Technical

Appendix

To

A Study of Recent Rises in Leukemia and Other Mortality Rates in Oregon Following Radioactive Releases from the Trojan Nuclear Plant

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Technical Appendix

I) Background of Study

As discussed in the 1988 Oregon Vital Statistics Report (1), cancer mortality rates in Oregon in recent years have continued a sharp rise that began to exceed the rate for the U.S. as a whole since 1985. Likewise, total mortality due to all causes combined began to exceed that for the U.S. that same year, and the rates for five leading causes of death have worsened in Oregon relative to the U.S., as indicated in the discusion of Oregon mortality and the table of Selected Leading Causes of Death reproduced below as ANNEX I- A. Also during the years since the Three Mile Island and Chernobyl nuclear reactor accidents, there has been growing evidence that cancer and leukemia rates may have risen in areas where nuclear plants have been operating, as recently reviewed in the latest report published by the National Academy of Sciences (BEIR V Report, January 1990)(2).

The present study was undertaken to examine the possibility that the recent upward changes in the leading causes of death in Oregon may have been affected by releases of radioactivity from the Trojan reactor located 35 miles northwest of Portland.

II) Methodology

Since very detailed health statistics were available for the State of Oregon, it was decided to examine the changes in congenital defects, immature births, leukemia, cancer,and total mortality in relation to the reported annual releases of radioactive iodine and other fission products in the form of particulates reported to the NRC (3) as a measure of the relative radiation dose. In addition, because of recent publications pointing out an unexpected rise in asthma deaths in the U.S.and the evidence for an unusually large rise of respiratory system mortality in Oregon (1), asthma deaths were added to the studyand correlated with the annual radioactivity releases.

In order to allow for the delay in the effect of the releases and the additive character of the accumulated dose, correlations were run with one to seven year moving values of the cumulative releases. Since different health effects have different delays, this technique allowed a determination of the effective delay by the determination of the highest correlation coefficient for either a linear or a logarithmic or concave downward dose-response.

The base-line period chosen for the correlation studies extended from the end of large-scale atmospheric and peaceful "Plowshare" nuclear tests in Nevada in 1970 to the beginning of operation of the Trojan nuclear plant in 1975, a period during which cancer mortality in Oregon had reached a plateau (1), as did the mortality due to chronic obstructive lung disease (COPD). For the case of total mortality, where a declining rate exists during the base-line period, the rate of decline was established using a fit to the logarithm of the rate, since the normal trend before nuclear fallout appeared in the environment in Oregon and for the entire U.S. was that of decline at a constant rate or percent per year. From the difference between the normally expected trend-line and the actual rate, the excess deaths and death rates were calculated. A similar technique beginning at the time of the fuel failure allows one to estimate the excess deaths after exposure to the radioactive releases from this increased release.

In order to detect a geographical pattern, it was also possible to utilize a recent study of age-adjusted death-rates by counties for the years 1978-1986 (4) carried out by the Health Division of the State of Oregon since this coincided with the period when the Trojan plant had been in operation for two to ten years, long enough for cancer and other causes of death to have had a chance to appear.

Because a major fuel failure occurred in the Trojan reactor in 1981-82 as reported to the NRC (5) in the course of which the radioactive releases increased significantly (3) as reproduced in Table 1, the changes in cancer rates were analyzed separately for the period before start-up to just before this abnormal event took place in order to examine the nature of the dose-response relation under normal operating conditions.

In addition to the releases from the Trojan plant, there was the fallout from the Chernobyl accident, which arrived in Oregon about May 9-10, 1986. Since this added to the total radiation dose in a very short period that was carefully monitored by both state (6) and federal agencies(7), this event provided another test of the hypothesis that immediate, short-term effects can be detected within a matter of months to years at dose levels some one hundred times below present maximum permissible discharges or levels in the milk and diet, or of the same order as the efects attributed earlier to the low doses from Trojan releases on immature births (less than 2500gm birth weight), births with congenital defects, and total mortality for all ages and causes combined.

Both temporal and geographic changes with distance from the reactor were examined and tested for their statistical significance using standard methods similar to those suggested in the Oregon Vital Statistics for 1988 (1). The results of the various tests are shown in tabular and graphic form below.

In order to establish the possible role of milk transported over long distances from large milk producing counties to urban areas as a means of exposure to both long-lived and short-lived radioactive materials such as strontium-89 (Half-life 50 days), strontium-90(Half-life 28 years), barium-140 (Half-life 13 days) and iodine-131 (Half-life 8 days), data was obtained on the production and distribution of milk for the states of Oregon and Washington from a U.S.Department of Agriculture report (8).

Reports by the U.S.Environmental Protection Agency (EPA)(9) as well as environmental reports by the utility and the Radiation Control Section of the Health Division in the Oregon State Department of Human Resources were utilized to establish temporal and geographical patterns of environmental radioactivity.

III) Reactor Releases

The Trojan reactor is located in Columbia County 35 miles nothwest of Portland on the Columbia River, as shown in the maps for Oregon and Washington in Figures 1 and 2. It went into operation in December 1975, and experienced growing problems with leakages from the fuel rods as shown in Table 1 and Fig.3.

As described in a report by the NRC (5), relevant pages from which are enclosed as Annex III-A, major damage was discovered in 1981 and found to have been due to excessive vibrations which required an extensive shut-down in 1982, during which the largest releases occurred.

Figures 4 to 7 present the evidence that significant amounts of strontium-90 appear to have escaped into the environment and reached the public primarily via the milk pathway but also via the water and other components of the diet, as shown by measurements of the milk at different distances from the plant as early as 1976 that decrease with distance away from the plant both to the north and to the south (Fig.4).

It should be noted that these levels exceeded by a factor of three or more the maximum permissible level of 2 pCi/l agreed to between the operators of the plant and the NRC Staff as spelled out in Section 2.4 of the operating license for the milk alone (10). Figure 4 also shows that the maximum levels of strontium-90 in milk near the plant measured in

Clatskanie were three times as large as those measured during the same period in Seattle, and 83 times as large as those measured by the EPA in San Francisco, California, so that they are unlikely to have been due to nuclear bomb testing by China as claimed by the utility at the time.

In order to obtain an idea as to the significance of these strontium-90 releases for human health, the levels of strontium-90 in the milk during the period of large atmospheric testing by the U.S. and other nations is shown in Fig. 5 for the years 1953 to 1976, both for Portland and San Francisco. It shows that for Portland, he highest levels recorded were 30 picoCuries (pCi) or 30 trillionths of a Curie in 1964, compared with only 10 in San Francisco due to the difference in the rainfall in the areas were the milk originates. Since 90% of the fallout comes down in the rain or snow, the Portland area, whose milk comes primarily from high rainfall coasta areas such as Pacific, Cowlitz and Clark Counties, Washington and Tillamook, Clatsop and Columbia Countis in Oregon, was therefore more heavily contaminated with fallout than San Francisco andSacremento milk, which comes from the drier in land areas.

These levels were of great concern at the time because of the irradiation of the bone-marrow by strontium-90, which resembles calcium needed for bone-growth, leading to leukemia and and damage to the cells of the immune system that originate in the bone-marrow.

Thus, the jump fom 2 to 5 pCi per liter of milk in 176 recorded by the EPA for Portand in Fig.5 was highly significant, since just 1 picoCurie consumed in the milk or diet daily for a year gives a bone dose of about 6 millirems to a young child, as used by Archer in relating strontium-90 to the rise in childhood leukemia for the U.S. as a whole (11). A dose of 18 millirads per year was therefore added to the natural background dose of about 80 millirads by Trojan releases in 1976 by the milk alone, if the EPA data is taken to represent an aveage value for the year. This exceeds the limits set by the operating license (11), which says the following for gaseous wastes in Section 2.41(d):

> "The annual total quantity, above background, of all radioiodines and particulate forms with half-lives greater than eight days, from all reactors at a site should not result in an annual dose to any organ of an individual in an unrestricted area from all pathways of exposure in excess of 5 mrems." [Note that strontium-90 is a particulate]

However, as shown in Figures 6 and 7, there were even larger gaseous releases in 1977 than in 1976 for the months of March through June that led to a peak of long-lived strontium-90 of 12 pCi per liter in the milk for the Portland area in May-June of that year.

That this cannot represent Chinese fallout is indicated by the fact that the strontium-90 peak was accompanied by a peak of cobalt-58 measured by the State Oof Oregon Health Department in algae in the Columbia river at Prescott where the Trojan plant is located, a radioactive chemical that is known to be released by nuclear reactors, but is not produced by nuclear bomb-tests, as indicated by the absence of cobalt-58 in September and October of 1976 when Chinese bomb fallout did come down and increased the concentration of strontium-90 in the milk from 2 to 7 pCi/l (Fig. 7).

Thus the releses from Trojan were equivalent to those from atmospheric bomb tests, and by no means negligible or undetectable, as claimed by the industry.

Inspection of the EPA measurements of strontium-90 in the milk for the succeeding years shows a continuing abnormally high concentration in Portland milk between 1976 and 1985, from a high of 83 times the San Francisco concentration in 1976 to a low of 1.3 times that of San Francisco, 1982 rising once more to greater than 10 times the level in the San Francisco milk as recently as 1984 and three times the Portland level in the summer of 1986, when the Chernobyl accident also added some further strontium-90 to the milk, in addition to the short-lived strontium-89 and barium -140 that also go to the bone.

Thus the data of the state and the EPA clearly are consistent with a pattern of air-borne strontium-90 and other "iodine and particulate" releases to the environment from the Trojan reactor that cannot be blamed on Chinese fallout, especially since there were no further atmospheric tests by China after 1980. Moreover, these releases appear to have exceeded the permissible levels set by the Trojan operating license at various periods during the operation of the plant.

IV) <u>Changes in mortality rates</u>

The changes in mortality rates and other indicators of adverse effects on heath are documented in Figures 8 through 20 and Tables 2 through 6 and are summarized in the main section of the report.

Fig.20 represents cases of hepatitis reported by year rather than deaths, and is taken from the 1988 Oregon Vital Statistics. It illustrates that the large increase in releases at the time of the fuel failure in 1981-82 appears to have affected the immune system so as to lower the ability of the body to fight off infections such as hepatitis that rose sharply in 1983, more than doubling in number of cases per year. This corresponds to the period when individuals born during the peak of the 1963-64 strontium-90 fallout who had their immune systems impaired at birth reached their early twenties and were exposed to further fallout from the Trojan reactor, which thus represented a second insult to their ability to detect and destroy viruses. The continuing impact of nuclear releases into the environment thus not only appears to increase mortality rates, but also debilitating diseases that affect particularly strongly the younger individuals in our society born during the years of massive nuclear testing.

REFERENCES FOR APPENDIX

1) Oregon Vital Statistics Report, 1988, p. 69 ,MORTALITY, Oregon Department of Human Resources, Health Division, Health Status Monitoring, Center for Health Statistics, 1400 S.W.Fifth Ave., Portland, OR 97201.(503)229-5897. Donna Clark, Acting Administrator and Edward J. Johnson II, State Registrar Center for HEALTH statistics.

2) National Academy of Sciences-National Research Council,Health Effects of Exposure to Ionizing Radiation (BEIR V) ,National Academy Press, Washington, D.C. 1990.

3) Nuclear Regulatory Commission, NRC Report (NUREG/CR-2907) Tichler,J. and Benkovitz C. Radioactive Materials Released from Nuclear Power Plants.Annual Reports to 1987, Brookhaven National Laboratory, Upton, New York 11973, prepared for the Nuclear Regulatory Commission. Washington, D. C. 20555 (National Technical Information Service, Springfield, VA 22161).

4) Study of age-adjusted mortality rates by county for the period 1976-1986, Oregon Health Division, Research and Statistics Unit, Center for Health Statistics.

5) Nuclear Regulatory Commission, NRC Report (NUREG/CR-3430, ONRL/NSIC-215, Vol.2)Silver, E.G.Nuclear Power Plant Operating Experience-1982.Oak Ridge National Laboratory, Oak Ridge, TN 37831(National Technical Information Service, Springfield, VA 22161), pages 85-86.

6) Public Health Concerns of Environental Radiation.Chernobyl Oregon's Response. Health Division, Oregon Department of Human Resources, Office of Environmental and Health Systems, Radiation Control Section, 1400 S.W. Fifth Avenue, Portland, Oregon 97201 (503) 229-5797.. Ray D. Paris, Manager. December 1986.

7) Chernobyl Radiation Data Summary, U.S.EPA, Washington, DC, May 14,1986 and later issues.

8) Sources of Milk for Federal Order Markets by State and County, U.S. Department of Agriculture, Agricultural Marketing Service, P.O.Box 96464, Washington, DC 20090-6464.

9) Radiation Data, Quarterly Reports. Pasteurized Milk Network, EPA. Assembled and published by the Eastern Environmental Radiation Laboratory, Montgomery, Alabama. Sources of Milk for Federal Order Markets by Stat and County, U.S. Department of Agriculture, Agricultural Marketing Service, P.O.Box 96464, Washington, DC 20090-6464.

10) Environmental Tecnical Specifications, Trojan Reactor. Appendix B to license, Section 2.4 RADIOACTIVE EFFLUENTS, page 2-15.

11) Archer, V. E. , Association of Nuclear Fallout with Leukemia in the United States, Arch. Env. Health, 42, 263-271, 1987.

OREGON COUNTIES

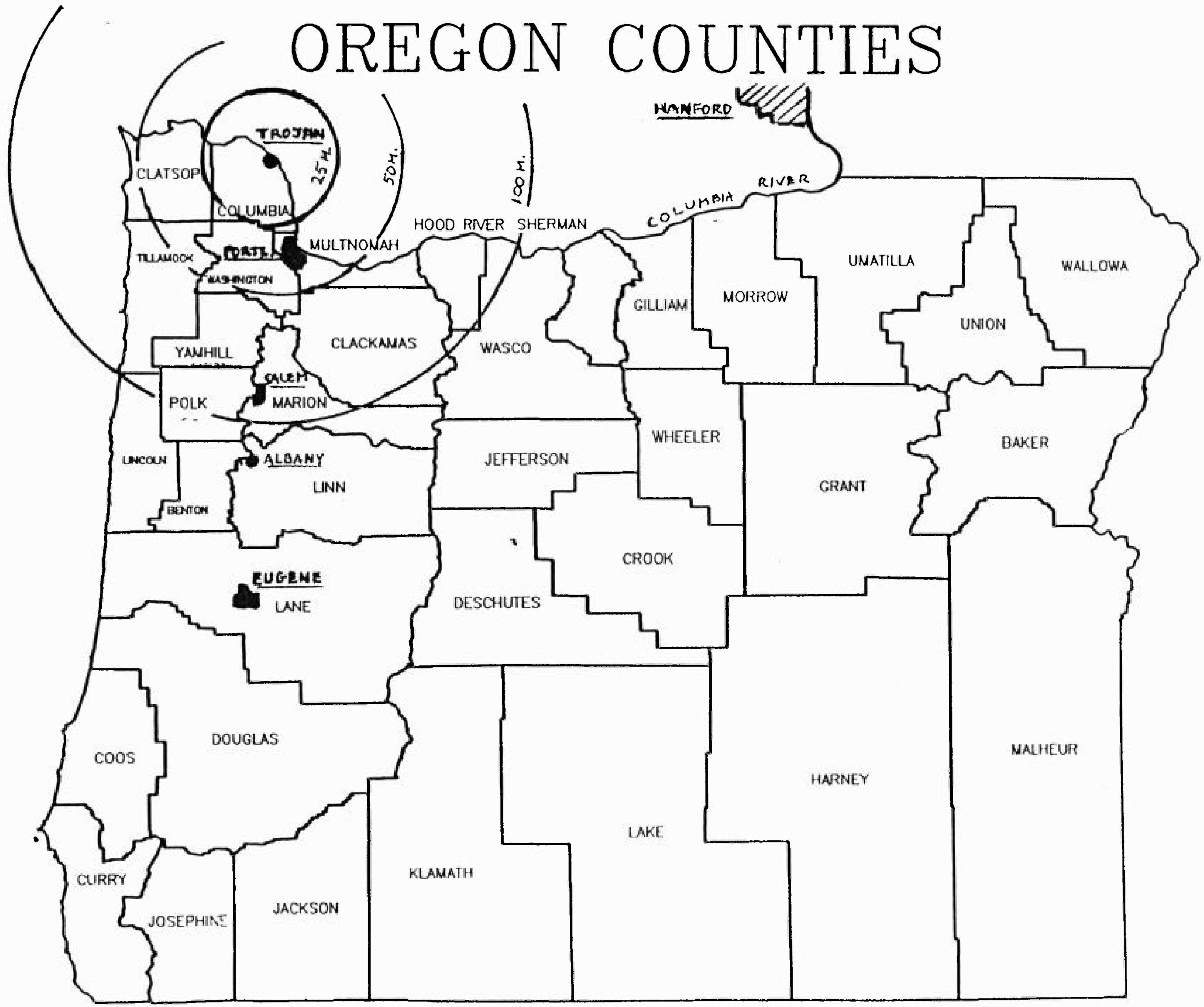
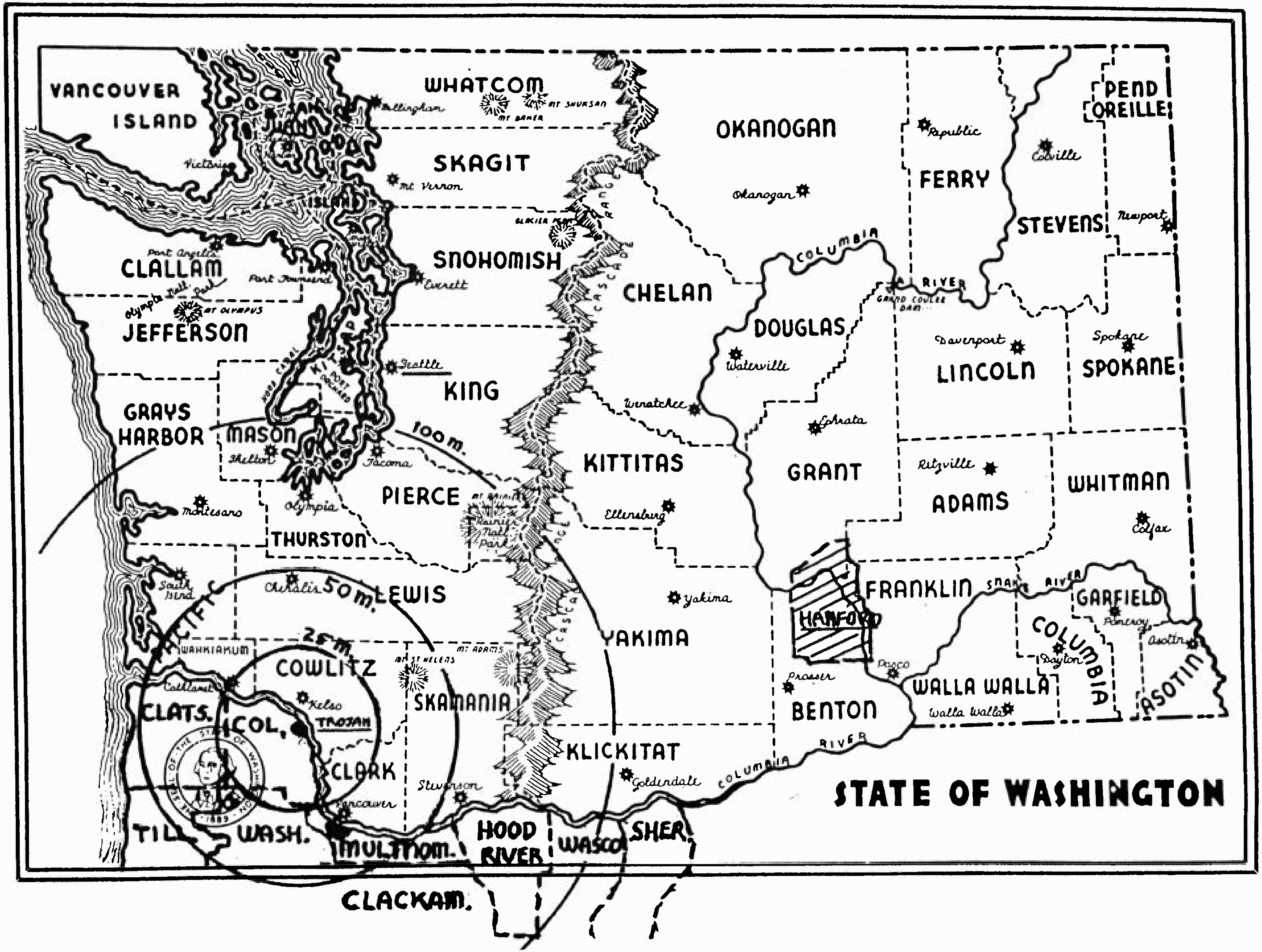


FIG. 1


STATE OF WASHINGTON
VANCOUVER ISLAND
WHATCOM
SKAGIT
SNOHOMISH
CLALLAM
JEFFERSON
GRAYS HARBOR
MASON
KING
PIERCE
THURSTON
LEWIS
WAHKIAKUM
COWLITZ
SKAMANIA
CLARK
CHELAN
KITTITAS
YAKIMA
KLICKITAT
OKANOGAN
DOUGLAS
GRANT
FERRY
STEVENS
PEND OREILLE
LINCOLN
SPOKANE
ADAMS
WHITMAN
FRANKLIN
HANFORD
BENTON
WALLA WALLA
COLUMBIA
GARFIELD
ASOTIN
CLATS.
COL.
TROJAN
TILL
WASH.
MULTNOM.
HOOD RIVER
WASCO
SHER.
CLACKAM.
COLUMBIA RIVER
SNAKE RIVER
CASCADE RANGE
GRAND COULEE DAM
100 m.
50 m.
25 m.
MT BAKER
MT SHUKSAN
MT OLYMPUS
MT ST HELENS
MT ADAMS
Bellingham
Mt Vernon
Everett
Seattle
Tacoma
Olympia
Shelton
Montesano
South Bend
Chehalis
Kelso
Vancouver
Stevenson
Goldendale
Yakima
Ellensburg
Wenatchee
Waterville
Ephrata
Okanogan
Republic
Colville
Newport
Davenport
Spokane
Ritzville
Colfax
Pasco
Prosser
Walla Walla
Dayton
Pomeroy
Asotin
Port Angeles
Port Townsend
Victoria

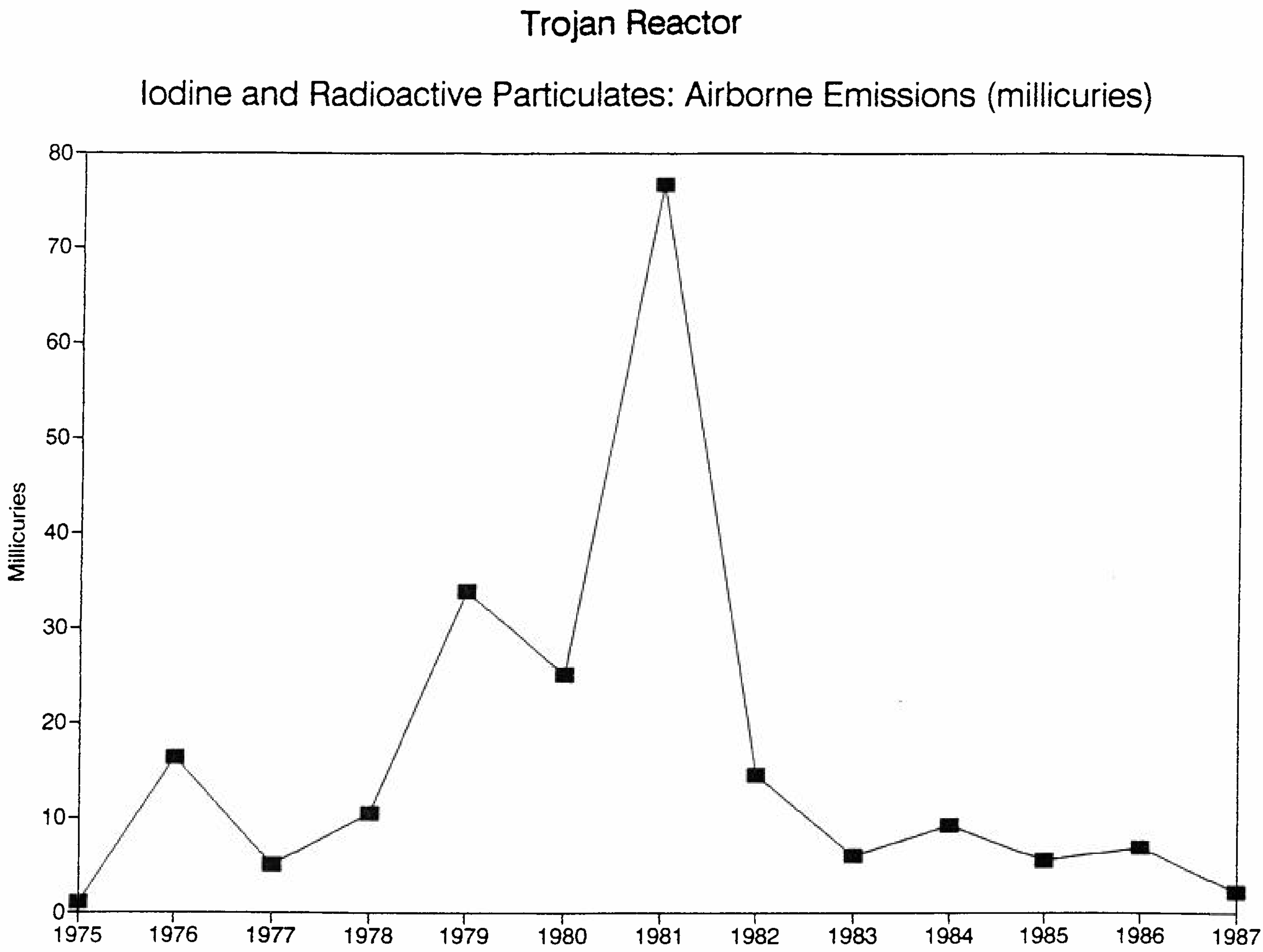

Trojan Reactor
Iodine and Radioactive Particulates: Airborne Emissions (millicuries)
Millicuries
0
10
20
30
40
50
60
70
80
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987

FIG.3

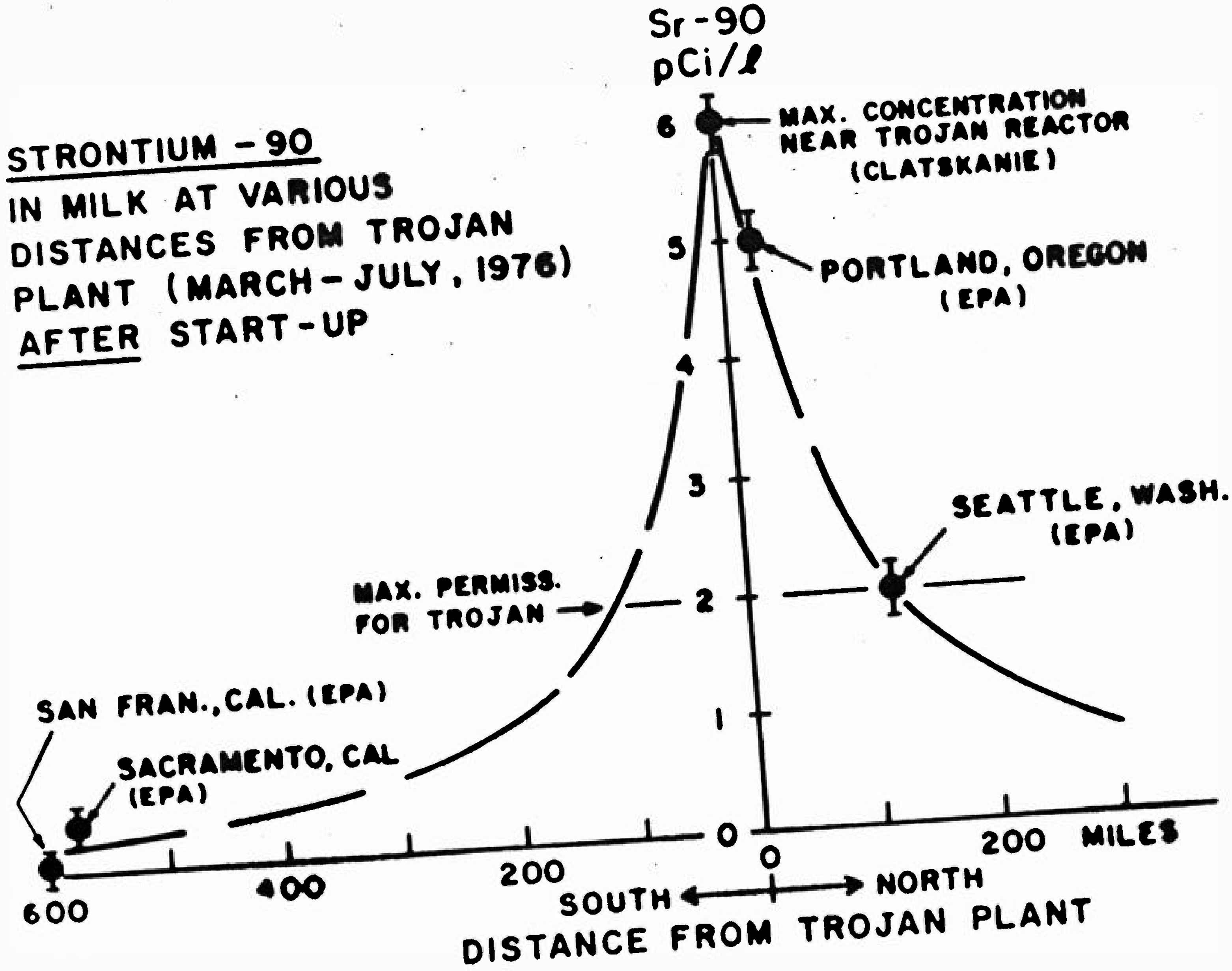

STRONTIUM - 90
IN MILK AT VARIOUS
DISTANCES FROM TROJAN
PLANT (MARCH - JULY, 1976)
AFTER START-UP
Sr-90
pCi/ℓ
6
5
4
3
2
1
0
MAX. CONCENTRATION
NEAR TROJAN REACTOR
(CLATSKANIE)
PORTLAND, OREGON
(EPA)
SEATTLE, WASH.
(EPA)
MAX. PERMISS.
FOR TROJAN
SAN FRAN., CAL. (EPA)
SACRAMENTO, CAL
(EPA)
600
400
200
0
200
MILES
SOUTH
NORTH
DISTANCE FROM TROJAN PLANT

FIG. 4

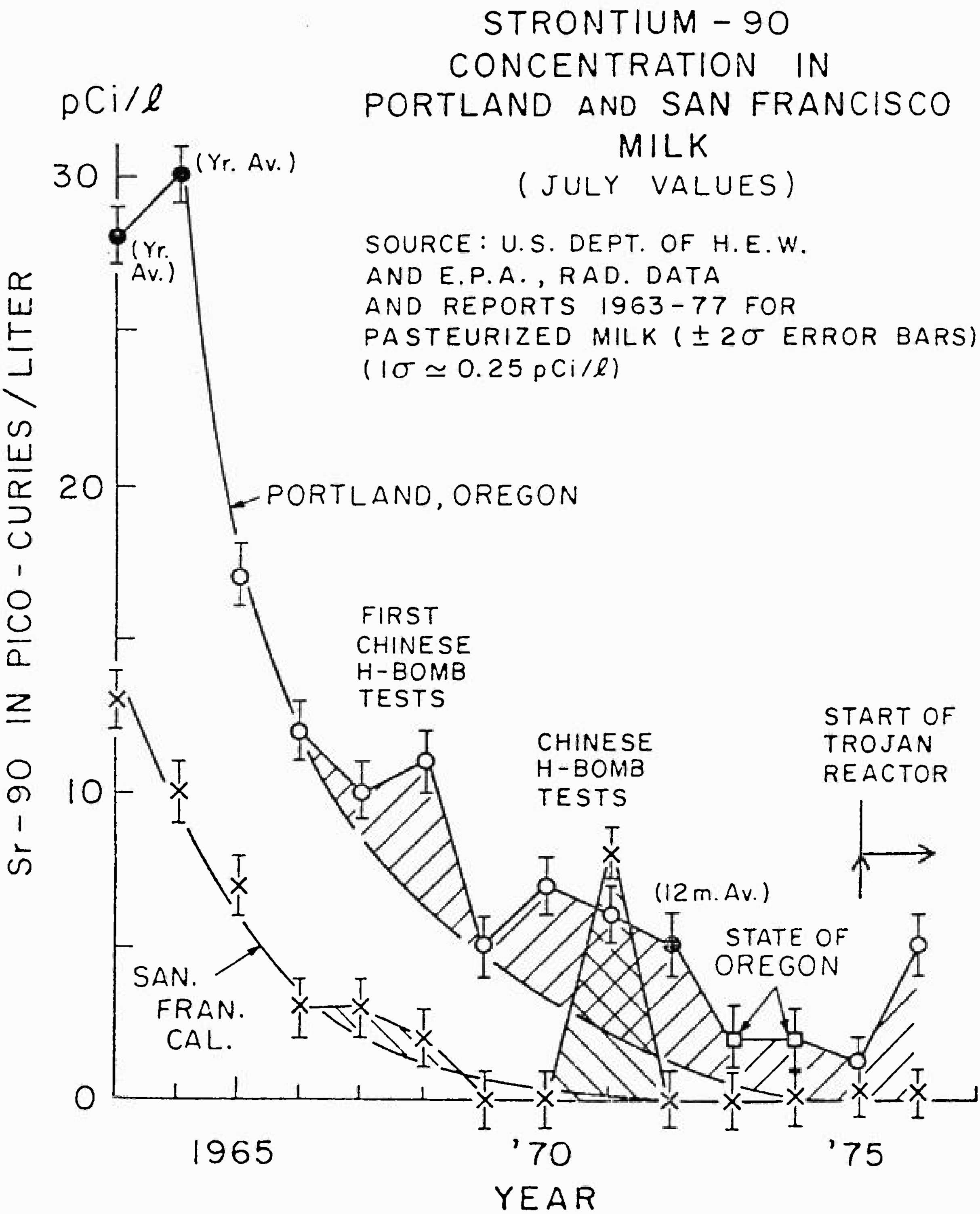

STRONTIUM - 90
CONCENTRATION IN
PORTLAND AND SAN FRANCISCO
MILK
(JULY VALUES)
SOURCE: U.S. DEPT. OF H.E.W.
AND E.P.A., RAD. DATA
AND REPORTS 1963-77 FOR
PASTEURIZED MILK (± 2σ ERROR BARS)
(1σ ≃ 0.25 pCi/ℓ)
pCi/ℓ
Sr - 90 IN PICO - CURIES / LITER
30
20
10
0
(Yr. Av.)
(Yr. Av.)
PORTLAND, OREGON
FIRST
CHINESE
H-BOMB
TESTS
CHINESE
H-BOMB
TESTS
START OF
TROJAN
REACTOR
(12m. Av.)
STATE OF
OREGON
SAN.
FRAN.
CAL.
1965
'70
'75
YEAR

FIG.5

GROSS BETA RADIOACTIVITY IN AIR AT RAINIER, OREGON 4 MILES NNW OF TROJAN REACTOR 1977

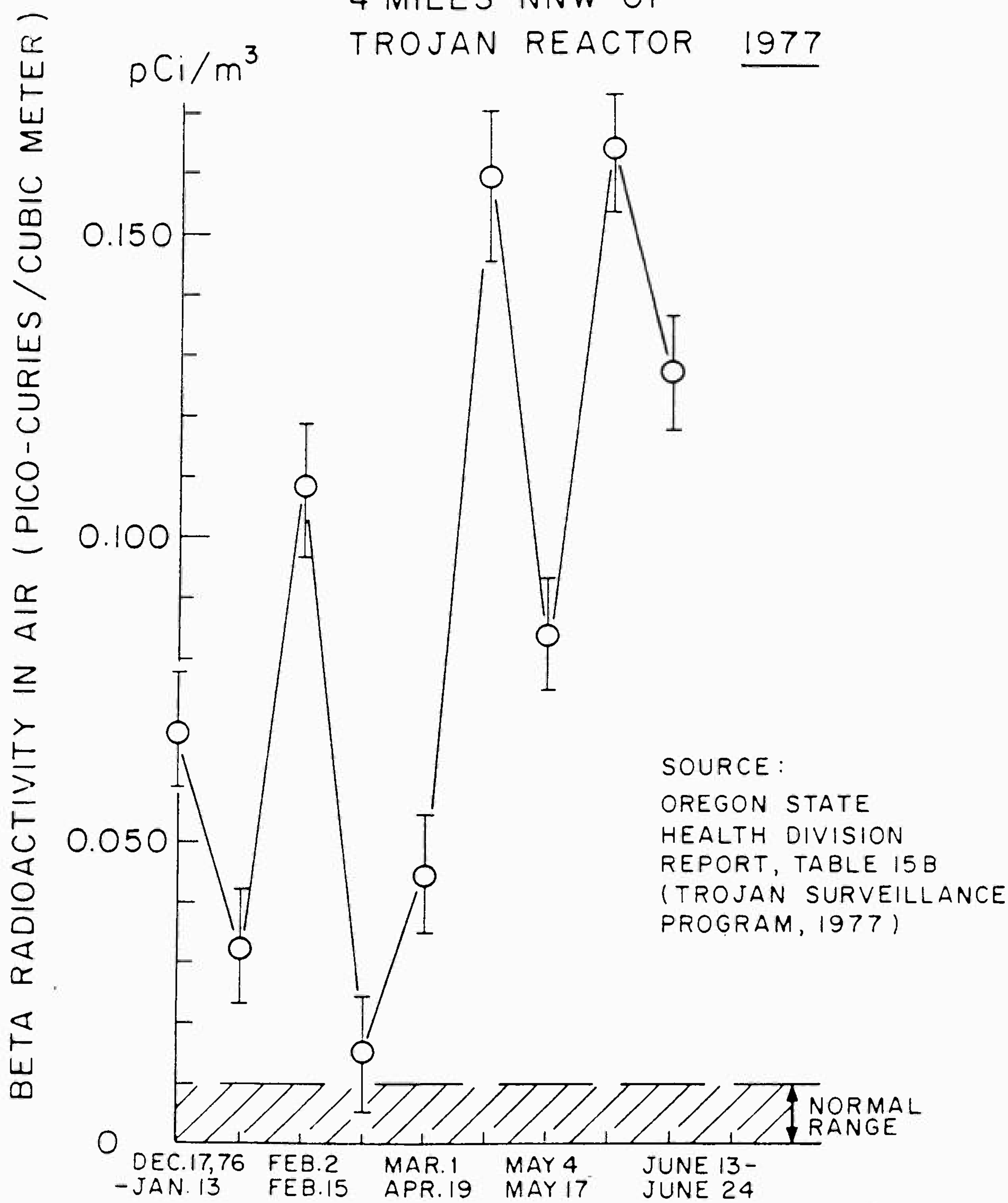


FIG. 6

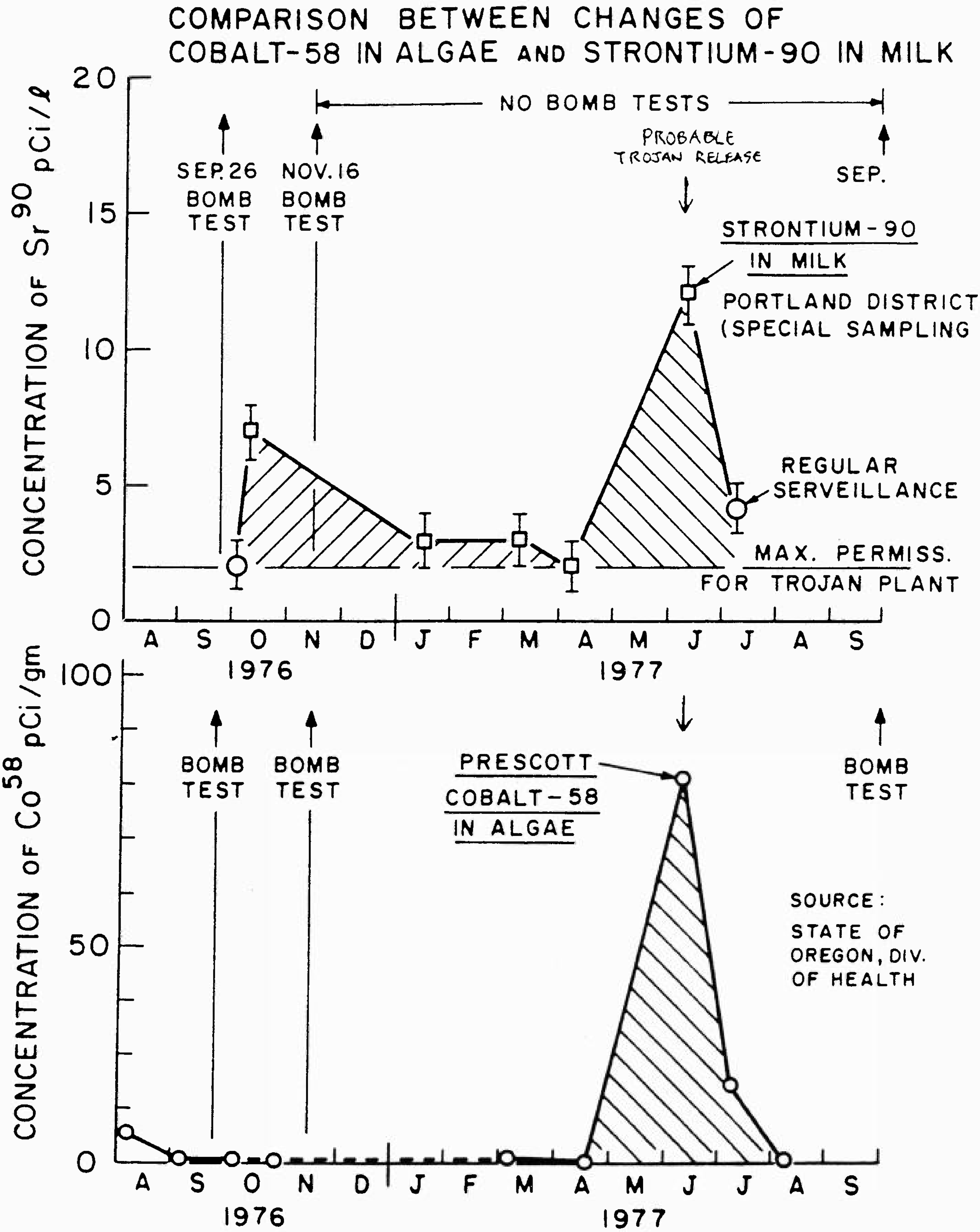
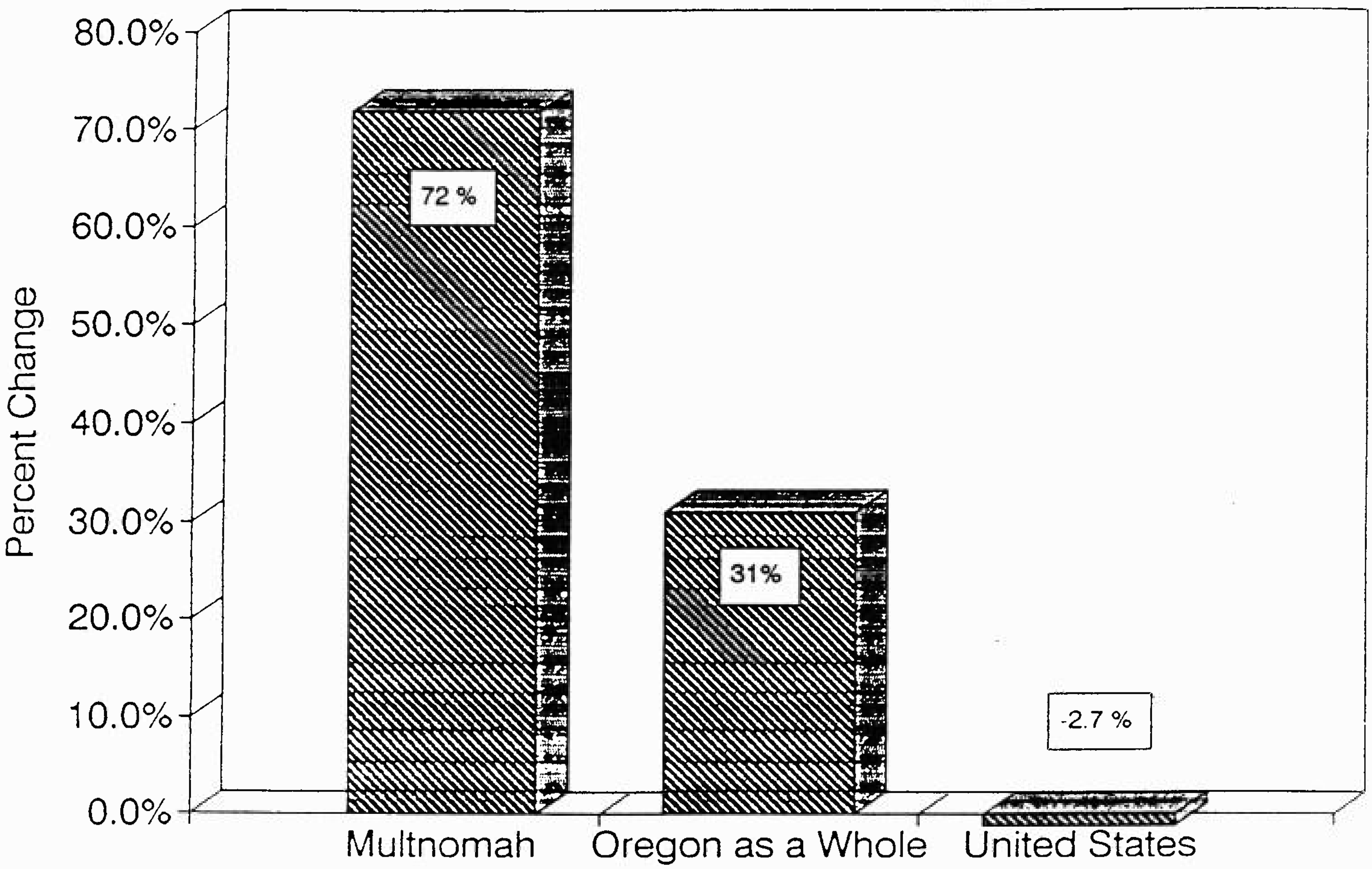

COMPARISON BETWEEN CHANGES OF
COBALT-58 IN ALGAE AND STRONTIUM-90 IN MILK
CONCENTRATION OF Sr90 pCi/ℓ
NO BOMB TESTS
SEP.26 BOMB TEST
NOV.16 BOMB TEST
PROBABLE TROJAN RELEASE
SEP.
STRONTIUM-90 IN MILK
PORTLAND DISTRICT (SPECIAL SAMPLING
REGULAR SERVEILLANCE
MAX. PERMISS. FOR TROJAN PLANT
20
15
10
5
0
A S O N D J F M A M J J A S
1976
1977
CONCENTRATION OF Co58 pCi/gm
100
50
0
BOMB TEST
BOMB TEST
PRESCOTT COBALT-58 IN ALGAE
BOMB TEST
SOURCE: STATE OF OREGON, DIV. OF HEALTH

FIG.7

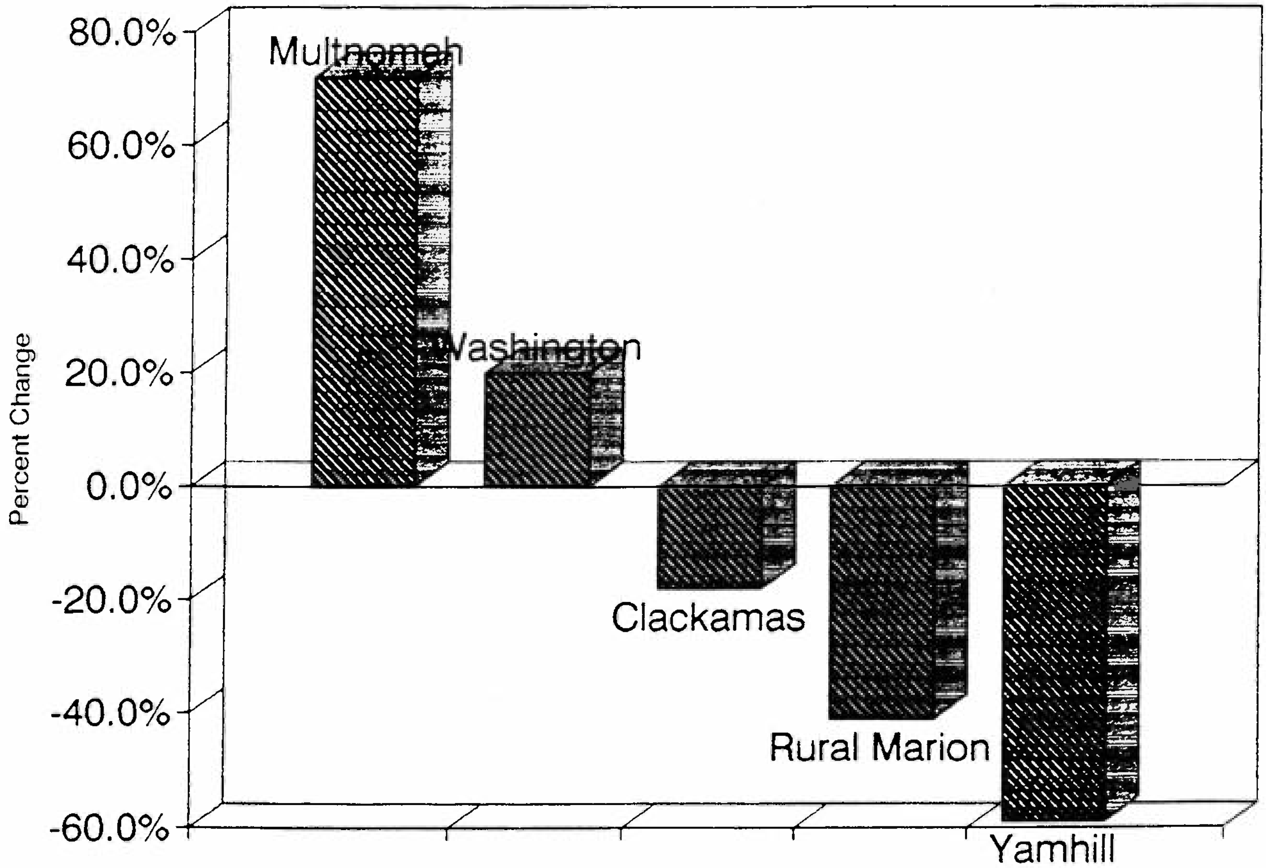
Change in Leukemia Rates 1980--1988 Multnomah County, Oregon and the U.S.



Source: Oregon Vital Statistics, Annual Reports

FIG.8

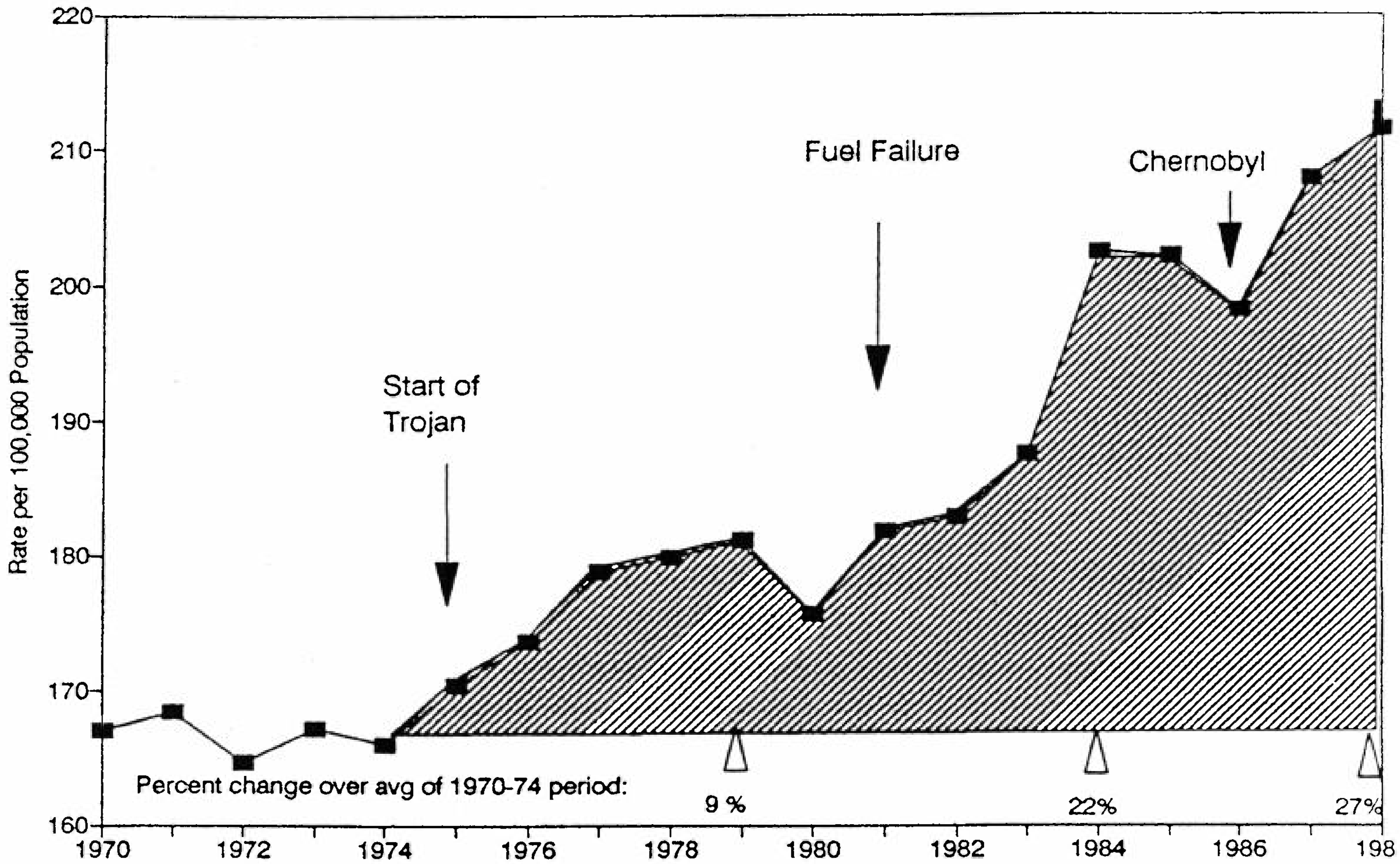
Change in Leukemia Mortality Rates for Major Counties
South of the Portland Area-- 1980-1988



Source: Oregon Vital Statistics, Annual Reports

FIG. 9

Oregon Total Cancer Rates, 1970-1988



Source: Oregon Vital Statistics, Annual Reports

FIG. 10

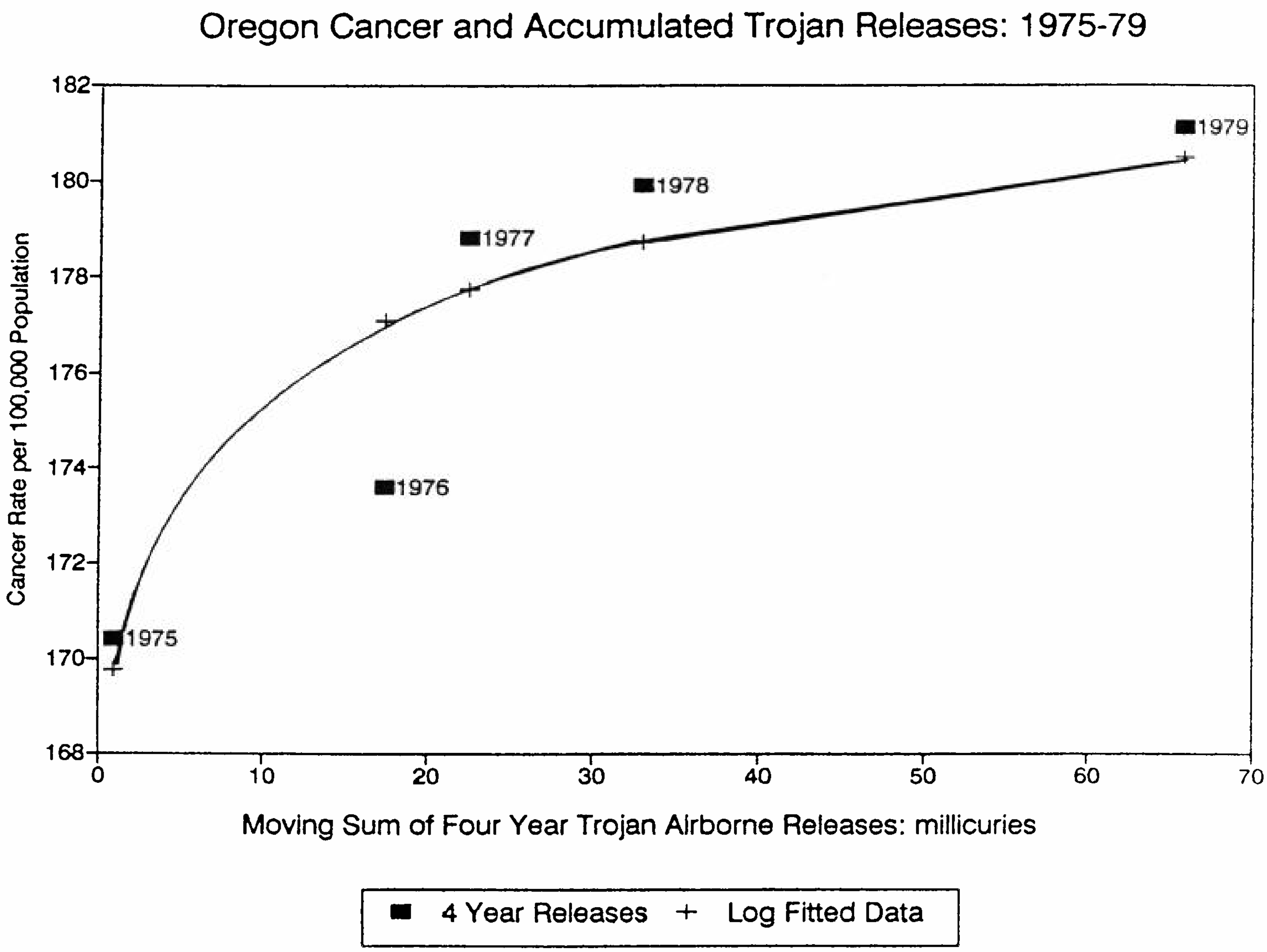

Oregon Cancer and Accumulated Trojan Releases: 1975-79
Cancer Rate per 100,000 Population
182
180
178
176
174
172
170
168
0
10
20
30
40
50
60
70
1975
1976
1977
1978
1979
Moving Sum of Four Year Trojan Airborne Releases: millicuries
4 Year Releases
Log Fitted Data

FIG. 11

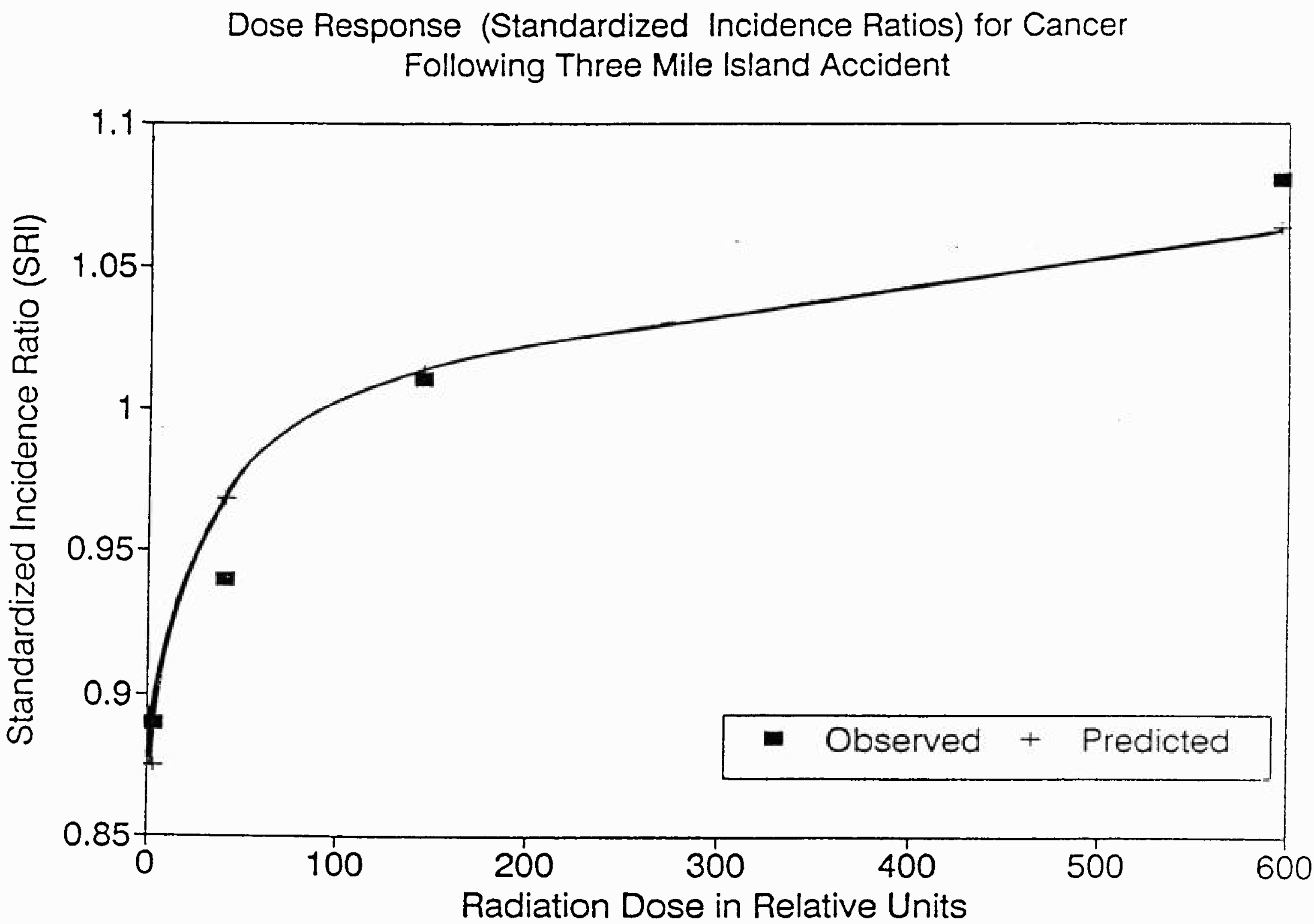
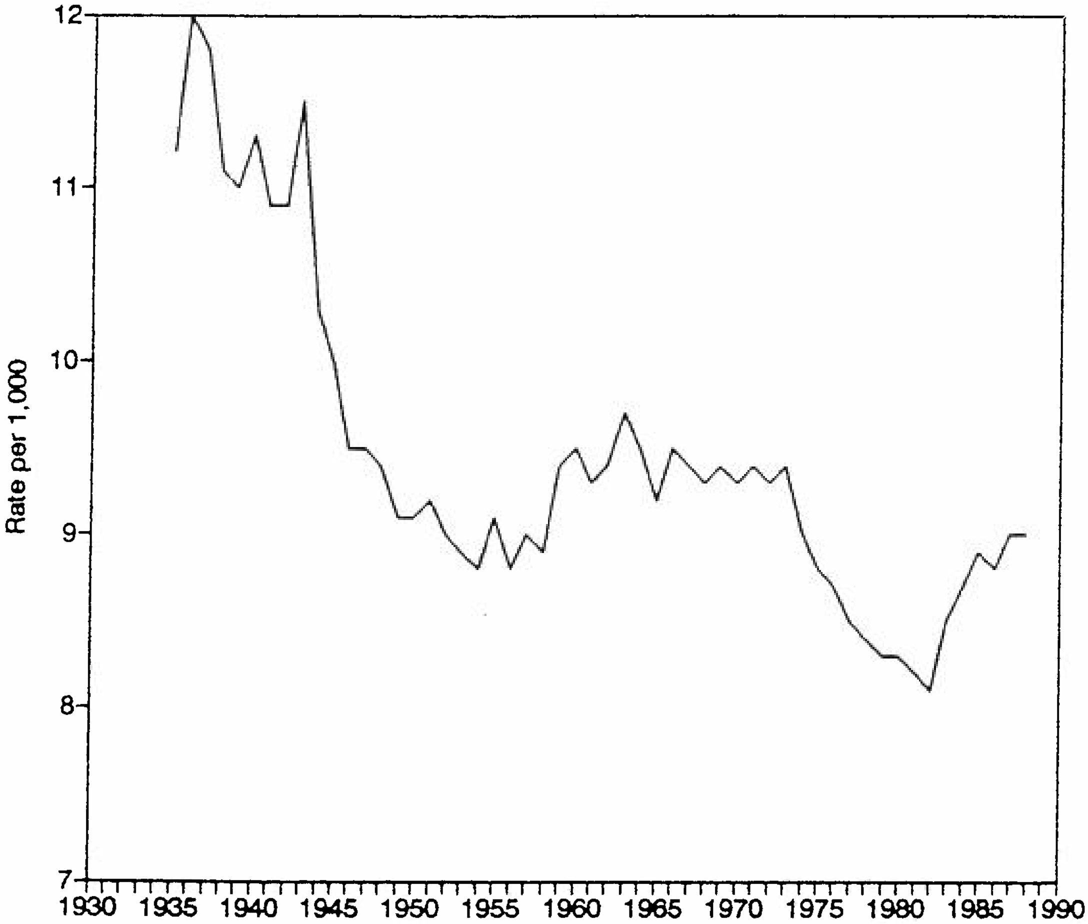

Dose Response (Standardized Incidence Ratios) for Cancer
Following Three Mile Island Accident
Standardized Incidence Ratio (SRI)
1.1
1.05
1
0.95
0.9
0.85
0
100
200
300
400
500
600
Radiation Dose in Relative Units
Observed
Predicted

FIG. 12

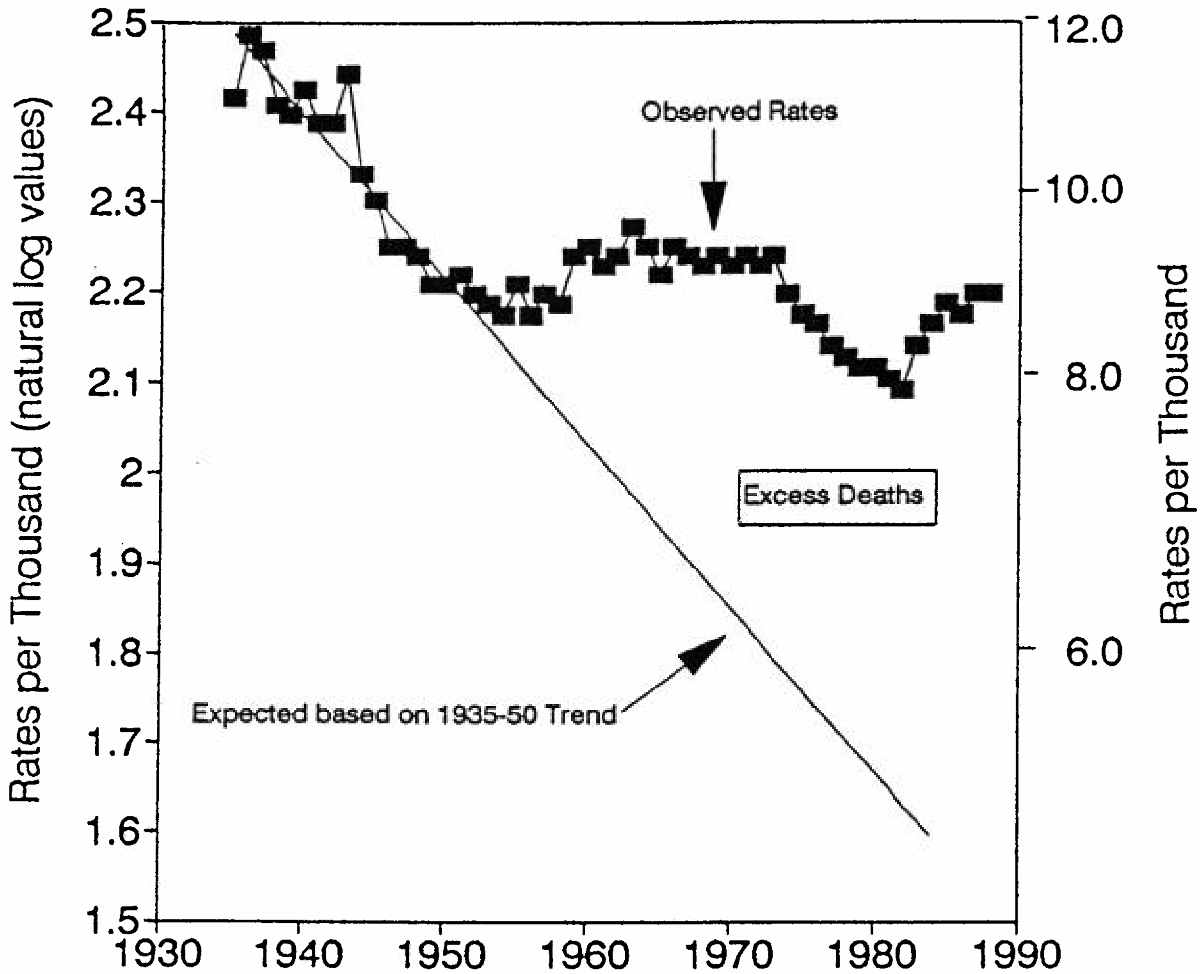
Oregon Total Mortality Rates per Thousand Population, 1935-88



Source: Oregon Vital Statistics, Annual Reprts. Oregon Department of Human Resources, Portland, OR 97201

FIG. 13

Oregon Total Mortality Rates, Observed and Expected, 1935-1988



Source: Oregon Vital Statistics, Annual Reports

FIG. 14

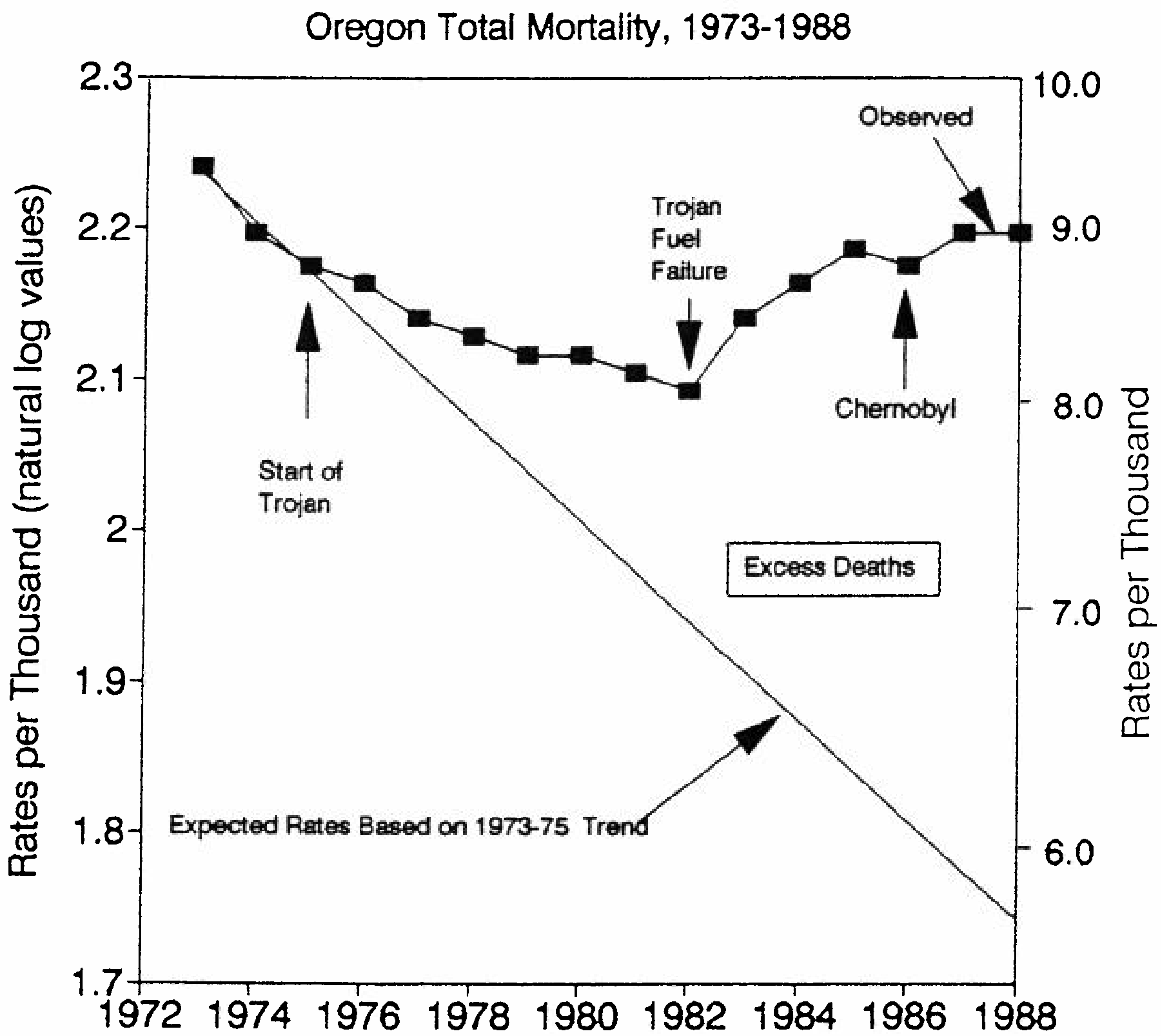
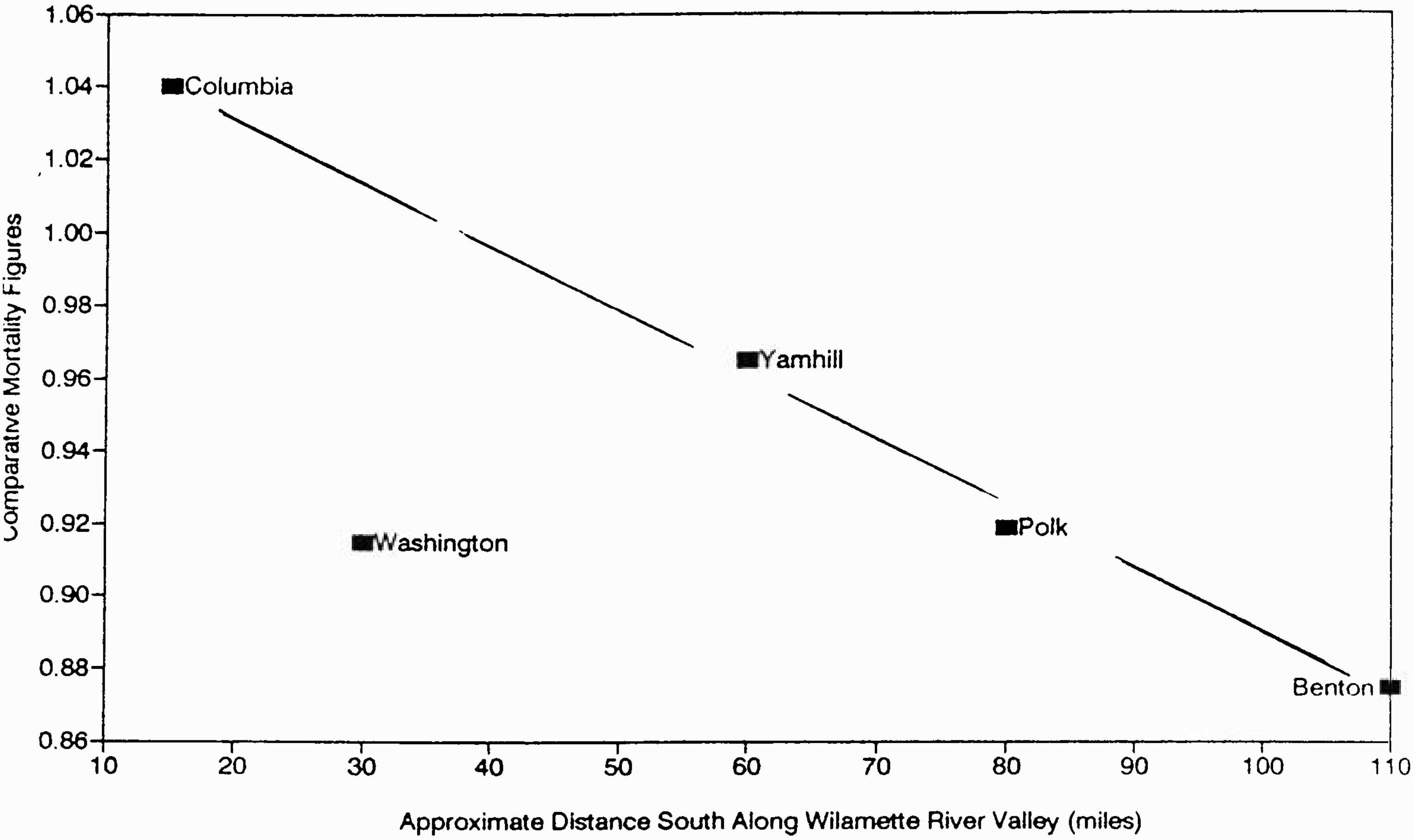

Oregon Total Mortality, 1973-1988
Rates per Thousand (natural log values)
Rates per Thousand
2.3
2.2
2.1
2
1.9
1.8
1.7
10.0
9.0
8.0
7.0
6.0
1972
1974
1976
1978
1980
1982
1984
1986
1988
Observed
Trojan Fuel Failure
Chernobyl
Start of Trojan
Excess Deaths
Expected Rates Based on 1973-75 Trend

FIG.15

Comparative Mortality of Oregon Counties: 1978-86

Age adjusted mortality rates for the years 1978-86, relative to Oregon as a whole.

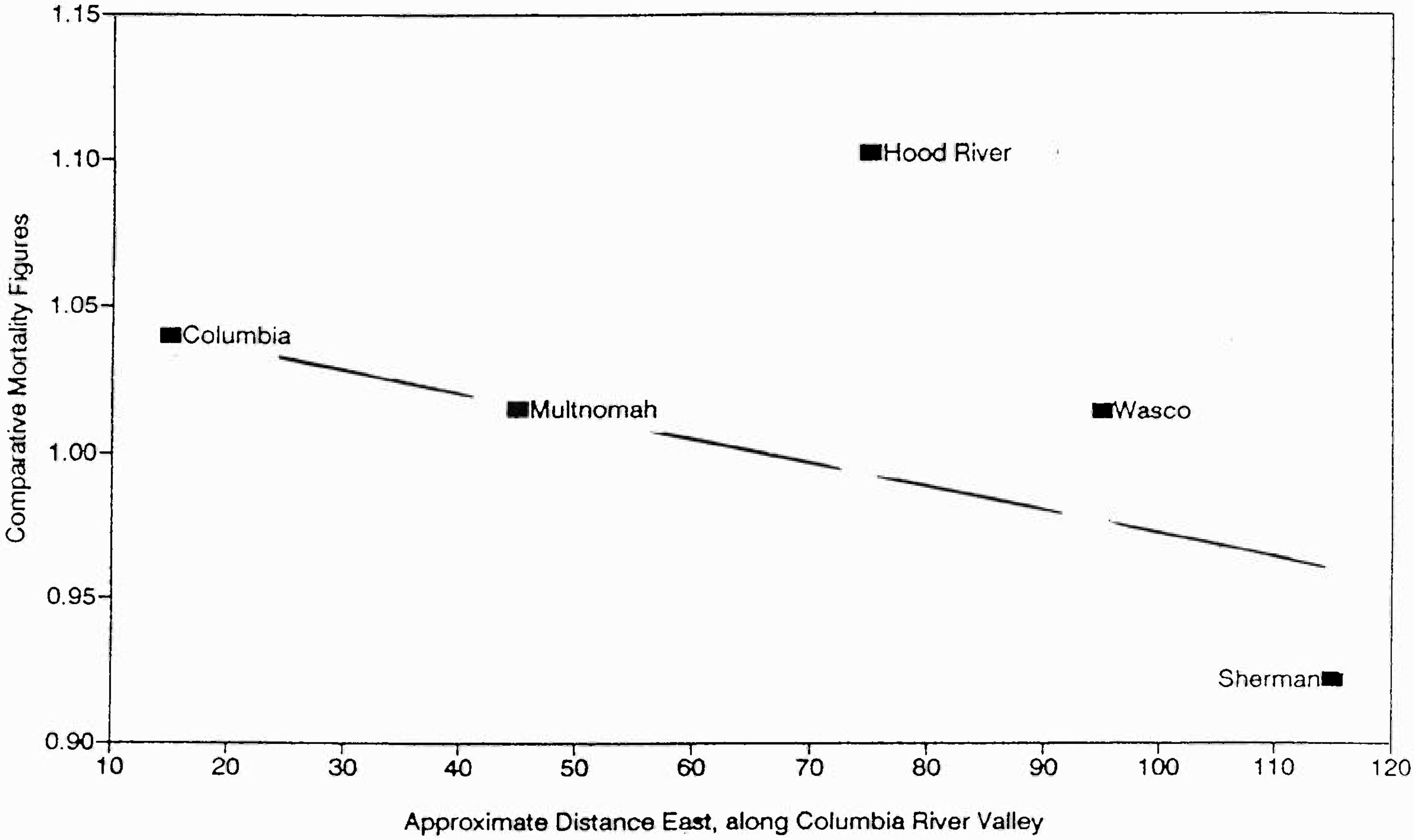


Source: Oregon Annual Vital Statistics 1987, Figure 4-16, pg 87.

FIG. 16

Comparative Mortality of Oregon Counties: 1978-86

Age adjusted mortality rates for the years 1978-86, relative to Oregon as a whole.



Source: Oregon Annual Vital Statistics 1987, Figure 4-16, pg 87.

FIG. 17

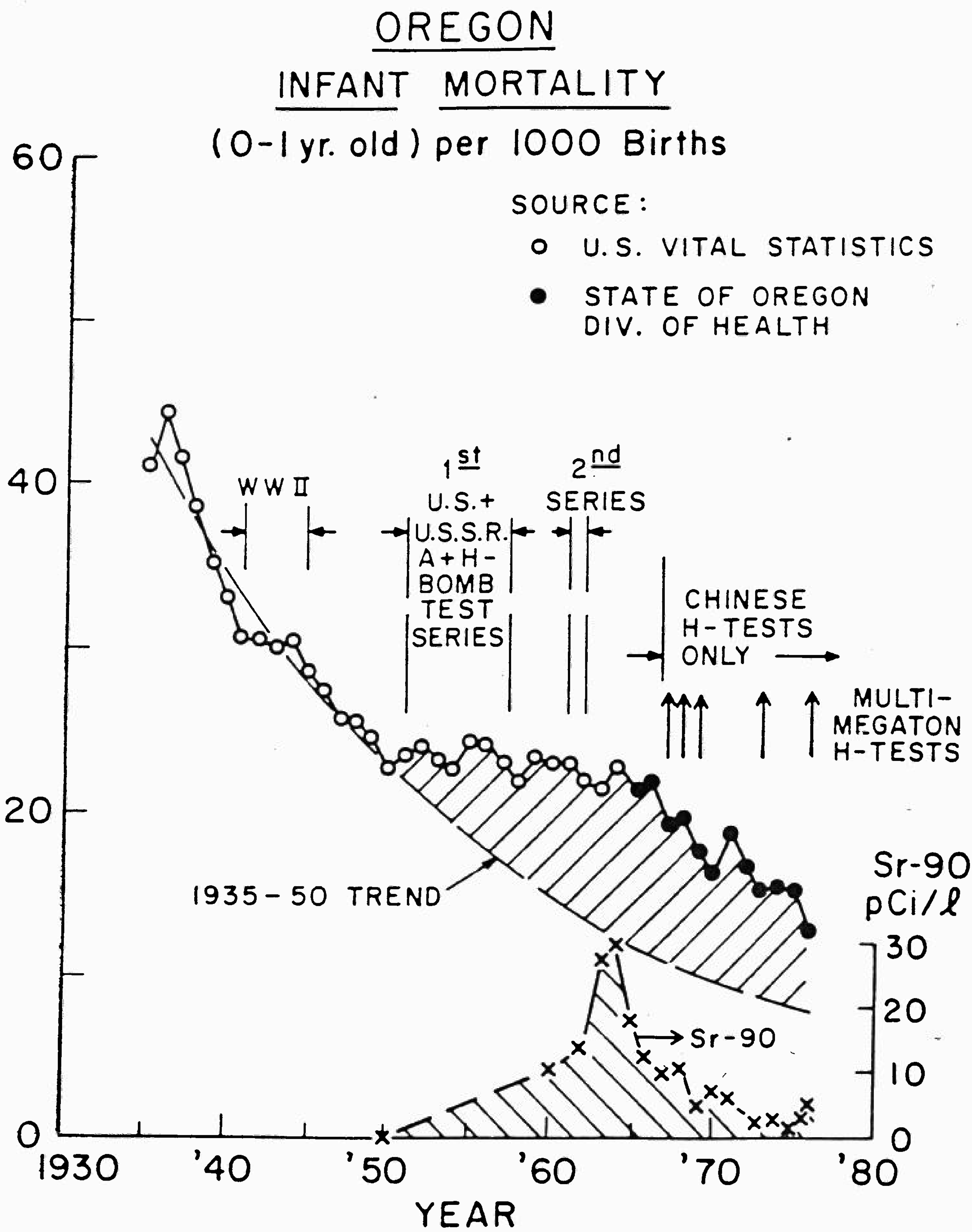
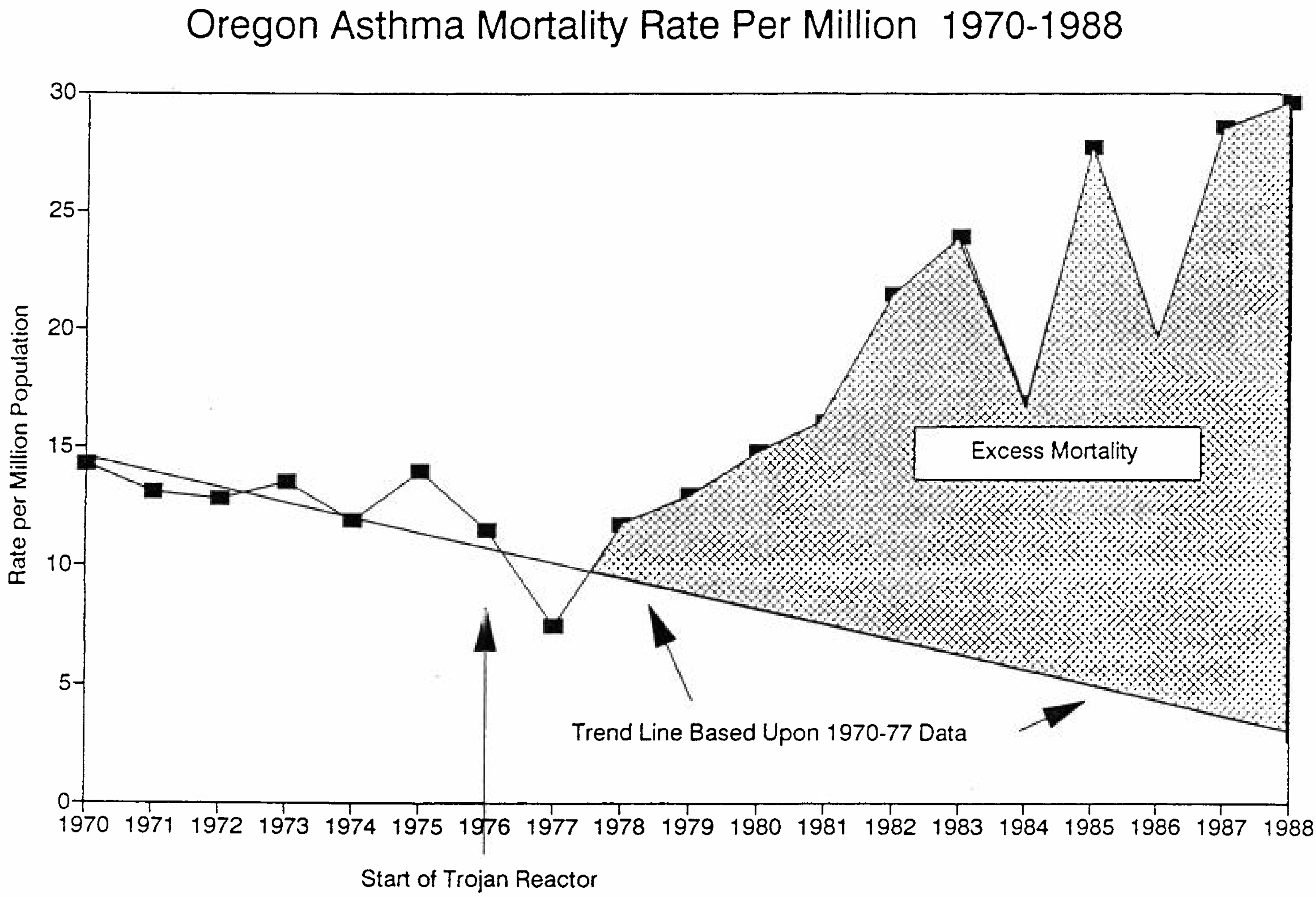
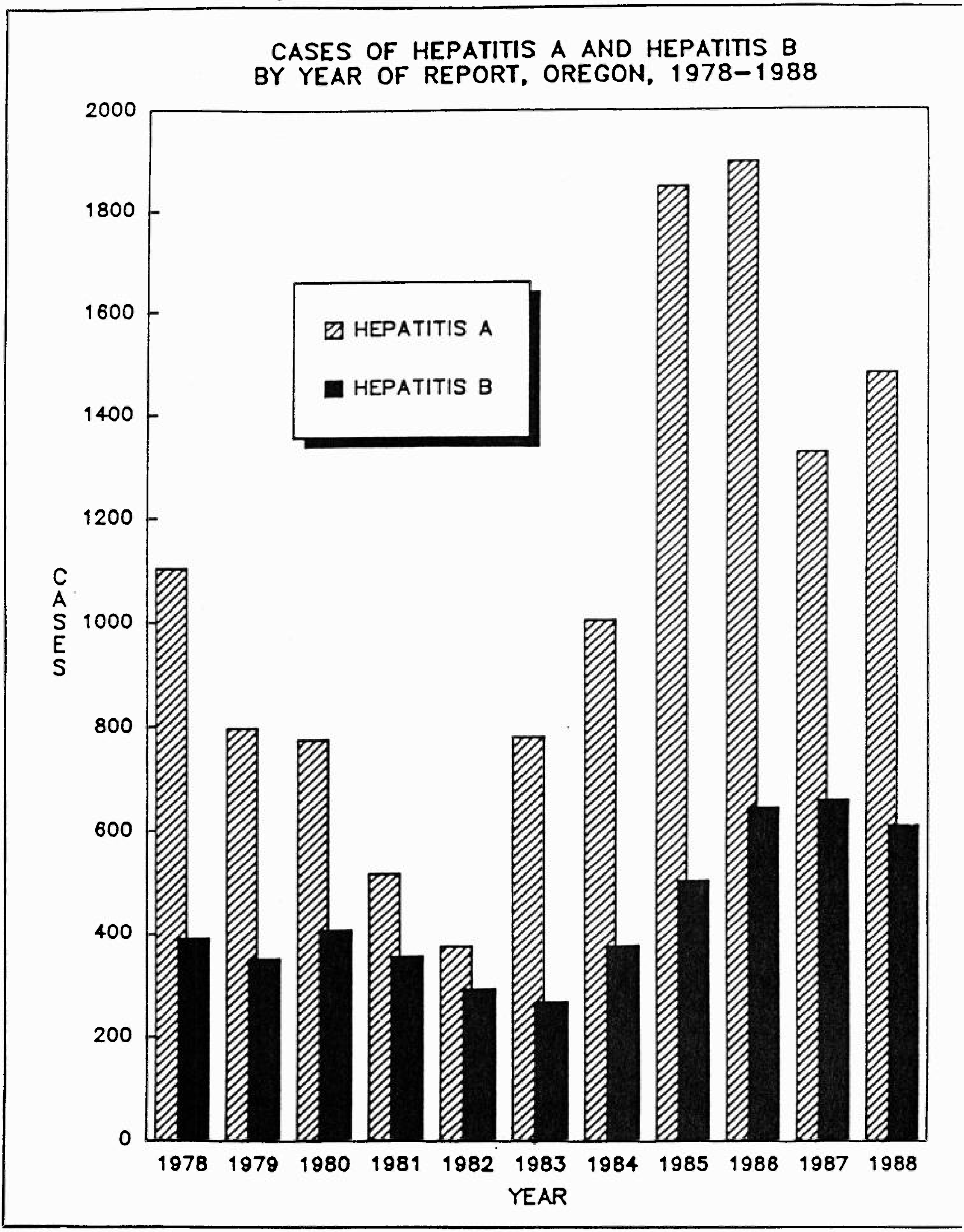

OREGON
INFANT MORTALITY
(0-1 yr. old) per 1000 Births
SOURCE:
U.S. VITAL STATISTICS
STATE OF OREGON DIV. OF HEALTH
WW II
1st U.S.+ U.S.S.R. A+H-BOMB TEST SERIES
2nd SERIES
CHINESE H-TESTS ONLY
MULTI-MEGATON H-TESTS
1935-50 TREND
Sr-90 pCi/ℓ
Sr-90
60
40
20
0
30
20
10
0
1930
'40
'50
'60
'70
'80
YEAR

FIG. 18



Source: Oregon Vital Statistics, Annual Reports. Oregon Department of Human Resources, Portland, OR 97201

FIG. 19



CASES OF HEPATITIS A AND HEPATITIS B
BY YEAR OF REPORT, OREGON, 1978-1988
HEPATITIS A
HEPATITIS B
CASES
2000
1800
1600
1400
1200
1000
800
600
400
200
0
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
YEAR

FIG.20

TABLE I

Emissions from Trojan and Pilgrim Reactors, 1976-1983

Year	Airborne Effluents Trojan (curies)	Pilgrim (curies)	Liquid Effluents Trojan (curies)	Pilgrim (curies)	Solid Wastes Trojan (curies)	Pilgrim (curies)
1976	0.016	0.674	2.770	2.330	4.3	36900
1977	0.051	0.690	4.190	3.410	83.1	5700
1978	0.010	0.181	0.707	1.770	448.0	49200
1979	0.034	0.145	0.555	0.512	330.0	22200
1980	0.025	0.104	0.787	2.730	45.9	1600
1981	0.076	0.069	0.994	1.940	1040.0	938
1982	0.015	0.044	0.856	0.872	287.0	959
1983	0.006	0.047	0.310	0.935	1670.0	1480
Totals	0.233	1.954	11.169	14.499	3908.3	118977

Emissions from the Trojan and Pilgrim Reactors, 1976-1983

This Table indicates that since 1976, emissions from the Trojan reactor were similar in magnitude to those of the malfunctioning Pilgrim reactor, which in the period 1976-1986, have been linked by the Massachusetts State Dept. of Health to a four-fold above normal rise in luekemia. Note that a curie is equal to one trillion pico curies, the unit in which concentrations of radionuclides in milk are measured. Thus the total volume of airborne effluents released from the Trojan reactor from 1976 to 1983 amounts to 233 billion pico curies. In May of 1986, when the Chernobyl fallout came down in the rain in the Pacific states, it was found that regional variations across the nation in the concentrations of iodine-131 were as low as 16 pico curies per liter of milk in the south west states of Texas and Arkansas,which had little rain in May,1986 and had no change in summer time mortality over the preceding year. At the other extreme, the Pacific states with heavy rain in May had average concentrations of I-131 in the milk of 44 pico curies per liter, and suffered a summertime increase in mortality of 5 percent over 1985.

The above data on airborne emissions are only those due to "iodine and particulates", which includes such highly toxic materials as iodine-131,strontium-89, strontium-90,barium-140, but not the chemically inert gases xenon and krypton. Liquid emissions includes iodine and all the particulates, but not the rare gases and tritium.

TABLE 2

Comparison of Oregon and U.S. Mortality Rates

Total, 25-44 and Over 45
Deaths per 100,000

Year	Oregon			U.S.		
	All Ages	25-44	45 and Over	All Ages	25-44	45 and Over
1982	813.0	132.0	2423.2	852.0	157.6	2540.0
1983	848.6	131.6	2517.8	862.8	155.3	2527.5
1984	868.5	137.8	2563.4	862.3	162.3	2536.4
1985	890.4	141.5	2631.8	873.9	159.3	2550.5
1986	877.2	145.4	2690.3	873.0	167.4	2516.7
1987	898.9	140.8	2601.8	871.0	166.9	2516.3
1988	895.9	145.3	2582.8	883.0	171.2	2473.7
%Increase 1982-1988	10.2%	10.1%	6.6%	3.6%	8.6%	-2.6%

Mortality rates in Oregon have been rising more rapidly since 1982 than in the U.S. for all age groups, including those between the ages of 25 and 44, and those over 45. This is the first peace time period in the 20th century that mortality rates of young people aged 25-44 have been rising. For Oregon this may reflect not only the impact of fallout from atmospheric bomb tests on developing immune and hormonal systems, but also fallout from Hanford releases after 1945, exacerbated by Trojan emissions beginning in 1975.

The age group 25 to 44 was born between 1944 and 1963, the years of large scale atmospheric bomb testing, when, according to the Natural Resources Defense Council, the superpowers released into the biosphere fission products equivalent to exploding 40,000 Hiroshima bombs.Andrei Sakharov predicted in 1958 that millions would die world-wide from ingesting such bone-seeking fission products, which would irradiate the bone-marrow, where the cells of the immune system originate. As a result a significant portion of this age group appears to have an impaired immune system function, less able to resist viruses, bacteria and cancer cells. Although the developing infant is most sensitive to immune system damage, irradiation of the bone-marrow of adults also affects their ability to detect and destroy cancer cells and other antibodies.Note that the mortality rates in Oregon of those over 45 are increasing far more rapidly than in the U.S.

TABLE 4-3. SELECTED LEADING CAUSES OF DEATHS WITH RATES, OREGON RESIDENTS, 1970-1988, CONTINUED

YEAR	CIRRHOSIS OF LIVER	CERTAIN CAUSES IN EARLY INFANCY	CONGENITAL ANOMALIES	SIDS	AIDS	EXTERNAL CAUSES		
						Accident	Suicide	Homicide
1970	288	298	149	+	-	1,347	303	93
1971	338	314	175	+	-	1,314	319	81
1972	348	272	158	+	-	1,379	301	116
1973	367	240	154	+	-	1,307	364	112
1974	365	228	160	+	-	1,354	362	123
1975	331	233	153	+	-	1,204	361	130
1976	348	177	157	+	-	1,257	351	96
1977	377	194	168	84	-	1,324	399	125
1978	312	190	168	118	-	1,387	385	125
1979	352	195	155	94	-	1,367	351	113
1980	349	219	160	132	-	1,319	388	145
1981	370	214	140	117	-	1,285	398	118
1982	299	168	165	104	-	1,064	396	146
1983	301	148	156	97	2	1,156	417	112
1984	318	136	152	109	6	1,185	423	135
1985	283	135	154	107	24	1,207	417	123
1986	308	119	142	121	70	1,184	450	181
1987	253	160	142	115	78	1,185	400	164
1988	289	128	133	99	114	1,190	461	152
1970	13.8	14.2	7.1	+	0.0	64.4	14.5	4.4
1971	15.8	14.7	8.2	+	0.0	61.3	14.9	3.8
1972	15.9	12.5	7.2	+	0.0	63.2	13.8	5.3
1973	16.5	10.8	6.9	+	0.0	58.7	16.4	5.0
1974	16.1	10.1	7.1	+	0.0	59.8	16.0	5.4
1975	14.4	10.1	6.7	+	0.0	52.4	15.7	5.7
1976	14.9	7.6	6.7	+	0.0	53.7	15.0	5.1
1977	15.7	8.1	7.0	3.5	0.0	55.3	16.7	5.2
1978	12.6	7.7	6.8	4.8	0.0	56.1	15.6	5.1
1979	13.8	7.7	6.1	3.7	0.0	53.7	13.8	4.4
1980	13.3	8.3	6.1	5.0	0.0	50.1	14.7	5.5
1981	13.9	8.0	5.3	4.4	0.0	48.3	15.0	4.4
1982	11.3	6.3	6.2	3.9	0.0	40.1	14.9	5.5
1983	11.4	5.6	5.9	3.7	0.0	43.9	15.8	4.3
1984	12.0	5.1	5.7	4.1	0.0	44.5	15.9	5.1
1985	10.6	5.0	5.8	4.0	0.9	45.1	15.6	4.6
1986	11.6	4.5	5.3	4.5	2.6	44.5	16.9	6.8
1987	9.4	5.9	5.3	4.3	2.9	44.1	14.9	6.1
1988	10.5	4.7	4.9	3.6	4.2	43.4	16.8	5.5

All rates per 100,000 population.
+ Unknown prior to 1977; there was no ICD code for SIDS.

TABLE 4-3. SELECTED LEADING CAUSES OF DEATHS WITH RATES, OREGON RESIDENTS, 1970-1988

YEAR	TOTAL	MAJOR CARDIOVASCULAR DIS.			MALIGNANT NEOPLASMS	CHRONIC RESPIRATORY DISEASES*	INFLUENZA AND PNEUMONIA	DIABETES MELLITUS
		DISEASES OF HEART	CEREBRO-VASCULAR DISEASE	ARTERIO-SCLEROSIS				
1970	19,530	7,158	2,429	461	3,493	520	554	312
1971	20,087	7,492	2,377	455	3,608	577	566	285
1972	20,216	7,581	2,453	433	3,594	529	599	290
1973	20,881	7,569	2,593	501	3,718	633	782	331
1974	20,320	7,441	2,408	451	3,762	609	584	272
1975	20,142	7,342	2,355	429	3,917	624	606	310
1976	20,459	7,306	2,264	445	4,065	664	800	300
1977	20,457	7,239	2,096	445	4,283	625	562	284
1978	20,870	7,249	2,079	485	4,447	698	658	297
1979	21,024	7,329	2,041	444	4,608	728	608	285
1980	21,756	7,659	2,021	486	4,625	829	704	297
1981	21,798	7,639	1,986	509	4,839	856	609	303
1982	21,594	7,601	1,901	482	4,859	912	609	297
1983	22,361	7,910	2,021	470	4,943	971	634	329
1984	23,101	8,010	1,919	431	5,387	957	725	343
1985	23,824	8,192	2,000	432	5,410	1,097	838	317
1986	23,328	7,788	1,926	417	5,272	1,090	742	328
1987	24,181	7,936	1,958	440	5,594	1,233	743	395
1988	24,557	7,662	2,010	378	5,801	1,203	900	439
1970	933.8	342.3	116.1	22.0	167.0	24.9	26.5	14.9
1971	937.3	349.6	110.9	21.2	168.4	26.9	26.4	13.3
1972	926.0	347.2	112.4	19.8	164.6	24.2	27.4	13.3
1973	938.5	340.2	116.5	22.5	167.1	28.5	35.1	14.9
1974	896.7	328.4	106.3	19.9	166.0	26.9	25.8	12.0
1975	871.6	319.4	102.4	18.7	170.4	27.1	26.4	13.5
1976	873.7	312.0	96.7	19.0	173.6	28.4	34.2	12.8
1977	853.8	302.1	87.5	18.6	178.7	26.1	23.5	11.9
1978	844.3	293.2	84.1	19.6	179.9	28.2	26.6	12.0
1979	826.4	288.1	80.2	17.5	181.1	28.6	23.9	11.2
1980	826.4	290.9	76.8	18.5	175.7	31.5	26.7	11.3
1981	819.2	287.1	74.6	19.1	181.9	32.2	22.9	11.4
1982	813.0	286.2	71.6	18.1	182.9	34.3	22.9	11.2
1983	848.6	300.2	76.7	17.8	187.6	36.9	24.1	12.5
1984	868.5	301.1	72.1	16.2	202.5	36.0	27.3	12.9
1985	890.4	306.2	74.7	16.1	202.2	41.0	31.3	11.8
1986	877.2	292.8	72.4	15.7	198.2	41.0	27.9	12.3
1987	898.9	295.0	72.8	16.4	208.0	45.8	27.6	14.7
1988	895.9	279.5	73.3	13.8	211.6	43.9	32.8	16.0

All rates per 100,000 population.

* Includes Bronchitis, Emphysema, Asthma, and Chronic Obstructive Pulmonary Disease (ICD 490-496).

TABLE 1-4. DEATHS, MATERNAL DEATHS, INFANT DEATHS, NEONATAL DEATHS, FETAL DEATHS, OREGON, 1908-1988

YEAR	DEATHS		MATERNAL DEATHS		INFANT DEATHS		NEONATAL DEATHS		FETAL DEATHS	
	Number	Rate	Number	Rate	Number	Rate	Number	Rate	Number	Rate
1908	4,970	8.0	59	709.0	676	81.2	---	---	---	---
1909	5,470	8.4	70	808.7	756	80.7	---	---	---	---
1910	6,089	9.0	91	991.7	733	79.9	---	---	---	---
1911	6,360	9.2	91	951.7	753	78.7	---	---	---	---
1912	5,898	8.4	63	563.1	653	58.6	---	---	---	---
1913	6,714	9.4	60	543.8	684	61.9	---	---	---	---
1914	6,446	8.9	72	619.4	577	49.6	---	---	---	---
1915	6,718	9.1	74	605.0	583	47.6	---	---	---	---
1916	7,107	9.5	88	679.0	725	55.9	---	---	---	---
1917	7,349	9.7	87	661.7	837	63.6	---	---	---	---
1918	9,842	12.8	106	797.3	907	68.2	---	---	---	---
1919	8,881	11.4	101	740.6	845	61.9	---	---	---	---
1920	9,186	11.6	112	749.0	927	61.9	---	---	---	---
1921	8,324	10.2	117	749.7	791	50.6	---	---	---	---
1922	9,381	11.3	115	762.2	886	58.7	---	---	---	---
1923	8,983	10.6	103	687.0	853	56.9	---	---	---	---
1924	9,511	11.1	94	594.3	834	52.7	---	---	---	---
1925	9,596	10.9	95	609.8	787	50.5	---	---	---	---
1926	9,885	11.1	85	569.4	769	51.5	---	---	---	---
1927	10,222	11.2	91	621.7	693	47.3	---	---	---	---
1928	10,493	11.3	86	607.4	651	46.0	---	---	410	29.0
1929	10,680	11.3	75	566.3	633	47.7	---	---	415	31.4
1930	10,544	11.0	81	601.2	671	49.8	---	---	390	28.9
1931	10,245	10.6	61	461.2	578	43.7	---	---	360	27.2
1932	10,272	10.5	64	498.2	530	41.3	---	---	322	25.1
1933	10,450	10.5	64	523.4	493	40.3	---	---	329	26.9
1934	10,539	10.5	79	604.4	519	39.7	---	---	320	24.5
1935	11,429	11.2	72	547.8	537	40.8	---	---	300	22.8
1936	12,434	12.0	77	545.4	626	44.3	409	29.0	300	21.5
1937	12,369	11.8	56	361.4	649	41.9	415	26.8	340	22.4
1938	11,777	11.1	53	324.5	631	38.6	418	25.6	353	21.6
1939	11,779	11.0	43	257.1	580	34.7	381	22.8	322	19.3
1940	12,329	11.3	45	256.8	592	33.2	413	23.6	365	20.8
1941	12,123	10.9	43	228.9	589	30.7	397	20.9	333	17.7
1942	12,520	10.9	37	166.0	669	30.0	456	20.4	362	16.2
1943	13,440	11.5	37	145.8	776	30.6	466	18.4		
1944	12,580	10.3	41	147.9	706	30.1	504	21.5	454	19.4

TABLE 1-4. DEATHS, MATERNAL DEATHS, INFANT DEATHS, NEONATAL DEATHS, FETAL DEATHS, OREGON, 1908-1988 (Continued)

YEAR	DEATHS		MATERNAL DEATHS		INFANT DEATHS		NEONATAL DEATHS		FETAL DEATHS	
	Number	Rate	Number	Rate	Number	Rate	Number	Rate	Number	Rate
1945	12,325	10.0	29	124.3	660	28.3	473	20.3	402	17.2
1946	12,828	9.5	28	94.7	803	27.2	594	20.1	515	17.4
1947	13,460	9.5	35	96.7	896	24.8	645	17.8	562	15.5
1948	13,872	9.4	15	42.9	892	25.5	671	19.2	508	14.5
1949	13,698	9.1	20	57.0	862	24.6	661	18.9	488	13.9
1950	13,888	9.1	22	61.1	816	22.7	627	17.4	493	13.7
1951	14,489	9.2	5	13.4	883	23.7	637	17.1	498	13.3
1952	14,438	9.0	11	27.7	951	23.9	696	17.5	500	12.6
1953	14,598	8.9	15	37.6	938	23.5	680	17.1	524	13.1
1954	14,665	8.8	9	23.3	868	22.5	632	16.4	512	13.3
1955	15,303	9.1	8	20.7	934	24.1	681	17.6	497	12.8
1956	15,328	8.8	11	28.6	887	23.1	645	16.8	504	13.1
1957	15,633	9.0	8	21.1	828	21.9	587	15.5	499	13.2
1958	15,449	8.9	6	16.5	844	23.3	597	16.4	448	12.3
1959	16,699	9.4	9	24.6	927	25.3	664	18.1	469	12.8
1960	16,787	9.5	14	36.5	891	23.2	635	16.6	493	12.9
1961	16,885	9.3	8	21.3	861	23.0	604	16.1	454	16.1
1962	17,221	9.4	7	18.9	811	21.9	554	15.0	461	12.5
1963	18,017	9.7	7	20.1	747	21.4	551	15.8	410	11.8
1964	18,138	9.5	4	11.9	754	22.5	532	15.9	402	12.0
1965	18,133	9.2	1	3.0	696	21.1	477	14.5	421	12.8
1966	18,979	9.5	3	9.2	697	21.5	506	15.6	387	11.9
1967	18,908	9.4	4	12.7	616	19.6	436	13.9	395	12.6
1968	19,017	9.3	3	9.3	637	19.8	460	14.3	365	11.4
1969	19,548	9.4	4	11.8	592	17.5	410	12.1	194	1/
1970	19,530	9.3	5	14.1	555	15.7	381	10.8	486	13.7
1971	20,087	9.4	5	15.0	615	18.4	416	12.5	408	12.2
1972	20,216	9.3	5	16.0	528	16.9	359	11.5	391	12.5
1973	20,881	9.4	1	3.2	466	15.1	329	10.6	312	10.1
1974	20,320	9.0	3	9.2	488	15.0	330	10.2	266	8.2
1975	20,142	8.8	3	9.0	502	15.1	330	9.9	284	8.5
1976	20,459	8.7	-	-	444	12.7	277	8.0	280	8.0
1977	20,457	8.5	5	13.3	453	12.1	293	7.8	283	7.6
1978	20,870	8.4	2	5.1	502	12.9	299	7.7	302	7.8
1979	21,024	8.3	1	2.4	450	10.8	276	6.6	307	7.4

1\ Incomplete total

TABLE 1-4. DEATHS, MATERNAL DEATHS, INFANT DEATHS, NEONATAL DEATHS, FETAL DEATHS, OREGON, 1908-1988 (Continued)

YEAR	DEATHS		MATERNAL DEATHS		INFANT DEATHS		NEONATAL DEATHS		FETAL DEATHS	
	Number	Rate	Number	Rate	Number	Rate	Number	Rate	Number	Rate
1980	21,756	8.3	1	2.3	521	12.1	303	7.0	294	6.8
1981	21,798	8.2	3	7.0	466	10.8	299	7.0	298	6.9
1982	21,594	8.1	8	19.5	433	10.6	253	6.2	253	6.2
1983	22,361	8.5	6	15.0	385	9.6	215	5.4	268	6.7
1984	23,101	8.7	4	10.1	388	9.8	190	4.8	257	6.5
1985	23,824	8.9	4	10.1	387	9.8	211	5.3	237	6.0
1986	23,328	8.8	4	10.3	368	9.5	183	4.7	268	6.9
1987	24,181	9.0	2	5.2	402	10.4	213	5.5	222	5.7
1988	24,557	9.0	3	7.5	339	8.5	181	4.5	235	5.9

Rate per 1,000 population for deaths.
Rate per 1,000 live births for infant, neonatal, and fetal deaths.
Rate per 100,000 live births for maternal deaths.

TABLE 5

Low-Birth Weight Babies, Birth Defects, 1971-1988, Clatsop, Columbia and Oregon

	Clatsop			Columbia			Oregon		
Year	No. of Births	No.<2500 grams	No. with Birth Defects	No. of Births	No.<2500 grams	No. with Birth Defects	No. of Births	No.<2500 grams	No. with Birth Defects
1971	385	26	7	502	22	10	33344	1915	400
1972	410	25	6	412	29	7	31308	1829	368
1973	413	17	1	469	22	2	30902	1818	233
1974	411	14	4	425	22	7	32506	1826	315
1975	423	14	5	476	18	9	33352	1839	390
1976	451	16	8	521	24	2	34840	1823	423
1977	471	14	6	552	26	7	37467	1939	481
1978	498	19	1	587	18	5	38964	1982	380
1979	509	26	7	561	22	3	41564	2129	418
1980	524	n.a.	4	607	n.a.	7	43091	n.a.	480
1981	531	23	6	523	27	15	42974	2083	445
1982	509	22	6	562	33	12	41012	2016	465
1983	463	28	7	522	28	19	39949	1997	470
1984	438	21	5	505	30	12	39536	2036	447
1985	496	18	5	509	31	12	39419	2020	419
1986	443	25	8	474	24	13	38850	1993	481
1987	446	29	7	467	35	14	38674	2086	467
1988	421	13	10	491	24	13	39850	2096	412

TRANSCRIPTION ERROR (HAS 2 COLUMNS COMBINED IN SOME CASES)

Source: Successive Annual Reports of the Oregon Department of Human Resources. Data refers to live births by county of residence. Low birth-weight babies are defined here to weigh less than 2500 grams (5.5 lbs.) Such babies are referred to as "immature births" in the Oregon Vital Statistics. Babies with birth defects are recorded as born with "congenital malformations".

TABLE 6

Summary Table, Low-Birth Babies, Birth Defects in Clatsop, Columbia and Oregon, 1971-74 Compared With 1983-86.

		1971-74	1983-86	Ratio of Change
Clatsop				
	No.of Live Births	1619	1840	1.14
	No < 2500 gr.	82	92	1.12
	% of Total	5.06	5	0.99
	No. with birth defects	18	25	1.39
	% of Total	1.11	1.36	1.23
Columbia				
	No.of Live Births	1808	2010	1.11
	No < 2500 gr.	95	113	1.19
	% of Total	5.25	5.62	1.07
	No. with birth defects	8	31	3.88
	% of Total	0.44	1.54	3.5
Both counties				
	No.of Live Births	3427	3850	1.12
	No < 2500 gr.	177	205	1.16
	% of Total	5.16	5.32	1.03
	No. with birth defects	26	56	2.15
	% of Total	0.76	1.45	1.91
Oregon				
	No.of Live Births	128060	157754	1.23
	No < 2500 gr.	7388	8046	1.09
	% of Total	5.77	5.1	0.88
	No. with birth defects	1316	1817	1.38
	% of Total	1.03	1.15	1.12

Note: Using the change in the percentage of low-weight babies (i.e., those weighing less than 2500 grams) and the corresponding percentage of babies born with congenital malformations for Oregon as a yardstick, it is clear that a significant divergent upward movement can be observed in the counties of Columbia and somewhat less so in Clatsop. The time periods chosen here are 1971-74, before the Trojan reactor began operations in 1975 and 1983-86, a similar four year period after the large releases in 1981-2. The probability that chance could account for the 91 percent increase in the percent of live births with congenital malformations in the two counties over the period when the corresponding increase for Oregon was only 12 percent is less than .01.

Mortality

ALL CAUSES. One Oregonian dies every 21 minutes on the average. For the decade prior to 1982, the Oregon death rate fell sharply; however, since then the rate has increased annually, except during 1986 and 1988. During 1988, the rate changed little compared to the previous year, 895.9 versus 898.9 per 100,000 population. A record high 24,557 Oregonians died during 1988. Notable increases occurred among deaths due to influenza and pneumonia, suicide, diabetes, and AIDS. For the fourth straight year, the death rate was higher in Oregon than in the nation (883.0). The Oregon rates for the five individual leading causes of death worsened over the previous year compared to the nation as a whole.

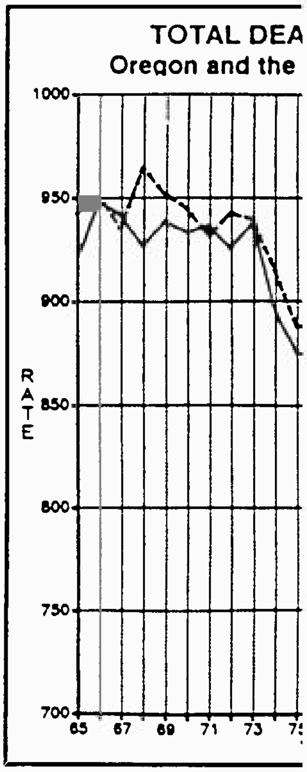
During the early and mid 1980s, the death rate for males was on the increase. Since then, however, the rate has declined annually, but is still above the 1980 value (Table 4-1). Overall, the male rate has increased just 1.3 percent since 1980 to 943.6. Females have not been so fortunate. Their death rate (850.1) is now higher than at any time since 1950. In just eight years the female death rate has risen 17.4 percent.

Oregonians under 5 years of age have experienced the greatest drop in death rates; since 1980 the rate has fallen 40.8 percent. During 1988, the death rate for females increased in all age groups except one, while the opposite was true for males (Table 4-1). The median age at death remained unchanged during 1988 with one-half of all Oregonians dying by age 75.

HEART DISEASE. The heart disease death rate fell to a record low in 1988, declining 5.3 percent over the previous year to 279.5. This masks, however, a dichotomy between the sexes: the rate for males has fallen 12.1 percent, from 339.0 in 1980 to 297.7 in 1988, while that of females has risen 7.3 percent, from 244.3 in 1980 to 262.1 in 1988.

Heart disease is the preeminent cause of death, accounting for about one of every three resident deaths, or one death every 69 minutes. The Oregon death rate has consistently been lower than the national rate, and is 10.5 percent lower than the estimated 1988 national rate of 312.2. In recent years, residents of the northern Willamette Valley have been significantly more likely than other Oregonians to die from heart disease.[1] Many conditions are included in the complex of heart disease. Most common are myocardial infarctions, coronary occlusions, coronary thromboses, and arteriosclerotic and cardiovascular heart disease, which comprise about 80 percent of all heart disease. The infarc-

Figur



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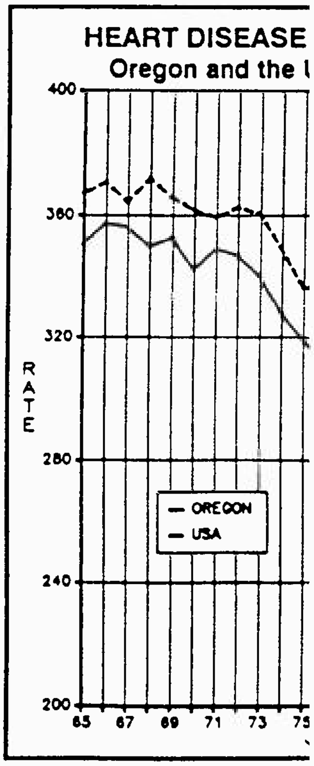
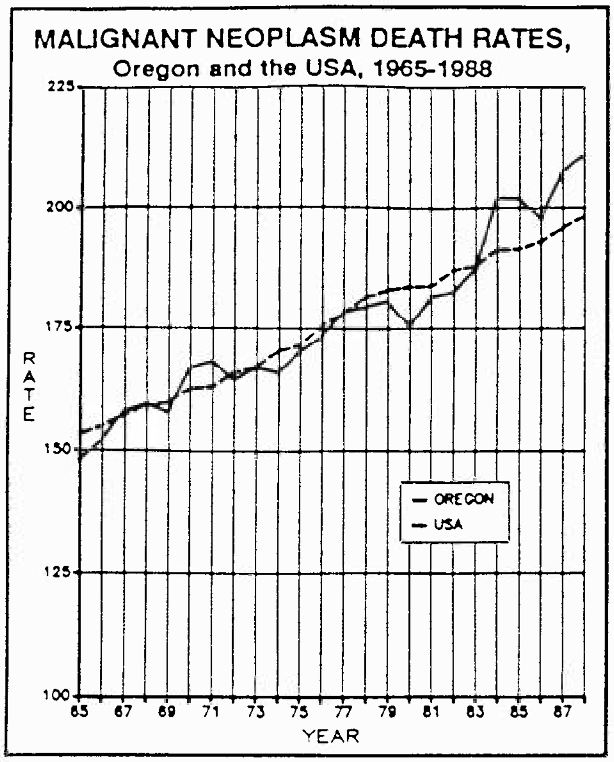


1. *Oregon Leading Causes of Mortality, 1978-1986*. Center for Health Statistics, Health Division, Oregon Department of Human Resources. June 1988.

Figure 4-5.

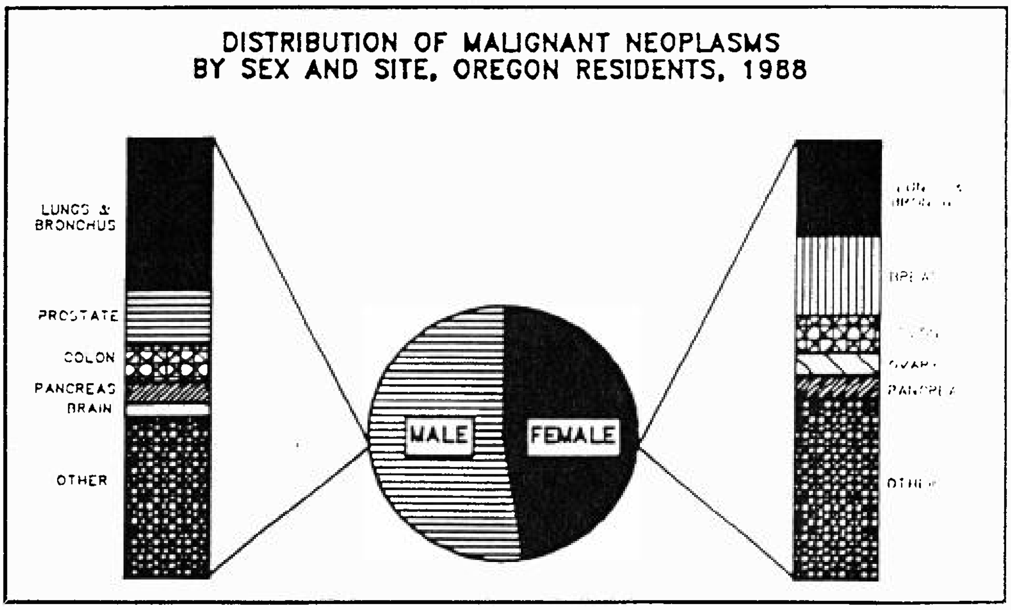


tions, occlusions, and thromboses are acute, often terminal events, while the others represent chronic ailments of the cardiac function.

CANCER. The long-term upward trend of the malignant neoplasm death rate continued during 1988, reaching a new high. The rate increased slightly from last year's record high (208.0) to 211.6. The lungs are the most common site for both males and females. Lung cancer deaths are becoming increasingly prevalent among women. A decade ago, there were 2.8 male deaths for every female death. By 1988, the ratio declined to 1.7-to-1. The death rate for lung cancer among men was 4.0 times higher in 1988 than in 1950 (19.3 to 77.7), but among women rose to a level 8.5 times higher (5.1 to 43.6). Overall, the total lung cancer death rate has more than quintupled, increasing from 11.6 to 60.3. Parenthetically, this has been accompanied by a sharp increase in chronic obstructive respiratory disease deaths. For additional information on this topic, see *A Legacy of Death: Smoking and Respiratory Disease in Oregon*, also published by the Center for Health Statistics.

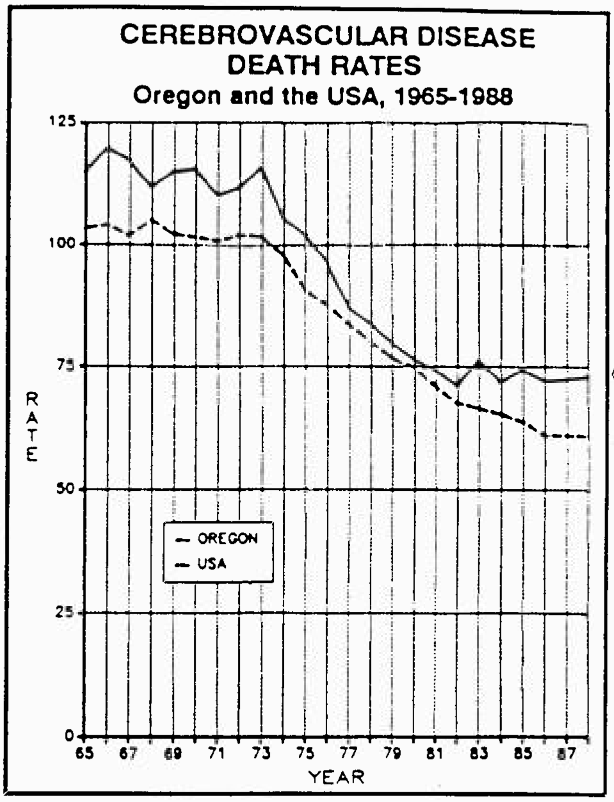
Malignant neoplasms are the leading cause of death in each ten-year age group between 45 and 74 years. The death rates are substantially higher among males than females after age 54. Following lung cancer, the other common sites of malignant neoplasms for males are: prostate, colon, pancreas, and brain (Figure 4-6). For females the sites are: breast, colon, ovary, and pancreas. The Oregon death rate is 6.5 percent higher than the estimated national rate of 198.6. Cancer claims an Oregonian every 1.5 hours.

Figure 4-6.



CEREBROVASCULAR DISEASE. Until 1983, the death rate for cerebrovascular disease was on a downward trend. Since then the rate has fluctuated and currently stands at 73.3 (Figure 4-7). Cerebrovascular disease ranks third overall after heart disease and malignant neoplasms, but fourth (56.5) among males following accidents (60.2). The cerebrovascular disease death rate for females is 89.5 per 100,000 females, 58.4 percent higher than for males (who tend to die at younger ages from other causes). The death rate for this cause has consistently been higher in Oregon than in the rest of the nation for the past 20 years; it is currently 20.0 percent above the estimated national rate of 61.1. Every 4.4 hours, on the average, an Oregon resident succumbs to cerebrovascular disease. Sudden circulatory crises such as strokes, cerebral thromboses and hemorrhages are common acute forms of these diseases; cerebral arteriosclerosis is a chronic form. These cerebral conditions account for about one death in ten, and are more common in the older age groups.

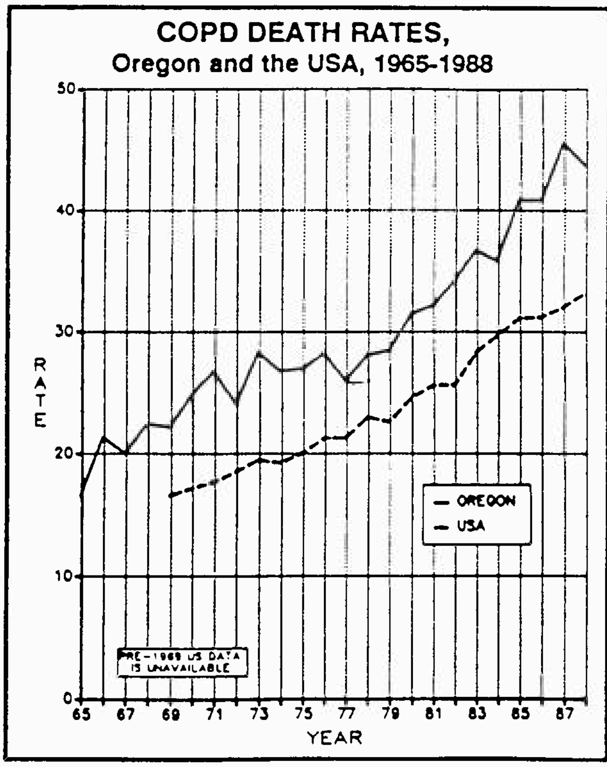
Figure 4-7.



RESPIRATORY DISEASE. In 1987, chronic obstructive pulmonary disease (COPD) became the fourth leading cause of death by displacing unintentional injuries. During 1988 the death rate declined marginally to 43.9; nevertheless, COPD remained the fourth most common killer of Oregonians. In just this decade, the death rate has increased 39.4 percent. Much of this increase has occurred among females. Between 1980 and 1988, the death rate for Oregon women increased 79.6 percent, from 20.1 to 36.1. Despite a smaller increase among males (20.3 percent), the rates were and remain higher than for females; in 1980, the male death rate for this cause was 43.2 compared to 52.0 in 1988.

This group of allied conditions includes four principal diseases: bronchitis, emphysema, asthma, and chronic airways obstruction. Since 1980, the bronchitis death rate has declined 5.0 percent but the other three diseases have increased—emphysema by 21.1 percent, chronic airways obstruction by 50.5 percent, and asthma by 100.0 percent.

Figure 4-8.



In addition to the 1,203 Oregonians whose deaths were due to chronic obstructive pulmonary diseases, these conditions contributed to the deaths of an additional 1,417 residents. Oregon's death rate (43.9) has long been higher than the nation's and currently is 31.8 percent higher than the estimated U.S. death rate of 33.3. The largest difference is seen in the emphysema death rate where Oregonians were 60.9 percent more likely to die from this cause than the average U.S. resident. In the state, the highest rates have been in southwestern and eastern Oregon.[1] Every 7.3 hours, chronic obstructive pulmonary disease claims the life of an Oregonian.

UNINTENTIONAL INJURIES. The unintentional injury[2] death rate was on a downward trend for the past several decades until the early 1980s. Since then, the rate has fluctuated slightly, but changed little compared to 1983. However, it still exceeds the estimated national rate by 9.3 percent, 43.4 compared to 39.7. Rates for deaths due to unintentional

2. "Unintentional injuries" is synonymous with accidents (ICD 800-949).

5. FUEL PERFORMANCE

5.1 Introduction

The NRC does not monitor every fuel failure that occurs in licensed operating nuclear power plants. The approach taken is to set up operating limits for radioactivity in the coolant (due to fuel failures) that are stringent enough to ensure that the dose limits specified in the *Code of Federal Regulations* are not exceeded and to monitor only those fuel failures that are significant from the viewpoint of the number of fuel rods that failed or those in which the failure is due to a new fuel failure mechanism. Periodic meetings are held with the nuclear fuel vendors to review the operating experience of their fuel. Operating reactors typically have 40,000 fuel rods, and the average fuel rod failure rate during the last few years has been near or below 0.02% per cycle.[1] (This excludes the TMI-2 reactor, which is estimated to have a large portion of its fuel damaged as a result of the 1979 accident.) Fuel performance has continually improved, yet deviations from the normal occur occasionally.

5.2 Specific Fuel-Related Incidents

Several events related to fuel performance were reported during calendar year 1982. One was considered significant enough to be included in NRC's *Report to Congress On Abnormal Occurrences* (NUREG-0090 series). The history of fuel performance for 1982 is discussed in the report NUREG/CR-3602 (PNL-4817), *Fuel Performance Annual Report for 1982*;[2] fuel failure events are also reported in LERs. A summary of significant fuel-related incidents culled from these sources is presented in this chapter.

5.2.1 Reactor fuel degradation at Trojan

This occurrence, although not severe enough to be classified as an abnormal occurrence, was nevertheless of sufficient significance to be included in the category of "Other Items of Interest" in the report series *Report to Congress on Abnormal Occurrences*, NUREG-0090, appearing in Vol. 5, No. 2 of that series (April—June 1982).

This event was also documented in Ref. 2 (p. 40, Sect. 5.1.2 PWR Baffle Jetting) and also gave rise to Trojan LER 82-006.

On April 26, 1982, scheduled inspections of reactor fuel assemblies at Trojan identified abnormal degradation of several 17 × 17 assemblies. Trojan utilizes a W PWR and is located in Columbia County, Oregon.

In late 1981, during Cycle 4 operation, higher than normal fission product and gross activity levels were detected in the reactor coolant. These levels were carefully monitored and were observed to increase slowly (except during periods of plant shutdown and power reduction) until the facility began a planned refueling outage in April 1982. The observed coolant activity levels remained below the limits provided in the facility license.

The inspections performed by the licensee identified eight damaged peripheral assemblies by visual examination using an underwater television camera. Nine other fuel failures, not obvious to visual examination, were detected by fuel sipping, a technique that checks for the release of fission products from the fuel assembly.

An investigation of the fuel failures determined them to be caused by fuel rod vibration. All the damaged rods were located in peripheral locations in the core, and the damage was found to have been caused by water jetting through joints in the core baffle, a bolted steel assembly that surrounds the reactor core.

To prevent a recurrence of such failures, the licensee replaced a number of the fuel rods most subject to vibration (in peripheral assemblies) with solid stainless steel rods. Additional stiffener grids were installed on fuel assemblies adjacent to the baffle joints. These modifications have had a negligible effect on core performance; this was verified by testing during plant startup. During a future refueling outage, the licensee plans to modify the core baffle to eliminate the baffle jetting phenomenon.

The observed fuel failures had no effect on public safety or the environment and did not result in radioactivity levels or effluent releases in excess of those allowed by the operating license.

NRC I&E Information Notice 82-27 (Ref. 3) was issued on August 5, 1982, to inform licensees of this event.

5.2.2 Iodine spiking and gas release incidents

Iodine spiking (i.e., a temporary increase in coolant iodine concentration) is frequently observed at reactors where leaking fuel rods are present. These temporary increases in iodine concentrations have been observed to occur following shutdowns, startups, rapid power changes, and coolant depressurization. Iodine spikes are characterized by a rapid increase in coolant concentration by as much as three orders of magnitude, followed by a return to prespike concentration. The latter characteristic distinguishes the spiking phenomenon from a stepwise permanent increase in coolant activity level caused by the sudden failure of one or more fuel rods.

Many Technical Specifications for primary coolant iodine concentrations make allowance for iodine spikes by permitting temporary excursions (not to exceed 48 h) above the equilibrium concentration limit. For each excursion above the equilibrium limit, an LER is required. Four BWRs (Brunswick 1 and 2, Hatch 2, and La Crosse) and approximately one-half of the operating PWRs have this type of Technical Specifications.