AMMONIA EMISSIONS IN THE SOUTH COAST AIR BASIN 1982

by

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Open File Report 84-2

Environmental Quality Laboratory
California Institute of Technology
Pasadena, California 91125

December 1984

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APPENDIX

Tabulation of Emission Factors, Activity Levels, and Ammonia Emission Rates

TABLE A.1

Emission Factors for Ammonia from Combustion Sources

	VALUE REPORTED	REFERENCE	EMISSION FACTOR (Kg $NH_3/10^9$ Btu)	VALUE ADOPTED FOR EMISSION INVENTORY USE (Kg $NH_3/10^9$ Btu)
STATIONARY SOURCES				
Fuel Combustion				
Natural Gas				
Average of Los Angeles Source Tests	0.4 mg/m^3 NH_3 in exhaust	(a)	0.119	
New York Emission Inventory Emission Factor	0.5 lb $NH_3/10^6$ ft^3 gas burned	(b)	0.214	
Literature Survey (1969)	0.3 to 0.56 lb $NH_3/10^6 ft^3$ gas	(c)	0.128-0.240	
Literature Review (1956)	0.010 tons $NH_3/10^6 ft^3$ gas	(d)	8.56	
Recent Source Test: 200,000 Btu/hr combustor				
(1) at 2% excess O_2; 17 test avg	14.44 ppm NH_3 in exhaust	(e)	3.25	3.25
(2) at 4% excess O_2; 23 test avg	6.00 ppm NH_3 in exhaust	(e)	1.351	1.35
(3) at 6% excess O_2; 15 test avg	1.00 ppm NH_3 in exhaust	(e)	0.225	0.22
Residual Fuel Oil				
Average of Los Angeles Source Tests	0.4 mg/m^3 NH_3 in exhaust	(a)	0.125	
New York Emission Inventory Emission Factor	1 lb/1000 gal oil	(f)	3.03	
Literature Survey (1956)	0.001 tons NH_3/ton oil	(g)	23.1	
Recent Source Test: 200,000 Btu/hr combustor at 2% excess air; avg of 2 tests	11.3 ppm in exhaust	(h)	2.8	2.8
Distillate Oil				
New York Emission Inventory Emission Factor	1 lb/1000 gal oil	(i)	3.29	3.3
Coal				
Literature Review (1956)	2 lb NH_3/ton coal	(j)	37.8	38
Mass Balance over N.W. Europe	1.21 g NH_3/920 g coal	(k)	50	
Recent Source Test: 200,000 Btu/hr combustor at 4% excess air, 1 test	85 ppm NH_3 in exhaust	(l)	~20	
Wood				
Literature Review (1956)	2.4 lb NH_3/ton wood	(m)		

Notes:

(a) Magill and Benoliel (1952)
(b) Hovey, Risman and Cunnan (1966), Range reported 0.3 to 20 lb $NH_3/10^6 ft^3$ natural gas
(c) Miner (1969); literature survey
(d) Wohlers and Bell (1956)
(e) Muzio and Arand (1976)
(f) Hovey, Risman and Cunnan (1966); Range reported 0.06 lb/1000 gal to 8 lb/1000 gal; converted at 0.011 scf prod/btu; 6.11×10^6 btu/bbl
(g) Wholers and Bell (1956); value appears high but note that data may be rounded up to 0.001 tons NH_3/ton oil
(h) Muzio and Arand (1976); 2 tests range 20 ppm - 2.54 ppm
(i) Hovey, Risman and Cunnan (1966); converted at 0.011 scf prod/btu; 5.8×10^6 btu/bbl
(j) Wohlers and Bell (1956)
(k) Soderlund (1977)
(l) Muzio and Arand (1976); combustion product data unavailable, converted from ppm to $Kg/10^9$ btu in proportion to oil and natural gas data
(m) Wohlers and Bell (1956)

TABLE A.2

Fuel Economy Calculation for 1982 Automobile Fleet

Age (years)	Model Year	Percentage of Total Vehicles in Use (a)	Percent Sold with Diesel Engines (b) (US)	Percentage of Vehicles in Use (gasoline engine)	Percentage of Vehicles in Use (diesel engine)	Annual Average Mileage Driven (c)	Fraction of Light Duty Fleet Miles Traveled by Gasoline Engines	Fraction of Light Duty Fleet Miles Traveled by Diesel Engines	Fuel Economy for Gasoline Cars MPG (d)	Weighted Average Fuel Economy for Gasoline Cars MPG	Weighted Average Fuel Economy for Diesel Cars MPG
1	1982	7.77	4.6	7.41	0.36	15,900	0.111	0.0054	26.2		
2	1981	7.77	5.9	7.31	0.46	15,000	0.104	0.0065	25.1		
3	1980	8.76	4.6	8.36	0.40	14,000	0.111	0.0053	23.5	21.10	24.69
4	1979	9.20	2.2	9.0	0.20	13,100	0.111	0.0025	20.3		
5	1978	8.50	0.4	8.47	0.03	12,200	0.098	0.0004	19.9	fleet avg. for cat. autos	fleet avg. for diesel autos
6	1977	6.73	0.1	6.72	0.01	11,300	0.072	0.00011	18.3		
7	1976	5.51	0.1	5.5	0.01	10,300	0.054	0.00010	17.5		
8	1975	5.37	0.1	5.36	0.01	9,400	0.048	0.00009	15.8		
9	1974	6.45	0.1	6.44	0.01	8,500	0.052	0.00008	14.2		
10	1973	5.78	-	5.78		7,600	0.042		13.6		
11	1972	4.90	-	4.9		6,700	0.031		13.6	13.65	
12	1971	3.88	-	3.88		6,700	0.025		13.6	fleet avg. for non-cat. autos	
≥13	1970(-)	19.38	-	19.38		6,700	0.123		13.6		
									13.6		

NOTES:

(a) Derived from California Department of Finance (1982), Table J-5, p. 170.

(b) Values for 1980 and previous years are from Diesel Impacts Study Committee (1982), pp. 1 and 90. Values for 1981 and 1982 are Automotive News, 7/5/82, as cited by Holman and Lauderdale (1983), p. 7. Data shown are based on nationwide sales statistics.

(c) U.S. Environmental Protection Agency, 1976.

(d) Motor Vehicle Manufacturers' Association (1983).

(e) A fuel economy value of 27 MPG is given by Cadle (1983) for General Motors light duty diesel vehicles. Since fuel economy for all automobiles has been improving in recent years, we estimate a fleet average fuel economy weighted over new and older diesel cars to be about 25 MPG.

TABLE A.3

Emission Factors for Ammonia from Highway Vehicles

	VALUE FOR VEHICLES IN PROPER OPERATING CONDITION (mg/km)	REFERENCE	VALUE ADOPTED FOR EMISSION INVENTORY (mg/km)	(kg $NH_3/10^9$ Btu)
HIGHWAY VEHICLES				
Autos and Lt. Trucks (gasoline engines)				
Catalyst Equipped Engines				
Oxidation Catalyst Only				
1. 1977 and 1978 production vehicles, 1975 FTP cycle	2.5	(a)		
2. California emission controls, 1975 FTP cycle	3.06	(b)		
3. 1978 Buick, Ford, Volvo, Oldsmobile, Chevrolet, Chrysler, 1979 FTP cycle, unleaded fuel	5.7	(c)	10 (z)	2.7
4. 1978 Chevrolet Malibu, 1978 Ford Granada, 1977 FTP cycle, unleaded fuel, with air pump	3.6	(d)		
5. 1978 Chevrolet Malibu, 1978 Ford Mustang II, 1977 FTP cycle, unleaded fuel, without air pump	3.1	(d)		
3-way Catalyst				
1. General Motors vehicles; 1975 FTP cycle	5.0	(e)		
2. 1978 Pontiac Sunbird; 1978 Saab 99; 1978 FTP cycle	3.6	(f)		
3. 1979 Mercury (2); 1978 Volvo; 1979 FTP cycle	10.7	(g)		
4. 1977 Volvo (California model); 1975 FTP cycle	4.7	(h)	35 (z)	
5. 1980 Lincoln Continental, 1975 FTP cycle	16.7	(i)		
6. 1978 Pontiac Sunbird; 1978 FTP cycle	11.1	(j)		
7. 1978 Saab; 1978 FTP cycle	60.8	(j)		
3-way Catalyst Plus Oxidation Catalyst				
1. 1978 Ford Pinto; 1979 Mercury Marquis; 1978 FTP cycle	2.6	(k)		
2. 1978 Ford Pinto; 1980 Chevrolet Caprice; 1975 FTP cycle	20.1	(l)	10 (z)	
3. 1978 Ford Pinto; 1979 Mercury Marquis; 1978 FTP cycle	5.6	(m)		
Non-Catalyst Pre-1975 Cars				
1. General Motors vehicles; 1975 FTP cycle; unleaded fuel	2.5	(n)		
2. 1977 AMC Pacer; 1977 FTP cycle; unleaded fuel	3.1	(o)	5 (z)	0.87
3. 1956 Oldsmobile engine on driving cycle	2.5	(p)		
4. 1972 HDV driving cycle	5	(q)		
Catalyst Medium Trucks				2.7 (y)
Non-Catalyst Medium and Heavy Gasoline Trucks				0.87 (z)
Diesel Vehicles				
Diesel Automobiles				
1. Diesel automobile	0.62	(r)	0.6	0.19
2. Experimental diesel auto, FTP cycle	0.6	(s)		
3. Peugot, driving cycle	10.92	(t)		
4. 1972 Mercedes Benz, 60 mph	0.35	(u)		
5. Lt. duty diesel vehicles	0-8	(v)		
Diesel Trucks				
1. Three 8-cylinder diesel engines	2.3	(w)	2	0.14
2. Heavy duty diesel	0-33	(v)		
LPG for Carburetion				0.87 (z)

NOTES:

(a) Cadle (1983); NH_3 emission rate from properly running oxidation catalyst car is about 4 mg/mi.
(b) Cadle and Mulawa[3] (1980), Table V; Average of 5 tests (runs 9 through 13), range 0.6 to 14.8 mg/mi (avg. equals 4.9 mg NH_3/mi or 3.06 mg/km).
(c) Smith and Carey (1982), Tables C-1 to C-6; average values of oxidation-catalyst-equipped cars 1, 4, 6, 7, 8, 9, 10. All values are measured before tune-up in "as received" condition.
(d) Urban and Garbe (1979); Avg. values from Table 8.
(e) Cadle et al. (1979), Table 8; avg. value for dual and 3-way catalysts under normal operation. Note that NH_3 emissions from malfunctioning cars of this type can be very high, about 114 mg/km.
(f) Smith and Black (1980); value of 3.43 (mg/km) used for Sunbird as given in Table B-16; value of 3.83 mg/km used for Saab as discussed in text on page 2465. Value shown in table is average of these two results. Saab emissions are much higher (21.68 mg/km) if car is tested with initial malfunction.
(g) Smith and Carey (1982), Tables C-2 and C-4; avg. values for cars 2, 3, and 5 in "as received" condition.
(h) Bradow and Stump (1977), Table 5; average of two tests with sensor active.
(i) Braddock (1981); value from Figure 8 at 78°F. Value from test on Buick Century is not used because value is high (212.36 mg/mi) due to vehicle malfunction.
(j) Urban and Garbe (1980); Table 4.
(k) Smith and Black (1980), Table B-16; average of results for the two cars indicated.
(l) Braddock (1981), Figure 8; average of values for two cars indicated at 78°F.
(m) Urban and Garbe (1980), Table 4; average of values for two cars indicated.
(n) Cadle et al. (1979), Table 8; non-catalyst cars.
(o) Urban and Garbe (1979), Table C-1; unmodified condition.
(p) Harkins and Nicksic (1967); value reported is 2.2 ppm; converted to mg/km at fuel consumption rate of 13.6 mpg.
(q) Hunter (1971), Figure 2; standard carburetion.
(r) Cadle et al. (1979); text gives value of 1 mg/mile.
(s) Williams and Chock (1980), Table XIII.
(t) Hanein (1975), Table 3; original value equal to 11.1 ppm NH_3 in exhaust; converted to mg/km assuming stoichiometric combustion of the fuel and fuel economy of 24.69 mpg.
(u) Gentel et al. (1973), Table 38; original value equal to 0.36 ppm NH_3 in exhaust; converted to mg/km assuming stoichiometric combustion of the fuel and fuel economy of 24.69 mpg.
(v) Harvey et al. (1983), Table 1.
(w) Perez (1980); maximum value reported is 0.4 mg NH_3/m^3 exhaust; converted to mg/km assuming stoichiometric combustion of the fuel and fuel economy of 5.5 mpg.
(x) Based on recommended values given by Pierson and Brachaczek (1983), text page 759. Values adopted for use with emission inventory are higher than for average of properly operated cars. These higher figures are needed to reflect actual vehicle fleet that includes cars with malfunctions that lead to high NH_3 emission rates. See notes above.
(y) Assumed similar to catalyst automobiles.
(z) Assumed similar to non-catalyst automobiles.

TABLE A.4

Ammonia Emission Estimates for Stationary Combustion Sources

Six-County South Coast Air Basin--1982

	ESTIMATED 1982 FUEL USE (10^9 Btu/day)		EMISSION FACTOR (Kg $NH_3/10^9$ Btu)		AMMONIA EMISSIONS (metric tons/day)
STATIONARY SOURCES					
FUEL COMBUSTION					
Electric Utilities					
Natural Gas	802.	(a)	1.47	(k)	1.18
Residual Oil	134.	(a)	2.8	(l)	0.38
Digester Gas	0.6	(a)	1.47	(m)	0.0009
Refinery Fuel					
Natural Gas	101.	(b)	1.17	(n)	0.118
Residual Oil	5.3	(b)	2.8	(o)	0.015
Refinery Gas	334.	(b)	1.17	(p)	0.39
Industrial and Low Priority Commercial					
Natural Gas	324.	(c)	1.45	(q)	0.47
LPG	5.52	(d)	1.45	(r)	0.008
Residual Oil	8.	(e)	2.8	(s)	0.022
Distillate Oil	37.23	(e)	3.3	(t)	0.123
Digester Gas	18.04	(f)	1.45	(r)	0.026
Coke Oven Gas	37.53	(g)	0.40	(u)	0.015
Residental and High Priority Commercial					
Natural Gas	918.	(h)	0.225	(v)	0.207
LPG	16.85	(i)	0.225	(w)	0.004
Residual Oil	30.4	(i)	2.8	(x)	0.085
Distillate Oil	23.86	(i)	3.3	(x)	0.079
Coal	0.6	(j)	38.	(x)	0.023
TOTAL					3.15

NOTES:

(a) 1982 average daily use, from South Coast Air Quality Management District (1983a) and Ventura County (1983).
(b) 1982 average daily use, from South Coast Air Quality Management District (1983b).
(c) 1982 average daily use, by all industries from Southern California Gas Company (1983) and City of Long Beach (1983), less electric utility and refinery natural gas usage cited above.
(d) U.S. Department of Energy (1983) gives the ratio of industrial to chemical LPG sales in the U.S. as 0.22. This ratio was used for data from the state of California to break LPG sales into sales to chemical and industrial plants. This value includes sales for refinery fuel use which cannot be separated from the total.
(e) State of California total residual and distillate fuel oil use by industries other than oil companies and electric utilities was taken from U.S. Department of Energy (1983). Seventy-five percent of the non-refinery industrial heating demand in Southern California is within the six-county 1974 boundaries of the South Coast Air Basin (Cass, 1978), and 64% of state industrial fuel use is in Southern California (Stanford Research Institute, 1973). Therefore, air basin fuel oil use by industry is estimated as 0.48% of total state use by industry. Kerosene use has been added to the distillate fuel use number shown.
(f) From survey of eight large sewage treatment plants in the inventory area.
(g) Based on 1973 fuel use data at Kaiser Steel, from Cass (1978).
(h) 1982 average daily use by residential and commercial users taken from Southern California Gas Company (1983) and City of Long Beach (1983). Fuel use in south coastal strip of Santa Barbara County estimated as 78% of county total on the basis of fraction of 1970 population living in southern portion of that county (U.S. Bureau of the Census, 1972).
(i) State total LPG, residual fuel oil and distillate oil use by residential and commercial customers is given by U.S. Department of Energy (1983). Forty percent of residential/commercial oil use in the state is in Southern California (Stanford Research Institute, 1973) and 77% of Southern California population is within the six-county boundaries of the South Coast Air Basin (Southern California Association of Governments, 1982). SCAB LPG use thus is estimated as 31% of state total (i.e., 0.40x0.77=0.31).
(j) 1973 data from Cass (1978).
(k) Weighted average: 33% emission factor at 2% O_2 in stack, 22% factor at 4% O_2, 45% factor at 6% O_2 based on frequency of occurrence of O_2 levels given by Bartz et al. (1974; tests 279-289, 298-301).
(l) From Table A.1.
(m) Assumed similar to utility boiler burning natural gas.
(n) Weighted average: 19% emission factor at 2% O_2 in stack, 33% factor at 4% O_2, 48% factor at 6% O_2 based on frequency of occurrence of O_2 levels given by Bartz et al (1974; tests 12-73, 95-103).
(o) From Table A.1.
(p) Assumed similar to refinery equipment burning natural gas.
(q) Weighted average: 35% emission factor at 2% O_2 in stack, 15% factor at 4% O_2, 50% factor at 6% O_2 based on frequency of occurrence of O_2 levels for industrial fuel-burning equipment given by Bartz et al. (1974).
(r) Assumed similar to industrial equipment burning natural gas.
(s) From Table A.1.
(t) From Table A.1.
(u) Weighted average: 2% emission factor at 2% O_2 in stack, 10% factor at 4% O_2, 88% factor at 6% O_2 based on frequency of occurrence of O_2 levels for steel mill equipment given by Bartz et al. (1974; tests 104-157).
(v) Source tests by Bartz et al. (1974) show that home heaters have high levels of excess O_2 in their exhaust.
(w) Assumed similar to home heaters burning natural gas.
(x) From Table A.1.

TABLE A.5

Ammonia Emission Estimates for Stationary Combustion Sources

Six-County South Coast Air Basin--1982

	ESTIMATED 1982 FUEL USE (10^9 Btu/day)		EMISSION FACTOR (Kg $NH_3/10^9$ Btu)		NH_3 EMISSIONS (metric tons/day)
MOBILE SOURCES					
Highway Vehicles					
Catalyst Autos and Lt. Trucks	870.4	(a)	2.7	(l)	2.35
Non-Catalyst Autos and Lt. Trucks	557.3	(a)	0.87	(l)	0.485
Diesel Autos and Lt. Trucks	18.3	(b)	0.19	(l)	0.0035
Catalyst Medium Vehicles	85.1	(a)	2.7	(l)	0.23
Non-Catalyst Medium and Heavy Trucks	159.8	(a)	0.87	(l)	0.14
Diesel Trucks	162.4	(b)	0.14	(l)	0.023
LPG for Carburetion	8.2	(c)	0.87	(l)	0.0071
Civil Aviation					
Jet Aircraft	49.5	(d)	0.14	(m)	0.0069
Aviation Gasoline	2.4	(d)	0.87	(n)	0.0021
Commercial Shipping					
Residual Oil-Fired Ships' Boilers	24.3	(e)	2.8	(o)	0.068
Diesel Ships	11.2	(e)	0.14	(m)	0.0016
Railroad					
Diesel Oil	24.8	(f)	0.14	(m)	0.0035
Military					
Gasoline	5.65	(g)	0.87	(n)	0.0049
Diesel Oil	16.7	(h)	0.14	(m)	0.0023
Jet Fuel	16.71	(i)	0.14	(m)	0.0023
Residual Oil (Bunker Fuel)	0.28	(j)	2.8	(o)	0.0008
Miscellaneous					
Off-Highway Vehicles and Miscellaneous Sources	46.26	(k)	0.14	(m)	0.0065
TOTAL					3.34

NOTES:

(a) State of California total sales of leaded and unleaded gasoline taken from Ethyl Corporation (1982). Fuels apportioned to six-county air basin based on ratio of that region's population to entire state's population. Fuels apportioned among vehicle types based on fraction of VMT and fuel economy for each vehicle class.

(b) State of California total sales of distillate oil for on-highway use taken from U.S. Department of Energy (1983), apportioned to six-county air basin in proportion to percentage of state truck registrations in that region from County Supervisors Association of California (1981). Fuel apportioned among light trucks, autos, and heavy vehicles on basis of the fraction of VMT by each vehicle type.

(c) State of California total taken from U.S. Department of Energy (1983), value of LPG for internal combustion use. Apportioned to study region on basis of fraction of state population in that region.

(d) Aircraft operations taken from Carter and Trembley (1981). Fuel use computed from operations by the procedure outlined by U.S. Environmental Protection Agency (1980).

(e) Computed by procedure described by Cass (1978). Ship traffic in local harbors is given by U.S. Army Corps of Engineers (1980). Fraction of ships sailing northward and southward along the coast determined from data given by Alber (1984). Residual-to-distillate fuel use ratio taken from dockside fuel sales data of the U.S. Bureau of Census (1981a). Ship fuel economy given by U.S. Environmental Protection Agency (1981).

(f) Fuel sales to railroads in California taken from U.S. Department of Energy (1983). Fuel use apportioned to six-county study region in proportion to fraction of railroad track in the region versus in the entire state.

(g) Scaled from 1973 value given by Cass (1978). Scale factor is ratio of 1982 to 1973 diesel fuel sales to military in California from U.S. Department of Energy (1983) and the 1973 issue of that report series.

(h) 20% of statewide sales of distillate oil to the military as given by U.S. Department of Energy (1983). See Cass (1978) for justification of procedure.

(i) 1973 data from Cass (1978).

(j) 2% of total California sales of residual fuel oil to the military as given by U.S. Department of Energy (1983). See Cass (1978) for justification of procedure.

(k) California sales of distillate oil to off-highway vehicles plus "other" sources given by U.S. Department of Energy (1983). Fuel use apportioned to six-county study area on the basis of population. Kerosene use has been added to the distillate fuel use numbers shown.

(l) From Table A.3.

(m) Assumed to emit NH_3 at the same rate as a diesel truck from Table A.3.

(n) Assumed to emit NH_3 at the same rate as the non-catalyst gasoline engine automobile given in Table A.3.

(o) Assumed to emit NH_3 at the same rate as the industrial boiler given in Table A.1.

TABLE A.6

Emissions from Industrial Process Sources

	NH_3 Emissions (metric tons/day)	
Ammonia Storage	0.06	(a)
Refinery FCC Units	0.67	(a)
Refinery Waste Water Treatment	0.35	(a)
Steel Industry	0.23	(a)
Chemical Plants	0.76	(a)
Refrigerant Loss	0.38	(b)

NOTES:

(a) From survey of Cass et al. (1982).
(b) See Table A.28.

Table A.7 Estimated NH_3 Emissions from Municipal Waste Water Treatment - 1982 (excluding sludge processing)

Plant	Treatment Stage	Flow Rate (mgd)	Flow Rate (10^6 ℓ/day)	Influent NH_3-N (mg/ℓ)	Effluent NH_3-N (mg/ℓ)	Effluent NO_2^--N (mg/ℓ)	Effluent NO_3^--N (mg/ℓ)	NH_3-N Loss from water: To Bacterial Cells[a] (mg/ℓ)	NH_3-N Loss from water: To Atmosphere as NH_3 or as N_2[b] (mg/ℓ)	Nitrogen-Containing Gases to Atmosphere (metric tons -N/day)	NH_3 Emission to Atmosphere (metric tons/day as NH_3)
COUNTY SANITATION DISTRICTS OF L.A. COUNTY											
1. San Jose Creek	Secondary	36.84	139.4	19.9	15.6	0.603	2.0	0.8	0.9	0.125	0.15
2. Whittier Narrows	Secondary	13.41	50.8	20.4	16.4	0.967	1.5	0.82	0.71	0.036	0.044
3. Pomona	Secondary	9.26	35.0	18.8	11.8	0.845	2.0	0.75	3.4	0.119	0.144
4. Los Coyotes (Has 3 separate secondary units.)											
Unit 1	Secondary	11.36	43.0	23.3	10.5	1.326	2.6	0.93	7.94	0.342	0.414
Unit 2	Secondary	11.44	43.3	23.3	11.5	0.04	3.0	0.93	7.83	0.339	0.410
Unit 3	Secondary	11.37	43.0	23.3	7.6	0.719	4.8	0.93	9.25	0.398	0.482
5. Long Beach	Secondary	9.95	37.7	21.7	11.1	0.922	2.3	0.87	6.51	0.245	0.296
6. Joint Plant	Primary	360	1362.6	36	36					0	
CITY OF LOS ANGELES											
7. Hyperion Plant	Primary	379	1434.5	18.8	18.5	0	0	0	0.3	0.43	0.52
	Secondary	100	378.5	18.5	2.5	0.2	5.2	0.74	9.86	3.73	4.51
8. Terminal Island	Secondary	17.8	67.4	39.1	12.6	0.79	5.3	1.56	18.85	1.27	1.54
9. L.A. Glendale Reclaimation Plant	Secondary	10	37.9	19.5	6.5	(11.70)(c)		0.78	0.52	0.020	0.024

Table A.7 Estimated NH_3 Emissions from Municipal Waste Water Treatment - 1982 (excluding sludge processing) (Continued)

Plant	Treatment Stage	Flow Rate (mgd)	Flow Rate (10^6 ℓ/day)	Influent NH_3-N (mg/ℓ)	Effluent NH_3-N (mg/ℓ)	Effluent NO_2^--N (mg/ℓ)	Effluent NO_3^--N (mg/ℓ)	NH_3-N Loss from water: To Bacterial Cells[a] (mg/ℓ)	NH_3-N Loss from water: To Atmosphere as NH_3 or as N_2[b] (mg/ℓ)	Nitrogen-Containing Gases to Atmosphere (metric tons -N/day)	NH_3 Emission to Atmosphere (metric tons/day as NH_3)
ORANGE COUNTY SANITATION DISTRICT											
10. Fountain Valley	Secondary	60	227.1	23	12	(9.20)(d)		0.92	0.88	0.2	0.242
11. Huntington Beach	Secondary	160	605.6	23	12	(9.20)(d)		0.92	0.88	0.533	0.645
OTHER AGENCIES											
12. Water Factory 21	NH_3 Stripping Tower	8	30.3	24.22	19.59				4.63	0.14	0.17
13. Irvine Ranch Water District	Secondary	8.5	32.2	20	2	(17)(e)		0.8	0.2	0.0064	0.008
14. Los Alisos Water District	Secondary	2.5	9.5	50	12	(30)(f)		2.0	6	0.057	0.069
15. Aliso Water Management Agency	Secondary	3	11.4	35	20	(5.25)(g)		1.4	8.35	0.095	0.115
16. Laguna Hills Sanitation District	Secondary	4.5	17.0	(21)(h)	5	(3.15)(i)		0.84	12.01	0.204	0.247
17. South East Regional Reclaimation Authority	Secondary	8.5	32.2	(21)(h)	2	(3.15)(i)		0.84	15.01	0.483	0.584

Table A.7. Estimated NH_3 Emissions from Municipal Waste Water Treatment - 1982 (excluding sludge processing) (continued)

Plant	Treatment Stage	Flow Rate (mgd)	Flow Rate (10^6 ℓ/day)	Influent NH_3-N (mg/ℓ)	Effluent NH_3-N (mg/ℓ)	Effluent NO_2^--N (mg/ℓ)	Effluent NO_3^--N (mg/ℓ)	NH_3-N Loss from water To Bacterial Cells[a] (mg/ℓ)	NH_3-N Loss from water To Atmosphere as NH_3 or as N_2[b] (mg/ℓ)	Nitrogen-Containing Gases to Atmosphere (metric tons -N/day)	NH_3 Emission to Atmosphere (metric tons/day as NH_3)
OTHER AGENCIES (Cont)											
18. Moulton-Niguel Water District	Secondary	0.4	1.5	(21)(h)	(12)(j)	(3.15)(i)		0.84	5.01	0.0075	0.0069
19. South Coast County Water District	Primary	3.5	13.2	28	23	0		0	5	0.066	0.080
	Secondary	3.5	13.2	23	6	(3.45)(i)		0.92	12.63	0.167	0.202
20. City of San Clemente	Secondary	3.2	12.1	(21)(h)	0.5	(3.15)(i)		0.84	16.51	0.200	0.242
21. Capistrano Beach Sanitary District	Secondary	0.85×10^{-3}	3.2×10^{-3}	(21)(h)	(12)(j)	(3.15)(i)		0.84	5.01	0.016×10^{-3}	0.019×10^{-3}
22. City of Riverside	Secondary	23.5	88.9	24.5	12.5	(3.68)(i)		0.98	7.34	0.653	0.790
23. Hemet Treatment Plant	Secondary	5.1	19.3	22.5	15	(3.38)(i)		0.9	3.22	0.062	0.075
24. Sun City Treatment Plant	Secondary	0.7	2.6	(21)(h)	4.6	(3.15)(i)		0.84	12.41	0.032	0.039
25. Sunnymead Treatment Plant	Secondary	3	11.4	(21)(h)	(12)(j)	(3.15)(i)		0.84	5.01	0.057	0.069
26. City of San Bernardino	Secondary	21	79.5	19	16	(0)(k)		0.76	2.24	0.178	0.215

Table A.7 Estimated NH_3 Emissions from Municipal Waste Water Treatment - 1982 (excluding sludge processing) (Continued)

Plant	Treatment Stage	Flow Rate (mgd)	Flow Rate (10^6 ℓ/day)	Influent NH_3-N (mg/ℓ)	Effluent NH_3-N (mg/ℓ)	Effluent NO_2^--N (mg/ℓ)	Effluent NO_3^--N (mg/ℓ)	NH_3-N Loss from water: To Bacterial Cells[a] (mg/ℓ)	NH_3-N Loss from water: To Atmosphere as NH_3 or as N_2[b] (mg/ℓ)	Nitrogen-Containing Gases to Atmosphere (metric tons -N/day)	NH_3 Emission to Atmosphere (metric tons/day as NH_3)
OTHER AGENCIES (cont)											
27. Chino Basin Regional Plant #1	Secondary	19	71.9	20	6.4	(12)(l)		0.8	0.8	0.058	0.070
28. Chino Basin Regional Plant #2	Secondary	3.5	13.2	19.8	2.2	(11.88)(l)		.79	4.93	0.065	0.079
29. Chino Basin Regional Plant #3	Primary	3.2	12.1	25	25					0	
30. City of Colton	Secondary	3.4	12.9	(21)(h)	6	(3.15)(i)		0.84	11.01	0.142	0.172
31. City of Redlands	Secondary	4	15.1	(21)(h)	(12)(j)	(3.15)(i)		0.84	5.01	0.076	0.092
32. City of Rialto	Secondary	3.5	13.2	(21)(h)	(12)(j)	(3.15)(i)		0.84	5.01	0.066	0.080
33. City of Santa Barbara	Secondary	8.5	32.2	28	20	(4.20)(i)		1.12	2.68	0.086	0.104
34. Montecito Sanitation District	Secondary	1.0	3.8	21(h)	<1	(3.15)(i)		0.84	16.01	0.061	0.074
35. Goleta Sanitation District	Primary	6.2	23.5	(22.5)(m)	22.5					(0)	
36. Carpinteria Sanitation District	Secondary	1.3	4.9	(21)(h)	0.01	(3.15)(i)		0.84	17	0.083	0.1

Table A.7 Estimated NH_3 Emissions from Municipal Waste Water Treatment - 1982 (excluding sludge processing) (Continued)

Plant	Treatment Stage	Flow Rate (mgd)	Flow Rate (10^6 ℓ/day)	Influent NH_3-N (mg/ℓ)	Effluent NH_3-N (mg/ℓ)	Effluent NO_2^--N (mg/ℓ)	Effluent NO_3^--N (mg/ℓ)	NH_3-N Loss from water To Bacterial Cells[a] (mg/ℓ)	NH_3-N Loss from water To Atmosphere as NH_3 or as N_2[b] (mg/ℓ)	Nitrogen-Containing Gases to Atmosphere (metric tons -N/day)	NH_3 Emission to Atmosphere (metric tons/day as NH_3)
OTHER AGENCIES (cont)											
37. Summerland Sanitation District	SECONDARY	0.15	0.57	(21)(h)	(12)(j)	(3.15(i)		0.84	5.01	0.0028 10.77	0.0034 13.03

NOTES

(a) Estimated to be 4% of influent NH_3-N for secondary treatment processes (Hartling, 1984)

(b) By difference between influent, effluent and bacterial nitrogen fluxes, stated as mg/ℓ relative to influent flow.

(c) Most of the ammonia in the influent to this plant is oxidized during the secondary treatment process (Cecotti, 1984). A value equal to 60% of secondary influent NH_3-N is assumed to be nitrified.

(d) This agency tries to remove 40-50% of NH_3 during the secondary treatment stage (Pampson, 1984). A value equal to 40% of secondary influent NH_3-N is assumed to be nitrified.

(e) Nitrification removes almost all of the NH_3-N (Walters, 1984). A value equal to 85% of secondary influent NH_3-N concentration is assumed to be nitrified.

(f) Most of the NH_3-N at this plant is nitrified (Warner, 1984). A value equal to 60% of secondary influent NH_3-N concentration is assumed to be nitrified.

(g) Operators of this plant try not to nitrify the NH_3-N (Williams, 1984). The average percentage of nitrification during secondary treatment at L.A. County Sanitation District facilities is 15% and that degree of nitrification is assumed here.

Table A.7 Estimated NH_3 Emissions from Municipal Waste Water Treatment - 1982 (excluding sludge processing) (Continued)

Plant	Treatment Stage	Flow Rate (mgd)	Flow Rate (10^6 ℓ/day)	Influent NH_3-N (mg/ℓ)	Effluent NH_3-N (mg/ℓ)	Effluent NO_2^--N (mg/ℓ)	Effluent NO_3^--N (mg/ℓ)	NH_3-N Loss from water: To Bacterial Cells[a] (mg/ℓ)	NH_3-N Loss from water: To Atmosphere as NH_3 or as N_2[b] (mg/ℓ)	Nitrogen-Containing Gases to Atmosphere (metric tons -N/day)	NH_3 Emission to Atmosphere (metric tons/day as NH_3)

NOTES (Continued)

(h) Estimated based on average secondary influent NH_3-N concentration for Plants #1-5, 7, 9-11, 18, 20, 21, 24-26, 31.

(i) The average percentage nitrification of NH_3-N at plants operated by the County Sanitation District of Los Angeles County is equal to 15% of secondary influent ammonia concentration. That degree of nitrification is assumed here.

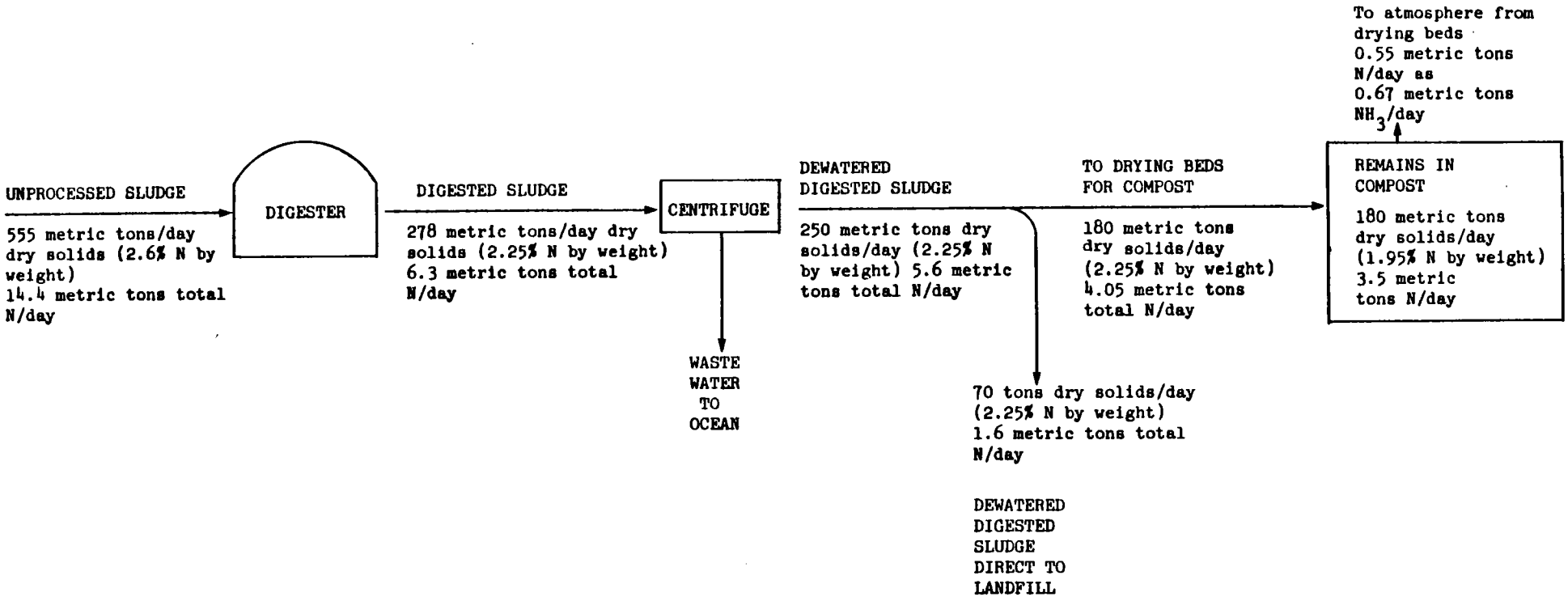
(j) Estimate based on average secondary effluent NH_3-N concentration for plants #1-5, 7, 9-11, 18, 20, 21, 24-26, 31.

(k) Since there is little difference between influent and effluent ammonia concentrations, it is assumed that very little nitrification occurred.

(l) Operators at this plant try to keep the NH_3-N concentrations low by encouraging nitrification (Coe, 1984). It is assumed that 60% of incoming NH_3-N is nitrified.

(m) For primary treatment only, influent NH_3-N will be very close to effluent NH_3-N.

Figure A.1 Emission Factors for NH_3 Loss from Sludge Processing at the Joint Water Pollution Control Plant Operated by the County Sanitation Districts of Los Angeles County (Reference: Livingston, 1984)



Possible Emission Factors

NH_3 to atmosphere/ton of unprocessed sludge (corrected for sludge sent to landfill) = 1.36 kg NH_3-N/metric ton unprocessed sludge

NH_3 to atmosphere/ton of dry digested sludge sent to drying beds = 3.03 kg NH_3-N/metric ton digested sludge

NH_3-N loss as % of total N in unprocessed sludge (corrected for sludge sent to landfill) = 5.2%

NH_3-N loss as % of total N in digested sludge sent to drying beds = 13.5%

Table A.8 Ammonia Emissions from Sludge Processing at Wastewater Treatment Plants

Plant	Undigested Sludge metric tons/day (dry solids)[a]	Digested Sludge metric tons/day (dry solids)[a]	NH_3-N Content of digested sludge (a)	Emission Factor Used (c)	Ammonia lost to the atmosphere (metric tons/day)
1. Joint Water Pollution Control Plant	400[b]	180[b]	2.25% by weight	13.5% of NH_3-N in digested sludge	0.66
2. Terminal Island	27	11 $\wedge$ (120×10^3 gal/day) 2.5% solids	700 mg/lit	13.5% of NH_3-N in digested sludge	0.052
3. Orange County Sanitation District	202.5	133	3200 mg NH_3-N/ kg of dry sludge	13.5% of NH_3-N in digested sludge	0.695
4. Irvine Ranch Water District		10	50 mg/lit	3.03 kg NH_3-N/metric tons of digested sludge	0.037
5. South East Regional Reclaimation Authority		65×10^3 gal/day (before drying) 12.12×10^3 gal/day (after drying)	(50 mg/lit)(d)	13.5% of NH_3-N in digested sludge	0.037×10^{-2}
6. Aliso Water Management Agency	9	4.8	1000 mg/lit	3.03 kg NH_3-N/metric tons of digested sludge	0.018
7. City of Riverside Plant		9.5		3.03 kg NH_3-N/metric tons of digested sludge	0.035
8. Hemet Treatment Plant	4.5	1.93	0.2% by weight(e)	13.5% of NH_3-N in digested sludge	0.0006

Table A.8 Ammonia Emissions from Sludge Processing at Wastewater Treatment Plants (Continued)

Plant	Undigested Sludge metric tons/day (dry solids)[a]	Digested Sludge metric tons/day (dry solids)[a]	NH_3-N Content of digested sludge (a)	Emission Factor Used (c)	Ammonia lost to the atmosphere (metric tons/day)
9. Sun City Treatment Plant	0.52			1.36 kg of NH_3-N/metric tons of unprocessed sludge	0.0009
10. Sunnymead Treatment Plant	0.32	0.013		3.03 kg NH_3-N/metric tons of digested sludge	0.0476×16^{-3}
11. City of San Bernardino	19			1.36 kg NH_3-N/metric tons of unprocessed sludge	0.0313
12. Chino Basin Regional Plant #1	14.5	9.1		3.03 kg NH_3-N/metric tons of digested sludge	0.0334
13. Chino Basin Regional Plant #2	3.6	2.3		3.03 kg NH_3-N/metric tons of digested sludge	0.0083
14. City of Colton		1.25		3.03 kg NH_3-N/metric tons of digested sludge	0.0046
15. City of Santa Barbara		5.5	0.8% by weight	13.5% of NH_3-N in digested sludge	0.0072
16. Summerland Sanitation District	0.34	0.11		3.03 kg NH_3-N/metric tons of digested sludge	0.0004
					1.584

(a) Sludge quantities and NH_3-N content are from mail survey form completed by each plant.

(b) Based on only that portion of sludge that will contribute to compacting operations (72% of total unprocessed sludge output of plant).

(c) Emission factor based on percentage of NH_3-N in sludge lost at Joint Water Pollution Control Plant. See Figure A.1 for nitrogen balance.

(d) Assume same value as Irvine Ranch Water District

(e) 1977 data are the latest available

TABLE A.9

Emission Factors for Ammonia Release from Soil Surface

	VALUE REPORTED	REFERENCE	EMISSION FACTOR ADOPTED ($kg\ NH_3/km^2$-day)
LAND SURFACE TYPE			
Cropland	11 kg N/ha-yr	(a)	3.65
Lawn Surface (campus sidewalk)	0.5 to 1.5 mg NH_3/m^2-day	(b)	1
Bare Soil	1 to 2 mg NH_3/m^2-day	(c)	1 (f)
Ungrazed Grass-Clover Pasture	2 g N/ha-hr	(d)	5.81
Forest Land (estimate)		(e)	(1)
Pasture (near animals - no manure)			
Pasture Grass (>30 m from manure source)	1 to 2 mg NH_3/m^2-day	(b)	1.5
Grassland Near Swine Barn with no manure	2 to 3 mg NH_3/m^2-day	(b)	2.5
Pasture (with manure)			
Pasture with dried manure	2 to 5 mg NH_3/m^2-day	(b)	(g)
Pasture with recent liquid dairy manure	5 to 20 mg NH_3/m^2-day	(b)	(g)
Grazed Pasture	15 kg N/ha-yr	(a)	(g)
	13 g N/ha-hr	(d)	(g)

NOTES

(a) Porter et al. (1975) and Elliot et al. (1971). Note that Denmead et al. (1978) give much higher values over short periods of time.
(b) Miner (1976)
(c) Miner (1976; bare soil located more than 30 m from university dairy farm
(d) Denmead et al. (1976)
(e) Release from decomposition of organic matter in forests estimated as being low
(f) Taken at low end of range given in order not to exceed estimate for lawns
(g) Not used; emissions of NH_3 due to presence of animal wastes will be estimated separately

TABLE A.10

Ammonia Estimates for Release from Soil Surfaces

	LAND AREA DEVOTED TO THIS USE (km^2) (a)	FRACTION OF LAND NOT MASKED BY BUILDINGS AND PAVEMENT	EMISSION FACTOR ($Kg\ NH_3/Km^2$-day)	NH_3 EMISSIONS METRIC TONS PER DAY
SOIL SURFACE RELEASE (Excluding Chemical Fertilizers & Manures)				
Urban or Built-up Land				
11 Residential (single and multiple)	2884.41	44% (b)	1 (e)	1.27
12 Commercial and Services	826.21	34% (b)	1 (e)	0.28
13 Industrial	429.16	47% (b)	1 (e)	0.2
14 Transportation, Communication & Utilities	218.91	55% (b)	1 (e)	0.12
15 Industrial and Commercial Complexes	20.83	40% (c)	1 (e)	0.01
16 Mixed Urban or Built-Up Land	43.95	43% (d)	1 (e)	0.02
17 Other Urban or Built-Up Land	348.23	43% (d)	1 (e)	0.15
Agricultural Land				
21 Cropland and Pasture	1770.72		3.4 (f)	6.02
22 Orchards, Groves, Vineyards, Nurseries, and Ornamental	857.65		(3.6)(g)	3.09
23 Confined Animal Feeding Operations	47.26		estimated separately (h)	
24 Other Agricultural Land	25.32		(3.4)(i)	0.09
Rangeland				
31 Herbaceous Rangeland	686.48		(1) (j)	0.69
32 Shrub and Brush Rangeland	8053.08		(1) (j)	8.05
33 Mixed Rangeland	1165.01		(1) (j)	1.17
Forest Land				
41 Deciduous Forest Land	12.53		(1) (k)	$\leq$0.01
42 Evergreen Forest Land	2291.58		(1) (k)	$\leq$2.29
43 Mixed Forest Land	40.08		(1) (k)	$\leq$0.04
Wetland				
61 Forested Wetland	33.10			neglected
62 Non-Forested Wetland	53.89			neglected
Barren Land				
72 Beaches	16.21		$\leq$ (1) (l)	$\leq$0.02
73 Sandy Areas (other than beaches)	107.35		$\leq$ (1) (l)	$\leq$0.11
76 Transitional Areas	149.76		1 (m)	0.15
77 Mixed Barren Land	10.62		1 (m)	0.01
				$\leq$23.79

NOTES:

(a) Obtained by counting areas in each category as shown on land use maps prepared by U.S. Geological Survey (1976a-e).
(b) Obtained by examination of aerial photographs (Fretz, 1980). Twenty-four zone photos distributed widely over Los Angeles County were overlayed with land use categories and examined to estimate the fraction of land in each category which had been paved or built upon. Values shown are averages of the 24 photographs examined.
(c) Estimated by average of commercial and industrial categories shown above.
(d) Estimated by weighted average of land use categories 11 through 14.
(e) Emission factor of lawn and bare soil from Table A.9.
(f) Average of cropland, ungrazed clover, and two types of grassland without animals present on land.
(g) Assumed same as cropland from Table A.9.
(h) Emissions from livestock operations estimated separately based on animal head count and wastes produced.
(i) Assumed similar to crop and pasture combination.
(j) Assumed similar to bare soil/grass combination.
(k) Estimate.
(l) Less than or equal to bare soil data from Table A.9.
(m) Bare soil data from Table A.9.

TABLE A.11

Nitrogen in Dry and Liquid Fertilizers for Farm Plus Non-Farm Use (3rd quarter 1982 from California Department of Food and Agriculture, 1982)

COUNTY	FERTILIZER TOTAL NITROGEN (metric tons/day)	PARTITION DRY[(a)]	PARTITION LIQUID[(a)]
Los Angeles	18	0.8	0.2
Orange	6.1	0.85	0.15
Riverside	49.6	0.21	0.79
San Bernardino	1.7	0.92	0.08
Santa Barbara	36.8	0.35	0.65
Ventura	17.3	0.47	0.53

(a) Fraction of total N applied in liquid and dry form estimated by summing N content of those liquid and dry fertilizers for which nitrogen content data were given.

TABLE A.12

Percentage of N Applied, Apportioned Between Farm and Non-Farm Use (California Department of Agriculture, 1982)

	FARM		NON-FARM	
COUNTY	DRY	LIQUID	DRY	LIQUID
Los Angeles	43	11	37	9
Orange	49	9	36	6
Riverside	20.7	77.7	0.3	1.3
San Bernardino	37	3	55	5
Santa Barbara	34.7	64.5	0.3	0.5
Ventura	45	50.5	2	2.5

(a) Example: Fraction (farm N/total N) x fraction dry from Table A.11.

TABLE A.13

Fertilizer Nitrogen Applied
(Tons N/day)

COUNTY	DRY		LIQUID	
	FARM	NON-FARM	FARM	NON-FARM
Los Angeles	7.7	6.7	2	1.6
Orange	3	2.2	0.5	0.4
Riverside	10.3	0.15	38.5	0.65
San Bernardino	0.63	0.94	0.05	0.09
Santa Barbara	12.8	0.11	23.7	0.18
Ventura	7.8	0.35	8.7	0.43

Estimated by combining data of Tables A.11 and A.12

TABLE A.14

Percentage of Farm Fertilizer Applied on Crops

(From U.S. Bureau of the Census, 1977)[a]

COUNTY	% of Farm Fertilizer Applied on Crops(a)	
	% DRY	% LIQUID
Los Angeles	63	80
Orange	57	34
Riverside	63	84
San Bernardino	31	42
Santa Barbara	79	95
Ventura	60	39

(a) Data taken from U.S. Bureau of the Census (1977) as shown in Table A.11 of Cass et al. (1982). 1982 Census of Agriculture does not contain this information.

TABLE A. 15

Nitrogen Applied on Crops, Orchards, and Non-Farm Areas
(County Totals in Metric Tons/day)

COUNTY	DRY			LIQUID		
	CROP[a]	ORCHARDS AND ORNAMENTALS	NON-FARM	CROP[a]	ORCHARDS AND ORNAMENTALS	NON-FARM
Los Angeles	4.85	2.85	6.7	1.6	0.4	1.6
Orange	1.7	1.3	2.2	0.17	0.33	0.4
Riverside	6.5	3.8	0.15	32.3	6.2	0.65
San Bernardino	0.2	0.43	0.94	0.02	0.03	0.09
Santa Barbara	10	2.7	0.11	22.5	1.2	0.18
Ventura	4.7	3.1	0.35	3.4	5.3	0.43

(a) Farm use split between crops vs. orchards and ornamentals using crop percentages of Table A.14 applied to total farm use given in Table A.13.

TABLE A.16

Percentage of Land Use in Each County Located within the Gridded Inventory Map Area and within the South Coast Air Basin

County	Cropland	Orchards	Non-Farm Fertilized Land[a]
Los Angeles	34	84	99
Orange	100	100	100
Riverside	53	43	77
San Bernardino	69	100	82
Santa Barbara	7	100	78
Ventura	95	100	100

[a] Estimated from percentage of county population living within the air basin in 1980.

TABLE A.17

Fertilizer Nitrogen Applied Inside the South Coast Air Basin
(metric tons/day)[a]

COUNTY	DRY			LIQUID		
	CROP	ORCHARDS AND ORNAMENTALS	NON FARM	CROP	ORCHARDS AND ORNAMENTALS	NON FARM
Los Angeles	1.65	2.4	6.6	0.54	0.34	1.58
Orange	1.7	1.3	2.2	0.17	0.33	0.4
Riverside	3.45	1.6	0.12	17.1	2.67	0.5
San Bernardino	0.14	0.43	0.77	0.01	0.03	0.07
Santa Barbara	0.7	2.7	0.09	1.58	1.2	0.14
Ventura	4.5	3	0.35	3.23	5.3	0.43
TOTAL	12.14	11.4	10.1	22.63	9.87	3.12

(a) Data of Tables A.15 and A.16 combined.

TABLE A.18

Ammonia Loss Due to Fertilizer Application by County—3rd Quarter-- 1982
(handling loss given separately)

COUNTY	DRY						LIQUID						TOTAL NH_3 LOSS KG/DAY
	CROPLAND		ORCHARDS AND ORNAMENTALS		NON-FARM		CROPLAND		ORCHARDS AND ORNAMENTALS		NON-FARM		
	FERTILIZER N APPLIED METRIC TONS/DAY	NH_3 LOSS KG/DAY[a]	FERTILIZER N APPLIED METRIC TONS/DAY	NH_3 LOSS KG/DAY[a]	FERTILIZER N APPLIED METRIC TONS/DAY	NH_3 LOSS KG/DAY[b]	FERTILIZER N APPLIED METRIC TONS/DAY	NH_3 LOSS KG/DAY[c]	FERTILIZER N APPLIED METRIC TONS/DAY	NH_3 LOSS KG/DAY[c]	FERTILIZER N APPLIED METRIC TONS/DAY	NH_3 LOSS KG/DAY[b]	
Los Angeles	1.65	200	2.4	290	6.6	2396	0.54	13	0.34	8	1.58	573.5	3480.5
Orange	1.7	206	1.3	157	2.2	799	0.17	4	0.33	8	0.4	145	1319
Riverside	3.45	417	1.6	194	0.12	44	17.1	414	2.67	65	0.50	182	1316
San Bernardino	0.14	17	0.43	52	0.77	280	0.01	0.24	0.03	0.73	0.074	27	377
Santa Barbara	0.7	85	2.7	327	0.09	33	1.58	38	1.2	29	0.14	51	563
Ventura	4.5	544	3	363	0.35	127	3.23	78	5.3	128	0.43	156	1396
TOTAL	12.14	1469	11.43	1383	10.15	3679	22.6	547	9.9	239	3.12	1135	8452

Total NH_3 Loss = 8452 kg/day (for the 3rd quarter)
= 8.45 metric tons/day

(a) Assuming 10% of N applied is lost to atmosphere as NH_3 (Meyer, 1981)

(b) Assuming 30% of N applied is lost to atmosphere as NH_3 (Meyer, 1981)

(c) Assuming 2% of N applied is lost to atmosphere as NH_3 (Meyer, 1981)

TABLE A.19
Loss of Anhydrous Ammonia Due to Handling and Field Application
(3rd Quarter, 1982)

COUNTY	ANHYDROUS AMMONIA (metric tons N/day) (County Total)[a]	% OF LIQUID FERTILIZER APPLIED ON CROPS	% OF CROPLAND IN BASIN	% OF ORCHARDS IN BASIN	ANHYDROUS AMMONIA IN BASIN[b] (metric tons N/day)	1% LOSS DUE TO HANDLING(c) (metric tons N/day)	3% LOSS DURING APPLICATION ON FIELD(c) (metric tons N/day)
Los Angeles	1.28	80	34	84	0.56	0.006	0.017
Orange	-	34	100	100	-	-	-
Riverside	15	84	53	43	7.71	0.08	0.23
San Bernardino	-	42	69	100	-	-	-
Santa Barbara	1.53	95	7	100	0.18	0.002	0.005
Ventura	-	39	95	100	-	-	-
TOTAL	17.8				8.45	0.088	0.25

Total loss = 0.34 metric tons N/day

= 0.41 metric tons NH_3/day

(a) From liquid fertilizer sales classed as 82-00-00 by the California Department of Food and Agriculture (1982)

(b) County total multiplied by [% of liquid fertilizer applied to crops (Table A.14) x % cropland in basin (Table A.16) + % of liquid fertilizer applied to orchards x % orchards in basin.]

(c) Walkup and Nevins (1966)

TABLE A.20

Summary of NH_3 Emissions from Fertilizer Application and Handling

COUNTY	LOSS FROM FARM APPLICATION OF FERTILIZER(metric tons/day) CROPS	ORCHARDS	LOSS FROM NON-FARM APPLICATION (metric tons/day)	LOSS DUE TO HANDLING (metric tons/day)	TOTAL NH_3 LOSS (metric tons/day)
Los Angeles	0.21	0.3	2.97	0.03	3.51
Orange	0.21	0.17	0.94	-	1.32
Riverside	0.83	0.26	0.23	0.38	1.7
San Bernardino	0.02	0.05	0.31	-	0.38
Santa Barbara	0.12	0.36	0.08	0.01	0.57
Ventura	0.62	0.49	0.28	-	1.39
				TOTAL	8.87

TABLE A.21

Summary of Animal Waste Data

ANIMAL	SOURCE	ANIMAL WEIGHT (kg)	MANURE (TOTAL WASTE) kg/head-day	TOTAL NITROGEN EXCRETED kg/head-day
Dairy Cattle	Dale (1971)	680	49	
	Fogg (1971)	600	45	
	Luebs et al. (1973b)			0.17
	Adrismo et al. (1974)			0.18
				0.19
Value Used		640	47	0.18
Beef Cattle	Fogg (1971)	400	34	0.24
	Peters & Blackwood (1977)	500	27	
	Taiganides & Hazen (1966)	450	29	0.17
	Scholz (1971)	500	45	
Value Used		450	32	0.21
Horses	Fogg (1971)	450	25	0.22
Hogs	Fogg (1971)	70	3.9	0.03
	Muehling (1971)	70	5.5	0.038
	Scholz (1971)	70	3.6	
	Taiganides & Hazen (1966)	45	3.2	0.023
Value Used		70	3.9	0.03
Sheep	Fogg (1971)	45	1.8	0.018
Chickens	Fogg (1971)	2	0.11	0.0014
	Scholz (1971)		0.185	
	Taiganides & Hazen (1966)	2	0.11	0.0019
Value Used		2	0.14	0.0016
Turkey	taken in proportion to chickens on body weight basis	5.5	0.39	0.0044

TABLE A.22

DISTRIBUTION OF CATTLE BETWEEN DAIRY, FEEDLOT AND RANGE

COUNTY	CATTLE & CALVES (a)	Heifers and Heifer Calves[a]							
		BEEF COWS(a)	MILK COWS(a)	BEEF HEIFERS(b)	MILK HEIFERS(b)	STEERS(a)	DAIRY CATTLE	FEEDLOT CATTLE[c]	RANGE CATTLE (c)
Los Angeles	33,604	4,907	6,019	5,116	4,536	13,026	10,555	12,677	10,372
Orange	12,889	4,000(d)	300(d)	2,226	592	4,226	892	48	11,949
Riverside	178,703	7,563	87,126	14,956	44,870	24,186	131,996	33,629	13,078
San Bernardino	283,742	6,707	167,120	80,167	10,932	18,816	178,052	42,276	63,414
Santa Barbara	94,605	30,425	4,628	18,210	3,997	37,345	8,625	43,850	42,130
Ventura	18,835	8,000(d)	2,500(d)	2,701	4,801	3,123	7,301	10,150	1,384

(a) U.S. Bureau of the Census (1984)

(b) Heifers and heifer calves apportioned between beef heifers and milk heifers in same ratio as given by U.S. Bureau of the Census (1977).

(c) Beef cattle apportioned between feedlot and range in same ratio as given by U.S. Bureau of the Census (1977).

(d) From California Crop and Livestock Reporting Service (1983).

TABLE A.23

Fraction of Animals Located Inside South Coast Air Basin Portion of Each County

ANIMAL TYPE	LOS ANGELES	ORANGE	RIVERSIDE	SAN BERNARDINO	SANTA BARBARA	VENTURA
Dairy Cattle	90[b]	100[a]	100[a]	97[b]	0[d]	100
Feedlot Cattle	(60)[c]	100	20	100	0[d]	100
Range Cattle	100	100	100	100	16[e]	100
Horses	98	100	98	98	16[e]	100
Sheep	10	100	(50)	100	16[e]	100
Hogs	10	100	90	90	16[e]	100
Chickens	100	100	100	100	16[e]	100
Turkeys	100	100	100	100	16[e]	100

Estimates are by Addis (1981) unless noted otherwise:

(a) Bishop (1981)
(b) 2000 dairy cows in desert area of Los Angeles County and 3835 dairy cows located in desert portion of San Bernardino County (Bishop, 1981).
(c) Most Los Angeles County feedlot cattle are located within the South Coast Air Basin; Addis (1981) estimates more than 10,000 within the air basin (i.e. 54% or greater are in the air basin). We will estimated that 60% of the total are in the air basin.
(d) U.S. Geological Survey (1976) maps show negligible land area devoted to confined animal feeding in the South Coast Air Basin portion of Santa Barbara Count.
(e) Estimated in rough proportion to the fraction of the county land area within the air basin boundary.

Table A.24a

Livestock Inventory

COUNTY	COUNTY TOTALS[a]			LOCATED IN SOUTH COAST AIR BASIN[b]		
	DAIRY	FEEDLOT	RANGE	DAIRY	FEEDLOT	RANGE
Los Angeles	10,555	12,677	10,372	9,500	7,606	10,372
Orange	892	48	11,949	892	48	11,949
Riverside	131,996	33,629	13,078	131,996	6,726	13,078
San Bernardino	178,052	42,276	63,414	172,710	42,276	63,414
Santa Barbara	8,625	43,850	42,130	-	-	6,741
Ventura	7,301	10,150	1,384	7,301	10,150	1,384
				322,399	66,806	106,938

(a) See Table A.22

(b) See Table A.23

TABLE 24b

Livestock Inventory (continued)

COUNTY	HORSES		SHEEP		HOGS	
	COUNTY TOTAL[a]	IN SOUTH COAST AIR BASIN[b]	COUNTY TOTAL[c]	IN SOUTH COAST AIR BASIN[b]	COUNTY TOTAL[c]	IN SOUTH COAST AIR BASIN[b]
Los Angeles	54,700	53,606	32,330	3,233	5,706	571
Orange	10,500	10,500	166	166	699	699
Riverside	30,300	29,694	58,228	29,114	5,289	4,760
San Bernardino	19,900	19,502	34,915	34,915	6,875	6,188
Santa Barbara	8,300	1,328	19,131	3,061	1,226	196
Ventura	7,200	7,200	8,290(d)	8,290	1,904	1,904
				78,779		14,318

(a) Anderson (1979)

(b) See Table A.23

(c) U.S. Bureau of the Census (1984)

(d) U.S. Bureau of the Census (1981b)

TABLE A.24c

Livestock Inventory - Continued

COUNTY	CHICKENS		TURKEYS	
	COUNTY TOTAL[a]	IN SOUTH COAST AIR BASIN[b]	COUNTY TOTAL[a]	IN SOUTH COAST AIR BASIN[b]
Los Angeles	711,793	711,793	133,196	133,196
Orange	260,089	260,089	20	20
Riverside	8,411,609	8,411,609	26,875	26,875
San Bernardino	6,039,468	6,039,468	24,709	24,709
Santa Barbara	797,009	127,521	16(e)	3
Ventura	(1,438,861)(c)	1,438,861	38	38
		16,989,341		184,841

(a) U.S. Bureau of the Census (1984)

(b) 1974 data from U.S. Bureau of the Census (1977); more recent yeara data all withheld by the government.

(c) Estimated as 1.19 times the sales data given for chickens based on ratio of inventory to sales in Los Angeles, Riverside, San Bernardino and Orange Counties. Inventory data in Ventura County withheld by the government.

(d) See Table A.23

(e) 1978 data from U.S. Bureau of the Census (1981b); 1982 data withheld by the government

TABLE A.25

Total NH_3 Emissions from Livestock in the Modeling Region of the South Coast Air Basin - 1982

ANIMAL	INVENTORY IN SOUTH COAST AIR BASIN (HEAD)	TOTAL ANIMAL WASTE kg/head-day	NITROGEN EXCRETED kg/head-day	NH_3 EMISSIONS AT 50% RATE OF NITROGEN EXCRETED IN TOTAL WASTE[a] metric tons/day
Dairy Cattle	322,399	47	0.18	29.84(b)
Feedlot Cattle	66,806	32	0.21	7.21(b)
Range Cattle	106,938		0.21	13.59
Horses	121,830	25	0.22	16.22
Sheep	78,779	1.8	0.018	0.86
Hogs	14,318	3.9	0.03	0.26
Chickens	16,989,341	0.14	0.0016	16.45
Turkeys	184,841	0.39	0.0044	0.49
				84.92

(a) Adriano et al. (1974); Adriano et al. (1971): Giddens and Rao (1975); Viets (1971); Leubs et al. (1973ab)

(b) Since only 85% of manure from these animals is spread on soil, totals have been multiplied by 0.85 (see Adriano et al. (1974).

TABLE A.26

Emission Factors for Ammonia Loss Due to Non-Farm Animals

NON-FARM ANIMALS	ANIMAL WEIGHT (kg)[a]	TOTAL N EXCRETED IN URINE[a] (mg/kg body wt-day)	NITROGEN EXCRETED IN URINE DAILY[b] (kg/head-day)	EMISSION FACTOR[c] (kg NH_3/head-day)
Cats	2.5	500 - 1100	$2x10^{-3}$	$2.2x10^{-3}$
Dogs	12	250 - 800	$6.3x10^{-3}$	$6.9x10^{-3}$
Goats	50	120 - 400	$1.3x10^{-2}$	$1.4x10^{-2}$
Monkey	12	140 - 400	$3.2x10^{-3}$	$3.5x10^{-3}$
Rabbits	2	120 - 300	$4.2x10^{-4}$	$4.6x10^{-4}$
Rats	0.33	200 - 1000	$2.0x10^{-4}$	$2.2x10^{-4}$

(a) From Altman and Dittmer (1968) p. 528.

(b) Based on body weight and mid-point of range of nitrogen excretion rates given in adjacent columns.

(c) Cattle data show that about half of the nitrogen excreted in manure is in urine and half is in feces, and that when manure is applied to dry alkaline soil half of the total nitrogen is lost to the atmosphere as NH_3 (i.e. total N lost as NH_3 is approximately equal to nitrogen content of urine). We will estimate that loss rate is similar for other animals and that in the absence of data on total animal waste a value equal to 90% of urine N will reasonably estimate loss of N from total animal wastes.

TABLE A.27

NH_3-Emissions from Human and Domestic Animal Populations

COUNTY	COUNTY POPULATION (1980)(a)	RATIO: PEOPLE TO DOGS	RATIO: PEOPLE TO CATS	SOUTH COAST AIR BASIN POPULATION(a)	SOUTH COAST AIR BASIN EMISSIONS ANIMAL WASTE(i) (metric tons NH_3/day) DOGS	CATS	HUMANS (metric tons NH_3/day) RESPIR.(j)	PERSPIR.(k)
Los Angeles	7,462,000	7.8(b)	7.0(g)	7,357,300	6.51	2.31	0.03	5.0
Orange	1,920,700	5.8(c)	(7.0)(h)	1,921,000	2.29	0.60	0.008	1.3
Riverside	655,900	(4.5)(d)	(7.0)(h)	505,900	0.78	0.16	0.002	0.34
San Bernardino	882,500	4.5(e)	(7.0)(h)	724,000	1.11	0.23	0.003	0.49
Santa Barbara	298,674	5.8(f)	(7.0)(h)	232,981	0.28	0.07	0.001	0.16
Ventura	524,800	5.8(f)	(7.0)(h)	523,700	0.62	0.16	0.002	0.36
					11.59	3.53	0.046	7.65

(a) County population figures from Southern California Association of Governments (1982) except for Santa Barbara County, which is 1980 data from U.S. Bureau of the Census (1982). The portion of Santa Barbara County located within the study area is estimated on the basis of 1974 data, at which time 0.78 of the total county population lived on the south coastal side of the county.
(b) Richards, B. (1981)
(c) Hudson, R. (1981)
(d) Estimated from San Bernardino data
(e) San Bernardino (1981)
(f) Estimated from Orange County data
(g) Richards, B. (1981)
(h) Estimated from Los Angeles County response
(i) Computed using emission factors from Table A.26; (dogs, 6.9×10^{-3} kg NH_3/head day; cats 2.2×10^{-3} kg/head-day)
(j) Respiration loss estimated at 4µl NH_3 per min per person (Kupprat et al., 1976) This implies 4.4×10^{-6} kg NH_3 respired/person-day
(k) 24.5 g urea produced in human body/day (Altman and Dittmer, 1968); 5% released in perspiration (Healy et al., 1970; all of that assumed lost as NH_3. This implies 0.68 g NH_3/person-day.

TABLE A.28

Ammonia Emission Estimates for Refrigerants and Household Cleaning Chemicals--1982

COUNTY	SOUTH COAST AIR BASIN POPULATION[a]	NH_3 EMISSIONS[d] metric tons/day	
		CLEANING AGENTS(b)	REFRIGERATION(c)
Los Angeles	7,357,300	0.37	0.25
Orange	1,921,000	0.098	0.065
Riverside	505,900	0.026	0.017
San Bernardino	724,000	0.037	0.025
Santa Barbara	232,981	0.012	0.008
Ventura	523,700	0.027	0.018
		0.57	0.38

(a) See Table A.27

(b) U.S. Ammonia Production for 1980: 30.99×10^9 lb = 15.5×10^6 short tons/yr (Chem. & Eng. News, 1983-May 2): 0.03% of total synthetic ammonia is used in the manufacture of household ammonia from Kirk-Othmer Encyclopedia (1963)

(c) 0.02% of total synthetic ammonia is used for refrigeration (Kirk-Othmer Encyclopedia, 1963)

(d) Emissions were calculated based on ratio of air basin population in 1980 to U.S. population. 100% NH_3 loss to the atmosphere was assumed. The population of the United States in July 1981 was 227.6×10^6 persons from U.S. Bureau of Census (1981c).

TABLE A.29

Summary of Ammonia Emissions by Source Category in the South Coast Air Basin

1982

SOURCE CATEGORY	TOTAL EMISSIONS (kg/day)	
Stationary Fuel Combustion		
Electric Utility		
Natural Gas	1180.0	
Residual Oil	380.0	
Digester Gas	0.9	
Refinery Fuel Burning		
Natural Gas	118.0	
Residual Oil	15.0	
Refinery Gas	390.0	
Industrial Fuel Burning		
Natural Gas	470.0	
Liquified Petroleum gas (LPG)	8.0	
Residual Oil	22.0	
Distillate Oil	123.0	
Digester Gas	26.0	
Coke Oven Gas	15.0	
Residential/Commercial Fuel Burning		
Natural Gas	207.0	
Liquid Propane Gas (LPG)	4.0	
Residual Oil	85.0	
Distillate Oil	79.0	
Coal	23.0	
Subtotals	3145.9	(1.91%)
Mobile Source Fuel Combustion		
Automobiles		
Catalyst Autos and Light Trucks	2350.0	
Non-catalyst Autos and Light Trucks	485.0	
Diesel Autos and Light Trucks	3.5	
Catalyst Medium Vehicles	230.0	
Non-catalyst Medium and Heavy Trucks	140.0	
Diesel Trucks	23.0	
LPG for Carburetion	7.1	
Civilian Aircraft		
Jet	6.9	
Piston	2.1	
Shipping		
Residual Oil Boilers	68.0	
Diesel Ships	1.6	
Railroad—Diesel Oil	3.5	
Military		
Gasoline	4.9	
Diesel	2.3	
Jet Fuel	2.3	
Residual Oil	0.8	
Off-Highway Vehicles	6.5	
Subtotals	3337.5	(2.03%)
Industrial Point Sources	2450.0	(1.49%)
Sewage Treatment Plants	14,614.0	(8.88%)
Soil Surface	23,790.0	(14.5%)
Fertilizer		
Farm Crop	2010.0	
Orchards	1630.0	
Handling	420.0	
Non-farm	4810.0	
Subtotals	8870.0	(5.39%)
Livestock		
Cattle		
Dairy	29,840.0	
Feedlot	7210.0	
Range	13,590.0	
Horses	16,220.0	
Sheep	860.0	
Hogs	260.0	
Chickens	16,450.0	
Turkeys	490.0	
Subtotals	84,920.0	(51.6%)
Domestic		
Dogs	11,590.0	
Cats	3530.0	
Human Respiration	46.0	
Human Perspiration	7650.0	
Household Ammonia Use	570.0	
Subtotals	23,386.0	(14.2%)
*** Total ***	164,512.4	(100.0%)