and density as the particle. Some references use the term "free-falling diameter" for evaluations based on the terminal settling velocity in fluids other than air.

Aerodynamic Equivalent Diameter. The aerodynamic equivalent diameter of a particle also is based on the terminal settling velocity of a particle in still air. The aerodynamic equivalent diameter is the diameter of a sphere with a density of 1 gram per cubic centimeter that has the same terminal settling velocity as the particle. Thus, the aerodymaic equivalent diameter differs from the sedimentation diameter of a particle whenever the real particle has a density other than 1 gram per cubic centimeter. For convenience, the term "aerodynamic equivalent diameter" is often shortened to aerodynamic diameter.

Equivalent Hydraulic Diameter. Geologists, sedimentologists, and hydrologists interested in freshwater and marine sediment transport often use a type of equivalent diameter based on spheres with the density of quartz (2.65 grams per cubic centimeter). The equivalent hydraulic diameter of a particle is the diameter of a quartz sphere having the same settling velocity in water as the particle. The term "equivalent hydraulic diameter" is often shortened to hydraulic diameter.

Equivalent Quartz Grain Diameter. Soil scientists occasionally use the term "equivalent diameter" when discussing particle sizes associated with wind erosion, but define the term differently than do atmospheric scientists. The term used by soil scientists is less ambiguous if phrased as "equivalent quartz grain diameter". Soil scientists calculate their equivalent quartz grain diameter by multiplying the sieve diameter of a particle by the density of the suspended particle or particle aggregate and dividing that product by the particle density of quartz (2.65 grams per cubic centimeter). If particle aggregates are being considered, the density of the aggregate is treated as a bulk density (including pore spaces within the particle aggregate). The equivalent quartz grain diameter of soil scientists is not really an "equivalent" diameter in any mathematical sense, and will generally differ from the hydraulic diameter of sedimentologists.

Particle Size Ranges for TSP and PM10

Federal ambient air quality standards were first established in 1970. For some pollutants, separate standards have been set for different time periods. Federal ambient air quality standards are based primarily on public health protection criteria. The numerical values of various ambient air quality standards have been changed several times. In addition, the federal ambient air quality standards for suspended particulate matter have undergone a significant change in definition, as discussed below.

Until the mid 1980s, federal particulate matter standards applied to a broad range of particle sizes and were referred to as total suspended particulate matter (TSP) standards. The high volume samplers used at TSP monitoring stations are most effective in collecting particles with an aerodynamic diameter smaller than 30-50 microns, although larger particles also are collected (U.S. Environmental Protection Agency 1982, Lodge 1989).

Health concerns associated with suspended particles focus on those particles small enough to reach the lower respiratory tract (tracheo-bronchial passages and alveoli in the lungs) when inhaled. When breathing occurs through the nose, few particles with an aerodynamic diameter larger than 10 microns reach the lower respiratory tract. When breathing occurs through the mouth, some particles with aerodynamic diameters as large as 20 microns may reach the lower respiratory tract (U.S. Environmental Protection Agency 1982). It also should be noted that not all particles with small aerodynamic diameters reach the lower respiratory tract; some are removed in the nasal passages, mouth, or upper throat regions.

The federal air quality standards for particulate matter were revised in 1987 to apply only to "inhalable" particles (generally designated PM10) with a size distribution weighted toward particles having aerodynamic diameters of 20 microns or less. The particle size distribution implied by the PM_{10} definition is intended to approximate the size distribution of particles that reach the lower respiratory tract.

It is difficult to relate the former TSP and current PM_{10} standards to a precise range of physical particle sizes. Although the TSP designation does not have any obvious particle size connotations, the use of the word "total" in total suspended particulate matter implies 100% collection efficiency over a large range of particle sizes. As is explained below, very few particle sizes are sampled with 100% efficiency by a TSP sampler.

The PM_{10} designation seems to imply a rather precise size limit. The most widely used definition of PM_{10} is "particulate matter smaller than 10 microns in (aerodynamic) diameter." Unfortunately, that simple definition is both technically wrong and very misleading, as it implies an absolute physical or aerodynamic diameter size limit of 10 microns. The only absolute size limit that can be established for PM_{10} is substantially larger than 10 microns.

The true definitions of TSP and PM_{10} are most easily derived by considering the equipment used to collect samples of suspended particulate matter. As explained below, TSP is effectively any particulate matter collected with a conventional high volume TSP sampler.

PM_{10} is defined more rigorously, and represents a fractional sampling of suspended particulate matter that approximates the extent to which suspended particles with aerodynamic equivalent diameters smaller than 50 microns penetrate to the lower respiratory tract (tracheo-bronchial airways and alveoli in the lungs). The key feature of an accurate PM_{10} definition is the fractional sampling of cumulative particle mass. Particle size enters into the definition of PM_{10} as a probability distribution, not as a precise particle size limit.

Neither the human respiratory system nor mechanical collection devices provide absolute size discrimination of particle sizes. One cannot look at an individual airborne particle with an aerodynamic diameter below 50 microns and know with absolute certainty whether or not it would reach the lower respiratory tract if inhaled. Similarly, one cannot know with absolute certainty whether that specific particle would be collected by a PM_{10} or TSP sampler.

As a practical matter PM_{10} can be defined as any particles collected by a certified PM_{10} sampler. In more technical terms, the numerical values of the federal and state PM_{10} standards are applied to suspended particulate matter collected by a certified sampling device having a 50% mass collection efficiency for particles with aerodynamic equivalent diameters of 9.5-10.5 microns and a maximum aerodynamic diameter collection limit smaller than 50 microns. Collection efficiencies are greater than 50% for particles with aerodynamic diameters smaller than 10 microns and less than 50% for particles with aerodynamic diameters larger than 10 microns. The physical dimensions of particles meeting the definition of PM_{10} can vary considerably, depending on the combination of particle shape and density.

Sampling Criteria for TSP and PM_{10} Collectors

Both the former TSP standards and the current PM_{10} standards have been defined primarily by the type of equipment used to collect suspended particulate matter samples. The sampling equipment incorporates inlet designs which are intended to exclude particles with large aerodynamic diameters. Because aerodynamic diameters are not an actual physical dimension, perfect screening of particle sizes is not possible. Some particles outside the target size range will be collected and some particles within the target size range will be excluded.

The performance of TSP and PM_{10} sampling equipment is characterized by the "aerodynamic cutpoint diameter" of the collector inlet. The aerodymamic cutpoint diameter is the aerodynamic diameter at which the device excludes 50% of the mass of the corresponding ambient particles.

Design criteria for TSP samplers do not include tight tolerances on the size distribution of collected particles. Most TSP collectors have rectangular or square inlets with a peaked-roof precipitation shield. The design of standard TSP sampler inlets causes the cutpoint diameter of a TSP collector to vary with relative wind direction and wind speed.

No specific aerodynamic cutpoint diameter criteria were specified in the former federal TSP standards. Most references (e.g., U.S. Environmental Protection Agency 1982, Lodge 1989) indicate that TSP collectors have an aerodynamic cutpoint diameter of 30-50 microns under common wind speed conditions. The limited published literature on TSP collector sampling efficiency (Wedding et al. 1977, McFarland et al. 1979) implies a much broader range of aerodynamic cutpoint diameters (13-67 microns) depending on wind speed and relative wind direction. McFarland et al. (1979) indicate that the aerodynamic cutpoint diameter of TSP collectors decreases at high wind speeds and increases at low wind speeds.

The high volume samplers used to monitor compliance with the current PM_{10} standards have a narrow aerodynamic cutpoint diameter range of 9.5-10.5 microns. PM_{10} samplers also incorporate round inlet designs that are not sensitive to relative wind direction. In addition, PM_{10} samplers are much less sensitive to wind speed than are TSP samplers.

The 10-micron component of the PM_{10} definition refers to a 50% collection efficiency measure, not an absolute size limit. When operated during wind speeds of 1-15 mph, an acceptable PM_{10} sampler must collect 45-55% of the mass of particles with aerodynamic equivalent diameters of 9.5-10.5 microns. In addition, the size-based collection efficiency curve derived for the sampler must pass a test for total particle mass collection. When the collection efficiency curve is applied to a standardized particle mass distribution, the calculated total mass of collected particles must be within 10% of the total mass calculated for the "ideal" PM_{10} sampler collection efficiency curve. The standardized particle mass distribution used for the mass collection test includes particle sizes ranging from less than 1 micron to 45 microns in aerodynamic diameter.

Although the aerodynamic cutpoint diameter is useful as a single number for charaterizing collector performance, proper understanding of the particle sizes collected by TSP and PM_{10} samplers requires a more complete description of collection efficiencies at various particle sizes.

An ideal PM_{10} sampler would collect 50% of the particle mass present in the 10-10.5 micron aerodynamic diameter size range and would not collect any particles with aerodynamic diameters larger than 16 microns. In practice, most actual PM_{10} samplers will collect some particles with aerodynamic diameters of 25-30 microns (Purdue 1988, Lippmann 1989). The formal specifications for PM_{10} samplers imply an effective aerodynamic diameter limit of 45-50 microns (40 CFR 53.43).

TABLE C-1. SIZE AND DENSITY ESTIMATES FOR ATMOSPHERIC PARTICLES

DESCRIPTION	PHYSICAL DIAMETER (microns) Lower	PHYSICAL DIAMETER (microns) Upper	NOMINAL MASS MEDIAN DIAMETER (microns)	TYPICAL PARTICLE DENSITY (gm/cm^3)	ESTIMATED SHAPE FACTOR	APPROXIMATE AERODYNAMIC EQUIVALENT DIAMETER (microns) Lower	M-Median	Upper
Forest/range fire smoke	0.01	1.5	0.95	1.6	1.20	0.010	0.806	1.27
Ash from forest/range fires	5	1000	631	1.2	3.00	4.17	526	833
Photochemical smog aerosols	0.01	1.5	0.95	2.0	1.05	0.011	0.812	1.27
Oil smoke	0.04	1	0.64	2.0	1.05	0.043	0.555	0.856
Tobacco Smoke	0.01	1	0.63	1.6	1.20	0.010	0.543	0.850
Zinc oxide fumes	0.01	0.4	0.25	5.606	1.10	0.018	0.254	0.375
Ammonium chloride fumes	0.1	3	1.91	1.527	1.10	0.095	1.61	2.51
Sulfuric acid mist	1	20	12.8	1.841	1.05	0.854	10.7	16.7
Carbon black	0.01	0.3	0.19	1.95	1.08	0.011	0.180	0.271
Coal dust	1	100	63.2	1.5	1.08	0.847	52.7	83.3
Cement dust	3	100	63.6	3.2	1.08	2.53	53.1	83.4
Milled flour	1	90	56.9	0.8	1.10	0.825	47.4	75.0
Chalk dust	2	50	31.9	2.5	1.10	1.69	26.6	41.7
Ground talc	4	60	38.7	2.7	2.04	3.36	32.3	50.0
Dust storm particles	1	50	31.7	2.0	1.57	0.854	26.4	41.7
Sand storm particles	1	200	126	2.5	1.57	0.860	105	167
Clay	0.05	2	1.27	2.2	1.57	0.056	1.08	1.69
Silt	2	50	31.9	1.8	1.57	1.69	26.6	41.7
Fine sand	50	100	77.7	2.65	1.57	41.7	64.8	83.4
Medium sand	100	500	339	2.65	1.57	83.4	283	417
Coarse sand	500	1000	777	2.65	1.57	417	647	833
Very coarse sand	1000	2000	1,554	2.65	1.57	833	1,295	1,667
Gravel	2000	4000	3,107	2.65	1.57	1,667	2,589	3,333
Dolomite (or shell) sands	50	4000	2,530	2.3	1.75	41.7	2,109	3,333
Volcanic ash	2	500	315	2.5	2.00	1.69	263	417
Viruses	0.002	0.3	0.19	1.0	1.10	0.002	0.158	0.250
Bacteria	0.5	30	19.0	1.0	1.10	0.417	15.8	25.0
Spores	0.5	40	25.3	1.4	1.10	0.428	21.1	33.3
Pollen	10	100	65.2	1.4	1.10	8.35	54.4	83.3
Ocean whitecap spray	0.1	60	37.8	1.025	1.05	0.084	31.5	50.0
Sea salt nuclei	0.03	0.4	0.26	2.17	1.10	0.034	0.239	0.356
Na, Mg, Ca, K chloride mix	0.03	0.4	0.26	2.175	1.10	0.035	0.239	0.356
Sea salt crystals, RH < 70%	0.03	12	7.57	2.17	1.10	0.034	6.33	10.0
Sea salt crystals, hydrated	0.7	25	15.9	1.2	1.10	0.588	13.3	20.8
Hydraulic nozzle droplets	40	5000	3,158	1.0	1.05	33.3	2,632	4,167
Cloud/Fog droplet	7	40	26.9	1.0	1.05	5.83	22.4	33.3
Mist	40	300	198	1.0	1.05	33.3	165	250
Drizzle	200	500	370	1.0	1.05	167	309	417
Small Raindrops	500	3000	2,008	1.0	1.05	417	1,673	2,500
Large Raindrops	3000	10000	7,076	1.0	1.05	2,500	5,896	8,333

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Snowflakes	500	20000	12,706	0.4	3.00	417	10,588	16,667
Graupel	1000	7000	4,642	0.7	1.27	833	3,868	5,833
Sleet	200	3000	1,934	0.7	1.35	167	1,612	2,500
Hail	3000	100000	63,639	0.7	1.08	2,500	53,032	83,333

Note: Inconsistencies among data sources resolved by professional judgement.
Soil particle size classification based on U.S. Department of Agriculture terminology.
Aerodynamic diameter estimates account for densities, shape factors, and Cunningham slip factors. Cunningham slip factor calculations use six iterations for the lower size range, five iterations for the mass median size, and four interations for the upper size range.

Data Sources for particle size ranges:

Lapple, C. E. 1961. Characteristics of Particles and Particle Dispersoids. Stanford Research Institute Journal, Vol. 5, Page 95. Reproduced as page F-285 in R. C. Weast (ed.), 1980, Handbook of Chemistry and Physics, 61st Edition, CRC Press. Boca Raton, FL.

Schaefer, Vincent J. and John A. Day. 1981. A Field Guide to the Atmosphere. Peterson Field Guide Series 26. Houghton Mifflin Company. Boston, MA.

Wild, Alan. 1993. Soils and the Environment: an Introduction. Cambridge University Press. New York, NY.

Willeke, Klaus, and Paul A. Baron. 1993. Aerosol Measurement: Principles, Techniques, and Applications. Van Nostrand Reinhold. New York, NY.

Data Sources for particle density or specific gravity:

Cook, James L. 1991. Conversion Factors. Oxford University Press. New York, NY.

Gieck, Kurt, and Reiner Gieck. 1990. Engineering Formulas. Sixth Edition. McGraw-Hill, Inc. New York, NY.

Weast, Robert C. (ed.). 1980. Handbook of Chemistry and Physics. 61st Edition. CRC Press. Boca Raton, FL.

Data Sources for aerodynamic diameter calulations:

Hering, S. V. 1989. Inertial and gravitational collectors. Pages 337-385 in S. V. Hering (ed.), Air Sampling Instruments for Evaluation of Atmospheric Contaminants, Seventh edition. American Conference of Governmental Industrial Hygienists. Cincinnati, OH.

Hesketh, H. E. 1991. Air Pollution Control: Traditional and Hazardous Pollutants. Technomic Publishing Company. Lancaster, PA.

Willeke, Klaus, and Paul A. Baron. 1993. Aerosol Measurement: Principles, Techniques, and Applications. Van Nostrand Reinhold. New York, NY.

CONSTRUCTION ACTIVITY EVALUATION

TABLE C-37. ESTIMATED PM10 FRACTIONS FOR SOIL TEXTURE CATEGORIES

SOIL TEXTURE CLASS	PERCENT CLAY + SILT	ESTIMATED % PM10
Clay	55 - 100 %	40 - 85 %
Silt	80 - 100 %	40 - 80 %
Silty Clay	80 - 100 %	40 - 70 %
Silty Loam	50 - 100 %	30 - 70 %
Silty Clay Loam	80 - 100 %	30 - 60 %
Clay Loam	45 - 80 %	30 - 50 %
Loam	45 - 75 %	25 - 45 %
Sandy Clay	35 - 55 %	25 - 45 %
Sandy Clay Loam	20 - 55 %	15 - 40 %
Sandy Loam	15 - 55 %	10 - 30 %
Sand	0 - 15 %	0 - 10 %

Notes:

PM10 = inhalable particulate matter (a size-dependent fractional sampling of particles smaller than 50 microns aerodynamic equivalent diameter). PM10 samplers collect 100% of submicron particles, 50% of 10 micron particles, and 0% of 50 micron particles.

Clay = soil particles with a sieve diameter below 2 microns (but may form large particle aggregates).

Silt = soil particles with a sieve diameter between 2 and 50 microns.

1 micron = 0.001 millimeters = 0.00003937 inches

Soil texture classes and associated clay plus silt fractions are based on the U.S. Department of Agriculture texture classification system as presented in Wild (1993).

A sieve diameter is the width of the minimum screen opening (usually square) through which a particle will pass. Because many particles have complex shapes, the sieve diameter will usually be larger than the minimum physical dimension and smaller than the maximum physical dimension.

An aerodynamic equivalent diameter is a mathematical abstraction, not a physical dimension. The aerodynamic equivalent diameter is the diameter of a sphere with unit density (1 gram per cubic centimeter) having the same gravitational settling velocity as the actual particle under consideration.

Reference:

Wild, Alan. 1993. Soils and the Environment: An Introduction. Cambridge University Press.

TABLE C-38. FUGITIVE DUST GENERATED BY CONSTRUCTION TRAFFIC ON UNPAVED ROADS: ALTERNATIVE 1

MATERIAL HAULING:	N Pond	S Pond	Total
Aggregate, cubic yards:	10,944,000	10,093,000	21,037,000
Rip-rap, cubic yards:	226,000	264,000	490,000
Total, cubic yards:	11,170,000	10,357,000	21,527,000

Years for construction period:	4
Cubic Yards per Year:	5,381,750
Typical Load Density, tons/cubic yard:	1.5
Tons per Year:	8,072,625
Work Days per Year:	250
Haul Truck Capacity (tons):	100
Daily Truck Loads:	323
Empty Truck Weight (tons):	60

FUGITIVE DUST PARAMETERS:

silt+clay fraction =	5	percent
precipitation days =	15	days per year
dust control effect =	65	percent
Round trip time:	3.5	hours
Required haul trucks:	113	for 10-hour day

TYPE OF VEHICLE OR ITEM	NUMBER OF VEHICLES (if known)	1-WAY ROUTE DISTANCE (MILES)	TOTAL 1-WAY TRIPS PER DAY	ACTIVE USE DAYS PER YEAR	ANNUAL VMT ON UNPAVED ROADS	GROSS VEHICLE WEIGHT (tons)	NUMBER OF WHEELS	AVERAGE DRIVING SPEED (mph)	TONS OF FUGITIVE PM10 PER YEAR
	OPTIONAL DATA FOR VMT CALCULATIONS								
CONSTRUCTION WORKER VEHICLES	440	2	880	250	440,000	3.5	4	15	36.4
WATER TRUCK (2,500 gallons)		18	20	250	90,000	29.0	8	10	30.8
100-TON OFF-ROAD HAULER, LOADED	113	18	323	250	1,453,500	160.0	6	10	1,425.6
100-TON OFF-ROAD HAULER, EMPTY	113	18	323	250	1,453,500	60.0	6	15	1,076.2
HEAVY EQUIPMENT TRANSPORTERS, LOADED		2	20	5	200	92.0	12	10	0.2
HEAVY EQUIPMENT TRANSPORTERS, EMPTY		2	20	5	200	60.0	12	15	0.2
ANNUAL TOTALS									2,569.5

Notes: PM10 = inhalable particulate matter

VMT = vehicle miles traveled

Fugitive dust calculations are based on EPA unpaved road equations in AP-42 (Volume I, Section 13.2.2):

Tons/year = (0.36*5.9*((silt+clay)/12)*(speed/30)*((gvw/3)^0.7)*((wheels/4)^0.5)*(annual vmt)*
((365-precip days)/365)*((100-control)/100)/2000

TABLE C-39. EXHAUST EMISSIONS GENERATED BY CONSTRUCTION TRAFFIC: ALTERNATIVE 1

TYPE OF VEHICLE OR ITEM	CUMULATIVE OPERATING HOURS PER YEAR	ENGINE SIZE (hp)	EXHAUST EMISSION RATE (grams/vehicle-mile for light duty vehicles) (grams/horsepower-hour for heavy vehicles) ROG	NOx	CO	SOx	PM10	LOAD FACTOR	ANNUAL EXHAUST EMISSIONS (tons/year) ROG	NOx	CO	SOx	PM10
CONSTRUCTION WORKER VEHICLES	na	na	0.91	0.90	8.83	0.03	3.09	na	3.5	3.5	34.1	0.1	11.9
WATER TRUCK (2,500 gallons)	9,000.0	445	0.86	9.6	2.8	0.89	0.8	60%	2.3	25.4	7.4	2.4	2.1
100-TON OFF-ROAD HAULER, LOADED	145,350.0	940	0.86	9.6	2.8	0.89	0.8	95%	123.0	1,373.5	400.6	127.3	114.5
100-TON OFF-ROAD HAULER, EMPTY	96,900.0	940	0.86	9.6	2.8	0.89	0.8	50%	43.2	481.9	140.6	44.7	40.2
HEAVY EQUIPMENT TRANSPORTERS, LOAD	20.0	445	0.86	9.6	2.8	0.89	0.8	95%	0.0	0.1	0.0	0.0	0.0
HEAVY EQUIPMENT TRANSPORTERS, EMPT	13.3	445	0.86	9.6	2.8	0.89	0.8	50%	0.0	0.0	0.0	0.0	0.0
ANNUAL TOTALS									172.0	1,884.5	582.7	174.5	168.7

Notes: Construction worker vehicle emissions based on the EMFAC7 vehicle emission rate program.
Heavy truck emissions based on EPA 1991, Nonroad Engine and Vehicle Emission Study.

CONSTRUCTION WORKER TRAFFIC: 3499925 cumulative vmt/year — 1 pound: 453.59237 grams
mean trip time: 21.45 minutes
mean trip distance: 15.91 miles

mph:	15	25	35	45	55	mean	
% time vs speed:	5%	10%	10%	35%	40%	rate	
ROG rate:	1.17	0.72	0.61	0.54	0.57	0.61	
NOx rate:	0.87	0.72	0.71	0.82	1.07	0.90	
CO rate:	11.10	9.44	8.71	8.38	8.83	8.83	
SOx rate:	0.03	0.03	0.03	0.03	0.03	0.03	
PM10 rate:	3.09	3.09	3.09	3.09	3.09	3.09	includes 2.88 gm/vmt resuspended dust

soak: 0.42 g/trip drnl: 8.55 g/veh-day

TABLE C-40. FUGITIVE DUST GENERATED BY CONSTRUCTION TRAFFIC ON UNPAVED ROADS: ALTERNATIVES 2 AND 3

MATERIAL HAULING:	Towers	Hose Sets	Total
Number of Modules:			75
Items per module:	30	20	50
Total number of items:	2,250	1,500	3,750

Years for construction period:	3
Truck loads per tower assembly:	4
Truck loads per hose assembly:	2
Work Days per Year:	250
Haul Truck Capacity (tons):	10
Empty Truck Weight (tons):	19
Daily Truck Loads:	16

FUGITIVE DUST PARAMETERS:

silt+clay fraction =	5	percent
precipitation days =	15	days per year
dust control effect =	65	percent

TYPE OF VEHICLE OR ITEM	OPTIONAL DATA FOR VMT CALCULATIONS: NUMBER OF VEHICLES (if known)	1-WAY ROUTE DISTANCE (MILES)	TOTAL 1-WAY TRIPS PER DAY	ACTIVE USE DAYS PER YEAR	ANNUAL VMT ON UNPAVED ROADS	GROSS VEHICLE WEIGHT (tons)	NUMBER OF WHEELS	AVERAGE DRIVING SPEED (mph)	TONS OF FUGITIVE PM10 PER YEAR
CONSTRUCTION WORKER VEHICLES	260	1.5	520	250	195,000	3.5	4	15	16.13
10-TON TRUCKS, LOADED	16	1.5	16	250	6,000	29.0	8	10	2.06
10-TON TRUCKS. EMPTY	16	1.5	16	250	6,000	19.0	8	15	2.29
WATER TRUCK (2,500 gallons)		1.5	10	250	3,750	29.0	8	10	1.28
HEAVY EQUIPMENT TRANSPORTERS, LOADED		1.5	20	5	150	92.0	12	10	0.14
HEAVY EQUIPMENT TRANSPORTERS, EMPTY		1.5	20	5	150	60.0	12	15	0.16
ANNUAL TOTALS									22.1

Notes: PM10 = inhalable particulate matter
VMT = vehicle miles traveled
Fugitive dust calculations are based on EPA unpaved road equations in AP-42 (Volume I, Section 13.2.2):
Tons/year = (0.36*5.9*((silt+clay)/12)*(speed/30)*((gvw/3)^0.7)*((wheels/4)^0.5)*(annual vmt)*
((365-precip days)/365)*((100-control)/100)/2000

TABLE C-41. EXHAUST EMISSIONS GENERATED BY CONSTRUCTION TRAFFIC: ALTERNATIVES 2 AND 3

TYPE OF VEHICLE OR ITEM	CUMULATIVE OPERATING HOURS PER YEAR	ENGINE SIZE (hp)	EXHAUST EMISSION RATE (grams/vehicle-mile for light duty vehicles) (grams/horsepower-hour for heavy vehicles) ROG	NOx	CO	SOx	PM10	LOAD FACTOR	ANNUAL EXHAUST EMISSIONS (tons/year) ROG	NOx	CO	SOx	PM10
CONSTRUCTION WORKER VEHICLES	na	na	0.91	0.90	8.83	0.03	3.09	na	2.1	2.1	20.1	0.1	7.0
10-TON TRUCKS, LOADED	600.0	445	0.86	9.6	2.8	0.89	0.8	60%	0.2	1.7	0.5	0.2	0.1
10-TON TRUCKS, EMPTY	400.0	445	0.86	9.6	2.8	0.89	0.8	95%	0.2	1.8	0.5	0.2	0.1
WATER TRUCK (2,500 gallons)	375.0	445	0.86	9.6	2.8	0.89	0.8	50%	0.1	0.9	0.3	0.1	0.1
HEAVY EQUIPMENT TRANSPORTERS, LOAD	15.0	445	0.86	9.6	2.8	0.89	0.8	95%	0.0	0.1	0.0	0.0	0.0
HEAVY EQUIPMENT TRANSPORTERS, EMPT	10.0	445	0.86	9.6	2.8	0.89	0.8	50%	0.0	0.0	0.0	0.0	0.0
ANNUAL TOTALS									2.5	6.5	21.4	0.5	7.4

Notes: Construction worker vehicle emissions based on the EMFAC7 vehicle emission rate program.
Heavy truck emissions based on EPA 1991. Nonroad Engine and Vehicle Emission Study.

CONSTRUCTION WORKER TRAFFIC: 2068137. cumulative vmt/year   1 pound: 453.59237 grams
mean trip time: 21.45 minutes
mean trip distance: 15.91 miles

mph	15	25	35	45	55	mean	
% time at speed	5%	10%	10%	35%	40%	rate	
ROG rate	1.17	0.72	0.61	0.54	0.57	0.61	
NOx rate	0.87	0.72	0.71	0.82	1.07	0.90	
CO rate	11.10	9.44	8.71	8.38	8.83	8.83	
SOx rate	0.03	0.03	0.03	0.03	0.03	0.03	
PM10 rate	3.09	3.09	3.09	3.09	3.09	3.09	includes 2.88 gm/vmt resuspended dust

soak: 0.42 g/trip   drnl: 8.55 g/veh-day

TABLE C-42. FUGITIVE DUST GENERATED BY CONSTRUCTION TRAFFIC ON UNPAVED ROADS: ALTERNATIVE 4

MATERIAL HAULING:	N Pond
Aggregate, cubic yards:	10,944,000
Rip-rap, cubic yards:	226,000
Total, cubic yards:	11,170,000

Years for construction period:	3			
Cubic Yards per Year:	3,723,333	FUGITIVE DUST PARAMETERS:		
Typical Load Density, tons/cubic yard:	1.5	silt+clay fraction =	5	percent
Tons per Year:	5,585,000	precipitation days =	15	days per year
Work Days per Year:	250	dust control effect =	65	percent
Haul Truck Capacity (tons):	100			
Daily Truck Loads:	223	Round trip time:	3.5	hours
Empty Truck Weight (tons):	60	Required haul trucks:	78	for 10-hour day

	OPTIONAL DATA FOR VMT CALCULATIONS								
TYPE OF VEHICLE OR ITEM	NUMBER OF VEHICLES (if known)	1-WAY ROUTE DISTANCE (MILES)	TOTAL 1-WAY TRIPS PER DAY	ACTIVE USE DAYS PER YEAR	ANNUAL VMT ON UNPAVED ROADS	GROSS VEHICLE WEIGHT (tons)	NUMBER OF WHEELS	AVERAGE DRIVING SPEED (mph)	TONS OF FUGITIVE PM10 PER YEAR
CONSTRUCTION WORKER VEHICLES	300	2	600	250	300,000	3.5	4	15	24.8
WATER TRUCK (2,500 gallons)		18	20	250	90,000	29.0	8	10	30.8
100-TON OFF-ROAD HAULER, LOADED	78	18	223	250	1,003,500	160.0	6	10	984.2
100-TON OFF-ROAD HAULER, EMPTY	78	18	223	250	1,003,500	60.0	6	15	743.0
HEAVY EQUIPMENT TRANSPORTERS, LOADED		2	20	5	200	92.0	12	10	0.2
HEAVY EQUIPMENT TRANSPORTERS, EMPTY		2	20	5	200	60.0	12	15	0.2
ANNUAL TOTALS									1,783.3

Notes: PM10 = inhalable particulate matter
VMT = vehicle miles traveled
Fugitive dust calculations are based on EPA unpaved road equations in AP-42 (Volume I, Section 13.2.2):
Tons/year = (0.36*5.9*((silt+clay)/12)*(speed/30)*((gvw/3)^0.7)*((wheels/4)^0.5)*(annual vmt)*
((365-precip days)/365)*((100-control)/100)/2000

TABLE C-43. EXHAUST EMISSIONS GENERATED BY CONSTRUCTION TRAFFIC: ALTERNATIVE 4

TYPE OF VEHICLE OR ITEM	CUMULATIVE OPERATING HOURS PER YEAR	ENGINE SIZE (hp)	EXHAUST EMISSION RATE (grams/vehicle-mile for light duty vehicles) (grams/horsepower-hour for heavy vehicles) ROG	NOx	CO	SOx	PM10	LOAD FACTOR	ANNUAL EXHAUST EMISSIONS (tons/year) ROG	NOx	CO	SOx	PM10
CONSTRUCTION WORKER VEHICLES	na	na	0.91	0.90	8.83	0.03	3.09	na	2.4	2.4	23.2	0.1	8.1
WATER TRUCK (2,500 gallons)	9,000.0	445	0.86	9.6	2.8	0.89	0.8	60%	2.3	25.4	7.4	2.4	2.1
100-TON OFF-ROAD HAULER, LOADED	100,350.0	940	0.86	9.6	2.8	0.89	0.8	95%	85.0	948.3	276.6	87.9	79.0
100-TON OFF-ROAD HAULER, EMPTY	66,900.0	940	0.86	9.6	2.8	0.89	0.8	50%	29.8	332.7	97.0	30.8	27.7
HEAVY EQUIPMENT TRANSPORTERS, LOAD	20.0	445	0.86	9.6	2.8	0.89	0.8	95%	0.0	0.1	0.0	0.0	0.0
HEAVY EQUIPMENT TRANSPORTERS, EMPT	13.3	445	0.86	9.6	2.8	0.89	0.8	50%	0.0	0.0	0.0	0.0	0.0
ANNUAL TOTALS									119.4	1,309.0	404.3	121.2	117.0

Notes: Construction worker vehicle emissions based on the EMFAC7 vehicle emission rate program.
Heavy truck emissions based on EPA 1991, Nonroad Engine and Vehicle Emission Study.

CONSTRUCTION WORKER TRAFFIC: 2386312. cumulative vmt/year

mean trip time: 21.45 minutes

mean trip distance: 15.91 miles

1 pound: 453.59237 grams

mph:	15	25	35	45	55	mean	
% time vs speed:	5%	10%	10%	35%	40%	rate	
ROG rate:	1.17	0.72	0.61	0.54	0.57	0.61	
NOx rate:	0.87	0.72	0.71	0.82	1.07	0.90	
CO rate:	11.10	9.44	8.71	8.38	8.83	8.83	
SOx rate:	0.03	0.03	0.03	0.03	0.03	0.03	
PM10 rate:	3.09	3.09	3.09	3.09	3.09	3.09	includes 2.88 gm/vmt resuspended dust

soak: 0.42 g/trip drnl: 8.55 g/veh-day

TABLE C-44. FUGITIVE DUST GENERATED BY CONSTRUCTION TRAFFIC ON UNPAVED ROADS: ALTERNATIVE 5

MATERIAL HAULING:	S Pond
Aggregate, cubic yards:	10,093,000
Rip-rap, cubic yards:	264,000
Total, cubic yards:	10,357,000

Years for construction period:	3			
Cubic Yards per Year:	3,452,333	FUGITIVE DUST PARAMETERS:		
Typical Load Density, tons/cubic yard:	1.5	silt+clay fraction =	5	percent
Tons per Year:	5,178,500	precipitation days =	15	days per year
Work Days per Year:	250	dust control effect =	65	percent
Haul Truck Capacity (tons):	100			
Daily Truck Loads:	207	Round trip time:	3.5	hours
Empty Truck Weight (tons):	60	Required haul trucks:	72	for 10-hour day

	OPTIONAL DATA FOR VMT CALCULATIONS								
TYPE OF VEHICLE OR ITEM	NUMBER OF VEHICLES (if known)	1-WAY ROUTE DISTANCE (MILES)	TOTAL 1-WAY TRIPS PER DAY	ACTIVE USE DAYS PER YEAR	ANNUAL VMT ON UNPAVED ROADS	GROSS VEHICLE WEIGHT (tons)	NUMBER OF WHEELS	AVERAGE DRIVING SPEED (mph)	TONS OF FUGITIVE PM10 PER YEAR
CONSTRUCTION WORKER VEHICLES	300	2	600	250	300,000	3.5	4	15	24.8
WATER TRUCK (2,500 gallons)		18	20	250	90,000	29.0	8	10	30.8
100-TON OFF-ROAD HAULER, LOADED	72	18	207	250	931,500	160.0	6	10	913.6
100-TON OFF-ROAD HAULER, EMPTY	72	18	207	250	931,500	60.0	6	15	689.7
HEAVY EQUIPMENT TRANSPORTERS, LOADED		2	20	5	200	92.0	12	10	0.2
HEAVY EQUIPMENT TRANSPORTERS, EMPTY		2	20	5	200	60.0	12	15	0.2
ANNUAL TOTALS									1,659.4

Notes: PM10 = inhalable particulate matter
VMT = vehicle miles traveled
Fugitive dust calculations are based on EPA unpaved road equations in AP-42 (Volume I, Section 13.2.2):
Tons/year = (0.36*5.9*((silt+clay)/12)*(speed/30)*((gvw/3)^0.7)*((wheels/4)^0.5)*(annual vmt)*
((365-precip days)/365)*((100-control)/100)/2000

TABLE C-45. EXHAUST EMISSIONS GENERATED BY CONSTRUCTION TRAFFIC: ALTERNATIVE 5

TYPE OF VEHICLE OR ITEM	CUMULATIVE OPERATING HOURS PER YEAR	ENGINE SIZE (hp)	EXHAUST EMISSION RATE (grams/vehicle-mile for light duty vehicles) (grams/horsepower-hour for heavy vehicles) ROG	NOx	CO	SOx	PM10	LOAD FACTOR	ANNUAL EXHAUST EMISSIONS (tons/year) ROG	NOx	CO	SOx	PM10
CONSTRUCTION WORKER VEHICLES	na	na	0.91	0.90	8.83	0.03	3.09	na	2.4	2.4	23.2	0.1	8.1
WATER TRUCK (2,500 gallons)	9,000.0	445	0.86	9.6	2.8	0.89	0.8	60%	2.3	25.4	7.4	2.4	2.1
100-TON OFF-ROAD HAULER, LOADED	93,150.0	940	0.86	9.6	2.8	0.89	0.8	95%	78.9	880.3	256.7	81.6	73.4
100-TON OFF-ROAD HAULER, EMPTY	62,100.0	940	0.86	9.6	2.8	0.89	0.8	50%	27.7	308.9	90.1	28.6	25.7
HEAVY EQUIPMENT TRANSPORTERS, LOAD	20.0	445	0.86	9.6	2.8	0.89	0.8	95%	0.0	0.1	0.0	0.0	0.0
HEAVY EQUIPMENT TRANSPORTERS, EMPT	13.3	445	0.86	9.6	2.8	0.89	0.8	50%	0.0	0.0	0.0	0.0	0.0
ANNUAL TOTALS									111.2	1,217.0	377.5	112.7	109.3

Notes: Construction worker vehicle emissions based on the EMFAC7 vehicle emission rate program.
Heavy truck emissions based on EPA 1991, Nonroad Engine and Vehicle Emission Study.

CONSTRUCTION WORKER TRAFFIC: 2386312. cumulative vmt/year

1 pound: 453.59237 grams

mean trip time: 21.45 minutes

mean trip distance: 15.91 miles

mph:	15	25	35	45	55	mean
% time vs speed:	5%	10%	10%	35%	40%	rate
ROG rate:	1.17	0.72	0.61	0.54	0.57	0.61
NOx rate:	0.87	0.72	0.71	0.82	1.07	0.90
CO rate:	11.10	9.44	8.71	8.38	8.83	8.83
SOx rate:	0.03	0.03	0.03	0.03	0.03	0.03
PM10 rate:	3.09	3.09	3.09	3.09	3.09	3.09 includes 2.88 gm/vmt resuspended dust

soak: 0.42 g/trip drnl: 8.55 g/veh-day

TABLE C-46. FUGITIVE TSP GENERATED BY CONSTRUCTION TRAFFIC ON UNPAVED ROADS: ALTERNATIVE 1

MATERIAL HAULING:	N Pond	S Pond	Total
Aggregate, cubic yards:	10,944,000	10,093,000	21,037,000
Rip-rap, cubic yards:	226,000	264,000	490,000
Total, cubic yards:	11,170,000	10,357,000	21,527,000

Years for construction period:	4
Cubic Yards per Year:	5,381,750
Typical Load Density, tons/cubic yard:	1.5
Tons per Year:	8,072,625
Work Days per Year:	250
Haul Truck Capacity (tons):	100
Daily Truck Loads:	323
Empty Truck Weight (tons):	60

FUGITIVE DUST PARAMETERS:		
silt+clay fraction =	5	percent
precipitation days =	15	days per year
dust control effect =	65	percent
Round trip time:	3.5	hours
Required haul trucks:	113	for 10-hour day

	OPTIONAL DATA FOR VMT CALCULATIONS								
TYPE OF VEHICLE OR ITEM	NUMBER OF VEHICLES (if known)	1-WAY ROUTE DISTANCE (MILES)	TOTAL 1-WAY TRIPS PER DAY	ACTIVE USE DAYS PER YEAR	ANNUAL VMT ON UNPAVED ROADS	GROSS VEHICLE WEIGHT (tons)	NUMBER OF WHEELS	AVERAGE DRIVING SPEED (mph)	TONS OF FUGITIVE PARTICULATE MATTER PER YEAR
CONSTRUCTION WORKER VEHICLES	440	2	880	250	440,000	3.5	4	15	101.1
WATER TRUCK (2,500 gallons)		18	20	250	90,000	29.0	8	10	85.7
100-TON OFF-ROAD HAULER, LOADED	113	18	323	250	1,453,500	160.0	6	10	3,960.0
100-TON OFF-ROAD HAULER, EMPTY	113	18	323	250	1,453,500	60.0	6	15	2,989.5
HEAVY EQUIPMENT TRANSPORTERS, LOADED		2	20	5	200	92.0	12	10	0.5
HEAVY EQUIPMENT TRANSPORTERS, EMPTY		2	20	5	200	60.0	12	15	0.6
ANNUAL TOTALS									7,137.4

Notes: Emission estimates are for total particulate matter emissions
VMT = vehicle miles traveled
Fugitive dust calculations are based on EPA unpaved road equations in AP-42 (Volume I, Section 13.2.2):
Tons/year = (1.0*5.9*((silt+clay)/12)*(speed/30)*((gvw/3)^0.7)*((wheels/4)^0.5)*(annual vmt)*
((365-precip days)/365)*((100-control)/100)/2000

TABLE C-47. DEFAULT SETTLING/DEPOSITION VELOCITIES FOR FUGITIVE DUST EMISSIONS: PARTICLE DENSITY OF 2.00 gm/cubic

Particle Size Fractions, Aerodynamic Diameter	Mass Fraction	Mass-Median Diameter (microns)	Default Reflection Coefficient	Default Deposition Coefficient	Settling Rate (meters/sec)	Settling Rate (cm/sec)	Deposition Rate (cm/sec)
1 - 5 Microns	0.01250	3.39	0.96385	0.03615	0.00067	0.06712	0.00243
5 - 10 Microns	0.02250	7.77	0.89038	0.10962	0.00352	0.35217	0.03861
10 - 15 Microns	0.04000	12.66	0.78599	0.21401	0.00936	0.93604	0.20032
15 - 20 Microns	0.05500	17.62	0.71449	0.28551	0.01812	1.81153	0.51720
20 - 25 Microns	0.08000	22.59	0.67142	0.32858	0.02979	2.97878	0.97876
25 - 30 Microns	0.09500	27.58	0.63539	0.36461	0.04438	4.43782	1.61809
30 - 40 Microns	0.12000	35.24	0.56602	0.43398	0.07246	7.24613	3.14467
40 - 50 Microns	0.10500	45.18	0.45070	0.54930	0.11915	11.91512	6.54502
50 - 60 Microns	0.09250	55.15	0.30654	0.69346	0.17751	17.75126	12.30972
60 - 70 Microns	0.07750	65.13	0.13356	0.86644	0.24755	24.75459	21.44833
70 - 80 Microns	0.06500	75.11	0.00000	1.00000	0.32925	32.92512	32.92512
80 - 90 Microns	0.05750	85.10	0.00000	1.00000	0.42263	42.26286	42.26286
90 - 100 Microns	0.05000	95.09	0.00000	1.00000	0.52768	52.76781	52.76781
100 - 110 Microns	0.04000	105.08	0.00000	1.00000	0.64440	64.43997	64.43997
110 - 120 Microns	0.03000	115.07	0.00000	1.00000	0.77279	77.27934	77.27934
120 - 130 Microns	0.02000	125.07	0.00000	1.00000	0.91286	91.28593	91.28593
130 - 140 Microns	0.01500	135.06	0.00000	1.00000	1.06460	106.45973	106.45973
140 - 150 Microns	0.01000	145.06	0.00000	1.00000	1.22801	122.80074	122.80074
150 - 160 Microns	0.00750	155.05	0.00000	1.00000	1.40309	140.30897	140.30897
160 - 170 Microns	0.00500	165.05	0.00000	1.00000	1.58984	158.98442	158.98442
WEIGHTED AVERAGES:		55.39	0.37085	0.62915	0.25089	25.08931	22.73734
FOR MEAN AEROSOL SIZE:		55.39	0.30654	0.69346	0.17751	17.75126	12.30972

Notes: Mass-median diameter and settling rate equations from ISC model user's guide (Wagner 1987).
Reflection coefficient formula based on regression analysis of data points scaled from Figure 2-8 in the ISC model user's guide (Wagner 1987).
Default reflection and deposition coefficients are most appropriate for solid particles; coefficients ignored for liquid aerosols.

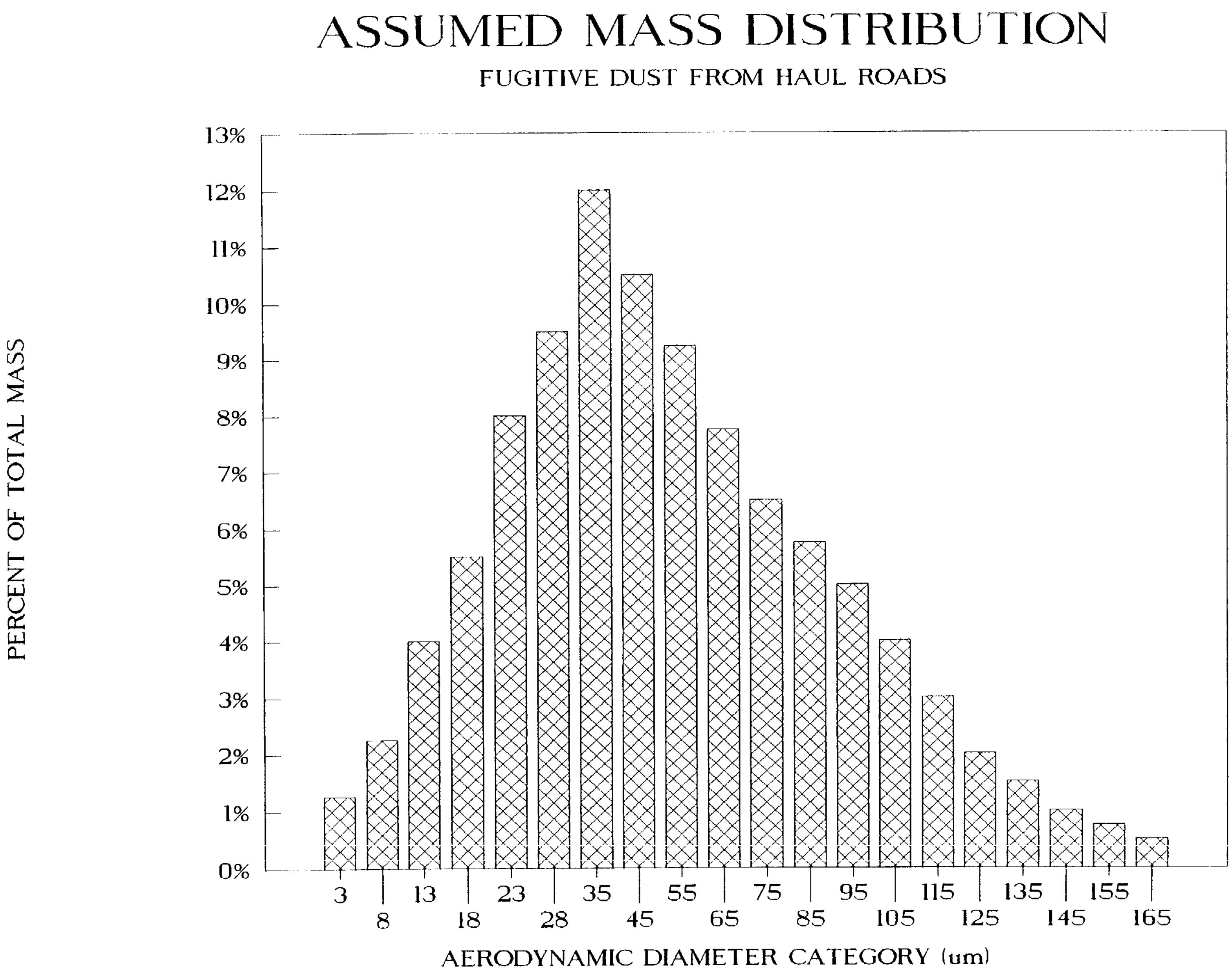

ASSUMED MASS DISTRIBUTION
FUGITIVE DUST FROM HAUL ROADS
PERCENT OF TOTAL MASS
13%
12%
11%
10%
9%
8%
7%
6%
5%
4%
3%
2%
1%
0%
3
8
13
18
23
28
35
45
55
65
75
85
95
105
115
125
135
145
155
165
AERODYNAMIC DIAMETER CATEGORY (um)

TABLE C-48. ESTIMATED MAXIMUM PM10 CONCENTRATIONS GENERATED BY TRUCK TRAFFIC ON THE HAUL ROAD FOR ALTERNATIVE 1

RESULTS FOR A WIND SPEED OF 1 METER PER SECOND AND NEUTRAL (CLASS D) STABILITY:

AVERAGING	PM10 CONCENTRATION (micrograms per cubic meter) AT VARIOUS DISTANCES (feet) FROM THE HAUL ROAD																				
TIME	50	100	150	200	300	400	500	600	700	800	900	1000	1250	1500	2000	2500	3000	3500	4000	4500	5000	6000
1-HOUR	3,558	2,232	1,721	1,425	1,067	887	773	683	608	545	491	449	373	323	262	226	200	180	164	152	144	130
10-HOURS	3,025	1,897	1,463	1,211	907	754	657	580	516	463	417	382	317	274	223	192	170	153	139	129	122	111
24-HOURS	1,512	949	731	606	453	377	328	290	258	231	209	191	158	137	111	96	85	77	70	64	61	55
BACKGROUND	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
24-HR TOTAL	1,562	999	781	656	503	427	378	340	308	281	259	241	208	187	161	146	135	127	120	114	111	105

RESULTS FOR A WIND SPEED OF 3 METERS PER SECOND AND NEUTRAL (CLASS D) STABILITY:

AVERAGING	PM10 CONCENTRATION (micrograms per cubic meter) AT VARIOUS DISTANCES (feet) FROM THE HAUL ROAD																				
TIME	50	100	150	200	300	400	500	600	700	800	900	1000	1250	1500	2000	2500	3000	3500	4000	4500	5000	6000
1-HOUR	1,397	852	647	532	403	329	280	245	219	201	186	174	150	132	105	87	77	68	61	55	51	47
10-HOURS	1,187	724	550	452	342	280	238	208	186	171	158	148	127	112	89	74	65	58	52	47	44	40
24-HOURS	594	362	275	226	171	140	119	104	93	85	79	74	64	56	44	37	33	29	26	24	22	20
BACKGROUND	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
24-HR TOTAL	644	412	325	276	221	190	169	154	143	135	129	124	114	106	94	87	83	79	76	74	72	70

TABLE C-48. ESTIMATED MAXIMUM PM10 CONCENTRATIONS GENERATED BY TRUCK TRAFFIC ON THE HAUL ROAD FOR ALTERNATIVE 1

Notes: Modeling analyses were performed with the CALINE4 dispersion model, assuming a 30,000-foot (5.68 miles) straight roadway alignment with receptors points perpendicular to the midpoint of the roadway segment. Wind directions were rotated in 10 degree increments to identify maximum concentrations at each receptor distance.

Neutral (Class D) stability conditions and a wind fluctuation (sigma theta) parameter of 20 degrees were assumed for all conditions.

The modeling analysis assumed a 1-hour traffic volume of 67 heavy trucks and an hourly PM10 emission rate of 767 grams (1.69 pounds) per vehicle-mile traveled.

To provide a conservative analysis. PM10 emissions were modeled without any particle settling or deposition.

A wind speed of 1 meter per second (2.2 mph) represents unfavorable meteorological conditions. A wind speed of 3 meters per second (6.7 mph) represents average wind speed conditions.

Worst case wind directions varied from 10 degrees off-axis close to the road to 40 degrees off-axis at distances of 4,500 feet or more from the road.

The maximum 10-hour average PM10 concentration is estimated as 85% of the maximum 1-hour average.

The maximum 24-hour average PM10 concentration is calculated for a 10-hour work day (no haul road traffic for the remaining hours).

The background 24-hour PM10 concentration is based on approximate annual average PM10 values for Westmoreland and Brawley.

The federal 24-hour PM10 standard is 150 micrograms per cubic meter. The state 24-hour PM10 standard is 50 micrograms per cubic meter.

TABLE C-49. ESTIMATED MAXIMUM TSP CONCENTRATIONS GENERATED BY TRUCK TRAFFIC ON THE HAUL ROAD FOR ALTERNATIVE 1

RESULTS FOR A WIND SPEED OF 1 METER PER SECOND AND NEUTRAL (CLASS D) STABILITY:

AVERAGING	TSP CONCENTRATION (micrograms per cubic meter) AT VARIOUS DISTANCES (feet) FROM THE HAUL ROAD																					
TIME	50	100	150	200	300	400	500	600	700	800	900	1000	1250	1500	2000	2500	3000	3500	4000	4500	5000	6000
1-HOUR	7,446	4,316	3,244	2,593	1,882	1,474	1,195	1,013	889	785	694	625	500	412	303	237	192	159	133	114	99	76
10-HOURS	6,329	3,669	2,757	2,204	1,600	1,252	1,015	861	755	667	590	531	425	350	257	202	163	135	113	97	84	65
24-HOURS	3,165	1,834	1,379	1,102	800	626	508	431	378	333	295	266	213	175	129	101	81	67	57	48	42	32
BACKGROUND	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
24-HR TOTAL	3,265	1,934	1,479	1,202	900	726	608	531	478	433	395	366	313	275	229	201	181	167	157	148	142	132

RESULTS FOR A WIND SPEED OF 3 METERS PER SECOND AND NEUTRAL (CLASS D) STABILITY:

AVERAGING	TSP CONCENTRATION (micrograms per cubic meter) AT VARIOUS DISTANCES (feet) FROM THE HAUL ROAD																					
TIME	50	100	150	200	300	400	500	600	700	800	900	1000	1250	1500	2000	2500	3000	3500	4000	4500	5000	6000
1-HOUR	3,614	2,226	1,689	1,385	1,041	845	714	629	566	515	475	441	375	326	254	214	186	162	143	130	120	107
10-HOURS	3,072	1,892	1,436	1,178	885	718	607	535	481	438	403	375	319	277	216	182	158	137	121	110	102	91
24-HOURS	1,536	946	718	589	442	359	303	267	240	219	202	187	160	139	108	91	79	69	61	55	51	45
BACKGROUND	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
24-HR TOTAL	1,636	1,046	818	689	542	459	403	367	340	319	302	287	260	239	208	191	179	169	161	155	151	145

TABLE C-49. ESTIMATED MAXIMUM TSP CONCENTRATIONS GENERATED BY TRUCK TRAFFIC ON THE HAUL ROAD FOR ALTERNATIVE 1

Notes: Modeling analyses were performed with the CALINE4 dispersion model, assuming a 30,000-foot (5.68 miles) straight roadway alignment with receptors points perpendicular to the midpoint of the roadway segment. Wind directions were rotated in 10 degree increments to identify maximum concentrations at each receptor distance.

Neutral (Class D) stability conditions and a wind fluctuation (sigma theta) parameter of 20 degrees were assumed for all conditions.

The modeling analysis assumed a 1-hour traffic volume of 67 heavy trucks and an hourly TSP emission rate of 2,130 grams (4.7 pounds) per vehicle-mile traveled.

TSP emissions were modeled with a particle settling rate of 7.25 cm/second and a particle deposition rate of 3.14 cm/second.

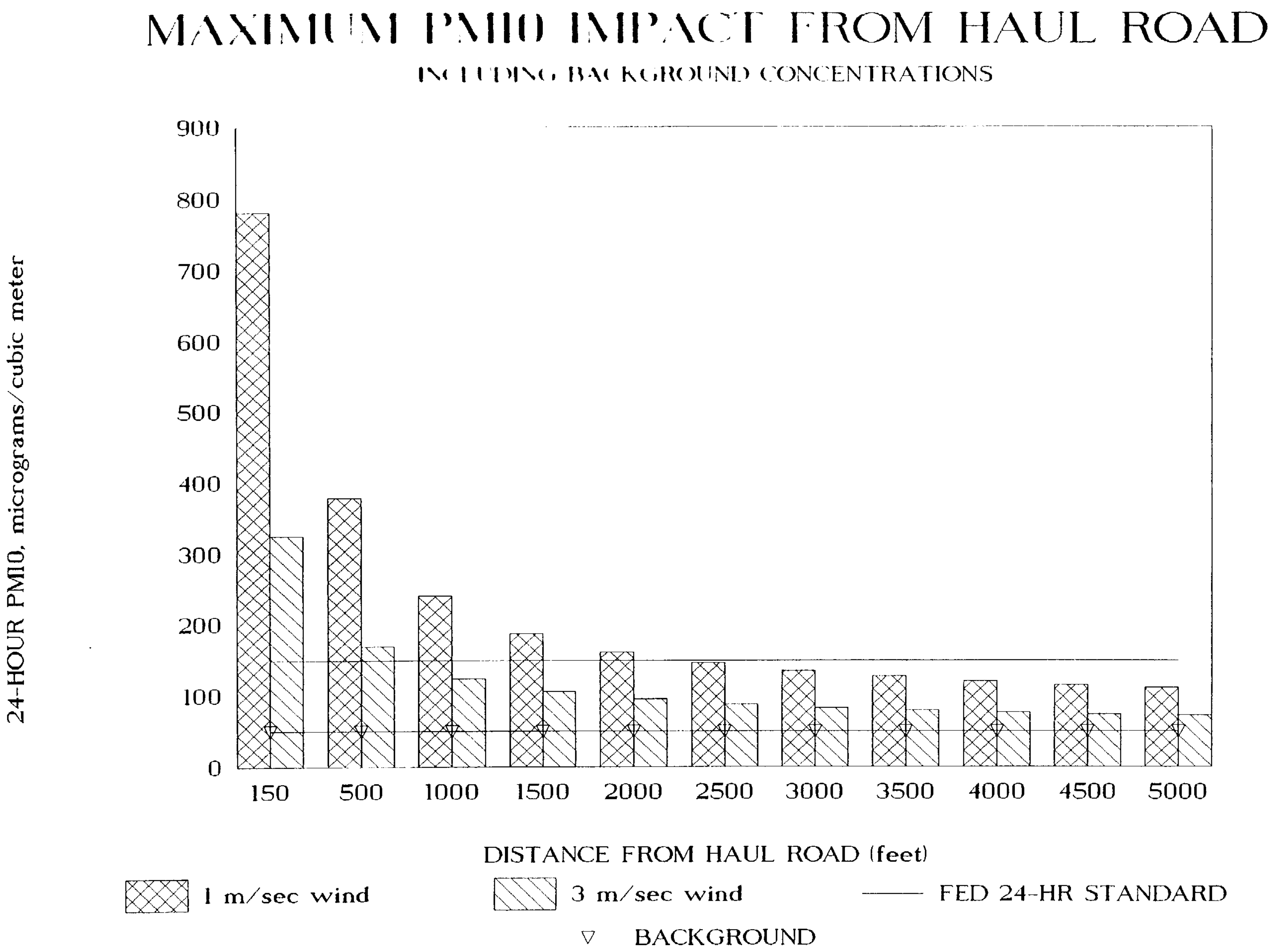
A wind speed of 1 meter per second (2.2 mph) represents unfavorable meteorological conditions. A wind speed of 3 meters per second (6.7 mph) represents average wind speed conditions.

Worst case wind directions varied from 10 degrees off-axis close to the road to 40 degrees off-axis at distances of 4,500 feet or more from the road.

The maximum 10-hour average TSP concentration is estimated as 85% of the maximum 1-hour average.

The maximum 24-hour average TSP concentration is calculated for a 10-hour work day (no haul road traffic for the remaining hours).

The background 24-hour TSP concentration is assumed to be twice annual average PM10 concentration for Westmoreland and Brawley.


MAXIMUM PM10 IMPACT FROM HAUL ROAD
INCLUDING BACKGROUND CONCENTRATIONS
24-HOUR PM10, micrograms/cubic meter
900
800
700
600
500
400
300
200
100
0
150
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
DISTANCE FROM HAUL ROAD (feet)
1 m/sec wind
3 m/sec wind
FED 24-HR STANDARD
BACKGROUND

SALTON SEA LEVELS AND SALINITY

TABLE C-50. EXISTING MIX OF MAJOR SALT IONS IN THE SALTON SEA

WATER QUALTIY PARAMETER	AVERAGE mg/L	SUM OF ATOMIC WEIGHTS	MOLAR EQUIVALENTS	ANION & CATION BALANCES	ANION & CATION RATIOS
CHLORIDE	16,332	35.4527	460.7	79.13%	921.5
SULFATE	11,236	96.0636	117.0	20.09%	234.0
BICARBONATE	246	61.01714	4.0	0.69%	8.1
CARBONATE	30	60.0092	0.5	0.09%	1.0
SODIUM	12,114	22.989768	526.9	85.62%	81.8
MAGNESIUM	1,384	24.305	56.9	9.25%	8.8
CALCIUM	1,006	40.078	25.1	4.08%	3.9
POTASSIUM	252	39.0983	6.4	1.05%	1.0
SUM OF MAJOR ANIONS:			582.2		
SUM OF MAJOR CATIONS:			615.4		
CHLORIDE:SULFATE RATIO:			3.94		

Notes: Dissolved ion concentrations from Holdren 1999.

TABLE C-51. ESTIMATED SALTON SEA DENSITY VERSUS SALINITY RELATIONSHIPS

NOMINAL SALINITY PERCENT	PARTS PER 1000, 20 deg C	SALTON SEA DENSITY ADJUSTMENT	RELATIVE DENSITY (kg/liter)	SPECIFIC GRAVITY, 20 deg C	GRAMS/TOTAL LITER		DISPLACED WATER (gm/liter)
					SALT	WATER	
0.5%	4.94	0.9954	0.9972	0.9990	5.0	996.9	1.33
1.0%	9.92	0.9954	1.0010	1.0028	10.1	995.5	2.73
1.5%	14.91	0.9954	1.0047	1.0065	15.1	994.1	4.13
2.0%	19.89	0.9954	1.0085	1.0103	20.3	992.7	5.53
2.5%	24.87	0.9954	1.0123	1.0141	25.4	991.2	7.03
3.0%	29.86	0.9954	1.0160	1.0178	30.6	989.7	8.53
3.5%	34.84	0.9954	1.0197	1.0216	35.8	988.1	10.13
4.0%	39.82	0.9954	1.0235	1.0253	41.1	986.6	11.63
4.5%	44.81	0.9954	1.0272	1.0290	46.4	985.0	13.23
5.0%	49.79	0.9954	1.0310	1.0328	51.8	983.3	14.93
5.5%	54.78	0.9954	1.0348	1.0366	57.1	981.6	16.63
6.0%	59.76	0.9954	1.0386	1.0404	62.5	979.9	18.33
6.5%	64.74	0.9954	1.0423	1.0442	68.0	978.1	20.13
7.0%	69.73	0.9954	1.0460	1.0479	73.5	976.3	21.93
7.5%	74.71	0.9954	1.0498	1.0517	79.0	974.6	23.63
8.0%	79.69	0.9954	1.0536	1.0555	84.6	972.9	25.33
8.5%	84.68	0.9954	1.0574	1.0592	90.2	971.2	27.03
9.0%	89.66	0.9954	1.0612	1.0631	95.9	969.3	28.93
9.5%	94.64	0.9954	1.0650	1.0669	101.6	967.5	30.73
10.0%	99.63	0.9954	1.0678	1.0697	107.3	965.6	32.63
10.5%	104.6	0.9950	1.0717	1.0736	113.1	963.7	34.58
11.0%	109.6	0.9946	1.0756	1.0775	118.9	961.7	36.53
11.5%	114.6	0.9943	1.0790	1.0810	124.8	959.8	38.48
12.0%	119.6	0.9939	1.0825	1.0844	130.6	957.8	40.43
12.5%	124.6	0.9936	1.0859	1.0878	136.6	955.8	42.48
13.0%	129.5	0.9932	1.0893	1.0913	142.5	953.7	44.53
13.5%	134.5	0.9928	1.0928	1.0947	148.6	951.6	46.63
14.0%	139.5	0.9925	1.0962	1.0981	154.6	949.5	48.73
14.5%	144.5	0.9921	1.0996	1.1016	160.7	947.4	50.88
15.0%	149.5	0.9918	1.1030	1.1050	166.8	945.2	53.03
16.0%	159.7	0.9910	1.1102	1.1121	179.2	940.6	57.67
17.0%	169.7	0.9903	1.1172	1.1192	191.8	935.7	62.51
18.0%	179.7	0.9896	1.1244	1.1264	204.5	930.6	67.64
19.0%	189.7	0.9889	1.1316	1.1336	217.4	925.1	73.11
20.0%	199.6	0.9882	1.1388	1.1409	230.5	919.3	78.96
21.0%	209.6	0.9875	1.1462	1.1482	243.7	913.0	85.26
22.0%	219.6	0.9867	1.1536	1.1556	257.1	906.2	92.07
23.0%	229.6	0.9860	1.1611	1.1631	270.7	898.8	99.44
24.0%	239.6	0.9853	1.1686	1.1707	284.5	890.8	107.46
25.0%	249.6	0.9846	1.1763	1.1784	298.4	882.0	116.19
26.0%	259.5	0.9839	1.1840	1.1861	312.5	872.5	125.73
27.0%	269.5	0.9832	1.1919	1.1940	326.8	862.1	136.14
28.0%	279.5	0.9824	1.1998	1.2019	341.3	850.7	147.53
29.0%	289.5	0.9817	1.2078	1.2099	355.9	838.2	159.99

TABLE C-51. ESTIMATED SALTON SEA DENSITY VERSUS SALINITY RELATIONSHIPS

NOMINAL SALINITY PERCENT	PARTS PER 1000, 20 deg C	SALTON SEA DENSITY ADJUSTMENT	RELATIVE DENSITY (kg/liter)	SPECIFIC GRAVITY, 20 deg C	GRAMS/TOTAL LITER SALT	GRAMS/TOTAL LITER WATER	DISPLACED WATER (gm/liter)
30.0%	299.5	0.9810	1.2159	1.2181	370.8	824.6	173.62
31.0%	309.5	0.9810	1.2250	1.2272	385.8	809.7	188.51
32.0%	319.4	0.9810	1.2343	1.2365	401.0	793.4	204.79
33.0%	329.4	0.9810	1.2436	1.2458	416.4	775.7	222.56
34.0%	339.4	0.9810	1.2531	1.2553	431.9	756.3	241.95
35.0%	349.4	0.9810	1.2627	1.2650	447.7	735.2	263.08
36.0%	359.4	0.9810	1.2725	1.2747	463.6	712.2	286.07
37.0%	369.3	0.9810	1.2823	1.2846	479.7	687.2	311.06
38.0%	379.3	0.9810	1.2923	1.2946	496.0	660.0	338.19
39.0%	389.3	0.9810	1.3025	1.3048	512.5	630.6	367.60
40.0%	399.3	0.9810	1.3128	1.3151	529.2	598.8	399.43
41.0%	409.3	0.9810	1.3232	1.3255	546.1	564.4	433.85
42.0%	419.3	0.9810	1.3338	1.3361	563.2	527.2	471.00
43.0%	429.2	0.9810	1.3445	1.3468	580.4	487.2	511.06
44.0%	439.2	0.9810	1.3553	1.3577	597.9	444.1	554.18
45.0%	449.2	0.9810	1.3663	1.3688	615.5	397.7	600.54
46.0%	459.2	0.9810	1.3775	1.3799	633.3	347.9	650.31
47.0%	469.2	0.9810	1.3888	1.3913	651.3	294.5	703.68
48.0%	479.2	0.9810	1.4003	1.4028	669.5	237.4	760.84
49.0%	489.1	0.9810	1.4119	1.4144	687.9	176.3	821.96
50.0%	499.1	0.9810	1.4237	1.4262	706.5	111.0	887.26
51.0%	509.1	0.9810	1.4357	1.4382	725.2	41.3	956.92

Data and calcualtions are based on ocean water, with adjustments for other types of saline waters being made to the relative density and specific gravity columns.
Most data for nominal salinities of up to 15% are from the sea water aqueous solution table (page D-258) in Weast (1980).
Relative densities for ocean water are adjusted to Salton Sea conditions based on comparative specific gravity estimates at 4.5% and 35% salinities (Ormat estimates for Salton Sea, calculations with this spreadsheet for ocean water).
Specific gravity and displaced water quantities are calculated from other data in the table (density of water is 998.23 grams per liter at 20 degrees C, 1,000 grams/liter at 4 deg C).
Grams of salt in solution, displaced water quantities, and relative densities for nominal salinities above 15% are calculated based on regression analyses (TABLECURVE 2D software) using data for lower salinities. Regression analyses are used to calculate nominal relative densities of ocean water because relative densities listed in Weast (1980) do not equal the sum of salt plus water grams per liter.
Grams of water in solution, salinity parts per thousand, and specific gravity for nominal salinities above 15% are calculated from other values.
Calculations for nominal salinties above 30% are somewhat artificial, since many salts will reach saturation concentration at lower total salinity levels.

Data Source: Weast, Robert C. (ed.). 1980. CRC Handbook of Chemistry and Physics. 61st Edition. CRC Press. Boca Raton, FL.

TABLE C-52. COMPARISON OF OWENS LAKE, MONO LAKE, AND SALTON SEA

FEATURE	OWENS LAKE	MONO LAKE	SALTON SEA
CURRENT LAKE SURFACE ELEVATION	3,553+/- feet for residual brine pool.	6,380+/- feet; water levels now rising.	-227 feet.
LAKE BASIN PREHISTORY	Long prehistory of periodic lake formation and dessication. Historic Owens Lake present from Pleistocene times until dessication in 1926.	Very ancient prehistory without any evidence of natural dessication. Lake may have existed continuously for more than 750,000 years.	Prehistory of periodic lake formation and dessication. Last deep natural lake dessicated about 300 - 500 years ago. Subsequent history of shallow temporary lakes formed by irregular Colorado River overflows.
LAKE BASIN SHAPE AND DRAINAGE CONTEXT	Shallow, flat depression. Terminal basin for surface flows. Under natural conditions, probably a terminal basin for groundwater flows. May have transformed into a groundwater recharge area due to groundwater pumping. Pre-diversion period maximum depth: 30 - 35 feet; deeper during high stands.	Deep bowl. Terminal basin for both surface and groundwater flows. Pre-diversion period maximum depth: about 185 feet; deeper during high stands.	Elongated valley. Terminal basin for surface flows. Status as terminal basin or recharge area for groundwater flows unclear. Current maximum depth: about 50 feet. Natural surface and groundwater flows insufficient to create a natural lake.
NATURAL SURFACE INFLOWS	Owens River plus small local streams.	Rush Creek, Lee Vining Creek, Mill Creek, and other Sierra streams.	Periodic Colorado River overflows. Seasonal flows in local rivers and creeks.
ARTIFICIAL SURFACE INFLOWS	Minimal.	Minimal (storm drainage from Lee Vining area).	Significant agricultural drainage flows.

TABLE C-52. COMPARISON OF OWENS LAKE, MONO LAKE, AND SALTON SEA

FEATURE	OWENS LAKE	MONO LAKE	SALTON SEA
NATURAL GROUNDWATER INFLOWS	Natural springs (some with artesian flow). Presumably, some groundwater inflow from north along Owens River channel. Other shallow groundwater inflows?	Natural springs (mostly non-saline, some with artesian flow). Non-saline groundwater from west and south; saline groundwater from north and east.	Presumably minimal under natural conditions. Agricultural irrigation may have augmented natural groundwater flows or created new groundwater flows.
WATER CHEMISTRY	Saline, alkaline, and sulfurous. High phosphate levels. Obvious influence from volcanic deposits in watershed (including high arsenic and cadmium levels).	Saline, alkaline, and sulfurous. High phosphate levels. Obvious influence from volcanic deposits in watershed (high boron, fluoride, arsenic, strontium, and lithium levels).	Saline and sulfurous. Sulfate content has increased somewhat faster than chloride content since 1907. Other chemical influences mostly from agricultural chemicals.
MAJOR DISSOLVED SALTS	Sodium chloride, sodium carbonate, sodium sulfate, sodium bicarbonate. Calcium carbonate deposition under natural conditions.	Sodium carbonate, sodium chloride, sodium sulfate. Significant calcium carbonate deposition under natural conditions.	Sodium chloride, magnesium chloride, sodium sulfate, sodium bicarbonate. Calcium carbonate and calcium sulfate deposition occurring?
WATER TEMPERATURES	Seasonal cycle probably below 25 deg C prior to dessication.	Seasonal cycle of 3 - 22 deg C at 2 meters.	Seasonal cycle of 15 - 30 deg C in most years.
PRE-INTERFERENCE SALINITY LEVELS	1866-1886: 6.5% - 10% 1905-1912: 9.6% - 21.4% Owens River diverted in 1917.	1941: 4.8% Major creeks diverted starting in 1941.	1907: 0.36% 1914: 1.14% 1929: about 3.3% 1960: about 3.6% 1970: about 3.9% 1999: 4.4%

TABLE C-52. COMPARISON OF OWENS LAKE, MONO LAKE, AND SALTON SEA

FEATURE	OWENS LAKE	MONO LAKE	SALTON SEA
POST-INTERFERENCE SALINITY	Lake dessicated between 1917 and 1926. Saturated brine pool remains.	1990: 9%. Salinity probably declining as lake levels rise.	7.5% in 2030 under No Action, lowest inflow. Otherwise, below 5.4%.
FATE OF DISSOLVED SALTS WITH INTERFERENCE	Different salts reached saturation in 1920 and 1921. Sequential precipitatation of salts. Brine within salt bed at saturation. 40% loss of 1912 salt load from the system; sodium chloride removal by groundwater movement suspected.	Salts have remained in solution. No salt deposition from Mono Lake itself.	Salts will remain in solution. No salt deposition expected within the forseeable future, even with inflows reduced to 800,000 acre-feet per year.
EXTENT AND SOURCE OF CURRENT SALT DEPOSITS	Massive salt deposits on lake bed, derived as precipitates from dessicating lake. Complex spatial mixtures of sodium chloride, sodium carbonate, sodium bicarbonate, and sodium sulfate salts; calcium carbonate also in bottom of deposit. Gradual shrinking of main salt bed area. Ongoing process of evaporative salt formation (mostly sulfate, carbonate, bicarbonate salts) and redissolving, mostly around eastern and southern sides of salt deposit. Presence of efflorescent salts indicates shallow saline groundwater along eastern and southern sides of lakebed.	Extensive salt deposits on north and east shore, above lake level. Salt deposits are evaporative deposits derived from saline groundwater, and formed only after the lake level was lowered below the natural zone of groundwater inflow to Mono Lake. Mineralogical phase changes in deposits indicate dominance by sodium carbonate, sodium bicarbonate, and sodium sulfate salts; sodium chloride probably present in some areas.	Historically, central salt pans left by dessication of temporary lakes (redissolved when flooded again). Currently, a narrow zone of shoreline salt deposits as would be expected around any saline lake. Deposits probably dominated by chloride salts having low inherent susceptibility to wind erosion. No evidence of significant salt deposits susceptible to wind erosion.

TABLE C-52. COMPARISON OF OWENS LAKE, MONO LAKE, AND SALTON SEA

FEATURE	OWENS LAKE	MONO LAKE	SALTON SEA
WIND EROSION HAZARD FOR CURRENT SALT DEPOSITS	Varies from very low (wet deposits and deposits dominated by sodium chloride) to very high (dryer sodium carbonate, sodium bicarbonate, and sodium sulfate deposits; these undergo mineralogical phase changes from nonerosive crystalline forms to noncrystalline, anhydrous powders that are extremely erosive).	Varies from very low (wet deposits) to very high (dryer sodium carbonate, sodium bicarbonate, and sodium sulfate deposits; these undergo mineralogical phase changes from nonerosive crystalline forms to noncrystalline, anhydrous powders that are extremely erosive).	Mostly low to very low (sodium chloride deposits and crusted soils). Relatively high water temperatures during most of the year indicate that sodium chloride (low wind erosion hazard) will precipitate with or before sulfate and carbonate salts, should the Salton Sea ever dessicate.
WIND EROSION HAZARD FOR OTHER SEDIMENTS AND SOILS	Mostly low emission rates, typical of desert basin soils.	Mostly low emission rates, typical of desert basin soils. Very low erosion hazard for exposed tufa deposits and basaltic sands. Moderate erosion hazards for sands derived from pumice. Very high erosion hazard for exposed diatomaceous sediments on Paoha Island.	Mostly low emission rates, typical of desert basin soils. Comparative emission rates for agricultural areas uncertain.

ENHANCED EVAPORATION SYSTEM EVALUATION

TABLE C-53. ENHANCED EVAPORATION SYSTEM LAYOUT ASSUMPTIONS FOR DISPERSION MODELING PURPOSES

PHYSICAL LAYOUT OF EACH MODULE:

EACH MODULE A 3-POND, 2-PASS SPRAY SYSTEM WITH LINEAR TOWER ARRAYS PARALLEL TO LENGTH OF POND (WIDTH OF OVERALL MODULE):

MODULE COMPONENTS			SPRAY SYSTEM COMPONENTS														POND AREA	
POND TYPE	LENGTH (feet)	WIDTH (feet)	LINES PER ARRAY	LINE MEMBER SPACING (feet)	LINE ARRAY WIDTH (feet)	GAP BETWEEN LINE ARRAYS (feet)	LINE ARRAYS IN POND	TOWER SPACING (feet)	TOWERS PER LINE ARRAY	CONNECT ZONE PER SIDE OF TOWER (feet)	ACTIVE SEGMENTS PER LINE ARRAY	TOTAL ACTIVE SPRAY LENGTH (feet)	BUFFER AT END OF ARRAY (feet)	OVERALL ARRAY LENGTH (feet)	OUTER LINE ARRAY BUFFER (feet)	LINE ARRAY HEIGHT (feet)	SQ FEET	ACRES
Second Pass	1,200	806	5	10	40	120	5	500	3	5	2	980	100	1,000	83	82	967,200	22.20
First Pass	1,200	672	5	10	40	120	4	500	3	5	2	980	100	1,000	96	131	806,400	18.51
Final Pond	1,200	806															967,200	22.20
MODULE:	1,200	2,284															2,740,800	62.92

Input parameters: Pond length and width; lines per array; line member spacing; tower spacing; connect zone per side of tower; line array height.

Gap between line arrays assumed to be 3 times the line array width.

All other parameters calculated directly from input parameters.

Basic Module Configuration:

```
          |-----------------|
|<----    |   second pass   |
|   |->   |   spray pond    |
|   |     |-----------------|
|   |     |   first pass    | <=== inflow
|   |<-   |   spray pond    |
|         |-----------------|
|---->    |   final salt    |
          |      pond       |
          |-----------------|
```

NUMBER OF MODULES:

75 for Phase 1

125 for Phase 2

TABLE C-54. WATER AND SALT FLOW RATES FOR LINE ARRAYS IN A MODULE

FLOWS FOR EACH FIRST PASS LINE ARRAY IN A MODULE
ESTIMATED FIRST PASS EVAPORATION FACTOR 63.5%

TOTAL FIRST PASS ACRE-FT PER YEAR	TOTAL FIRST PASS ACRE-FT PER DAY	WATER VOLUME AND MASS FOR EACH LINE ARRAY ACRE-FT PER DAY	GALLONS PER DAY	GALLONS PER HR	GALLONS PER MIN	POUNDS PER HR	POUNDS PER MIN	INITIAL SALT CONTENT	SALT RELEASE PER LINE ARRAY POUNDS PER HR	POUNDS PER MIN	FIRST PASS SALT EMISSIONS GM/HR/MILE OF LINE	OUTFLOW SALT CONTENT	MEAN DROPLET DENSITY (gm/cm^3)
2,000	5.48	1.37	446,372	18,599	310.0	159,207	2,653	4.3%	6,846	114.10	1.640E+07	11.0%	1.0487

NOZZLE SPACING ALONG LINES IN ARRAY: 9 FEET (= nozzle spray pattern diameter)
PER NOZZLE FLOW RATE (gal/min): 0.57 GAL/MIN

FLOWS FOR EACH SECOND PASS LINE ARRAY IN A MODULE:
ESTIMATED SECOND PASS CUMULATIVE EVAPORATION FACTOR: 87.2%
SECOND PASS INCREMENTAL EVAPORATION FACTOR: 64.9%

TOTAL SECOND PASS ACRE-FT PER YEAR	TOTAL SECOND PASS ACRE-FT PER DAY	WATER VOLUME AND MASS FOR EACH LINE ARRAY AC-FT PER DAY	GALLONS PER DAY	GALLONS PER HR	GALLONS PER MIN	POUNDS PER HR	POUNDS PER MIN	INFLOW SALT CONTENT	SALT RELEASE PER LINE ARRAY POUNDS PER HR	POUNDS PER MIN	SECOND PASS SALT EMISSIONS GM/HR/MILE OF LINE	OUTLFOW SALT CONTENT	MEAN DROPLET DENSITY (gm/cm^3)
751	2.06	0.41	134,081	5,587	93.1	49,966	833	11.0%	5,496	91.60	1.316E+07	26.0%	1.1279

NOZZLE SPACING ALONG LINES IN ARRAY: 9 FEET (= nozzle spray pattern diameter)
PER NOZZLE FLOW RATE (gal/min): 0.17 GAL/MIN

Line source emission rates computed using the gross array length of 1,000 feet (as opposed to the active spray length of 980 feet).

TABLE C-55. LINE SOURCE COORDINATE GUIDE FOR DISPERSION MODELING

RELATIVE COORDINATES FOR FIRST/LAST ARRAYS:		TOWER 1 X1	TOWER 1 Y1	TOWER 2 X2	TOWER 2 Y2	TOWER 3 X3	TOWER 3 Y3	NOZZLE SPRAY DIAMETER	5-LINE SOURCE WIDTH	OVERALL ARRAY LENGTH	COMBINED ARRAY WIDTH
Second Pass Module:	top array of lines	100	2201	600	2201	1100	2201	9	54		
	spacing between line arrays	0	-160	0	-160	0	-160				
	bottom array of lines	100	1561	600	1561	1100	1561	9	54	1,000	640
First Pass Module:	top array of lines	100	1395	600	1395	1100	1395	9	54		
	spacing between line arrays	0	-160	0	-160	0	-160				
	bottom array of lines	100	902	600	902	1100	902	9	54	1,000	493

Nozzle spray pattern diameter = line spacing in array - 1 foot
Modeled line source width = overall line array spray width = line array width + 2*(1/2 nozzle spray diameter) + 5 feet for line sway.
Relative coordinate system origin set at bottom left corner of module.

```
(0,2284) |---------------|(1200,2284)
         |  second pass  |
         |  spray pond   |
(0,1478) |---------------|(1200,1478)
         |  first pass   |
         |  spray pond   |
 (0,806) |---------------|(1200,806)
         |  final salt   |
         |     pond      |
   (0,0) |---------------|(1200,0)
```

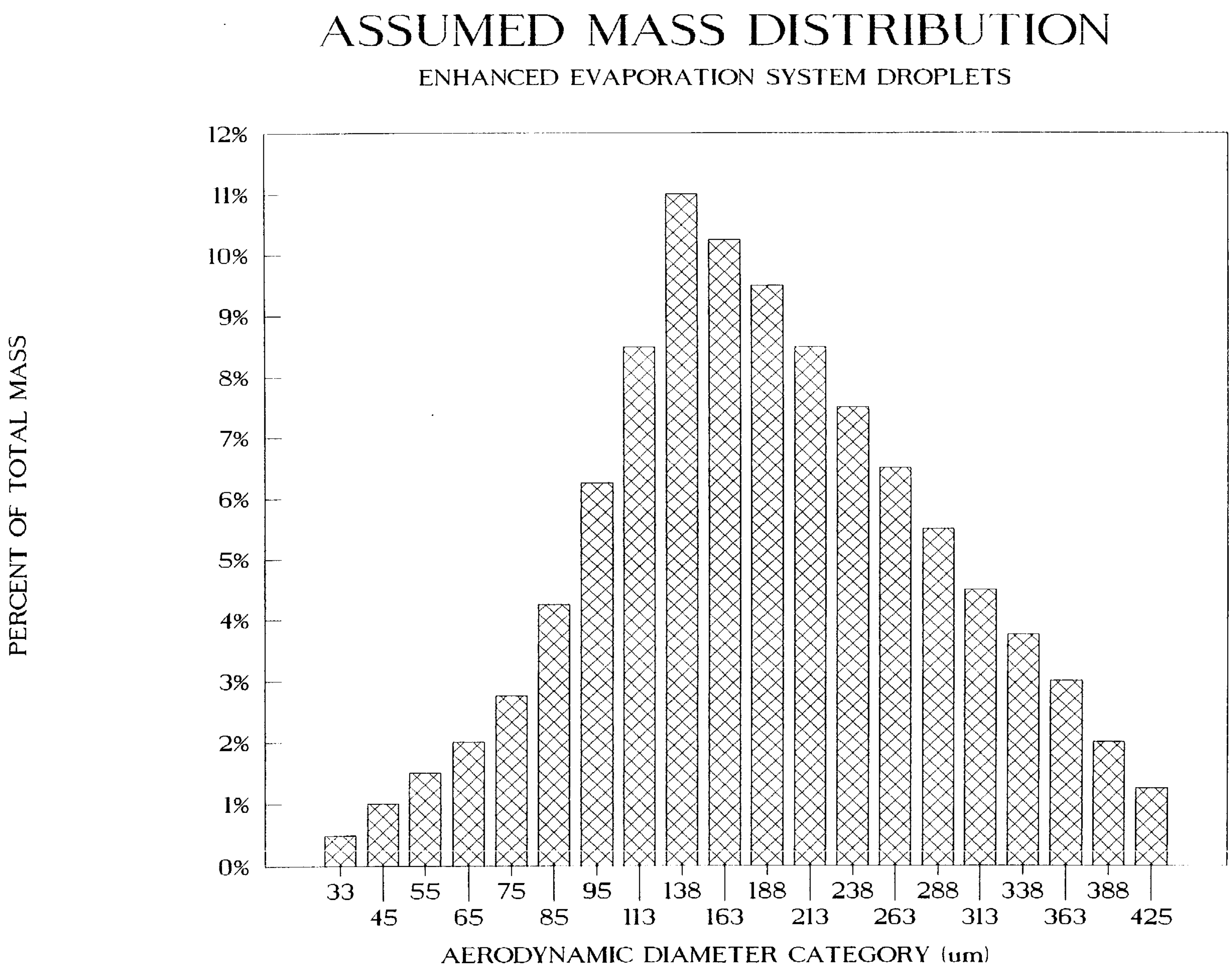
TABLE C-56. LOOKUP TABLE FOR DATA ASSOCIATED WITH FIRST PASS OR CUMULATIVE EVAPORATION

	NOMINAL PERCENT EVAP	POUNDS PER HOUR			NOMINAL SALINITY	KG PER LITER	POUNDS PER GAL	% OF INITIAL VOLUME
		TOTAL	WATER	SALT				
INITIAL CONDITIONS:		159,207	152,361	6,846	4.3%	1.0257	8.5600	100.0%
WATER CONTENT EVAPORATION FACTOR:	0.0%	159,207	152,361	6,846	4.3%	1.0257	8.5600	100.0%
	5.0%	151,589	144,743	6,846	4.5%	1.0272	8.5724	95.1%
	10.0%	143,971	137,125	6,846	4.8%	1.0295	8.5914	90.1%
	15.0%	136,353	129,507	6,846	5.0%	1.0310	8.6041	85.2%
	20.0%	128,735	121,889	6,846	5.3%	1.0333	8.6231	80.3%
	25.0%	121,117	114,271	6,846	5.7%	1.0363	8.6485	75.3%
	30.0%	113,499	106,653	6,846	6.0%	1.0386	8.6675	70.4%
	35.0%	105,881	99,035	6,846	6.5%	1.0423	8.6984	65.4%
	40.0%	98,262	91,417	6,846	7.0%	1.0460	8.7293	60.5%
	45.0%	90,644	83,799	6,846	7.6%	1.0506	8.7673	55.6%
	50.0%	83,026	76,180	6,846	8.2%	1.0551	8.8054	50.7%
	55.0%	75,408	68,562	6,846	9.1%	1.0620	8.8625	45.7%
	60.0%	67,790	60,944	6,846	10.1%	1.0686	8.9177	40.9%
	63.5%	62,458	55,612	6,846	11.0%	1.0717	8.9438	37.5%
	65.0%	60,172	53,326	6,846	11.4%	1.0783	8.9990	36.0%
	67.5%	56,363	49,517	6,846	12.1%	1.0832	9.0396	33.5%
	70.0%	52,554	45,708	6,846	13.0%	1.0893	9.0906	31.1%
	72.5%	48,745	41,899	6,846	14.0%	1.0962	9.1482	28.6%
	75.0%	44,936	38,090	6,846	15.2%	1.1044	9.2170	26.2%
	77.5%	41,127	34,281	6,846	16.6%	1.1144	9.3001	23.8%
	80.0%	37,318	30,472	6,846	18.3%	1.1266	9.4016	21.3%
	82.5%	33,509	26,663	6,846	20.4%	1.1418	9.5284	18.9%
	85.0%	29,700	22,854	6,846	23.1%	1.1619	9.6961	16.5%
	87.2%	26,348	19,502	6,846	26.0%	1.1840	9.8810	14.3%
	90.0%	22,082	15,236	6,846	31.0%	1.2250	10.2231	11.6%
	92.5%	18,273	11,427	6,846	37.5%	1.2873	10.7430	9.1%

TABLE C-57. SPRAY DROPLET SETTLING/DEPOSITION RATES FOR FIRST PASS ARRAYS

Spray Droplet Size Categories, Aerodynamic Diameter	Mass Fraction	Mass-Median Diameter (microns)	Default Reflection Coefficient	Default Deposition Coefficient	Settling Rate (meters/sec)	Settling Rate (cm/sec)	Deposition Rate (cm/sec)
25 - 40 Microns	0.00500	33.07	0.66235	0.33765	0.03346	3.34604	3.34604
40 - 50 Microns	0.01000	45.18	0.59068	0.40932	0.06248	6.24769	6.24769
50 - 60 Microns	0.01500	55.15	0.51510	0.48490	0.09308	9.30788	9.30788
60 - 70 Microns	0.02000	65.13	0.42439	0.57561	0.12980	12.98007	12.98007
70 - 80 Microns	0.02750	75.11	0.31857	0.68143	0.17264	17.26429	17.26429
80 - 90 Microns	0.04250	85.10	0.19763	0.80237	0.22161	22.16053	22.16053
90 - 100 Microns	0.06250	95.09	0.06158	0.93842	0.27669	27.66880	27.66880
100 - 125 Microns	0.08500	112.96	0.00000	1.00000	0.39048	39.04809	39.04809
125 - 150 Microns	0.11000	137.88	0.00000	1.00000	0.58174	58.17422	58.17422
150 - 175 Microns	0.10250	162.82	0.00000	1.00000	0.81125	81.12544	81.12544
175 - 200 Microns	0.09500	187.78	0.00000	1.00000	1.07902	107.90180	107.90180
200 - 225 Microns	0.08500	212.74	0.00000	1.00000	1.38503	138.50332	138.50332
225 - 250 Microns	0.07500	237.72	0.00000	1.00000	1.72930	172.93000	172.93000
250 - 275 Microns	0.06500	262.70	0.00000	1.00000	2.11182	211.18185	211.18185
275 - 300 Microns	0.05500	287.68	0.00000	1.00000	2.53259	253.25889	253.25889
300 - 325 Microns	0.04500	312.67	0.00000	1.00000	2.99161	299.16110	299.16110
325 - 350 Microns	0.03750	337.65	0.00000	1.00000	3.48888	348.88849	348.88849
350 - 375 Microns	0.03000	362.64	0.00000	1.00000	4.02441	402.44106	402.44106
375 - 400 Microns	0.02000	387.63	0.00000	1.00000	4.59819	459.81881	459.81881
400 - 450 Microns	0.01250	425.49	0.00000	1.00000	5.54013	554.01326	554.01326
WEIGHTED AVERAGE VALUES:		193.16	0.04644	0.95356	1.39048	139.04753	139.04753
FOR MEAN AEROSOL CATEGORY:		187.78	0.00000	1.00000	1.07902	107.90180	107.90180
FOR WEIGHTED AVERAGE SIZE:		193.16	0.00000	1.00000	1.14178	114.17772	114.17772

Notes: Mass-median diameter and settling rate equations from ISC model user's guide (Wagner 1987).
Reflection coefficient from regression analysis of data points scaled from Figure 2-8 in Wagner (1987).
Default reflection and deposition coefficients are most appropriate for solid particles; coefficients are ignored for liquid aerosols.
Spray droplet size range based on size range for mist and drizzle droplets.
Mass distribution weighted toward small mist droplets for maximum evaporation.
Mean droplet density of 1.0487 gm/cubic cm based on Salton Sea water evaporated to about 7.36% salinity.



ASSUMED MASS DISTRIBUTION
ENHANCED EVAPORATION SYSTEM DROPLETS
PERCENT OF TOTAL MASS
12%
11%
10%
9%
8%
7%
6%
5%
4%
3%
2%
1%
0%
33
45
55
65
75
85
95
113
138
163
188
213
238
263
288
313
338
363
388
425
AERODYNAMIC DIAMETER CATEGORY (um)

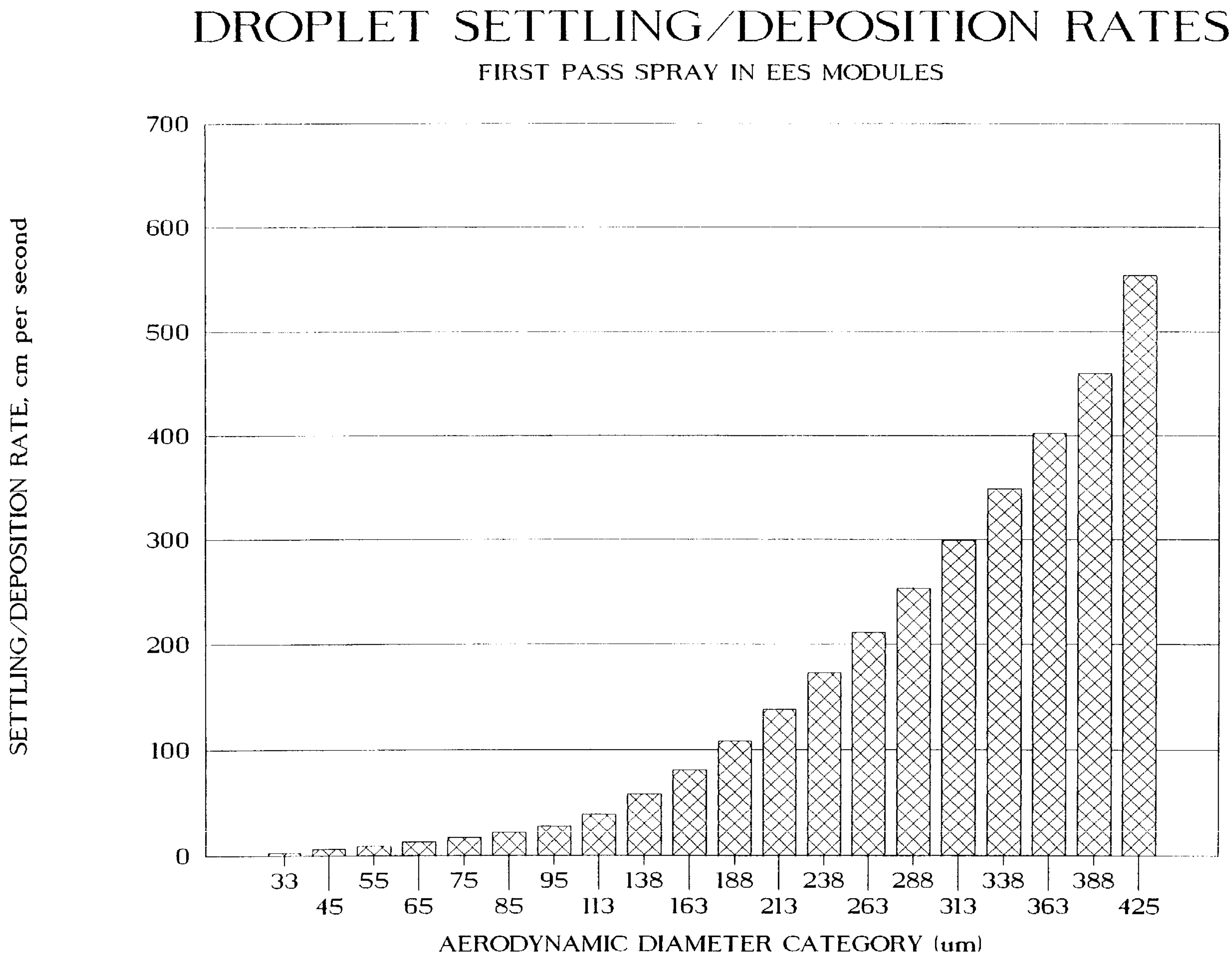
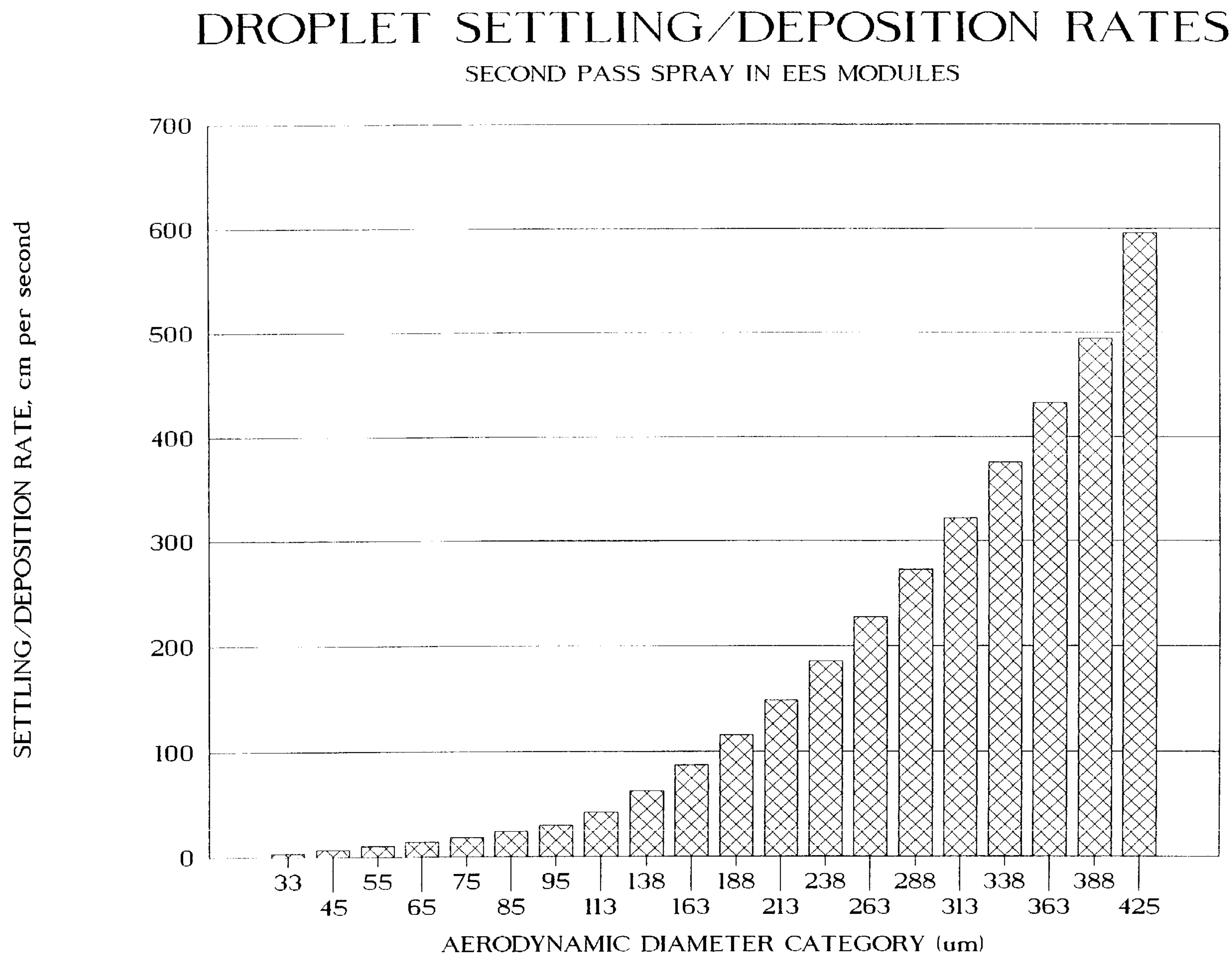

DROPLET SETTLING/DEPOSITION RATES
FIRST PASS SPRAY IN EES MODULES
SETTLING/DEPOSITION RATE, cm per second
700
600
500
400
300
200
100
0
33
45
55
65
75
85
95
113
138
163
188
213
238
263
288
313
338
363
388
425
AERODYNAMIC DIAMETER CATEGORY (um)

TABLE C-58. SPRAY DROPLET SETTLING/DEPOSITION RATES FOR SECOND PASS ARRAYS

Spray Droplet Size Categories, Aerodynamic Diameter	Mass Fraction	Mass-Median Diameter (microns)	Default Reflection Coefficient	Default Deposition Coefficient	Settling Rate (meters/sec)	Settling Rate (cm/sec)	Deposition Rate (cm/sec)
25 - 40 Microns	0.00500	33.07	0.65611	0.34389	0.03599	3.59874	3.59874
40 - 50 Microns	0.01000	45.18	0.57903	0.42097	0.06720	6.71953	6.71953
50 - 60 Microns	0.01500	55.15	0.49773	0.50227	0.10011	10.01083	10.01083
60 - 70 Microns	0.02000	65.13	0.40018	0.59982	0.13960	13.96035	13.96035
70 - 80 Microns	0.02750	75.11	0.28637	0.71363	0.18568	18.56812	18.56812
80 - 90 Microns	0.04250	85.10	0.15630	0.84370	0.23834	23.83414	23.83414
90 - 100 Microns	0.06250	95.09	0.00997	0.99003	0.29758	29.75840	29.75840
100 - 125 Microns	0.08500	112.96	0.00000	1.00000	0.41997	41.99708	41.99708
125 - 150 Microns	0.11000	137.88	0.00000	1.00000	0.62568	62.56766	62.56766
150 - 175 Microns	0.10250	162.82	0.00000	1.00000	0.87252	87.25220	87.25220
175 - 200 Microns	0.09500	187.78	0.00000	1.00000	1.16051	116.05077	116.05077
200 - 225 Microns	0.08500	212.74	0.00000	1.00000	1.48963	148.96337	148.96337
225 - 250 Microns	0.07500	237.72	0.00000	1.00000	1.85990	185.99003	185.99003
250 - 275 Microns	0.06500	262.70	0.00000	1.00000	2.27131	227.13075	227.13075
275 - 300 Microns	0.05500	287.68	0.00000	1.00000	2.72386	272.38552	272.38552
300 - 325 Microns	0.04500	312.67	0.00000	1.00000	3.21754	321.75436	321.75436
325 - 350 Microns	0.03750	337.65	0.00000	1.00000	3.75237	375.23727	375.23727
350 - 375 Microns	0.03000	362.64	0.00000	1.00000	4.32834	432.83424	432.83424
375 - 400 Microns	0.02000	387.63	0.00000	1.00000	4.94545	494.54528	494.54528
400 - 450 Microns	0.01250	425.49	0.00000	1.00000	5.95853	595.85349	595.85349
WEIGHTED AVERAGE VALUES:		193.16	0.03968	0.96032	1.49549	149.54869	149.54869
FOR MEAN AEROSOL CATEGORY:		187.78	0.00000	1.00000	1.16051	116.05077	116.05077
FOR WEIGHTED AVERAGE SIZE:		193.16	0.00000	1.00000	1.22801	122.80065	122.80065

Notes: Mass-median diameter and settling rate equations from ISC model user's guide (Wagner 1987).
Reflection coefficient from regression analysis of data points scaled from Figure 2-8 in Wagner (1987).
Default reflection and deposition coefficients are most appropriate for solid particles; coefficients are ignored for liquid aerosols.
Spray droplet size range based on size range for mist and drizzle droplets.
Mass distribution weighted toward small mist droplets for maximum evaporation.
Mean droplet density of 1.1279 gm/cubic cm based on Salton Sea water evaporated to 18.49% salinity.


DROPLET SETTLING/DEPOSITION RATES
SECOND PASS SPRAY IN EES MODULES
SETTLING/DEPOSITION RATE, cm per second
0
100
200
300
400
500
600
700
33
45
55
65
75
85
95
113
138
163
188
213
238
263
288
313
338
363
388
425
AERODYNAMIC DIAMETER CATEGORY (um)