The general public is mainly interested in the impact of corona generated interference, i.e., Radio Interference (RI) and Television Interference (TVI), to the quality of radio and television reception.

1. Radio Interference

RI from overhead transmission lines is any unwanted disturbance in AM frequency bands ($0.5 \leq f \leq 1.5$ MHz). RI is produced by corona and gap-type discharges.

RI from power lines has been studied extensively over the past 45 years. As a result, methodology for determining RI is well known (Ref. 87-88). RI is measured either in dB above 1 $\mu V/m$ or in $\mu V/m$.

For a given line design, the effect of RI on the quality of radio reception at a given location will depend upon weather conditions, receiving antenna location and orientation, and radio signal strengths.

To estimate the RI performance, a recommended approach is to determine signal to noise ratio before and after the operation of a proposed line.

2. Television Interference

TVI is any unwanted disturbance in VHF and UHF frequency range. TVI from overhead lines can be produced by either gap-type discharges or corona. The possible sources of gap-type discharge are small air gaps between ground wires and hardware, loose hardware, and unstrained insulators. TVI is measured either in dB above 1 μv/m or in μv/m.

Practically all fair weather TVI is caused by gap-type sources which can easily be eliminated by following good construction practices. However, with increasing transmission system voltages, corona during positive half-cycles produce measurable TVI known as precipitation TVI. This phenomena is caused by precipitation on conductors such as light drizzel, heavy rain, dry snow, or wet snow.

The methodology for estimating precipitation type TVI is not well developed. A procedure for evaluating TVI performance is the same as that of RI except that in TVI, the performance criteria is video reception quality.

B. STATE REGULATIONS

26 states require electric utilities to evaluate in environmental impact statements the impact of the proposed transmission line on the quality of radio and television reception and other communication facilities (Fig. 2).

However, there are no quantitative limits established or recommended for evaluating performance. Hence, the evaluation is made on a case-by-case basis by the reviewing state regulatory agency using the record developed. 12 states have rerouted proposed transmission lines because of radio and television interferences.

Additionally, some regulatory agencies have granted permits to construct overhead lines contingent upon satisfying RI and TVI complaints. Typically, a permit would state that if radio or TV interference is caused by or from the operation of the high voltage transmission line in those areas where good radio or TV reception is presently obtained, the utility company will initiate appropriate modification of the receiving antenna system or repair loose or damaged hardware in the high voltage line or take other action necessary to restore reception to present levels.

In the majority of the states where there are neither enabling legislation nor environmental impact statement requirements, power companies are required to mitigate radio and television interference complaints from the public living close to the line.

Table I displays the various combinations of the above requirements on a state-by-state basis.

C. FEDERAL REGULATIONS

The federal agency responsible for regulating overhead transmission line activity is the Federal Communication Commission (FCC). The FCC, according to its rules and regulations (Ref. 89) classifies overhead power transmission lines into an "incidental radiation device" category. The FCC does not have any quantitative limits for evaluating the performance of the incidental devices. However, it does state: "An incidental radiation device shall be operated so that the radio frequency energy that is emitted does not cause harmful interference." The term "harmful interference" is defined as, "any emission, radiation, or induction which endangers the functioning of a radio navigation service or of other safety services or seriously degrades, obstructs, of repeatedly interrupts a radio communication service."

The guidelines prepared by the Rural Electrification Administration (REA) of the US Department of Agriculture for the preparation of an environmental analysis for electric transmission facilities above 230 kV, require evaluation of impact from electromagnetic radiation (Ref. 90). Specifically, it requires estimation of the effect of electrical interference with radio and television reception or communication circuits.

The office of Nuclear Reactor Regulation (ONRR) of the US Nuclear Regulatory Commission (USNRC) requires information on proposed means to reduce impact on radio and television reception and other communication systems for addressing "Environmental Impacts of Station Operation-Transmission System Impacts: Impact to Man." (Ref. 91)

IV. PUBLIC SAFETY AND COMFORT

A. SUMMARY

Overhead transmission lines, if properly designed, built and maintained, do not present a potential hazard to humans, animals, and property. However, a possibility exists for exposing humans, animals, and property to potentially dangerous voltages and or currents from the following coupling modes (Ref. 92-93).

1. Conductive: Situations where direct contact is made to an energized part of the line.

2. Ground-Current Potential: Situations where current flow through the earth produces voltage differences due to earth resistance. Current flow through the earth is due to broken conductors; line faults from external causes such as the tree contact; lightning strikes to shield wires, phase conductors, and towers; and asymmetrical operating conditions. The voltages that arise are commonly known as touch and step potentials.

3. Electrostatic Induction: Situations where a person, animal, or any conducting object such as a vehicle,

fence, rain gutters, and antenna, etc.,..., located in an electric field and insulated from ground acquires a voltage with respect to ground due to charges induced on the person or object by the electric field.

For ac lines, the electric field is the same as electrostatic field while for HVdc lines, electric field is the total field due to both electrostatic and ion drift effects.

4. Electromagnetic Induction: Situations where electromagnetic coupling exists between an energized circuit carrying electric current and a parallel conducting object.

The methodology for estimating voltage differences due to above coupling modes and mitigation measures are well developed. Some more work, however, needs to be done in mitigating impact of ion drift during corona on insulated objects in proximity of HVdc lines. The long term biological effects on human and animals of electric and magnetic fields is of concern.

B. STATE REGULATIONS

All the states have adopted either National Electrical Safety Code (NESC) or some modification of it for, "practical safeguarding of persons from hazards arising from the installation, operation and maintenance of overhead supply and communication lines and their associated equipment"(Ref. 94). The 1977 edition of NESC requires vertical clearance of overhead lines exceed 140 kV ac rms to ground or 197 kV dc to ground so as to limit the current due to electrostatic effects to 5.0 mA, rms, if the largest anticipated truck, vehicle or equipment under the line were short-circuited to ground. (For this determination, the conductor sag shall be at final unloaded sag at 120°F).

Of the total, 28 states require evaluation of public safety and comfort and undue hazard to property along the area traversed by the proposed overhead line (Fig. 3). Oregon is the only state which currently has enacted a state law limiting electric field level. Oregon requires maximum ground level electric field of 9 kV/m within the right-of-way and compliance with latest standards of NESC.

For the remaining states, the evaluation of the impact on the health and safety of the public in close proximity of the line is undertaken on a case by case basis. In the past, ten states have conditionally permitted construction of overhead lines upon implementation of some safety precautions such as grounding of metal objects. Also, North Dakota and Minnesota, upon careful review of the record presented to them, have administered a maximum permissible ac electric field level of 8 kV/m and short-circuit current level of 5 mA. Furthermore, New York Public Service Commission has ordered 1 kV/m as the electric field limit at the edge of the right-of-way (ROW) (Ref. 95). This latter requirement is a result of the New York PUblic Service Commission Cases 26529 and 26559 and is intended to keep the calculated field strength at the edge of the ROW of new EHV in the same range of a typical 345-kV ROW.

Table-III summarized the recommended electric field and short-circuit levels by four different state regulatory agencies. There are no quantitative limits or nonquantitative requirements from any state concerning magnetic fields generated by overhead lines.

C. FEDERAL REGULATIONS

There is no single federal agency responsible for assuring public safety and comfort in proximity of overhead lines. Hence, each federal agency is responsible for the preparation and review of its environments impacts statement. None of the agencies have established standard

quantitative limits and evaluation is made on a case by case basis. REA requires discussion of induced voltages in metal fences, gates, underground and surface piping, and the safety practices involved for overhead transmission lines above 230 kV. However, REA does not specify the limits of induced voltages or currents above which these safety practices will have to be implemented.

ONRR requires the following information:

1. Maximum predicted electric field gradient(s) in kV/m and the design basis used for those predictions.

2. Proposed grounding procedure for stationary objects along rights-of-way.

3. Design basis and design parameters for reducing electrostatic shock potentials to moving vehicles such as school buses and tractor trailers.

The procedure for analysis used by the Office of Nuclear Reactor Regulation is as follows:

1. The reviewer must become familiar with the provisions of standards and guides pertinent to the operation and maintenance of transmission lines and corridors, including applicable state standards.

2. The reviewer will identify those operational and maintenance activities associated with transmission facilities having impact to men. Potential adverse impacts resulting from operation and maintenance activities include electromagnetic and electrostatic field effects, corona discharges (including resultant noise), and potential aesthetic and visual impacts.

For evaluating the environmental impact of a transmission system on terrestrial plants and animals, information on maximum ground-level electric field strengths for lines energized at 765 kV and above is required. The analysis procedure identifies potential adverse impacts resulting from operation and maintenance activities which included subtle effects of high energy electric fields on the behavior of animals. It further states that at voltages of 765 kV or above further consideration of possible effects of electric fields and corona discharge on terrestrial biota may be warranted.

The reviewer then evaluates the environmental impact and determines compliance with regulations and standards. Concerning the final recommendations, the draft, environmental standard review plan (Ref. 91) further requires that when the reviewer determines that predicted impacts resulting from the proposed operational design parameters and maintenance procedure are adverse, the reviewer will recommend consideration of imposing measures to mitigate the impact or of alternative transmission system design, operation, or maintenance that will avoid the impact.

V. AUDIBLE NOISE POLLUTION

A. SUMMARY OF TRANSMISSION LINE AUDIBLE NOISE EMISSION

During corona, random high energy discharges give rise to audible noise. For ac overhead lines, audible noise is a wet-conductor phenomena having two characteristic components pure-tone at a frequency of 120 Hz and broad-band noise ("frying" or "cracking"). Fair wheather audible noise, conductor surface gradients and conductor surface irregularities, is usually the same as ambient audible noises. Methods of estimating ac audible noise levels in dB(A) are available (Ref. 96).

For HVdc overhead lines, positive polarity conductor is the primary source of audible noise. HVdc line noise is impulsive during fair weather and is reduced somewhat during rain (Ref. 97).

Transmission line audible noise is generally measured on the 'A' weighted scale which simulates human ear response. The magnitudes of audible noise levels depend upon conductor surface gradient, conductor size, and weather.

The effect of audible noise produced by overhead lines depends upon the ambient audible noise levels, land-use type, distance from outermost conductor, and weather. Audible noise levels from ac and dc lines will decrease about 3 to 4 dB(A) and 2.6 dB(A) respectively for each doubling of the distance from the line.

B. STATE REGULATIONS

The noise control act of 1972 mandated a national policy "to promote an environment for all Americans free from noise that jeopardizes their public health and welfare". In this act, the states and other political subdivisions retain rights and authorities for primary responsibility to control the use of noise sources and the levels of noise to be permitted in their environment.

There are 24 states with enabling legislation for noise control (Fig. 4). It should however be pointed out that all the states have at least some municipalities with noise ordinances for nuisance, zoning, and construction. Of the 24 states, 14 states have nonquantitative noise emission limits while 10 states have noise guidelines. These noise limits are specified in one or more of the following ways:

1. dB(A) (Sound level measured in decibels with "A" weighting network).

2. sound pressure levels (SPL) in dB(A) at octave band frequencies.

3. audible noise in dB(A) and SPL at octave band frequencies for various land use classes such as class A (residential), class B (Commercial).

Transmission line audible noise is mainly "humming" and "crackling". Furthermore, it exhibits different noise levels at different frequencies. There are no state regulations specifically designed for overhead transmission lines. However, many regulatory agencies use existing applicable state pollution guidelines while evaluating impact of the proposed lines.

Table-IV summarizes audible noise emission limits of various states and shows that permissible audible noise emission limits at the property line vary from 40-70 dB(A). Also, the sound pressure levels at various octave band frequencies vary from state to state.

C. FEDERAL REGULATIONS

Under the noise control act of 1972, the Environmental Protection Agency (EPA) has the primary responsibility for noise source emission control. EPA has identified requisite noise levels to protect public health and welfare for a large number of situations (Ref. 98). Tables IV-H summarizes these noise levels which are based on sleep and speech interference criteria. We should, however, caution that since transmission line audible noise produced by corona has different energy content at higher frequencies, the levels identified in Table IV-H may not be applicable.

The Office of Nuclear Reactor Regulation of USNRC requires information on "predicted noise levels resulting from transmission system operation" (Ref. 91) The analysis procedure is similar to the one described earlier in connection with "public safety and comfort." For evaluation of noise impact to man, environmental standard review plan requires that the reviewer will compare predicted noise levels with applicable state and federal recommended noise criteria for residential areas and for other types of land use.

RÉA requires estimation of the effects of noise pollution from transformer hum, operation of circuit breakers,

corona (wet and dry weather) and detailed discussion of the corrective measure to be used to minimize adverse effects (Ref. 90). However, quantitative guidelines are not given.

VI. AIR QUALITY

A. SUMMARY

Ozone and nitrogen oxide are the regulated air pollutants of concern for siting transmission lines. Ozone is produced naturally by lightning discharges and solar radiation reacting with hydrocarbon pollutants.

The concentration of ozone and oxides of nitrogen depend on corona loss, conductor surface gradient, orientation of phase bundle conductors in relation to wind direction, wind speed and weather conditions. Corona discharges produce free electrons and excited molecules. Either or both of these combine with oxygen molecules to produce ozone. Because much higher energies are required for oxides of nitrogen production, its production rate is an order of magnitude less than ozone. Both plume dispersion and molecular diffusion models have been developed to estimate ozone concentration levels under overhead lines (Ref. 99-100).

B. STATE REGULATIONS

Of those states requiring environmental impact statements, 28 have enabling legislation for air quality. Twelve states have air quality standards

dealing with ozone and oxides of nitrogen emissions (Fig. 5). In some states, e.g., Wyoming, these regulations apply to electric generation facilities only. However, there is no legislation for not applying these regulations to overhead lines when necessitated by special routing situations.

Ozone and oxides of nitrogen are produced in minute (insignificant) amounts at ground levels by overhead transmission lines during foul weather conditions. As given in Table V, most of the 12 states, except Minnesota, Maryland, and Connecticut, have the following air quality standards:

a. Ozone (as regulated by photochemical oxidants)

   0.08 ppm for any one hour period, not to be exceeded more than once for consecutive 12-month periods.

b. Oxides of Nitrogen (as regulated by nitrogen dioxide)

   0.05 ppm arithmetic mean not to be exceeded during 12 consecutive months.

C. FEDERAL REGULATIONS

The national primary and secondary ambient air quality standards adopted by the U. S. Environmental Protection Agency for photochemical oxidants are the same as given

above (Ref. 101). REA requires estimation of ozone at 120 kV and above and discussion of impact of the proposed facility. It does not, however, specify any ozone limits.

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TABLE I: REGULATIONS PERTAINING TO ENVIRONMENTAL ASSESSMENTS AND ELECTRICAL EFFECTS: State and Federal

STATE	ENVIRONMENTAL ASSESSMENT	INTERFERENCE TO COMMUNICATION FACILITIES	PUBLIC SAFETY & COMFORT	NOISE POLLUTION	AIR QUALITY
Alaska	No	No	7	2	No
Alabama	No	No	7	No	No
Arizona	Yes	4, 6	6, 5	2	Table V
Arkansas	Yes	6	6	6 Table IV	6
California	Yes	6	6	6 Table IV	6
Colorado	No	No	7	No	None
Connecticut	Yes	6	5, 6	6, 3 Table IV	Table V
Delaware	Yes*	6	6	6	6
District of Columbia	No	No	7	No	No
Florida	Yes	6	6	6	6
Georgia	No	No	7	No	No
Hawaii	No	No	7	Yes	No

STATE	ENVIRONMENTAL ASSESSMENT	INTERFERENCE TO COM-MUNICATION FACILITIES	PUBLIC SAFETY & COMFORT	NOISE POLLUTION	AIR QUALITY
Idaho	No	No	7	No	Table V
Illinois	Yes	6	6	6, 3 Table IV	Table V
Indiana	No	1	7	2	No
Iowa	No	1	7	2	No
Kansas	No	No	7	No	No
Kentucky	Yes	6	6	6	6
Louisiana	No	No	7	No	No
Maine	Yes	1, 4, 6	5, 6	2, 6	6
Maryland	Yes	1, 4, 6	5, 6	3, 6 Table IV	Table V
Massachusetts	Yes	4, 6	5, 6	6, 2	Table V
Michigan	No	4	7	2	No
Minnesota	Yes	6	5, 6 Table III	Table IV 6	Table V
Mississippi	No	No	7	No	No
Missouri	No	1	7	2	6

STATE	ENVIRONMENTAL ASSESSMENT	INTERFERENCE TO COM-MUNICATION FACILITIES	PUBLIC SAFETY & COMFORT	NOISE POLLUTION	AIR QUALITY
Montana	Yes	1, 4, 6	5, 6	2, 6	6
Nebraska	No	No	7	No	No
Nevada	Yes	6	6	6	6
New Hampshire	Yes	6	6	6	6
New Jersey	Yes*	6	6	6 Table IV	Table V
New Mexico	Yes	No	7	2	No
New York	Yes	4, 6	5, 6 Table III	6	Table V
North Carolina	No	No	7	2	No
North Dakota	Yes	4, 6	5, 6 Table III	6	Table V
Ohio	Yes	4, 6	5, 6	6 Table IV	6
Oklahoma	No	No	7	No	No
Oregon	Yes	4, 6	5, 6 Table III	Table IV 6	Table V
Pennsylvania	Yes	6	6	6	6
Rhode Island	No	No	7	No	6

STATE	ENVIRONMENTAL ASSESSMENT	INTERFERENCE TO COM-MUNICATION FACILITIES	PUBLIC SAFETY & COMFORT	NOISE POLLUTION	AIR QUALITY
South Carolina	Yes	6	6	2	6
South Dakota	Yes	No	6	No	6
Tennessee	No	No	7	No	No
Texas	No	No	7	2	No
Utah	No	No	7	No	No
Vermont	Yes	6	6	6	6
Virginia	Yes	6	6	6	6
Washington	Yes	4, 6	6	6 Table IV	6
West Virginia	No	No	7	No	No
Wisconsin	Yes	6	6	6	6
Wyoming	Yes	4	6	No	Table V
FEDERAL AGENCIES					
FCC	Yes	6	NA	NA	NA
USNRC	Yes	6	6	6	6
USDOD	Yes	6	6	6	6

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FEDERAL AGENCIES	ENVIRONMENTAL ASSESSMENT	INTERFERENCE TO COM-MUNICATION FACILITIES	PUBLIC SAFETY & COMFORT	NOISE POLLUTION	AIR QUALITY
USEPA	Yes	NA	NA	Table IV	Table V
USDA-REA	Yes	6	6	6	6
BPA	Yes	6	6	6	6
TVA	Yes	None	NESC	None	None
U.S. National Parks Service	Yes	6	6	6	6

1. Power company is required to correct RI & TVI complaints.
2. There are no noise regulations by states, but municipal, city and township noise regulations should be complied with.
3. Specifies measurement method.
4. Certificate is conditioned upon Trans. line being routed around residential subdivisions due to Radio & TV interference on a case-by-case basis; however, no specific limits are given.
5. Certificate is conditioned upon implementation of safety precautions, if necessary, on a case-by-case basis.
6. Requires evaluation of the nature of the probable environmental impacts of the facility. However, no specific levels are given.
7. Power companies in these states do consider "Public Safety" in designing overhead lines, even though no formal report evaluating safety and comfort is filed.

* In coastal zone only.

NA - Not applicable

TABLE II: STATES WITH SITING LAWS REGULATING OVERHEAD TRANSMISSION LINES

STATE	TRANSMISSION LINE (Regulated minimum voltage level)
Arizona	69 kV
Arkansas	100 kV and 10 mile long, or 170 kV and 1 mile long
California	Line from plant to interconnection within state
Connecticut	69 kV
Delaware	Coast zone only
Florida	"Associated line" above 230 kV
Illinois	Any
Kentucky	400 kV
Maine	100 kV
Maryland	69 kV
Massachusetts	69 kV and 1 mile long
Minnesota	200 kV and 1 mile long
Montana	115 kV
Nevada	60 kV
New Hampshire	100 kV and 10 miles long
New Jersey	Coastal zone only
New Mexico	230 kV
New York	125 kV and 1 mile long, or 100 kV and 10 miles long

STATE	TRANSMISSION LINE (Regulated minimum voltage level)
North Dakota	200 kV and certain 69-200 kV
Ohio	125 kV
Oregon	230 kV and greater than 10 miles
Pennsylvania	100 kV
South Carolina	125 kV
South Dakota	All
Vermont	All
Virginia	200 kV
Washington	200 kV
Wisconsin	100 kV
Wyoming	Lines associated with power plants.

TABLE III: STATE RECOMMENDED ELECTRIC FIELD LEVELS

STATE	RECOMMENDING REGULATORY AGENCY	MAXIMUM ELECTRIC FIELD WITHIN THE ROW (kV/m)	MAXIMUM SHORT CIRCUIT CURRENT (mA)	ELECTRIC FIELD @ Edge of ROW (KV/m)
MINNESOTA	Environmental Quality Council	8 (ac) 12 (HVdc, steady state)	5 (ac)	-
NEW YORK	Public Service Commission	7.0-public roads 11.0-private roads	4.5 (ac)	1
NORTH DAKOTA	Public Service Commission	8 (ac) 33 (HVdc)[1]	5 (ac)[2] 34 (HVdc)	-
OREGON	The Energy Facility Siting Council	9	5 (ac)	-

1. High voltage direct current transmission.

2. Alternating current.

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TABLE IV: STATE NOISE ORDINANCES

STATE	Permissible Noise Levels
Arkansas	Federal EPA Levels, Table IV - H
California	Exterior Noise Limits as specified in Table IV - A
Connecticut	Table IV - B
Illinois	Both Impulsive Sound and Octave Sound Pressure Levels are specified in Table IV - C
Maryland	Environmental Noise Standards and Maximum Allowable Noise Levels by Zoning Category - Table IV - D
Minnesota	Table IV - E
New Jersey	Continuous airborne sound level of 50 dB(A) and octave band sound pressure level as specified in Table IV - F
New York	Proposed levels by land use
Ohio	Compliance with OSHA Noise Limits
Oregon	Noise regulations both in dB(A) and octave band sound pressure levels as specified in Table IV - G
Washington	60 dB(A) at the receiving property line for noise source class C (industrial) and the receiving property is class A (Residential)

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TABLE IV - A: EXTERIOR NOISE LIMITS: California

(Levels Not to be Exceeded More Than 30 Minutes In Any Hour)

Receiving Land Use Category	Time Period	Noise Level dB(A) Noise Zone Classification Rural Suburban	Suburban	Urban
One & Two Family Residential	10 pm-7 am	40	40	50
	7 am-10 pm	50	55	60
Multiple Dwelling Residential Public Space	10 pm-7 am	45	50	55
	7 am-10 pm	50	55	60
Limited Commercial Some Multiple Dwellings	10 pm-7 am		55	
	7 am-10 pm		60	
Commercial	10 pm-7 am		60	
	7 am-10 pm		65	
Light Industrial	Any Time		70	
Heavy Industrial	Any Time		75	

TABLE IV - B: Connecticut*

(a) No person in Class C Noise Zone shall emit noise exceeding the levels stated herein and applicable to adjacent Noise Zone:

	Receptor C	Receptor B	A/Day	A/Night
Class C[1] Emitter to	70 dB(A)	66 dB(A)	61 dB(A)	51 dB(A)

(b) No person in Class B Noise Zone shall emit noise exceeding the levels stated herein and applicable to adjacent Noise Zone:

	Receptor C	Receptor B	A/Day	A/Night
Class B[2] Emitter to	62 dB(A)	62 dB(A)	55 dB(A)	45 dB(A)

(c) No person in Class A Noise Zone shall emit noise exceeding the levels stated herein and applicable to adjacent Noise Zone:

	Receptor C	Receptor B	A/Day	A/Night
Class A[3] Emitter to	62 dB(A)	55 dB(A)	55 dB(A)	45 dB(A)

Levels emitted in excess of the values listed above shall be considered excessive noise.

---

1. - Class C: Lands designated Class C shall generally be industrial where protection against damage to hearing is essential, and the necessity for conversation is limited.

2. - Class B: Lands designated Class B shall generally be commercial in nature, areas where human beings converse and such conversation is essential to the intended use of the land.

3. - Class A: Lands designated Class A shall generally be residential areas where serenity and tranquility are essential to the intended use of the land.

* Noise measurement method is also specified

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TABLE IV - C-1: Illinois*- Day time

Octave Band Center Frequency (Hertz)	Allowable Octave Band Sound Pressure Levels (dB) of Sound Emitted to any Receiving Class A Land from Class C Land	Class B Land	Class A Land
31.5	75	72	72
63	74	71	71
125	69	65	65
250	64	57	57
500	58	51	51
1000	52	45	45
2000	47	39	39
4000	43	34	34
8000	40	32	32

TABLE IV - C-2: Night Time

Octave Band Center Frequency (Hertz)	Allowable Octave Band Sound Pressure Levels (dB) of Sound Emitted to any Receiving Class A Land from Class C Land	Class B Land	Class A Land
31.5	69	63	63
63	67	61	61
125	62	55	55
250	54	47	47
500	47	40	40
1000	41	35	35
2000	36	30	30
4000	32	25	25
8000	32	25	25

*Noise measurement method is specified

TABLE IV - C-3

Octave Band Center Frequency (Hertz)	Allowable Octave Band Sound Pressure Levels (dB) of Sound Emitted to any Receiving Class B Land from Class C Land	Class B Land	Class A Land
31.5	80	79	72
63	79	78	71
125	74	72	65
250	69	64	57
500	63	58	51
1000	57	52	45
2000	52	46	39
4000	48	41	34
8000	45	39	32

TABLE IV - C-4

Octave Band Center Frequency (Hertz)	Allowable Octave Band Sound Pressure Levels (dB) of Sound Emitted to any Receiving Class C Land from Class C Land	Class B Land & Class A Land
31.5	88	79
63	83	78
125	78	72
250	73	64
500	67	58
1000	60	52
2000	54	46
4000	50	41
8000	47	39

TABLE IV - C-5

Classification of Land on which Property-Line-Noise-Source is Located	Allowable dB (A) Sound Levels of Sound Emitted to Designated Classes of Receiving Land			
	Class C Land	Class B Land	Class A Land Day Time	Class A Land Night Time
Class A Land	57	50	50	45
Class B Land	57	57	50	45
Class C Land	65	61	56	46

* Noise measurement method is specified

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TABLE IV - D-1: Maryland*

Environmental Noise Standards

Zoning District	Level	Measure
Industrial	70 dBA	L_{eq} (24)
Commercial	64 dBA	L_{dn}
Residential	55 dBA	L_{dn}

TABLE IV - D-2

Maximum Allowable Noise Levels by Zoning Category (dBA)

Effective Date	Day/Night	Industrial	Commercial	Residential
Sept. 14 '77	Day	80	72	65
	Night	80	67	55
Jan. 1, '80	Day	75	67	60
	Night	75	62	50

* Noise measurement method is specified

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TABLE IV - E: Minnesota

NAC	Day (0700-2200)		Night (2200-0700)	
	L_{50}	L_{10}	L_{50}	L_{10}
1	60	65	50	55
2	65	70	50	55
3	75	80	75	80

NAC-1 (Noise Area classification-1) includes the following land use categories: Residential, hospital, educational and religious activities, designated camping and picnicing areas, cultural activities and natural exhibits.

NAC-2 includes: Railroad, bus, airport and marine terminals, retail trades, commercial services, governmental services, parks and recreational activities.

NAC-3 includes: Manufacturing, transportations, fairgrounds and amusement parks, agricultural, mining and fishing activities.

TABLE IV - F: New Jersey

Octave Band Center Frequency (Hz)	Octave Band Sound Pressure Level (dB)
31.5	86
63	71
125	61
250	53
500	48
1000	45
2000	42
4000	40
8000	38

TABLE IV - G: Oregon

NOISE LEVELS (dB(A))

	Day Time (7 AM - 10 PM)	Night Time (10 PM - 7 AM)
L_{50}	55	50
L_{10}	60	55
L_1	75	60

OCTAVE BAND SOUND PRESSURE LEVELS (dB)

Frequency	Day Time	Night Time
31.5	68	65
63	65	62
125	61	56
250	55	50
500	52	46
1000	49	43
2000	46	40
4000	43	37
8000	40	34

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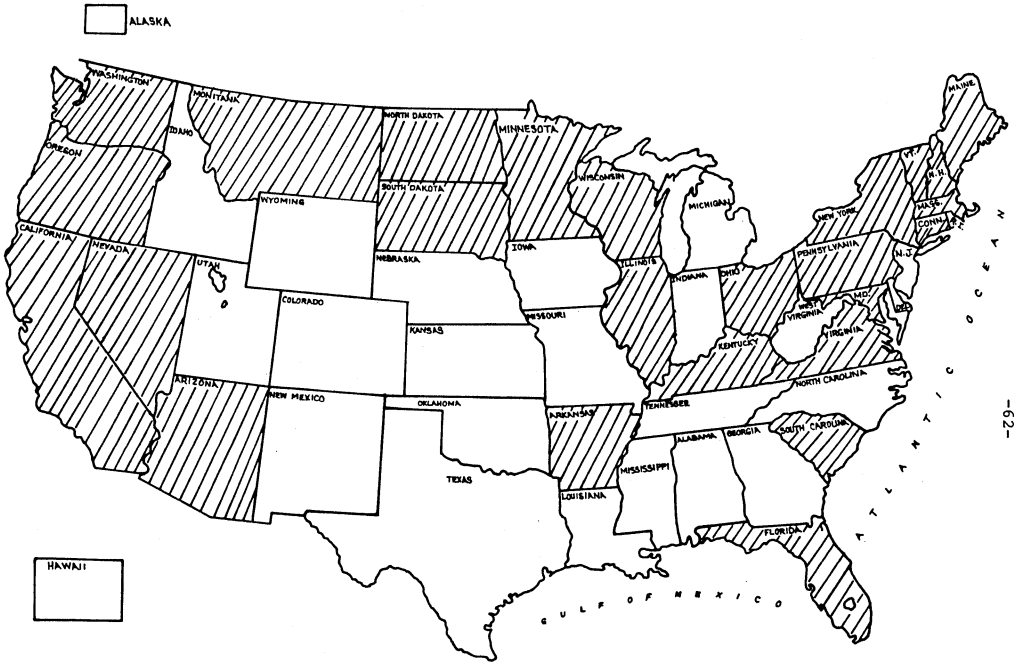
TABLE IV - H: US EPA

SUMMARY OF NOISE LEVELS IDENTIFIED AS REQUISITE TO PROTECT PUBLIC HEALTH AND WELFARE WITH AN ADEQUATE MARGIN OF SAFETY

Effect	Level	Area
Hearing Loss	$L_{eq(24)} \leq 70$ dB	All areas
Outdoor activity interference and annoyance	$L_{dn} \leq 55$ dB	Outdoors in residential areas and farms and other outdoor areas where people spend widely varying amounts of time and other places in which quiet is a basis for use.
	$L_{eq(24)} \leq 55$ dB	Outdoor areas where people spend limited amounts of time such as school yards, playgrounds, etc.
Indoor activity interference and annoyance	$L_{dn} \leq 45$ dB	Indoor residential areas
	$L_{eq(24)} \leq 45$ dB	Other indoor areas with human activities such as schools, etc.

TABLE V: AIR QUALITY GUIDELINES - Ozone and Oxides of Nitrogen

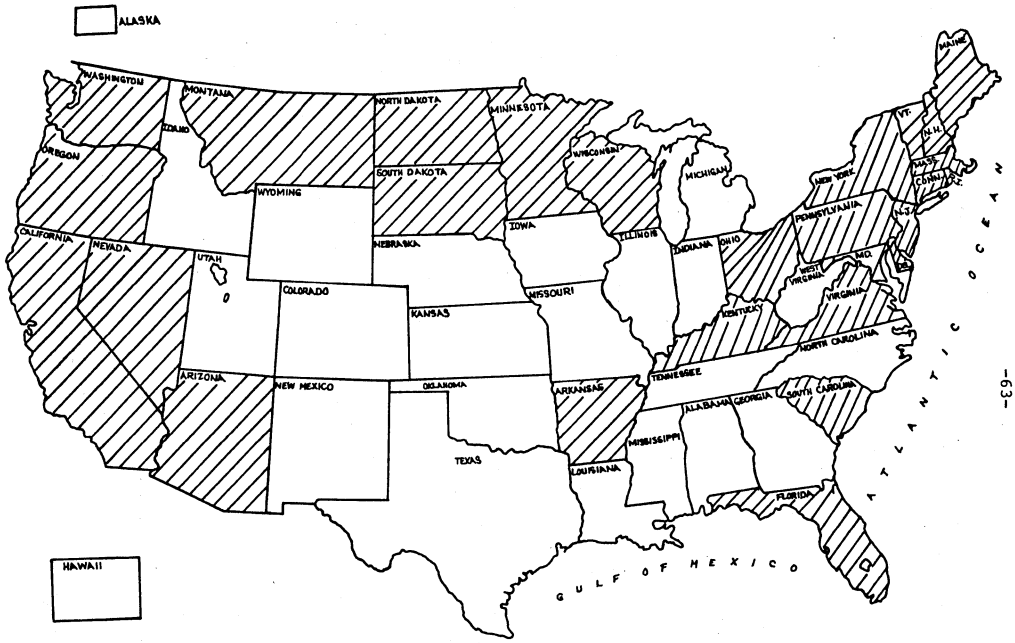
State	Ozone Levels (ppm)	Oxides of Nitrogen (ppm)
Arizona	0.08	0.05
Connecticut	0.08	0.01
Idaho	0.08	0.05
Illinois	0.08	--
Maryland	0.1	0.13-1 Hr. Avg. 0.15-24 Hr. Avg.
Massachusetts	0.08	0.05
Minnesota	0.07	0.05
New Jersey	0.08	0.05
New York	0.08	0.05
North Dakota	0.08	0.05
Oregon	0.08	0.05
Wyoming	--	0.05



STATE ENABLING LEGISLATION FOR ELECTRICAL EFFECTS OF TRANSMISSION LINES

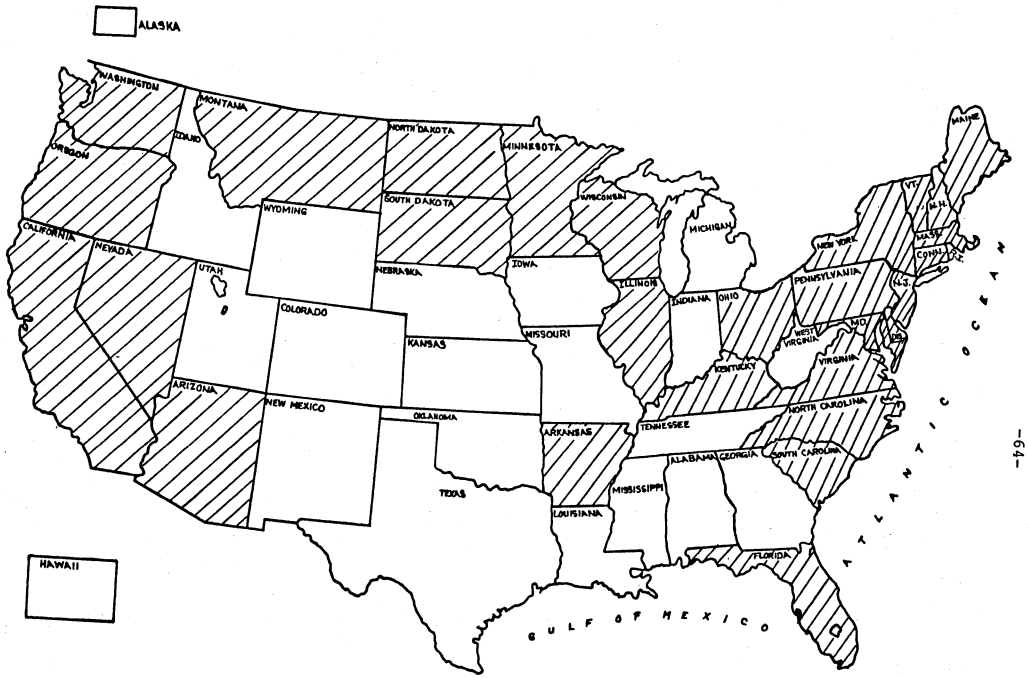
LEGEND
YES
NO

Fig. 1



STATE REQUIRING EVALUATION OF
INTERFERENCE TO COMMUNICATION FACILITIES

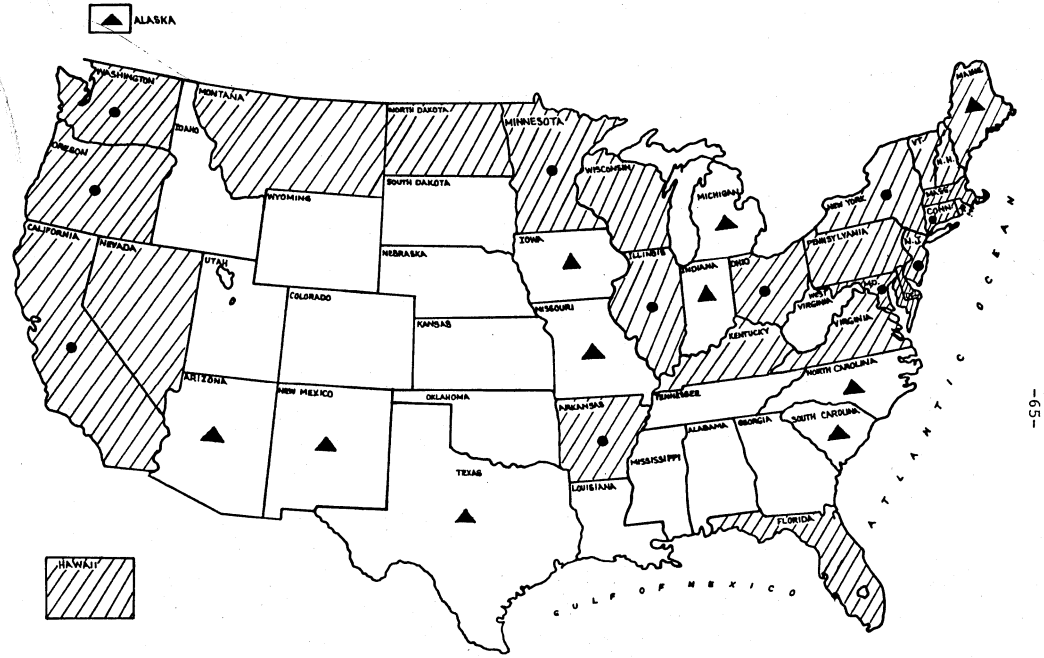
Fig. 2



STATE ENABLING LEGISLATION REQUIRING
EVALUATION OF PUBLIC SAFETY AND COMFORT

Fig. 3

LEGEND:
YES
NO

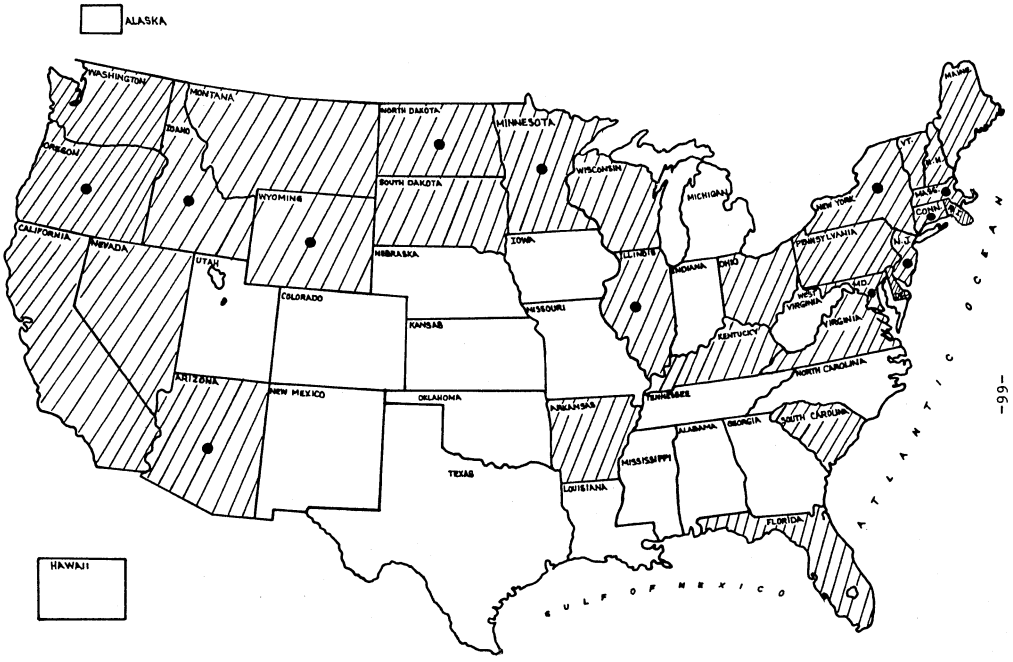


STATE ENABLING LEGISLATION FOR AUDIBLE NOISE

Fig. 4

LEGEND:

- LEGISLATION & GUIDELINES
- YES
- LOCAL ORDINANCES
- NO



STATE ENABLING LEGISLATION FOR AIR QUALITY

Fig. 5

LEGEND:
- LEGISLATION & GUIDELINES
- YES
- NO

GLOSSARY

Ambient - Surrounding, or background.

Ampere - A unit of electric current expressed in A.

Amplitude Modulation (AM) - Process used in standard radio broadcasting in which a continuous high-frequency carrier wave is caused to vary in amplitude by the action of another wave containing information.

Corona - Corona, characterized by luminous glow is a localized discharge and occurs when the voltage gradient on conductors, ground wires, insulators and hardware exceeds the dielectric strength of the surrounding insulating media. The magnitude of corona loss (discharge) depends upon conductor surface gradient, conductor surface condition and weather condition. During foul weather condition (i.e. rain, snow, fog, etc.), corona loss increases significantly over fair weather condition.

Corona Loss - Energy dissipation due to corona on transmission line conductors and hardware.

dB (A) - decibels (A weighted scale), measure of audible noise.

Electric Field - The measure of the force exerted on a unit electrical charge at a point in space. The charges on the high voltage conductors produce electric field.

Electromagnetic Interference (EMI) - The interference to electromagnetic waves over the entire frequency spectrum from 10 Hz to 100 MHz.

Electromagnetic Radiation - A form of energy characterized by transversely oscillating electric and magnetic field which propagates at velocity of light.

Electromagnetically Coupled - Electric coupling between two objects due to the changing magnetic field.

Electrostatic Coupling - Electrical coupling between objects through the electric field.

Electrical Environmental Impact - A change due to electrical effects in existing conditions. In overhead transmission lines, electrical effects consist of radio and television interference, audible noise emission, ozone generation, and induced voltages due to electric and magnetic fields.

Extra-high-voltage (EHV) - Voltages above 230 kV.

Field Intensity - The magnitude of a field expressed in kV/m for an electric field and gauss for magnetic fields.

Frequency Modulation (FM) - Process used in FM radio broadcasting in which the frequency of the carrier wave is varied by the action of another wave containing information.

Gauss (G) - Unit of magnetic flux density.

Hardware - Mechanical components of conductor and insulator assemblies, such as nuts, bolts, yoke plate, etc....

Hertz (Hz) - A unit of frequency equal to one cycle per second. In USA, ac power is transmitted at 60 Hz.

Interference - The disturbance of signal transmission by unwanted noise sources.

Joule (J) - A measure of energy. 1 Joule = 9.480×10^{-4} BTU.

Kilovolts per Meter - (kV/m) = 10^3 V/m.

L_{10} - The sound level in dB(A), which is exceeded 10% of the time for a one hour period.

L_{50} - The sound level in dB(A), which is exceeded 50% of the time for a one hour period.

Magnetic Field - The measure of the force acting on a unit magnetic pole at a point in space. In power transmission lines, the current produces magnetic field.

Milliampere (mA) - 10^{-3} A.

Millijoule (mJ) - 10^{-3} J.

Noise - Any unwanted extraneous electrical quantity or sound interfering with the proper reception of information which is intended to be received.

NA - Not applicable.

NAC - Noise Area Classification System according to land activity at Receiver.

ppm - Parts per million.

Pollution - Any disruption by man of the natural system.

Shield Wires - Grounded wires used to protect the transmission line from lightning.

Voltage Gradient - The rate at which voltage increases or decreases along a conductor or through a dielectric such as air.

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This final report was prepared under the cognizance of Mr. Douglas W. Boehm, Project Officer, Division of Environmental Control Technology, U.S. Department of Energy.

16. Abstract:

Environmental regulations pertaining to electrical effects of (a) interference to communication, (b) public safety and comfort, (c) noise, and (d) air quality were compiled for all of the states and Federal agencies as of June 1978. The following is a summary of the telephone canvassing: a) Communication Interference: Evaluation of the impact to communication is required by FCC, REA, NRC, and 26 states. No quantitative values are given. b) Public Safety and Comfort: All states have adopted the NESC requiring 5 ma short-circuit criteria. 28 states, REA and ONRR require evaluation of public safety and comfort, and undue hazard to the property in proximity of transmission line. Oregon has enacted a state law of a 9.0 kv/m electric field level in ROW. Various state regulatory agencies require different levels: MN 8kv/m ac and 12kv/m dc in ROW; NY 7.0kv/m in ROW over public roads, 11kv/m in ROW over private roads and calculated 1.0kv/m at edge of ROW for new EHV lines; and ND 8kv/m ac and 3.3kv/m in ROW. c) Noise: Of the 24 states with noise regulations, 15 have nonquantitative emission limits and 9 have noise guidelines The permissible noise limits at the property line vary from 40 to 70 dB(A). d) Air quality: EPA has set national primary and secondary ambient air quality standards for nitrogen dioxide and photochemical oxidant/ozone. Twenty eight states have enabling legislation for air quality and 12 of these have air quality standards.

Additionally, 27 states have enacted legislation requiring preparation on an environmental impact assessment for lines, and 2 states have coastal zone permit regulations.

This report will be updated in the future to reflect new regulations.

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THE INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, INC.

APPENDIX 7.

TECHNICAL ACTIVITIES BOARD
COMMITTEE ON MAN AND RADIATION

30 July 1979

PLEASE REPLY TO:

The Honorable Jerome Ambro
U.S. House of Representatives
Washington, D.C. 20004

Dr. Don R. Justesen, Director
Neuropsychology and Behavioral
Radiology Laboratories (151-L)
VA Medical Center
Kansas City, Missouri 64128
(816)861-4700, ext. 466

Dear Congressman Ambro:

During the recent (12 July) oversight hearings on non-ionizing radiations, which you conducted as Chairman of the Subcommittee on Natural Resources and Environment, testimony as respectively given by Dr. Louis Slesin of the Natural Resources Defense Council, and Mrs. Ruth Clusen, Assistant Secretary for Environment, DOE, raised some issues that deserve further comment. I offer the following comment for the Record.

It is clear from his written testimony that Dr. Slesin believes that advisory bodies with oversight and regulatory responsibilities should be administratively independent of user agencies. The thesis of independence is so basic and so sound--and so applicable to what is needed for the Electromagnetic Radiation Management Advisory Council (ERMAC)--that the Congress should, if necessary, force the requisite independence through legislation. In my testimony of 12 July before your Subcommittee, I recommended as have many others the return of ERMAC to the Executive Office of the President. Given the realities of the reorganization that led to the abolition of OTP and the associated demotion of ERMAC to the Department of Commerce, the ERMAC baby that was thrown out with the OTP bath may not be welcomed in its original home. That would be a pity, but the Congress in its quest for an independent ERMAC may wish to consider a relocation in its own bailiwick--in, for example, the General Accounting Office. The injury to ERMAC from loss of the Presidential Presence might well be redeemed by the aura of the Congressional Purse.

The argument for independence is sound and unassailable, but Dr. Slesin also argues that the user agencies are conducting a disproportionately large share of biological research on RF radiations. The edge of his argument is that data reported by scientists employed by or under contract to the military or the Department of Energy are less credible than data reported by scientists of regulatory agencies. I think it ironic that nearly every study that has generated evidence of potentially harmful effects of RF radiation--the very studies that Dr. Slesin alludes to in making a case for Congressional support of research--has been funded by the Navy, Army, or Department of Energy.

The issue of credibility is one that has disturbed me deeply ever since Paul Brodeur published his thesis of international conspiracy in the book

The Zapping of America. By implication, hundreds of engineering and biological scientists in North America and Western Europe stand accused of deliberately suppressing data on dangers of weak RF radiations.

Scientists are not paragons of virtue. They probably beat their wives, drink to excess, and commit traffic violations as frequently as the non-scientists, but as a class of individuals they do not and cannot suppress data or tamper with data or deliver data that conform with preconceived directives. The tribal code--the way that science works--is a powerful deterrant to mendacity or collusion. For every sinning scientist there are dozens more who will eagerly blow the whistle on him.

I detect in Dr. Slesin's testimony some of the same naiveté about scientists and science that is evident in Mr. Brodeur's book. I caution him and those whom he represents in the important cause of environmentalism to avoid propositions and arguments that would advance their cause at the expense of the disciplines and disciples that have given them the leisure and means to promote their goals--and doubtless will be required to achieve them. It may sound prosaic, but biting the hands that feed one is inimical to the goals of environmentalism and of science, which after all, should be and can be complimentary.

During Mrs. Clusen's testimony, she referred to an ambitious program of biological research initiated by the Department of Energy in 1976 on zero-frequency and low-frequency electromagnetic fields. I recall the Chairman's dismay at what appeared to be investments of millions of dollars in initiation of a program without subsequent evidence of completion. There was an ambiguity at work here that precluded a satisfactory answer to the implied question: What has been accomplished in the low-frequency studies? The ambiguity lay in the term "program." Programs of research are seldom completed in the scientific sense of the word. The operative terms are "projects" and "individual experiments," the smaller and smallest pieces of the scientific jig-saw puzzle.

To gain a purchase on DOE's progress as measured by completions of discrete experiments, I contacted one of COMAR's new members, Dr. Richard D. Phillips of Battelle's Pacific Northwest Laboratories in Richland, Washington. (Battelle is a prime contractor to DOE.) From Dr. Phillips I learned that 78 engineering projects and experimental studies have been completed to date; most of the biological studies that have generated positive findings have been performed twice.

To provide the Congress and the reader of the Record a grasp of the scope of the Battelle studies, I have appended a summary of positive findings obtained by Battelle Scientists as based on exposures of small animals to 60-Hz A.C. and to D.C. fields. It must be stressed that the large catalogue of effects is based on very high field strengths--much higher than those at which members of the general population are exposed. Power-line engineers do

encounter these fields, which occasions the need for biological assessment. Additional studies, which are now underway at Battelle, will be devoted to determination of thresholds at which the effects occur.

By way of a concluding comment, I note that rigorous scientific study that embraces the whole of biology is by its nature indefinite and costly. The only alternative is not to perform it, an alternative that eventually would cost much more.

Don R. Justesen
Chairman, IEEE Committee on
Man and Radiation

Copy to: Technical Activities Board, IEEE
Dr. Richard Phillips, Battelle PNW
Dr. Ian Marceau, U.S. Congress

Encl. [1]

BATTELLE PACIFIC NORTHWEST LABORATORIES

Richland, Washington

Summary of Positive Findings, Small-Animal and Microbial Studies

Effects of 60-Hz Fields

Behavior: Rats spend significantly more time out of a 60-Hz electrical field than in it at ≥ 90 kV/m during a 45 minute test. Exposed rats had a higher activity level than sham-exposed controls. (CONFIRMED).

Behavior: Rats exposed to E fields at 75 and 100 kV/m spend more time out of the area where a 60-Hz field is imposed than do sham-exposed controls during the 12-hour light period of a 24-hour test (12-hour light; 12-hour dark). Rats exposed at 25 and 50 kV/m spend more time in the area than do sham-exposed controls during the 12-hour period. During the 12-hour dark period the only significant effect is a preference by rats exposed at 100 kV/m to stay out of the field. (CONFIRMED).

Cell-Mediated Immunity: Mice exposed at 100 kV/m for 30 days show a statistically significant decrease in immune responsiveness to an antigenic protein applied to the skin as compared with the response of sham-exposed controls. (CONFIRMED).

Growth and Development: At 14 days of age a smaller percentage of rats exposed from conception until 8 days after birth exhibited the righting reflex (a measure of neurological development) and a higher percentage showed motil behaviors as compared with sham-exposed rats. Motil behavior is a combination of grooming, locomotor movement, and frequency of standing on the hind limbs. None of these differences between sham-exposed and exposed animals was apparent when the animals were retested at 21 days of age. (CONFIRMED).

Synaptic Transmission: Results of conditioning tests indicate that sympathetic ganglia (nervous tissues outside the central nervous system) of exposed rats are more excitable than are those of sham-exposed animals. (CONFIRMED).

Hematology: F_1 male and female mice exposed in utero and then for 80 days after birth had increased counts of neutrophilic and lymphocyte cells, a test of the humoral immune system. (CONFIRMED).

Endocrinology: Rats exposed at 100 kV/m for 35 days starting at weaning (21 days of age), and rats exposed at 100 kV/m for 120 days (from 56 to 176 days of age), had lower concentrations of serum testosterone than did sham-exposed controls. (UNCONFIRMED: confirmatory experiments are in progress).

Corticosterone: Rats exposed at 100 kV/m for 120 days had a lower serum corticosterone level than did sham-exposed controls, indicating sensitivity of the endocrine (hormone) system. (UNCONFIRMED: confirmatory experiments are in progress).

Hematology: Red-blood cell counts of F_3 male mice exposed *in utero* and for 80 days after birth were higher than those of sham-exposed controls. (CONFIRMED).

Effects of DC Fields

Salmonella TA-100 (Ames Assay): Bacterial cells exposed to DC electric fields show a statistically significant increase in back mutation frequency of genetic reversion. These cells regain the ability to grow without the amino acid histidine being provided in culture media. A positive result with this strain might indicate that a base-exchange mechanism of mutagenesis is involved. (CONFIRMED).

Photobacterium fisheri: Baterial cells exposed to DC electric fields are able to grow in the presence of previously inhibitory concentrations of the antibiotic tetracycline. This result might indicate a forward mutation (for which many mechamisms are possible). (CONFIRMED).

E. coli Lysogen induction: Preliminary data indicate that bacterial strains harboring "dormant" viruses begin producing them following electric-field exposures. (UNCONFIRMED).

E. coli drug-resistance plasmid-containing strains: Bacteria containing plasmids show a 15-25% reduction in cell numbers expressing drug resistance. The result is not due to loss of thh plasmids. (CONFIRMED).