INFANT MORTALITY CHANGES FOLLOWING THE THREE MILE ISLAND ACCIDENT

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Summary

An examination of the monthly changes in infant mortality in Pennsylvania and the nearby areas of Upstate New York as given in the U.S. Monthly Vital Statistics reports indicate that the mortality rate rose significantly shortly after the Three Mile Island accident in the directions where the plume of radioactive gases was known to have moved. The number of reported infant deaths per month rose from a minimum of 141 in March of 1979 just before the accident to a peak of 271 in July, declining again to 119 by August. This is an unprecedented and highly significant rise of 92% in the summer months when infant mortality normally reaches its lowest values. In the four month period following the accident, there were 242 deaths above the normally expected number in Pennsylvania and a total of about 430 in the entire Northeastern area of the United States. The hypothesis that this abnormal rise was associated with the gaseous releases from Three Mile Island is shown to be strongly supported by the following considerations. First, large amounts of radioactive Iodine-131 were released from the plant, estimated by the utility's own radiological consultants to have amounted to 14 curies, together with 10 million curies of other fission gases, most of the activity escaping in the first two days before the order to evacuate pregnant women and young children was issued. Secondly, infant mortality peaked three to four months after the initial releases took place. This corresponds to the period required for infants to be born whose thyroid glands were most active in taking up the radioactive iodine while producing growth hormone when the accident occurred, thus explaining the large rise in the number of immature and underweight infants that died of respiratory distress as indicated by an examination of hospital records. Thirdly, the greatest rises took place in areas closest to the plant, decreasing with distance away from Harrisburg and the state of Pennsylvania, until for states well to the west and south, there was a decline in infant mortality rates. Thus, while Pennsylvania

Although the major emphasis in estimates of the health impact produced by the accident at Three Mile Island has been on the increase in cancer risk and the effect of the psychological stress[1], the greatest immediate concern was connected with the possible effects on the developing infant in the mother's womb due to the known tendency of radioactive iodine to concentrate in the fetal and infant thyroid glands[2].

It was the existence of uncontrolled large releases of fission-produced radioactive gases including Iodine-131 that led Governor Thornburg of Pennsylvania to order the evacuation of all pregnant women and children below school age from within a radius of five miles around the plant on the third day of the accident, Friday, March 30, 1979.

Subsequent studies by various government and private organizations have confirmed that large quantities of radioactive Iodine-131 were in fact released in the course of the accident, the estimates ranging from 1.4 curies in an early study prepared by the NRC[3] to as high as 14 curies of Iodine-131 in a later study by a private consulting firm for the utility[4]. To appreciate the significance of these amounts, it is only necessary to point out that the unit which is used to measure concentrations of Iodine-131 in milk is the pico-curie, which is one millionth of one millionth of a curie.

These studies further showed that most of the gaseous releases took place in the first two days after the accident that began in the early morning of March 28. Thus, it was calculated that of the 10 million curies of radioactive gases released in the first five and a half days, 7 million curies has been emitted in the first 36 hours.[4]

increased from 10.4 per thousand live births in March to 18.5 in July of 1979, the United States rate as a whole declined from 14.1 to 12.5. The rise moved Pennsylvania from well below the U.S. average to the highest infant mortality rate for any state east of the Mississippi River. Other evidence supporting this conclusion is discussed, including the occurrence of abnormal increases of infant mortality rate in areas that received heavy fallout from nuclear weapons tests during the 1950's and 60's when Iodine-131 levels reached comparable levels, as well as similar effects in areas close to other nuclear reactors known to have released comparable amounts of radioactive gases from damaged fuel elements over a period of years in the course of normal operations. The implications for further health effects due to cancer and other diseases are discussed.

Likewise, most of the external gamma ray dose due to the passing clouds of fission gases estimated by all organizations to have been in the range of 70 to 80 millirems to individuals nearest the plant was found to have been received in the first few days of the accident.

These studies further showed that most of the thyroid dose was received through the inhalation of radioactive iodine isotopes rather than through the ingestion of milk or water[(4)].

For the infant thyroid, the maximum dose was calculated to have been of the order of 10 mrem by inhalation and 1.1 mrem by ingestion of milk[(4)]. Due to the smaller volume of air inhaled by infants, the maximum dose was found not to have been much larger than for adults despite the ten-fold smaller size of the infant thyroid.

No estimates were published for the fetal thyroid, which is known to begin functioning actively in about the fifth to sixth month of intra-uterine development.[(5)(6)] However, earlier measurements carried out for comparably small exposures during periods of heavy fallout from nuclear weapons testing clearly indicate that fetal thyroid doses can be some 10 to 20 times larger than for infants or 100 times that of adults[(7) (8)]. This arises from the fact that the early thyroid gland has a very small mass of the order of 0.10 to 0.20 grams, or some one to two hundred times smaller than the 20 gram adult human thyroid.

Thus, it is possible to estimate that the thyroid gland of fetuses in the more heavily exposed areas within five to ten miles of the Three Mile Island plant are likely to have received radiation doses of the order of 100 to 1000 mrems from Iodine-131 alone. To this must be added the whole-body gamma dose from noble gases and the contributions from the many short-lived iodine isotopes as well as the whole body doses from the other important isotopes such as Cesium-137, Cesium-134, Tritium, Barium-140, Strontium-89, etc., depending upon the mother's diet in the weeks following the accident.

Thus, typical thyroid doses 200 to 1100 (in excess of 200) mrems are likely to have been received by developing infants in their mother's womb for those in their 5th to 9th months of development. Due to the fact that the radioactive gas plume frequently touched the ground within a few miles of the plant, individuals in these areas could easily have received five to ten times higher doses than the average in the first one or two days of the accident, before the evacuation of pregnant women was ordered.

A dose of the order of 200 to 1100 mrems is comparable with that received by the fetus in the course of diagnostic x-ray examinations since a single abdominal film gives a fetal dose of the order of 200-300 mrem[9] [10].

The fact that diagnostic x-ray exposures during fetal development can lead to serious biological damage is by now widely recognized in the medical community as a result of the large scale epidemiological studies of Stewart[11], MacMahon[12], Diamond[13], Bross[14], Graham[15] and others.

Not only is there an increased risk of leukemia and cancer as first discovered by Stewart[11] but the more recent prospective study of Diamond and his associates at Johns Hopkins University[13] revealed an increased risk of death from all causes for those who received x-rays in utero, primarily within the first year of life. These included deaths from respiratory system problems, infectious diseases and diseases of the central nervous system. Furthermore, both the Johns Hopkins study and the study of Stewart[11] revealed that the earlier the exposure takes place, the greater is the risk of adverse effects.

Thus, Stewart's study showed that whereas the dose needed to double the risk of leukemia and cancer was of the order of 1,200 mrem just before birth when most x-rays were taken,a mere 80 mrem doubled the risk when x-rays were given in the first three months of pregnancy[11].

Thus, doses of 200 to 1100 mrem to the critical thyroid gland controlling the growth and development of the fetus beginning in the 5th to 6th month of pregnancy could be expected to produce a significant effect on the fetus through retardation in growth and maturation, thereby increasing the risk of mortality within the first year of life. The greatest mortality occurs during the critical period of transition from intra-uterine existence when the lung of the newborn must suddenly take over the life-sustaining function of respiration[16].

A large number of studies have shown that infants that are born immature, underdeveloped or underweight have a much higher incidence of respiratory distress or hyaline membrane disease[16]. Thus, even a small degree of retardation in development due to a reduced output of growth hormone by the thyroid gland during the last three to four months of intra-uterine development would be expected to increase the risk of death due to respiratory insufficiency immediately after birth. Failure of the critical lung surfactant to be produced in adequate amounts can therefore lead to respiratory problems and death as a result of damage either to the thyroid or the pituitary gland which in turn controls the thyroid's output of growth hormone[17].

The fact that radioactive iodine from nuclear weapons tests can indeed reduce human fetal and infant growth has been observed as a result of the accidental fallout exposure of the Marshallese Islanders following the large hydrogen bomb test BRAVO in 1954[18]. Not only was there an increase in fetal deaths among the women exposed at that time, but there was also a severe reduction in growth of the children exposed to fallout, the effect being greater the young the children were.

The effect of even small doses of radioactive iodine on fetal development is further supported by the fact that the birth-weight of babies born in the United States suddenly began to decline during the 1950's, [19] the period when the heaviest fallout from weapons testing occurred in the continental United States. Furthermore, since the end of large-scale atmospheric bomb-tests by the U.S. and the U.S.S.R., there has not only been an end to the trend towards smaller birth-weight but there was also an unexpected resumption in the decline of infant mortality which had also halted during the period of heavy fallout[20] [21].

This is shown graphically in Figure 1 taken from the most recent summary of infant mortality trends published by the U.S. Department of Health, Education and Welfare's National Center of Health Statistics[22]. As shown by the arrows added to indicate periods of heavy nuclear testing in the atmosphere, the decline of infant mortality rates in the United States came to a sudden halt between 1945 and 1951, when the testing of nuclear weapons at Alamogordo, New Mexico, in the Marshall Islands, and in Siberia began.

Between the years of heaviest weapons testing in the lower atmosphere namely 1956 to 1958, there was actually a reversal of the previous downward trend of infant mortality, which ended only when nuclear testing was temporarily halted during the years 1959 to 1961, after which there was a brief renewal of bomb testing that did not end until the 1963 test-ban treaty was concluded.

Although France and China continued to test nuclear weapons in the atmosphere, the end of large atmospheric tests by the U.S., U.S.S.R. and U.K. led to a gradual reduction in infant mortality rates, until in the last few years, both white and non-white populations showed a resumption of the pre-testing rate of decline that had so dramatically halted during the 1950's for reasons that were not understood at the time[23].

A connection between fallout and infant mortality changes was first suggested in 1969[20]. However, at that time the evidence that the fetus in the early phases of development may be fifteen times more sensitive to radiation than the full term infant had not yet been published by Stewart and Kneale[11] so that it was difficult to explain the large magnitude of the effect[24]. Also, the study of Diamond and his coworkers had not yet been published showing that all causes of death and not merely leukemia and cancer were increased by small intra-uterine exposures, so that a generalized effect on all forms of mortality was unsubstantiated.

As a result it was argued by some authors that the halt in the decline of infant mortality might be due to the fact that all possible effects of improved medical care, diet and drugs had been exhausted, and that therefore infant mortality had gone down as far as it would ever be able to decline in the United States[24].

However, as Figure 1 clearly shows this did not turn out to be the case: infant mortality started to decline once again after heavy fallout ended and in the most recent years has actually accelerated its rate of decline, rapidly approaching the projected rate that would have existed if there had been no halt during the time of massive nuclear weapons tests[21].

The effect of small amounts of short-lived fission products such as I-131 as distinct from the long-term trend that is correlated with the build-up of Strontium-90 in the bone of young women prior to pregnancy[21] is shown particularly strikingly in Figure 2.

Here, the infant mortality rate for New Hampshire some 2,500 miles to the east of the Nevada test site has been plotted for the years 1946 to 1974, together with the officially announced yields of small tactical nuclear weapons detonated in Nevada between 1951 and 1962[25].

Inspection of this plot shows that simultaneously with the onset of Nevada tests in 1951, there was a sudden halt in the long-term decline of infant mortality followed by brief periods of small reversals in the downward trend which occurred in the same years as the nuclear weapons tests in Nevada. Whenever there was a test in Nevada, there was a sharp rise in infant mortality in New Hampshire, where the fallout came down with the heavy rain and snow falls in the White Mountains.

Not until the Nevada tests ended did these highly abnormal spikes in infant mortality disappear, and only after the end of all large scale nuclear weapons tests did the infant death rate decline once more, finally reaching the low values that would have been reached had the pre-bomb testing rate of decline continued.

The significance of these results for the case of the Three Mile Island accident is that the external gamma ray doses from bomb fallout in the eastern United States in any given year were generally smaller than external gamma doses of 70 to 80 mrem measured in a few days at Three Mile Island.

Thus, the long-term gamma dose measurements carried out at the Brookhaven National Laboratories since the late 1940's[26] show that only in 1963 did the annual gamma ray dose reach 76 mrem,the same dose experienced at Three Mile Island in a matter of days.

Yet, both Figure 1 and 2 clearly show significant peaks in infant mortality associated with weapons tests in Nevada, the Pacific and Siberia. This indicates that the actual internal doses to critical organs from inhaled and ingested fission products far outweigh in their biological importance the external gamma dose recorded by badges and survey meters whenever fission products are released into the atmosphere[27].

This is supported by a more recent study that found a correlation of changes in infant mortality in different sections of Wisconsin with measured changes in Sr-90 levels in the milk following bomb-tests and the start-up of nuclear power plants[28].

Clearly, whatever the still not fully understood biological mechanisms are that cause prematurity and early neonatal death associated with respiratory distress, external gamma doses from fission products containing I-131 of the order of 10 to 50 millirems were associated with yearly infant mortality changes of the order of 5 to 25% in the eastern U.S. during the late 1950's, that is changes of about 0.5%/mr

It follows that the releases of fission products containing I-131 in the Three Mile Island accident should also be followed by detectable peaks in infant mortality associated with immaturity and respiratory distress within a few months after the accident, when the infants whose thyroids had begun to function when the iodine was released were born. Furthermore, since fetuses of less than 5-6 months gestational age do not have fully developed thyroid gland able to concentrate I-131 to the same extent as those that are present in the last 3 months of gestation,[5] there should be a rapid decline in newborn deaths beginning in the third and fourth month after the end of the gaseous releases.

That this is indeed the pattern of infant mortality changes that has taken place following the Three Mile Island accident is apparent from the following considerations.

Turning first to the data on the month-by-month infant mortality in Pennsylvania as reported in the Monthly Vital Statistics reports published by the National Center for Health Statistics[29] plotted in Figure 3, one sees that a large peak in the infant mortality rate occurred in the summer of 1979, some three to four months after the releases took place. Grouped in 3 months periods, the rise was 32% (Table I).

Compared with the normal pattern of infant mortality throughout the year, which generally declines in the summer months when the risk of pneumonia and influenza is small, the 78% rise from a rate of 10.4 per thousand live births in March to a peak of 18.5 in July, followed by a decline to the normally expected low of 8.5 in August, is totally anomalous. However, it is completely consistent with the expected action of radioactive Iodine-131 on the fetal thyroid.

The rise from 141 to 271 infant deaths is statistically highly significant representing an increase by more than 5 standard deviations for which the probability of a purely statistical fluctuation is much less than 1 in 1000 ($P \ll 0.001$).

Such a large rise did not occur for the United States as a whole as shown in the plot of Fig. 4[29]. Furthermore, it is seen that there was no such large rise in mid-summer in previous years as illustrated for 1977 and 1978 in Figure 4.

In fact, the July infant mortality rate of 18.5 per 1000 live births in Pennsylvania was the highest for any state in the entire United States east of the Mississippi, moving Pennsylvania above such rural states as Mississippi and Alabama, where the large non-white population with its poorer socio-economic status, medical care and diet had traditionally been associated with a much larger infant mortality[30]. (Table II).

Whereas prior to the Three Mile Island accident, Pennsylvania had an infant mortality rate well below the U.S. average, by July it had moved well above the U.S. average, returning to its normal position below the U.S. mean in August, 4 to 5 months after the accident. (See Figure 5). This was the time when infants were being born that did not have a fully developed active thyroid gland at the time of exposure.

Since for the first few days when the initial release occurred, the winds were mainly towards the West, North-West and North[3], one would expect significant increase in infant mortality in the summer months in upstate New York and Western Pennsylvania, but not in New York City directly to the East. (See maps of Figure 6 and 7). At the same time, the Harrisburg area should show the greatest increase in the newborn mortality rate.

This expectation is born out by the changes in infant mortality for three month periods before and after the Three Mile Island releases ended,(Fig. 8 and Table III). In this table, the data from the U.S. Monthly Vital Statistics is listed together with data obtained for a major hospital in each of Harrisburg and Pittsburgh,[31] since the county-by-county data in Pennsylvania were not yet available.

As can be seen from Table IV and Figures 8 and 9, there was a 7 fold rise or a 630% increase in the number of newborn deaths associated with immaturity and respiratory diseases in the Harrisburg hospital for the three month period of May-June-July 1979 relative to both the same period in 1978 and the immediately preceding three month period of February-March-April.

A similar pattern is seen to have occurred in the Pittsburgh area as reflected in the data for a major hospital that accounts for nearly half of all deliveries (Table V and **Fig. 10**) though with a smaller percent change. Again, there is an unusual summer peak in 1979 that did not occur in the previous year. In fact, examining the case for the peak month of July in Figure 11, it is seen that both the total number of deaths and the rate per thousand births was declining before 1978, **rising** again from 8 deaths in July of 1978 to 24 in July of 1979.

This unusual peak of infant deaths in July was also observed in Northern New England but not in Southern New England, as expected from the known northward direction of the winds in the first few days of the accident. (See TableVI).

Although the increases in the number of deaths among newborns in the Harrisburg Hospital are small in absolute numbers, they are nevertheless highly significant statistically. The average number of newborn deaths per month during 1978 was 0.42 per month with a standard deviation of ± 0.2, while the average for the summer months was only 0.33 per month. Thus four such deaths in June of 1979, exactly three months after the accident, represents a 10 to 12 fold increase above normal expectations, whose occurrence by mere chance is much less than 1 in 100.

Combined with the geographical pattern of infant mortality changes from Ohio to New England, and the absence of any similarly large summer peak of infant mortality in the previous years, it seems inescapable to conclude that the accident at Three Mile Island did in fact lead to a significant increase in infant mortality similar to those encountered from earlier comparable episodes involving fission products from nuclear weapons testing and releases from nuclear plants.

For the 3 month period May through July 1979, the total number of excess deaths was 352 compared with that normally expected in the states of Pennsylvania, Ohio and New York, using the rate of decline for the United States as a whole[†].

Comparable percent increases are likely to occur for childhood cancer and leukemia in the next ten to fifteen years[32] [33], as well as somewhat lower percent increases in all causes of death in the much larger general population according to the studies of Lave and his associates for the case of 50 metropolitan areas in the United States during the heavy fallout period of the early 1960's[34]. It would therefore appear that the Three Mile Island accident will turn out to have produced the largest death-toll ever resulting from an industrial accident, with total deaths from all causes likely to reach many thousands over the next 10 to 20 years.

Since for every infant that dies as a result of retarded growth and development, there are many more individuals (perhaps ten times as many) that are minimally damaged in their physical and mental abilities[16] [35], the effect on society will be much larger than premature death alone. In the light of these findings, it must be of great concern that the releases of radioactive gases and iodine from routine operations of nuclear reactors such as the Millstone Plant in Connecticut have been comparable in magnitude with

† If one adds the excess deaths in April, there were 40 in Pennsylvania and 35 in Upstate New York for a total of 427.

the releases from Three Mile Island, namely 3 million curies of mixed fission gases and 10 curies of I-131 in 1975 alone[36].

The full magnitude of the danger to the biological survival of nations that choose to pursue the development of nuclear reactors near their large population centers is therefore only now beginning to become apparent.

This is especially brought out by the fact that the greatest number of deaths actually occur in areas ten to one-hundred miles distant from the reactor site so that even a decision to locate nuclear reactors only in less populated areas would not appreciably change the mortality figures either for the effect of normal releases or major accidents. Nor would an evacuation plan for the population within 5 or 10 miles of the reactor significantly affect the overall number of deaths resulting from a repetition of the Three Mile Accident, since most of the deaths occur in the more distant areas due to the larger total populations they contain[37], though the greatest individual risk exists nearby.

This is illustrated by the observed infant mortality changes in the State of Rhode Island located between 20 and 50 miles downwind to the east of the Millstone Reactor near New London, Connecticut as shown in Figure 12.

In this plot, the infant mortality rate for Rhode Island has been plotted for the years 1965 to 1976, together with the releases of radioactive fission gases as published by the Nuclear Regulatory Commission (NRC)[36] since the start of operations in 1970.

For comparison, the infant mortality rate for the State of New Hampshire more than 150 miles to the northeast is also shown in this plot.

Inspection of Figure 12 shows that in the years prior to the start of the Millstone Plant in 1970 and the Connecticut Yankee plant at Haddam Neck in 1968, both states showed the same infant mortality rate.

However, beginning in 1970, the rate of decline of the Rhode Island infant mortality slowed down, while that of New Hampshire kept declining rapidly, leading to the development of a large gap in the mortality rates between the two states by early 1976. In the first quarter of that year, Rhode Island had a rate of 18.6 practically equal to its 1967 level of 19.3, while New Hampshire declined to an infant mortality only half as great, or 9.3 per 1000 live births.

The fact that the emissions from the Millstone plant are likely to be responsible for this dramatic gap is illustrated by Figure 13 which is a plot of the percent excess infant mortality in Rhode Island relative to New Hampshire versus the announced gaseous releases from the Millstone plant. A two-year moving average of the emissions is used in this plot to take account of both the short-lived I-131 and the longer-lived Cs-137 and Sr-90 in the releases that build up in the environment.

It is seen that the data fit a logarithmic or fractional power law of the form $a D^x$ with $a = 38\%$ and $x = \frac{1}{2}$. This is the type of law expected on the basis of a free-radical type of indirect chemical action on cell membranes discovered by Petkau[39], which rises more rapidly at low doses and low dose-rates than at high doses and dose-rates. It is also the type of dose-response relation expected on the basis of a wide difference in sensitivity of different individuals in the population as discussed by Baum[40], Bross[41] and Morgan[42], or a type of dose-response that leads of a large underestimate of health effects at low doses from data taken at high doses[43].

Based on an external gamma dose of 500 mr for the maximum permissible release of some 25 million curies per year[38], the slope of the dose-response curve increases from 2%/mr at 1 million curies per year to about 6%/mr at 0.1 million curies per year.

Based on the external dose from the gas-cloud alone, one would therefore expect an increase in infant mortality for the case of the Three Mile Island accident of 38 x 10½ or 120% in an area some 20-30 miles distant. This is in good agreement with the three month increase in newborn infant mortality in Harrisburg of 600%, which reduces to 150% when averaged over the period of a year.

Thus, both qualitatively and quantitatively, the releases from normal operation from the Millstone Plant and the accompanying increases in infant mortality in Rhode Island some 20 to 30 miles downwind correctly predict the infant mortality changes in the Harrisburg area from the comparable noble gas and iodine discharges at Three Mile Island.

The importance of releases of Cesium-137 and Strontium-90 in addition to Iodine-131 for the more distant large metropolitan areas is illustrated by the plots of the Cs-137 and Sr-90 spatial distribution around the Millstone plant as taken from the utility's own environmental reports to the NRC(44) shown in Figures 14 and 15. The 4 to 5 fold greater concentration of both of these isotopes in the milk near the stack of the plant as compared with the more distant areas strongly argues against the interpretation advanced by the utility(45), the NRC(46) and the EPA(47) that these levels can be explained by fallout from nuclear weapons tests.

The hypothesis that these highly localized levels are indeed due to plant emissions is also strongly supported by the fact that the changes in concentrations of these isotopes in the milk throughout the year are greatest near the plant in the summer months following spring refueling, and least at more distant locations such as Delaware along the Atlantic Coast as seen in Figure 16 for Cs-137. Particularly significant is the fact that both within 10 miles of the plant and in Rhode Island, there was a peak in Cs-137 concentrations in the summer of 1976 before the heavy

Chinese fallout arrived in October. It should be noted that this fallout episode was also followed by a sharp rise in infant mortality along the north-east coast 3-4 months later.

The fact that the increases in cancer mortality around the Millstone Plant after it began operating have the same geographical distribution as the measured CS-137 and Strontium-90 concentrations in the milk, and the fact that the increase in infant mortality in Rhode Island is correlated with the releases from the Millstone Plant indicates that there is likely to be a significant cancer increase from the Three Mile Island accident.

But perhaps the most significant confirmation of the serious biological effect of routine radioactive gas releases from nuclear reactors is the plot of infant mortality rates at different distances from the Millstone Plant for July 1978 shown in Fig. 18, before the releases from Three Mile Island affected the mortality rates in New England.

It is seen that while New Hamsphire, which has no operating nuclear reactor, declined to a low of only 1.9 infant deaths per thousand births from 21 in 1965, Rhode Island, directly downwind and close to both the Connecticut Yankee and Millstone Reactors, showed a ten-fold greater infant death rate of 19.9, completely nullifying 13 years of advances in public health and medical care.

Vermont, whose only nuclear reactor is located in its most southernly tip so that most of the state is not affected by the releases, reached a low of 4.2 per 1000 births. But all the other New England states with more nuclear generation of electricity, showed higher infant mortality rates than either New Hampshire or Vermont.

For these reasons, it appears doubtful whether any efforts to improve the safety of nuclear reactors, changes in their locations, or evacuation plants can significantly alter the public health impact of normal releases and such potentially more serious accidents as occurred at Three Mile Island, where only a small fraction of the total fission products generated actually escaped into the environment. Needless to say, the mortality changes following Three Mile Island would be enormously multiplied in the event of a complete melt-down and rupture of the containment, threatening areas as large as the entire eastern United States with enormous damage in terms of cancer and thyroid damage for all age groups out to distances of hundreds of miles[(37)].

Since neither coal nor oil nor gas nor solar energy lead to the large-scale production of short-lived radioactive iodine and other fission products that seek out the critical organs of the developing infant, it would seem prudent to apply future technological efforts to the more forgiving sources of energy that do not threaten the most precious of our nation's resources: the physical and mental well-being of our children for generations to come.

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30. See Appendix for original data on all states. The District of Columbia has a majority of non-white births and has for decades had an abnormally large infant mortality rate far above the rest of the United States.

31. The Harrisburg Hospital accounts for approximately 30% of all births in the Harrisburg area. The numbers of deaths refer only to those of newly born infants that die within a few hours after birth, and which account for 70-80% of all infant deaths within the first year. Magee Hospital accounts for approximately half of all births in the Pittsburgh area.

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APPENDIX I

Table 2. DEATHS AND INFANT DEATHS: EACH REPORTING AREA, JULY 1978 AND 1979, AND CUMULATIVE FIGURES, 1977-79

[By place of occurrence]

Area	Deaths (all ages)					Infant deaths (under 1 year)				
	July		January-July			July		January-July		
	1979	1978	1979	1978	1977	1979	1978	1979	1978	1977
New England	8,646	7,908	65,076	66,351	[4]65,594	110	107	998	880	889
Maine	889	916	6,117	5,996	6,057	12	10	92	68	87
New Hampshire	628	420	4,165	4,136	[4]4,215	8	2	73	54	66
Vermont	210	346	2,319	2,736	2,543	5	3	37	62	34
Massachusetts	3,997	3,372	32,035	32,542	32,415	54	44	479	401	429
Rhode Island	770	747	5,424	5,438	5,403	16	21	116	112	99
Connecticut	2,152	2,107	15,016	15,503	14,961	15	27	201	193	274
Middle Atlantic	29,747	29,115	200,050	206,655	206,296	649	633	4,018	4,032	4,175
New York[1]	14,708	14,249	94,410	97,987	97,882	295	316	2,100	2,094	2,241
New Jersey	5,424	5,429	37,274	37,794	37,643	83	114	616	619	705
Pennsylvania	9,615	9,437	68,366	70,874	70,771	271	203	1,302	1,319	1,229
East North Central	[2]20,698	27,704	[2]198,237	213,589	208,548	[2]443	654	[2]4,573	4,580	5,138
Ohio	7,729	7,090	54,265	57,340	57,231	147	151	1,120	1,137	1,278
Indiana	3,762	3,703	27,404	28,123	27,140	101	68	634	515	574
Illinois	---	8,006	[3]50,841	59,124	58,008	---	233	[3]1,379	1,486	1,643
Michigan	6,128	5,736	42,526	44,047	42,614	147	131	1,120	1,042	1,099
Wisconsin	3,079	3,169	23,201	24,955	23,555	48	71	320	399	[4]444
West North Central	[2]9,525	12,334	[2]86,213	95,573	90,159	[2]200	283	[2]1,818	2,083	2,041
Minnesota	---	2,741	[3]16,040	19,818	18,505	---	70	[3]324	423	417
Iowa	2,074	2,177	15,064	15,978	15,438	37	50	259	290	322
Missouri	[illegible]	[illegible]	28,025	31,222	[illegible]	75	88	667	715	715
North Dakota	519	453	3,212	3,369	3,214	21	11	97	88	103
South Dakota	520	476	3,661	3,837	3,647	7	9	77	105	119
Nebraska	1,138	1,232	8,167	8,636	8,256	25	34	168	203	140
Kansas	1,738	1,630	12,044	12,713	12,022	35	21	226	261	225
South Atlantic	25,268	[4]25,262	188,306	[4]191,473	184,363	632	[4]626	4,438	[4]4,364	4,414
Delaware	400	442	2,950	2,998	2,766	10	6	70	54	53
Maryland	2,609	2,651	18,506	19,058	18,343	66	68	301	323	313
District of Columbia	634	[4]724	5,492	[4]5,277	4,526	22	[4]52	232	[4]276	243
Virginia	3,230	3,207	23,289	24,026	23,168	91	77	593	556	504
West Virginia	1,474	1,425	11,336	12,169	11,317	27	29	251	285	232
North Carolina	3,952	3,810	27,553	28,378	27,588	104	98	726	783	802
South Carolina	1,933	2,075	13,837	13,950	14,108	59	64	472	523	469
Georgia	3,135	3,361	25,442	26,234	26,342	89	96	755	689	693
Florida	7,901	7,567	59,901	59,383	56,199	164	136	1,038	875	979
East South Central	10,440	10,958	77,782	79,761	79,345	250	325	2,116	2,149	2,245
Kentucky	2,453	2,839	19,315	20,198	20,407	50	55	435	402	485
Tennessee	3,463	3,214	24,483	24,662	24,529	81	98	650	696	672
Alabama	2,737	2,952	20,629	20,993	20,705	60	83	523	579	550
Mississippi	1,787	1,953	13,355	13,908	13,704	59	89	508	472	438
West South Central	15,591	[4]15,731	113,123	[4]113,017	108,316	476	469	3,169	3,411	3,400
Arkansas	1,785	1,605	12,717	12,910	12,561	49	25	268	275	230
Louisiana	2,794	2,941	20,649	21,456	20,498	99	109	655	760	767
Oklahoma	2,210	[4]2,270	16,035	[4]16,311	15,245	43	45	273	358	377
Texas	8,802	8,915	63,722	62,340	60,012	285	290	1,963	2,018	1,976
Mountain	6,372	6,356	45,607	45,001	42,941	238	200	1,566	1,459	1,458
Montana	475	534	3,715	3,775	3,613	16	15	85	79	97
Idaho	509	547	3,504	3,640	3,622	6	9	94	98	90
Wyoming	269	251	1,621	1,805	1,676	6	2	39	34	45
Colorado	1,545	1,617	10,887	11,192	10,654	51	43	324	306	329
New Mexico	799	730	5,109	5,059	4,690	29	26	217	190	187
Arizona	1,545	1,521	12,362	11,674	11,087	64	51	387	402	354
Utah	764	781	5,028	4,790	4,567	52	46	321	279	265
Nevada	466	375	3,381	3,066	3,032	14	8	88	72	81
Pacific	19,076	16,589	134,189	140,081	135,374	[illegible]	420	[2]2,890	3,581	3,619
Washington	2,548	2,290	[illegible]	17,705	[illegible]	34	52	353	419	[illegible]
Oregon	1,750	1,763	[illegible]	[illegible]	[illegible]	40	40	262	318	292
California	[4]14,176	[4]12,025	100,674	106,154	102,317	---	[4]298	[3]2,098	2,637	2,537
Alaska	167	172	952	[illegible]	955	8	19	80	93	72
Hawaii	[illegible]	333	3,020	[illegible]	2,738	18	11	97	114	120
New York City	5,902	5,564	41,927	42,911	43,767	150	141	1,045	1,067	1,146
Puerto Rico	---	1,533	---	10,753	10,757	---	---	---	---	787
Virgin Islands (U.S.)	---	34	---	264	226	---	2	---	36	32

[1]Includes figures shown below for New York City.
[2]Excludes July figures for State for which data are shown below as not available.
[3]Excludes figures for July.
[4]Figure is for a 4 week reporting period.
[illegible]

Table 1. LIVE BIRTHS AND MARRIAGES: EACH REPORTING AREA, JULY 1978 AND 1979, AND CUMULATIVE FIGURES, 1977-79

[By place of occurrence]

Area	Live births					Marriages				
	July		January-July			July		January-July		
	1979	1978	1979	1978	1977	1979	1978	1979	1978	1977
New England	14,562	[a]12,842	91,875	[a]85,970	[a]88,384	8,726	[a]9,076	49,907	[a]52,350	51,661
Maine	1,440	1,306	9,351	8,462	8,977	1,278	1,580	8,420	6,259	6,242
New Hampshire	1,089	[a]1,036	7,532	[a]6,989	[a]6,482	998	[a]1,209	5,003	[a]3,930	[a]4,636
Vermont	513	711	3,988	4,232	3,887	689	446	2,691	2,328	2,177
Massachusetts	8,690	5,556	42,733	39,354	42,032	2,810	2,691	18,551	23,569	22,021
Rhode Island	1,149	1,054	7,067	6,718	6,802	679	776	3,946	3,870	3,894
Connecticut	3,681	3,179	21,204	20,215	20,704	2,272	2,384	13,296	12,394	12,391
Middle Atlantic	45,576	42,747	277,887	272,059	280,300	33,149	30,131	155,959	147,330	145,232
New York[1]	22,855	21,435	134,175	133,065	140,166	15,514	14,179	80,184	73,004	71,275
New Jersey	8,041	8,110	52,425	51,932	52,293	4,916	5,584	29,650	28,454	26,983
Pennsylvania	14,680	13,202	91,287	87,062	87,841	12,719	10,358	46,125	45,872	46,974
East North Central	[2]40,574	54,133	[2]350,253	349,347	360,218	41,309	[a]43,451	218,548	[a]213,701	213,526
Ohio	14,071	11,617	92,954	86,950	92,546	10,053	10,749	56,550	55,126	53,325
Indiana	7,885	8,681	48,687	47,340	48,741	6,642	6,492	33,293	32,410	32,277
Illinois	---	15,210	[3]85,164	96,716	99,453	11,101	11,539	58,854	57,618	60,604
Michigan	12,346	12,409	80,717	78,609	78,366	8,924	10,271	44,315	46,384	45,600
Wisconsin	6,272	6,216	42,731	40,232	40,112	4,589	[a]4,350	22,936	[a]22,163	21,220
West North Central	[2]18,315	22,694	[2]151,652	153,432	148,941	18,077	17,113	94,687	95,566	91,260
Minnesota	---	5,492	[3]31,210	35,635	34,432	3,745	3,469	19,192	18,010	16,652
Iowa	4,122	3,988	26,360	[illegible]	[illegible]	[illegible]	[illegible]	14,257	[illegible]	[illegible]
Missouri	6,350	5,872	43,881	44,058	40,183	6,069	5,313	30,148	31,693	30,077
North Dakota	1,126	1,072	7,361	7,028	7,101	699	691	3,243	3,158	3,156
South Dakota	1,150	900	7,143	6,732	6,801	971	1,003	6,154	5,873	5,740
Nebraska	2,307	2,213	14,800	14,497	14,730	1,579	1,547	8,150	7,779	7,302
Kansas	3,260	3,157	20,897	19,758	19,682	2,523	2,265	14,143	13,814	13,537
South Atlantic	44,172	[a]42,056	294,032	[a]284,437	289,111	38,240	38,786	228,912	222,115	216,566
Delaware	830	798	5,203	5,213	5,213	395	529	2,418	2,363	2,220
Maryland	4,179	4,128	28,027	26,898	26,864	4,612	4,458	25,917	24,988	24,994
District of Columbia	1,133	[a]1,219	9,907	[a]12,016	12,733	549	411	2,828	2,607	2,707
Virginia	6,535	6,477	41,741	39,971	40,721	5,716	6,269	33,158	32,768	32,761
West Virginia	2,520	2,755	17,580	18,797	17,351	1,870	1,769	9,937	9,492	10,013
North Carolina	7,660	7,420	47,690	46,930	48,091	4,493	4,392	25,957	25,206	24,993
South Carolina	4,253	3,949	28,422	25,903	27,394	5,039	5,764	30,628	30,300	29,014
Georgia	6,700	5,614	48,905	47,270	48,193	6,293	6,480	37,752	38,798	37,312
Florida	10,362	9,496	66,557	61,439	62,546	9,273	8,706	60,317	55,593	52,077
East South Central	21,043	19,570	135,897	130,135	135,034	16,252	17,745	95,973	93,954	92,000
Kentucky	5,618	4,838	34,762	32,946	34,938	3,261	4,047	19,367	19,470	20,177
Tennessee	8,281	5,956	40,785	39,052	40,168	5,867	5,999	33,344	31,754	30,889
Alabama	4,893	4,789	34,917	32,533	34,344	4,509	4,982	28,067	27,676	25,808
Mississippi	4,253	3,987	25,433	25,604	25,584	2,615	2,717	15,205	15,054	15,126
West South Central	32,890	34,052	232,054	216,234	220,757	23,468	23,300	158,159	151,036	146,677
Arkansas	3,039	2,640	19,665	17,751	19,709	2,828	2,457	13,612	12,938	14,067
Louisiana	7,235	7,523	43,241	41,526	42,122	3,989	3,498	24,143	22,141	20,449
Oklahoma	4,318	3,659	27,182	24,518	25,021	4,106	3,817	25,325	24,840	23,101
Texas	18,298	20,230	141,966	132,439	133,905	12,543	13,528	95,079	91,117	88,060
Mountain	19,073	16,896	123,402	113,320	110,821	22,821	[a]25,526	143,385	[a]133,061	[a]128,948
Montana	1,149	1,065	7,949	7,749	7,615	1,030	955	4,574	4,345	4,138
Idaho	1,628	1,847	11,607	11,071	10,513	1,319	942	7,371	7,244	7,379
Wyoming	738	695	4,954	4,345	4,140	732	584	3,305	3,451	3,016
Colorado	4,243	4,152	27,496	25,189	24,988	3,127	3,329	17,700	17,129	16,254
New Mexico[4]	2,617	1,341	15,262	12,503	12,732	1,662	[a]1,598	9,713	[a]9,851	[a]9,412
Arizona[5]	3,686	3,206	24,998	23,898	23,693	2,362	2,206	17,130	16,831	15,457
Utah	4,108	3,815	24,918	22,684	21,236	1,510	1,381	9,717	9,341	8,569
Nevada	904	775	6,218	5,681	5,904	11,079	14,531	73,875	69,868	64,723
Pacific	37,678	37,855	269,767	274,697	264,943	23,992	21,749	135,270	125,891	126,765
Washington	5,075	4,504	[illegible]	32,935	31,734	5,163	4,196	24,933	[illegible]	21,557
Oregon	3,870	3,547	24,312	22,931	22,249	2,222	2,239	11,343	10,918	11,272
California	[6]26,580	[6]27,065	[illegible]	204,571	196,403	14,981	13,767	83,463	82,359	85,252
Alaska	676	768	5,270	5,009	4,758	507	516	2,917	[illegible]	2,929
Hawaii	1,477	1,351	9,935	9,251	9,749	1,109	1,011	6,814	5,923	5,750
New York City[4]	9,300	8,530	61,668	61,022	64,844	5,470	4,800	33,866	31,473	30,987
Puerto Rico	---	5,561	---	40,892	42,336	---	3,046	---	21,529	---
Virgin Islands (U.S.)	---	192	---	1,450	1,325	---	---	---	---	510

[1] Includes figures shown below for New York City.
[2] Excludes July figures for state for which data are shown below as not available.
[3] Excludes figures for July.
[4] Figures for marriages are marriage licenses issued.

TABLE I

Infant Mortality Changes in Pennsylvania Following the

Three Mile Island Accident on March 28, 1979

1979	No. of Infant Deaths	No. of Live Births	Rate 1000	Average Rate	% Change in Rate
February	147	11,892	12.4		
March	141	13,589	10.4	11.9	
April	166	12,520	13.3		
May	198	13,201	15.0		
June	163	12,293	13.3	15.7	+32%
July	271	14,680	18.5		

Source: U.S. Monthly Vital Statistics

TABLE II

Infant Mortality East of the Mississippi in July of 1979.

1979

	Infant deaths	Live births	Rate per 1000
Pennsylvania	271	14,680	18.5
New York+	295	22,855	12.9
N.J.	83	8,041	10.3
Maine	12	1,440	8.3
N. Hampshire	8	1,089	7.3
Vermont	5	513	9.7
Mass.	54	6,690	8.1
Rhode Island	16	1,149	13.9
Conn.	15	3,681	4.1
Ohio	147	14,071	10.4
Indiana	101	7,885	12.8
Illinois	N.A.	N.A.	N.A.
Michigan	147	12,346	11.9
Wisconsin	48	6,272	7.7
Delaware	10	830	12.0
Md.	66	4,179	15.8
D.C.*	22	1,133	19.6*
Virginia	91	6,535	13.9
W. Va.	27	2,520	10.7
N. Carolina	104	7,660	13.6
S. Carolina	59	4,253	13.9
Georgia	89	6,700	13.3
Florida	164	10,362	15.8
Kentucky	50	5,616	8.9
Tennessee	81	6,281	12.9
Alabama	60	4,893	12.3
Mississippi	59	4,253	13.9
New York City	150	9,300	16.1
U.S.	3,800	306,000	12.4

\+ Includes N.Y. City

* Majority of population is non-white and has had much above average infant mortality for decades.

Table III

Comparison of Changes in Infant Mortality Rates Following the Three Mile Island Accident in Harrisburg and Adjoining Areas at Increasing Distance East and West of Harrisburg

	Feb., March, April		May, June July		% Change in Death Rate	Approximate Distance in Miles
	No.	Rate	No.	Rate		
Ohio	482	12.0	480	11.7	-3%	200m West
Pennsylvania	454	11.9	632	15.7	+32%	180m West
Pittsburgh#	31	14.2	52	23.4	+65%	180m West
Harrisburg+	1	1.9	7	13.9	+630%	10-20m North
Upstate New York	404	13.0	477	14.3	+8%	100m Northeast
New York City	429	17.1	438	16.4	-4%	200m East
United States		14.0		12.6	-10%	200m

PA and NY State	1769	2027
Change in No.		+ 258

For Magee Hospital with 50% of births in the area

+ For Harrisburg Hospital with 35% of births in the area

TABLE IV

Newborn Mortality Rate Changes in the Harrisburg Hospital in 3 Months Period Before and After the Three Mile Island Accident March 28, 1979*, Compared with the Same Periods in 1978.

1978	No. of Infant Deaths	No. of Live Births	Rate 1000	Average Rate	%Change in Rate
February	0	128	0.0		
March	1	187	5.3	2.2	
April	0	137	0.0		
May	1	175	5.7		
June	0	154	0.0	2.1	-5%
July	0	154	0.0		
1979					
February	1	186	5.4		
March	0	172	0.0	1.9	
April	0	167	0.0		
May	2	166	12.0		
June	4	154	26.0	13.9	+630%
July	1	182	5.5		

* This hospital accounts for about one-third of all deliveries in the Harrisburg area. Newborn infant mortality is defined as a live-born infant that dies within a short time, most die within a few hours. (Data from monthly Pediatric Conference Records).

Table V

Newborn Infant Mortality Rate Changes in the Pittsburgh Area
From Hospital Records for Three Months Before and After the Three Mile
Island Accident March 28, 1979, Compared With the Same Period in 1978

	No. of Infant Deaths	No. of Live Births	Rate 1000	Average Rate	% Change in Rate
1978					
February	7	633	11.0		
March	6	750	8.0	14.4	--
April	16	625	25.6		
May	11	719	15.3		
June	8	684	11.7	12.5	-13%
July	8	763	10.5		
1979					
February	10	682	14.7		
March	11	786	14.0	14.2	--
April	10	721	13.9		
May	21	664	31.6		
June	7	759	9.2	23.4	+65%
July	24	798	30.1		

+ Data are from Magee Womens Hospital, which handles approximately one-half of all Pittsburgh area deliveries. Newborn infant death is defined as a live-born infant that dies within one month; most die within hours after birth. (Data supplied by Department of Pathology.)

Table VI

Infant Mortality Changes In Northern and Southern New England in July 1979 After Three Mile Island Accident Compared with July 1978

	JULY 1978			JULY 1979			
Northern New England States	No. of Deaths	No. of Live Births	Rate per 1000	No. of Deaths	No. of Live Births	Rate	% Change in Rate
New Hampshire	2	1036	1.9	8	1089	7.3	+284%
Vermont	3	711	4.2	5	513	9.7	+131%
Maine	10	1306	7.7	12	1440	8.3	+8%
Northern New England	15	3053	4.9	25	3042	8.2	+67%
Southern New England States							
Connecticut	27	3179	8.5	15	3681	4.1	-52%
Rhode Island	21	1054	19.9	16	1149	13.9	-30%
Massachusetts	44	5556	7.9	54	6690	8.1	+3%
Southern New England	92	9789	9.4	85	1152	7.4	-21%

Source: U.S. Monthly Vital Statistics

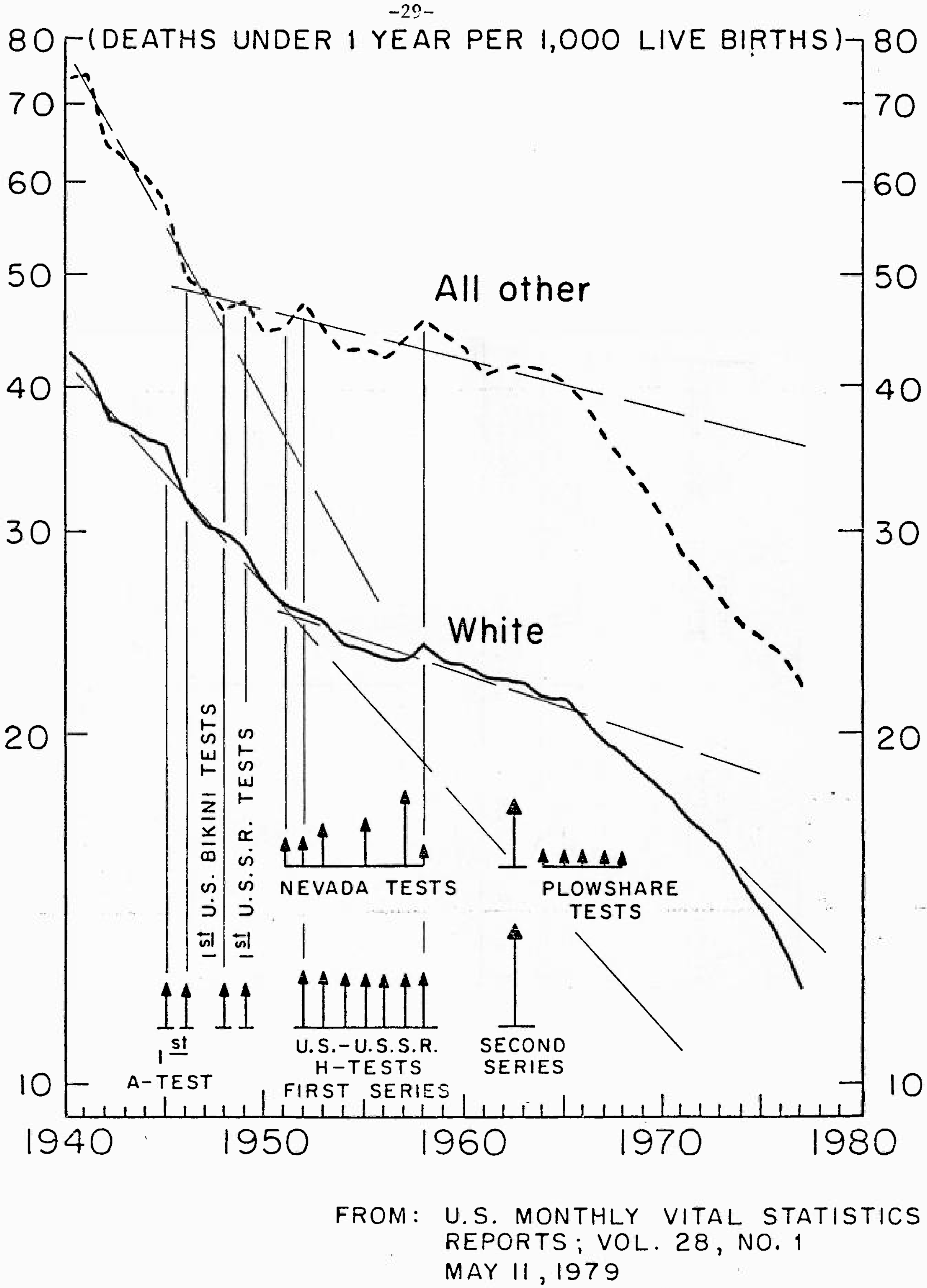


Figure 1. Infant Mortality Rates By Color: United States, 1940-1977

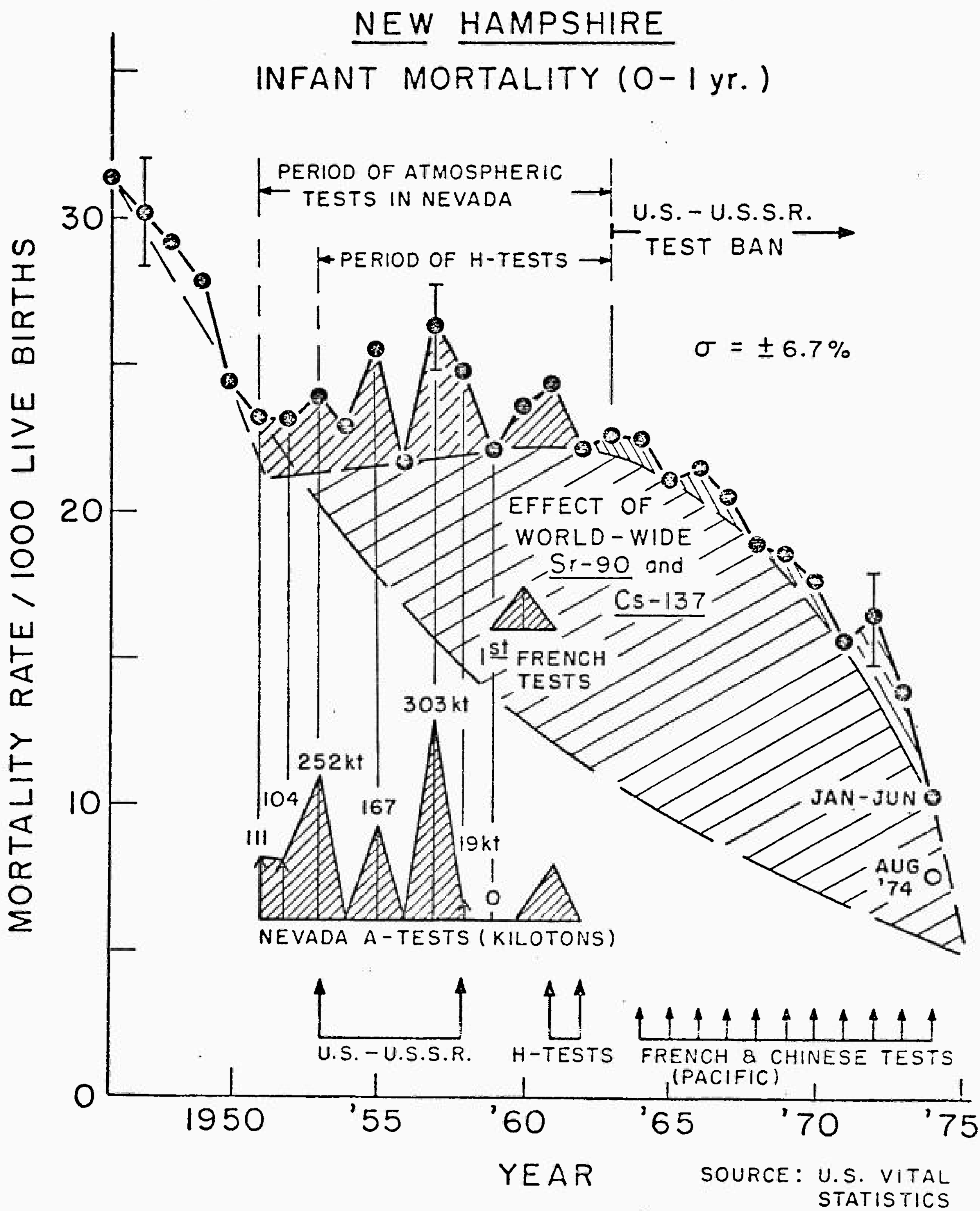


Figure 2. Infant mortality rate in New Hampshire between 1945 and 1974 together with announced yields of atmospheric nuclear weapons tests in Nevada. Note close correspondence between the sharp peaks in mortality rates and the peaks of weapons test yields in Nevada.

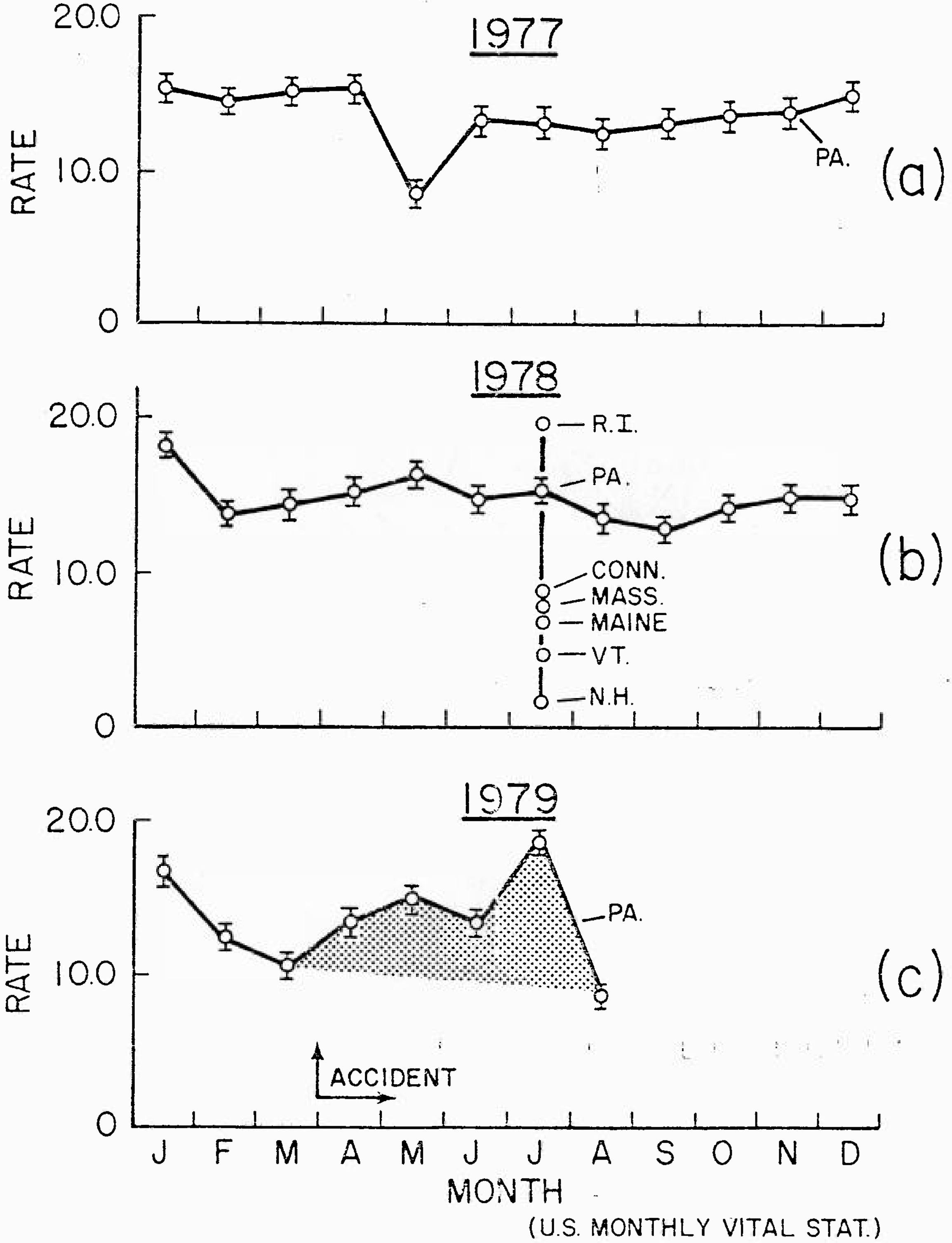


Figure 3. Monthly infant mortality rates in Pennsylvania before and after the Three Mile Island accident of March 28, 1979. (a) 1977, (b) 1978 and (c) 1979. In (b) the July 1978 infant mortality rates have been plotted for the New England states. Note that Rhode Island downwind from the Millstone Reactor had the highest mortality rate, and distant New Hampshire the lowest.

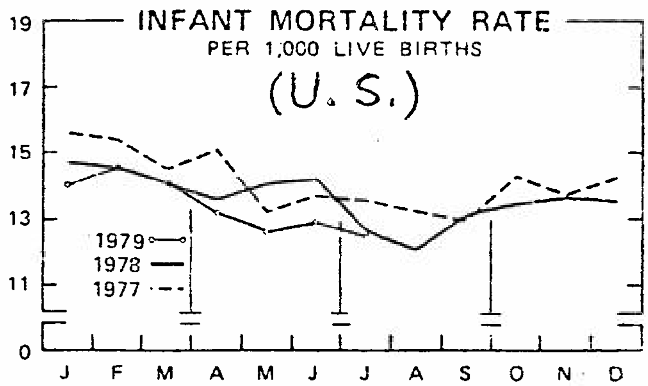


Figure 4. Monthly U.S. infant mortality rate for 1977, 1978 and 1979 (to July). Note normal pattern of low infant mortality rates in the summer months.

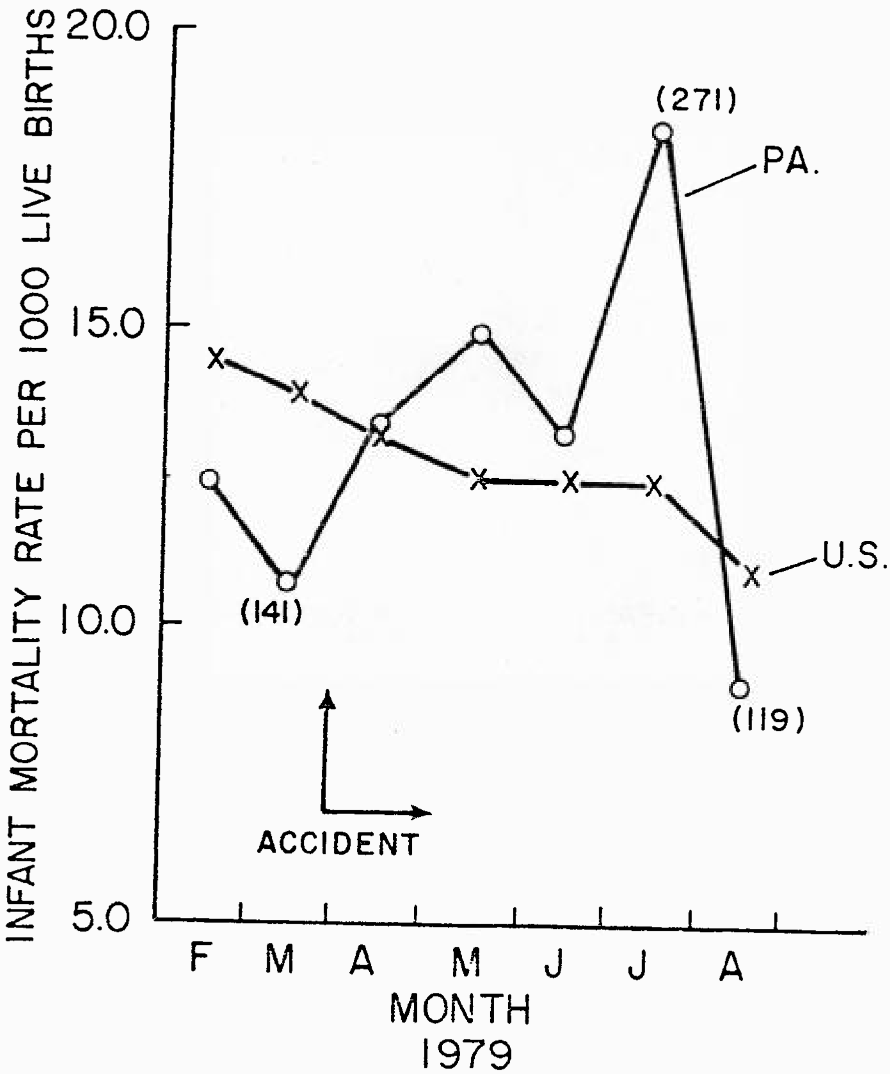


Figure 5. Comparison of the monthly infant mortality rates for Pennsylvania and the United States as a whole for February to August 1979, before and after the Three Mile Island accident on March 28. Figures in brackets indicate number of infant deaths.

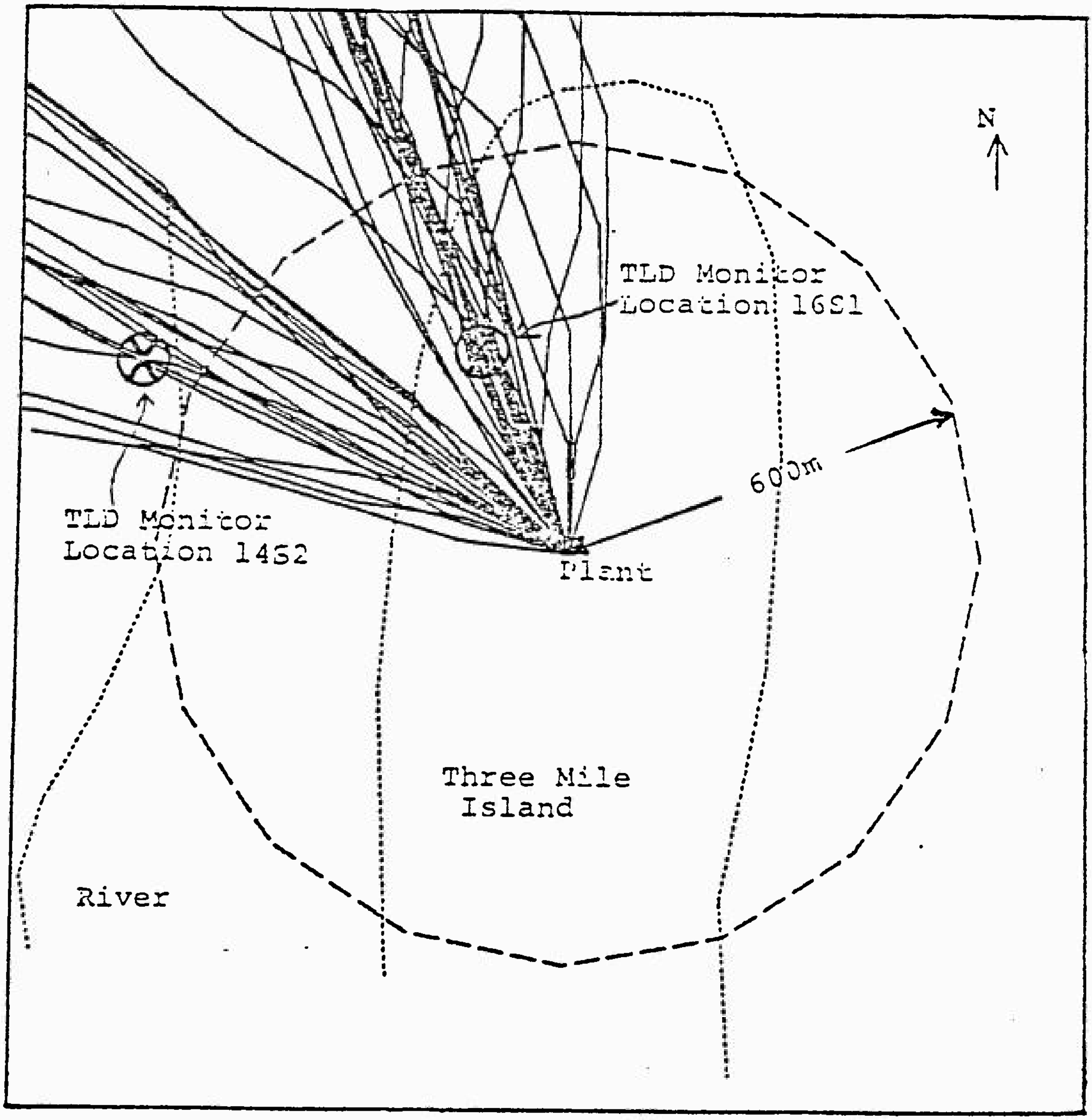


Figure 6. Approximate tracks of plume centerlines for the radioactive gases released during the Three Mile Island accident every 15 minutes starting at 5 p.m. March 29, 1979. (Based on TMI Outsite, Meteorological Tower Data, Reference 4, Figures 4-5).

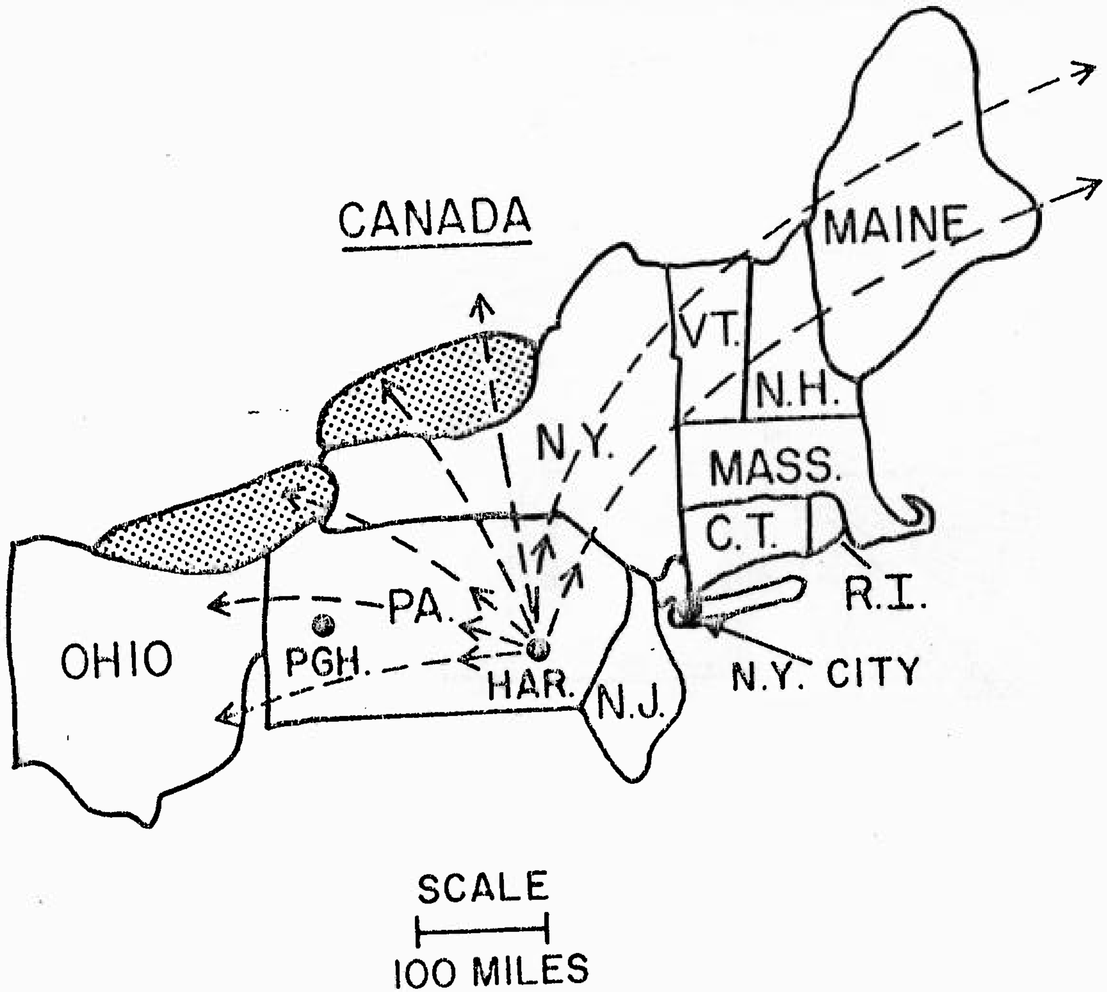


Figure 7. Map of the north-eastern United States showing location of Harrisburg, Pittsburgh and neighboring states together with the principal directions in which the radioactive gases drifted in the first two days of the accident at Three Mile Island.

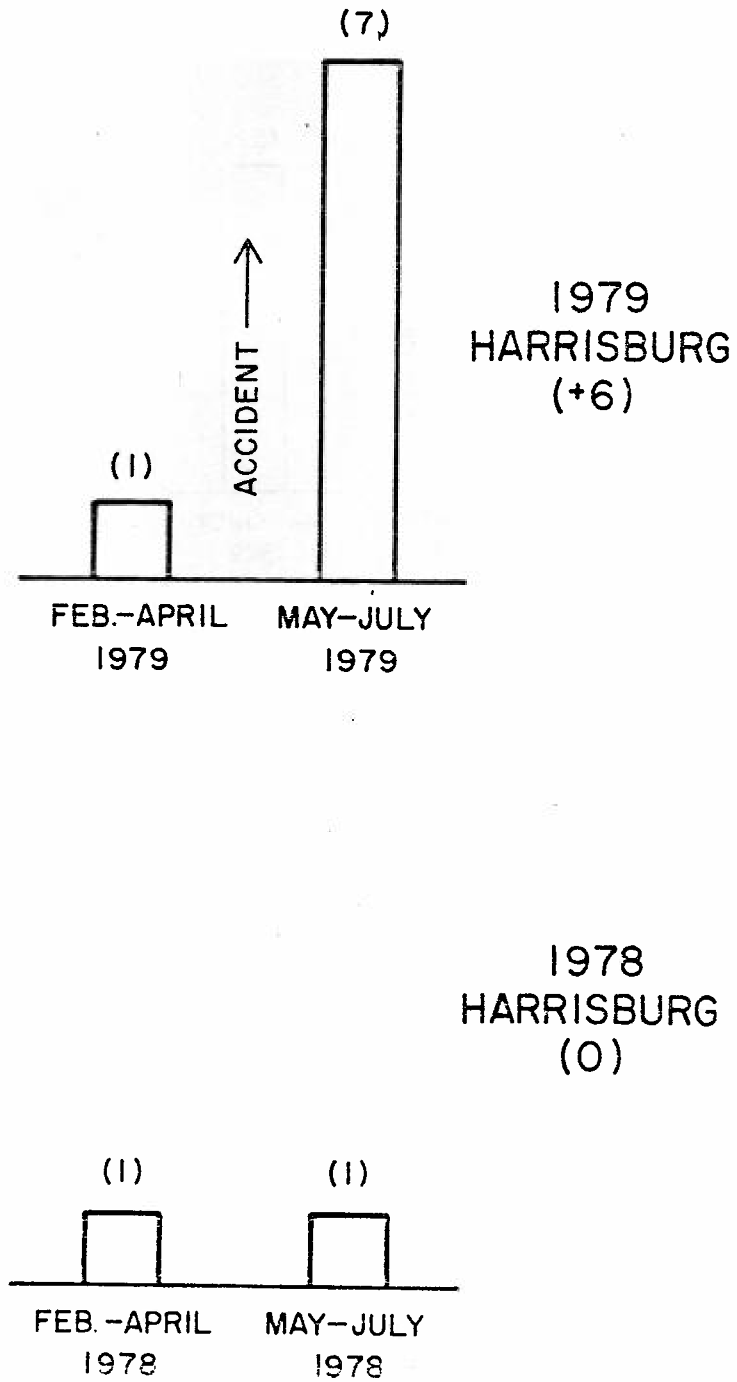
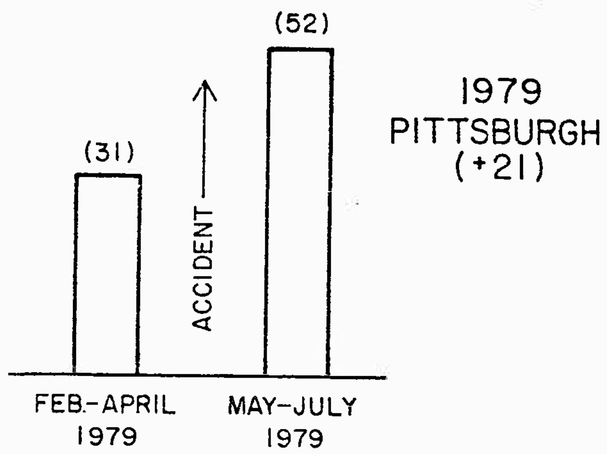


Figure 8. Newborn infant deaths in the Harrisburg Hospital for three month periods before and after the accident at Three Mile Island, March 28, 1979. Figures in brackets represent the change in the number of deaths. Note the absence of any increase in May/June/July of 1978.



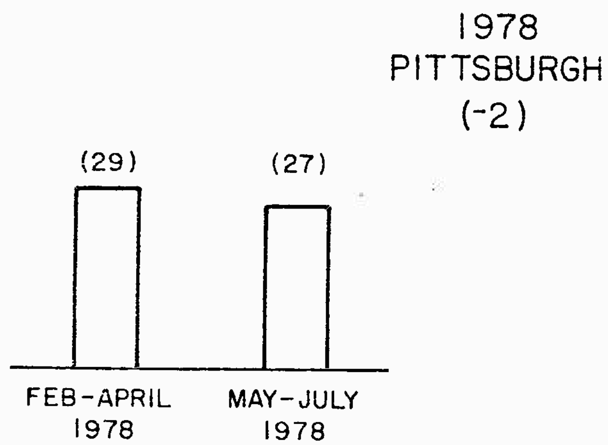


Figure 9. Newborn infant deaths in Pittsburgh (Magee Hospital) for 3 month periods before and after the Three Mile Island Accident of March 28, 1979. Note the absence of any rise in May/June/July of 1978.

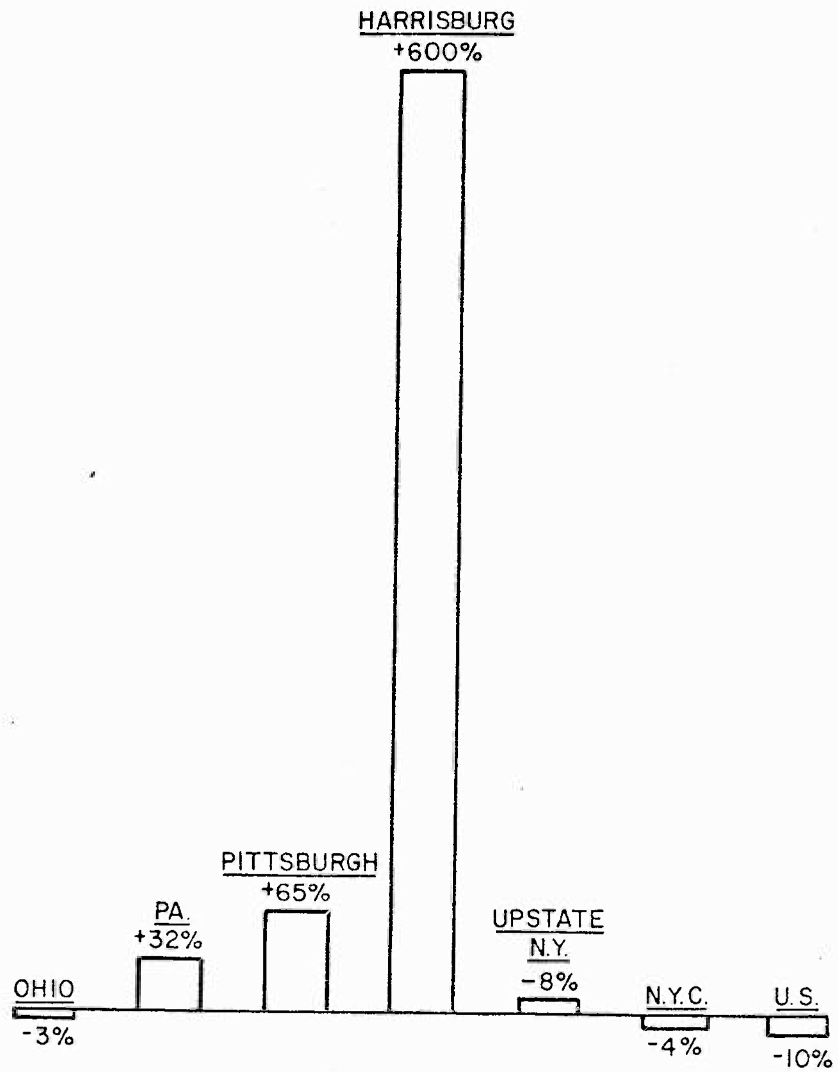


Figure 10. Geographical pattern of newborn infant mortality changes at various distances from the Three Mile Island plant located 10 miles south of Harrisburg. Figures represent percent changes between February/March/April and May/June/July 1979. Note that greatest rises occurred closest to the plant.

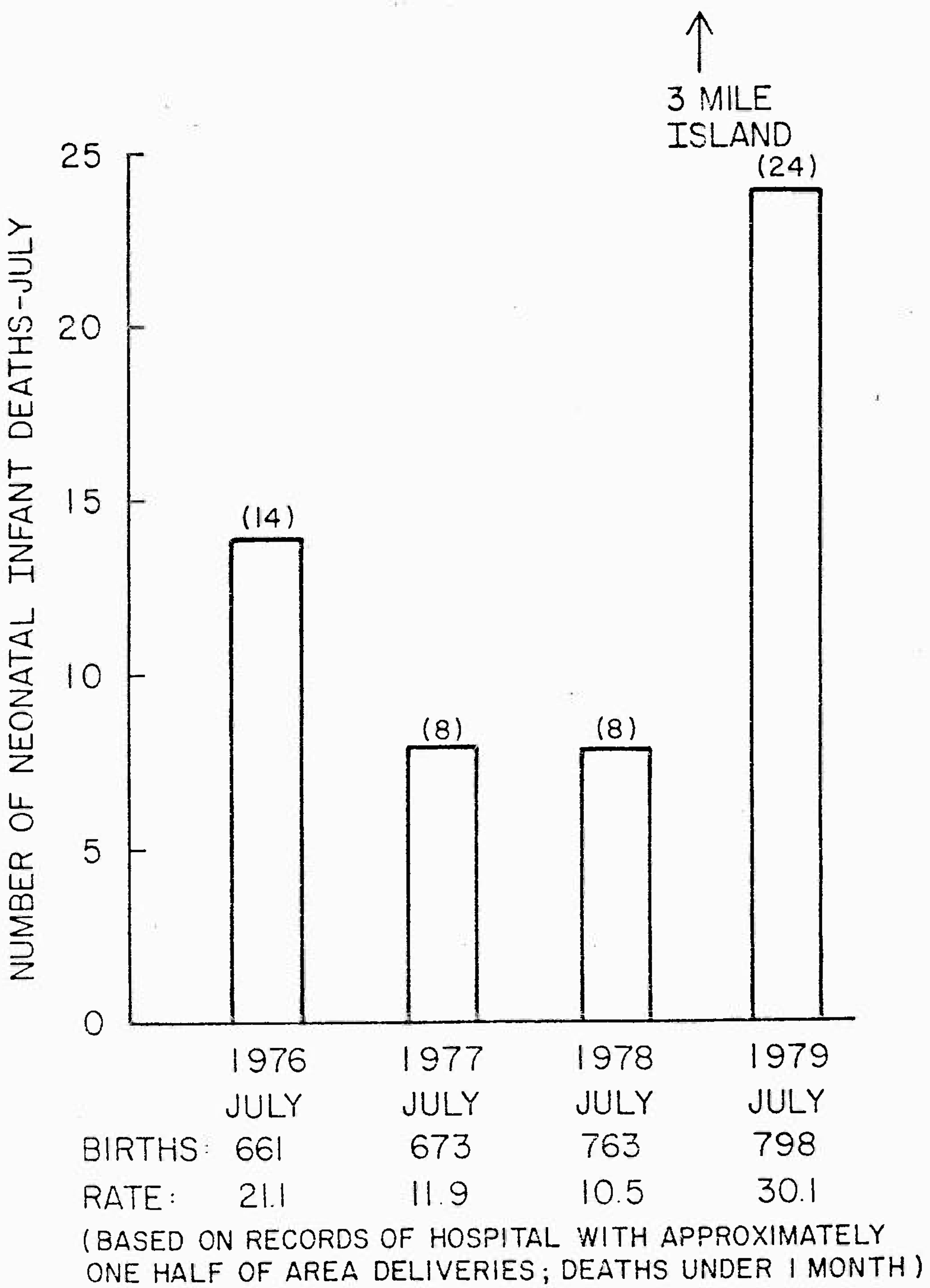


Figure 11. Trend in the July infant mortality rates in the Pittsburgh area before and after the Three Mile Island accident in March 1979. Numbers in brackets refer to the number of newborn infant deaths at Magee Hospital for the month of July 1976, 1977, 1978 and 1979. Note that the death-rate tripled between July 1978 and July 1979.

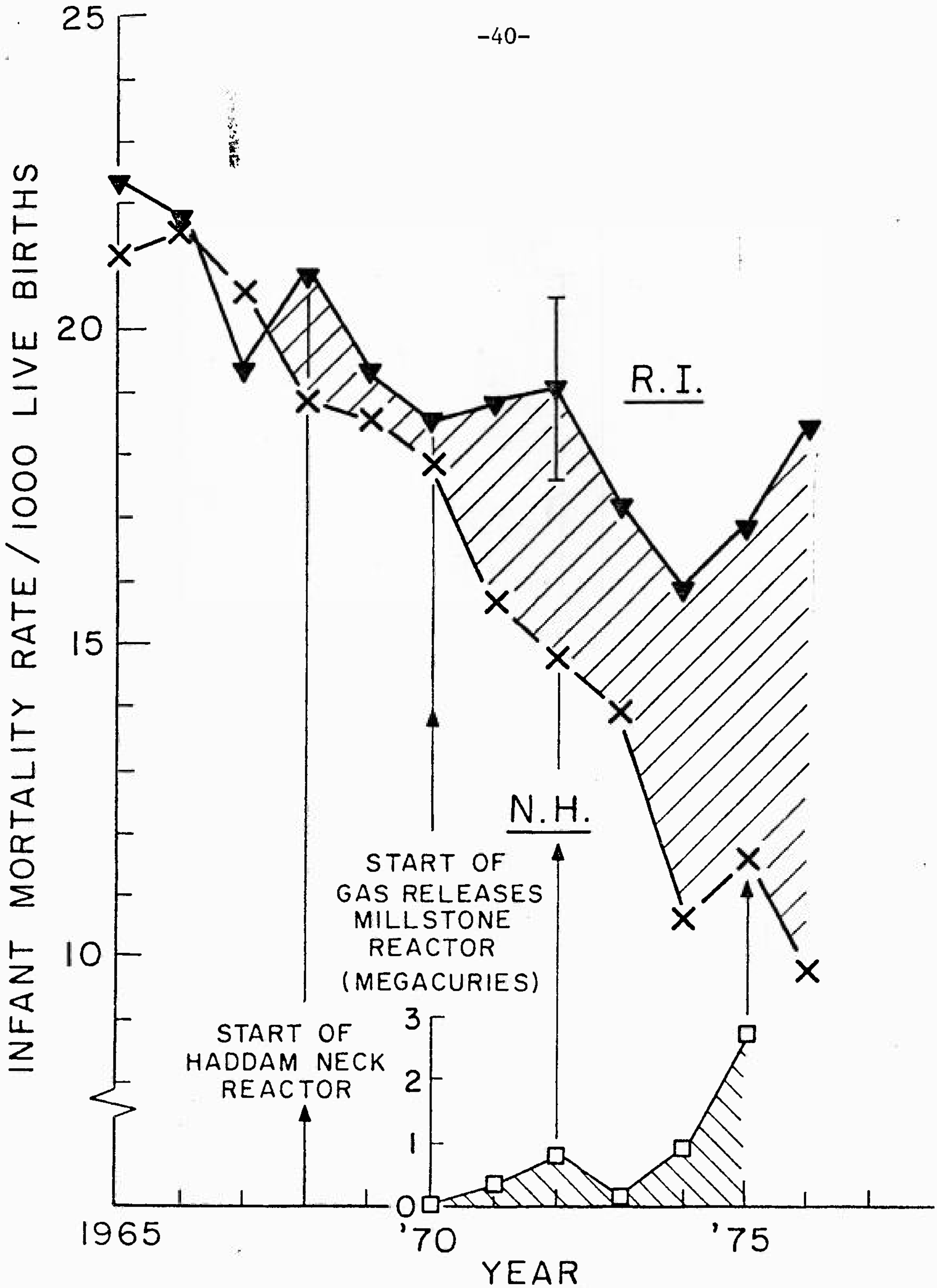


Figure 12. Infant mortality rate trends in Rhode Island 20-40 miles downwind from the Millstone Reactor in Connecticut between 1965 and 1975 compared with the rate for New Hampshire more than 100 miles to the north. Also shown are the annual releases of gaseous radioactivity in millions of curies. Note the widening gap between the two states indicated by the shaded area following the start of nuclear reactor operations.

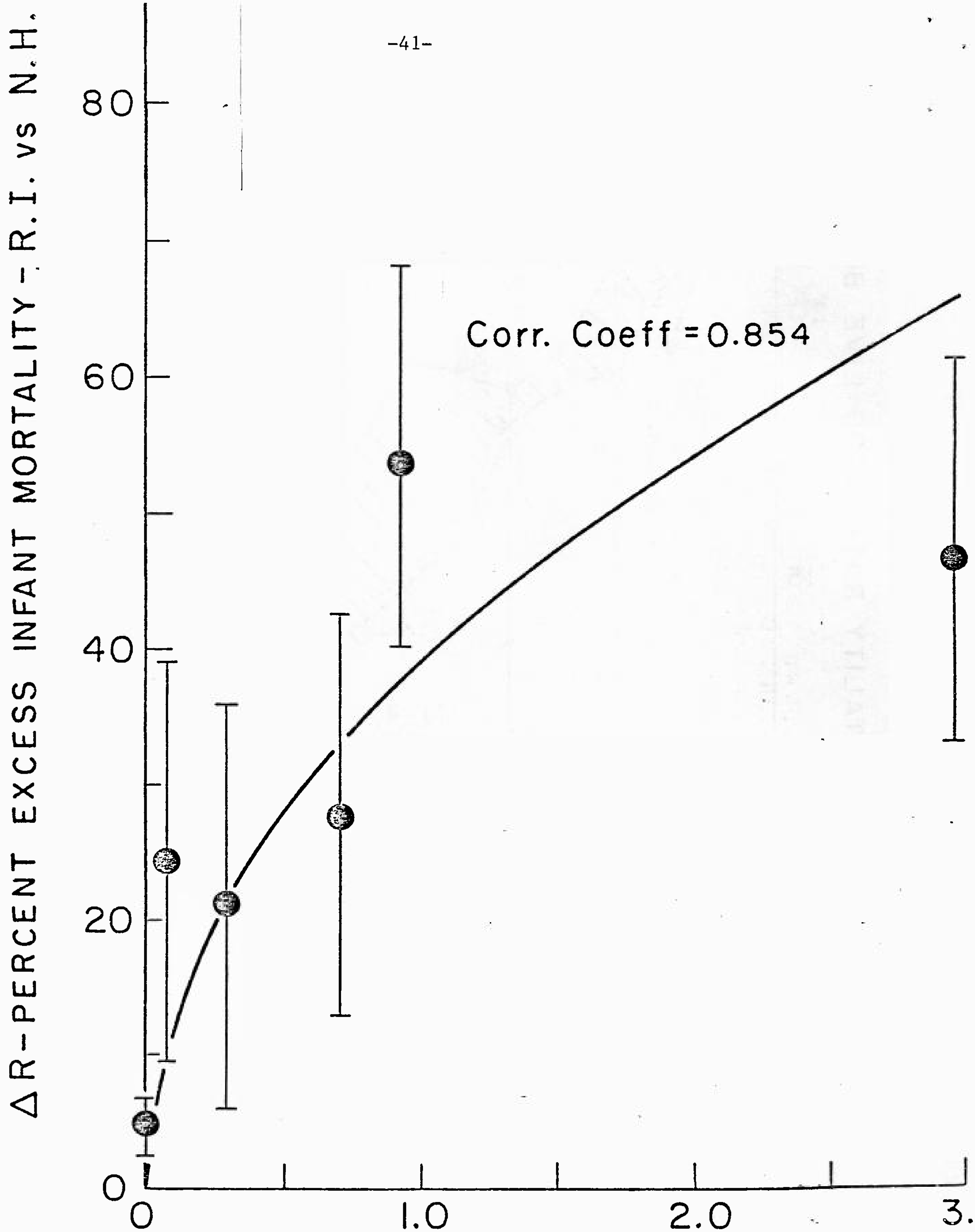


Figure 13. Percent change in the excess infant mortality in Rhode Island relative to the more distant state of New Hampshire as a function of the total gaseous radioactivity releases from the Millstone plant near the Rhode Island border taken from Figure 12. (Two year moving averages). Note that the data points are best fitted by a curve that rises more rapidly at low doses than at high doses.

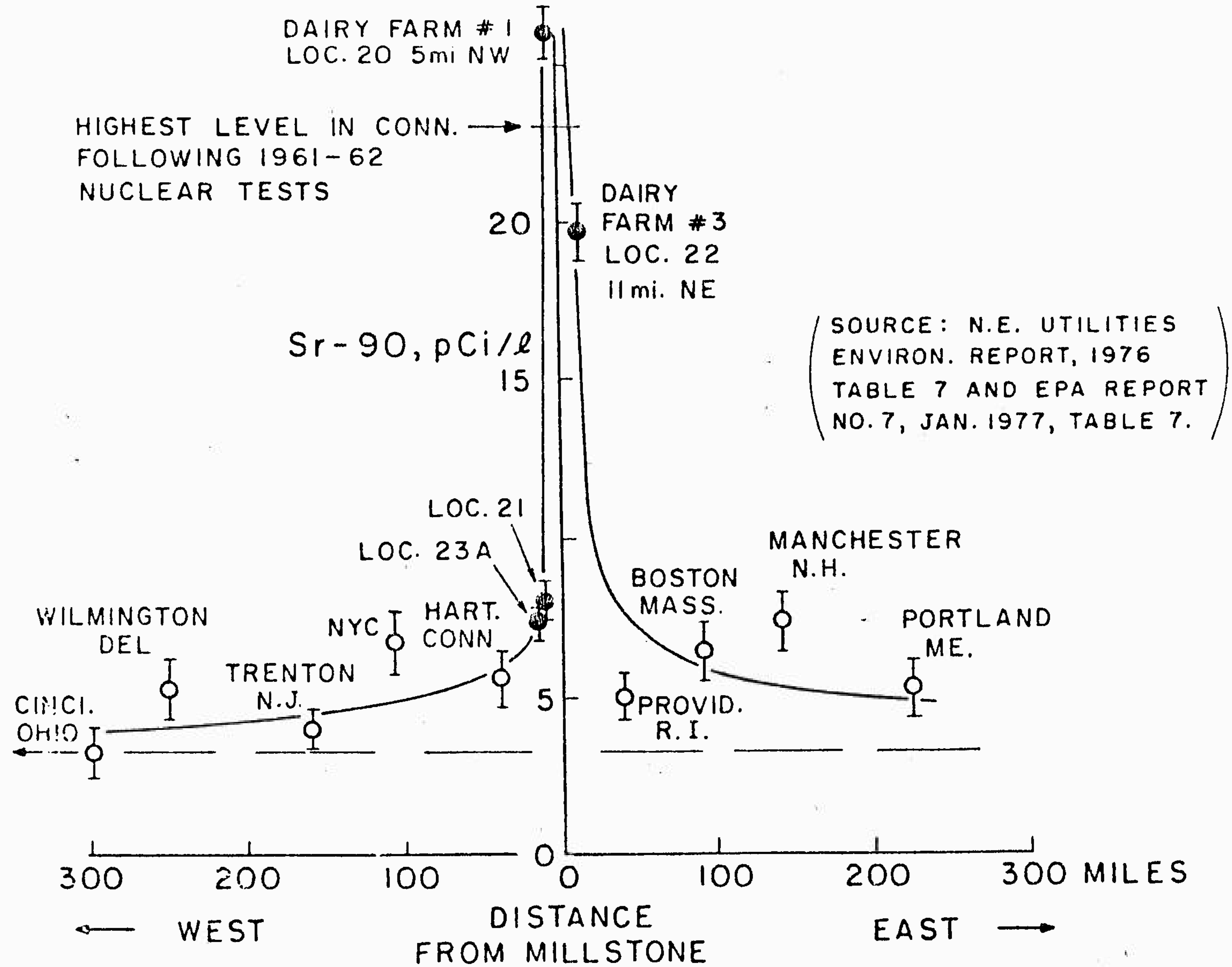


Figure 14. Geographical pattern of Strontium-90 in milk at different distances from the Millstone Nuclear plant near Waterford, Connecticut for July 1976. Solid points represent the samples collected by the utility, open points represent EPA measurements. Note that the concentrations measured nearest the plant are close to those measured during heavy nuclear weapons testing in the early 1960's.

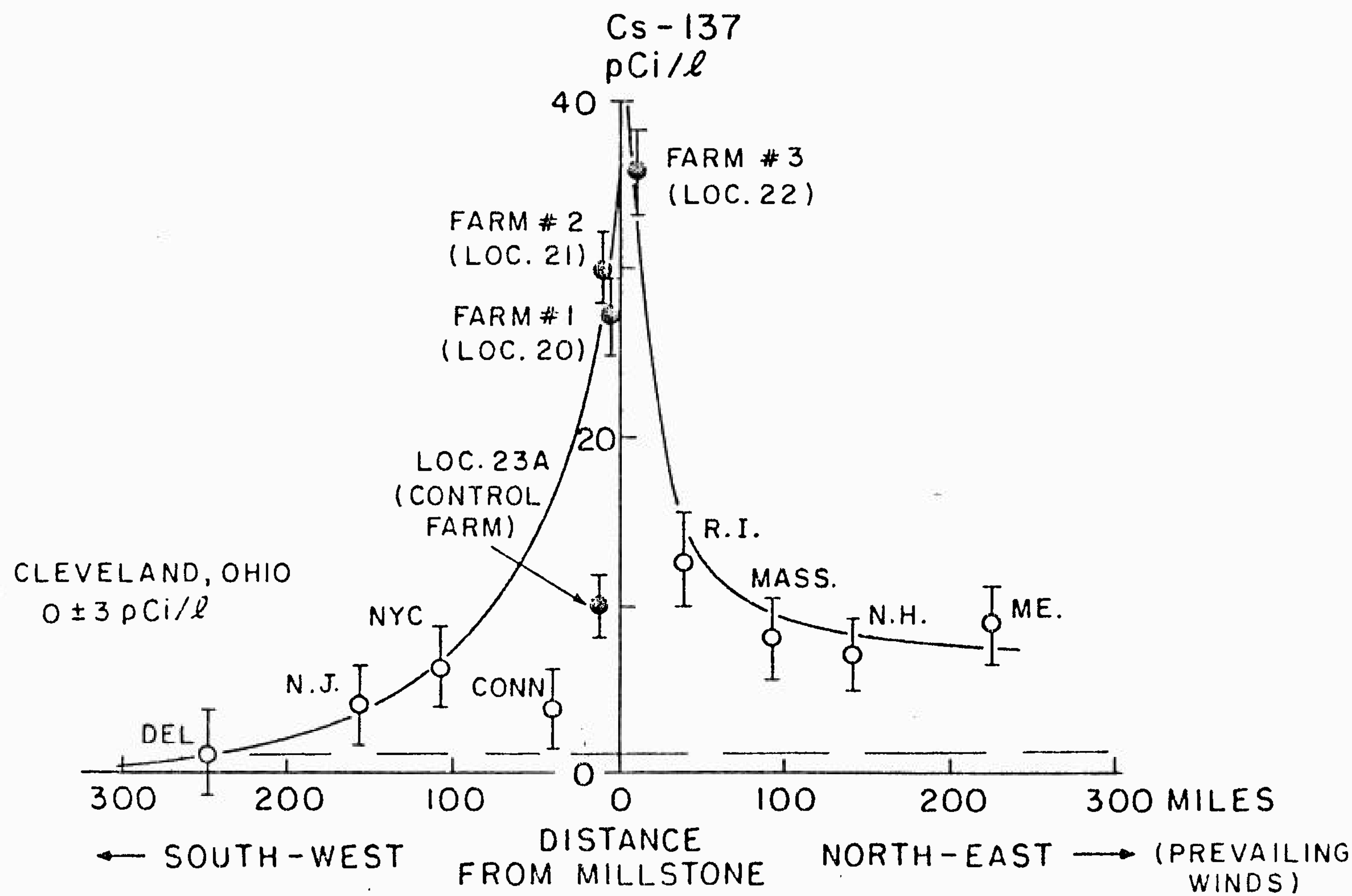


Figure 15. Geographical pattern of Cesium-137 concentrations in the milk at different distances from the Millstone Nuclear plant in August of 1976. Solid points represent data collected by the utility, open points EPA data. Note that highest levels near the plant are three times greater than for the control form (Location 23A), and as much as 10 times greater than for the upwind locations in New Jersey and New York City.

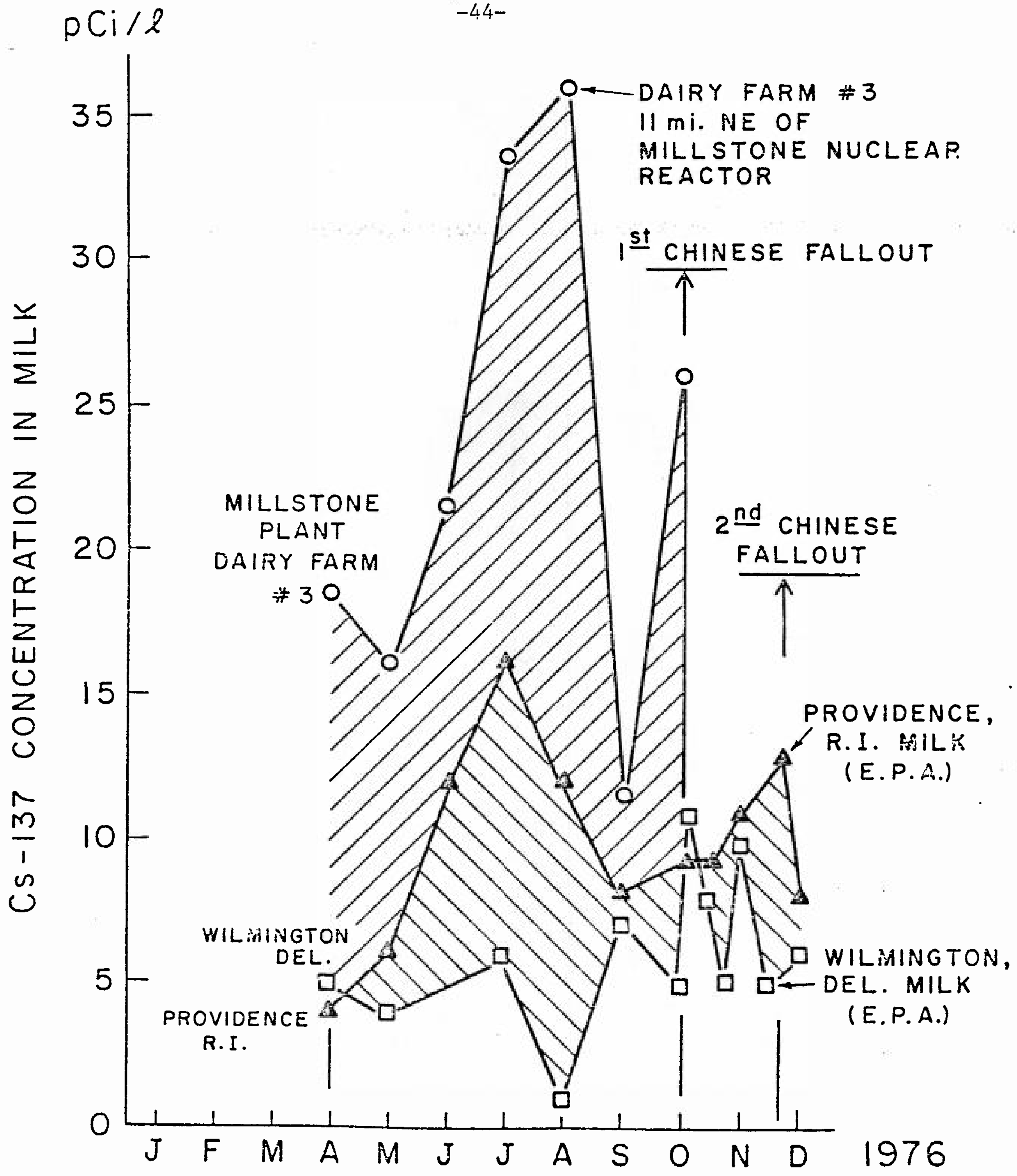


Figure 16. Changes in monthly values of Cesium-137 concentrations in milk in 1976 for three different locations at different distances from the Millstone Nuclear Reactor in Waterford, Connecticut. Note that the largest value occurred closest to the plant in August 1976, the next largest in Providence, Rhode Island, and the lowest in Wilmington, Delaware far to the south. Furthermore, it occurred before the nuclear test by China in September. Also note that the peak associated with the arrival of the heavy fallout from the September 1976 Chinese atmospheric bomb test has a lower magnitude than the July/August maximum measured near the plant, further indicating that the high Cs-137 levels near the plant cannot be attributed to fallout from Chinese bomb tests.

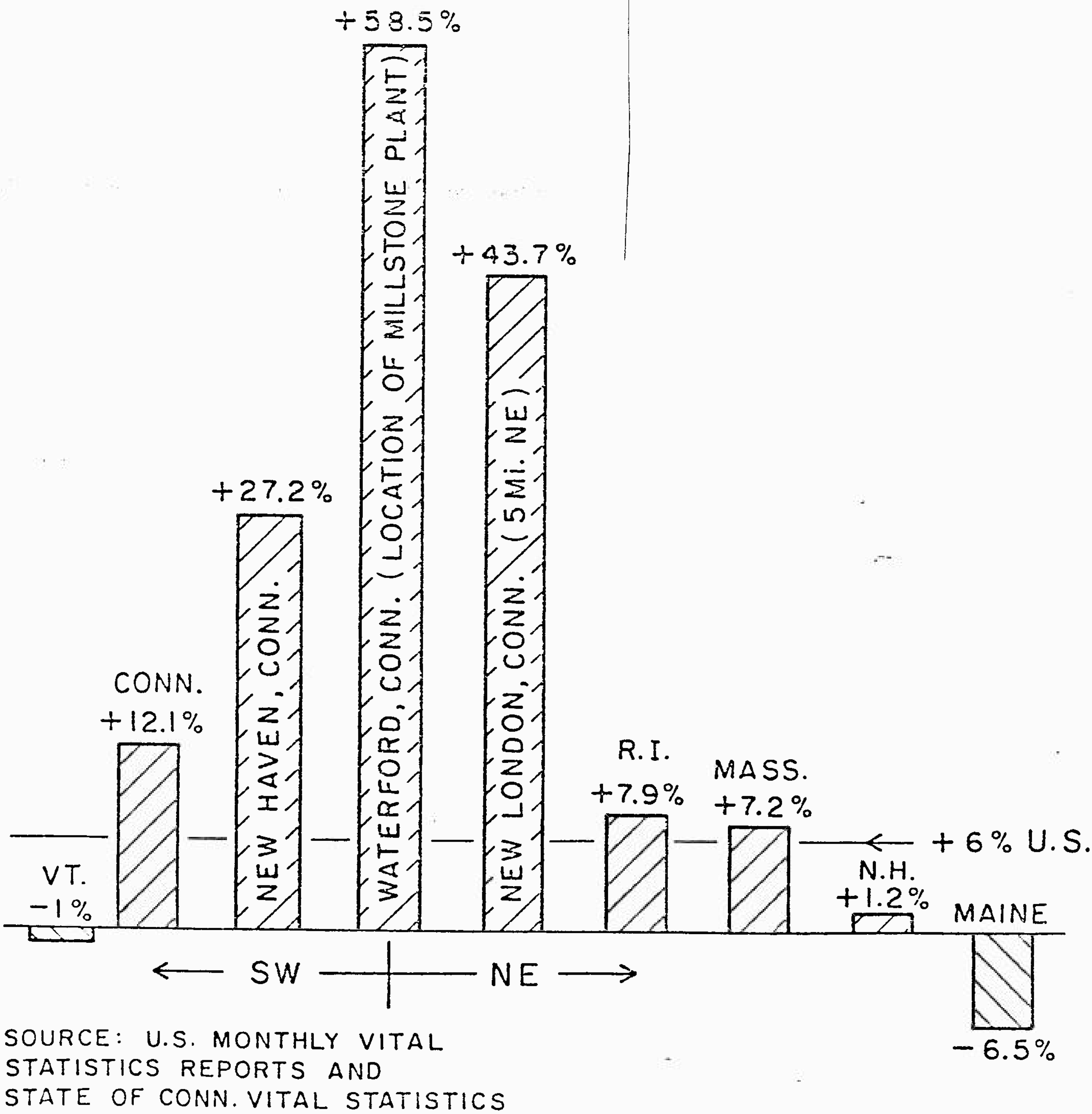


Figure 17. Geographical pattern of cancer mortality changes near the Millstone Nuclear Reactor in Waterford, Connecticut between the start of the plant in 1970 and 1975. Note that this pattern is similar to that of the Sr-90 and Cs-137 concentrations in milk of Figure 15 and 16.

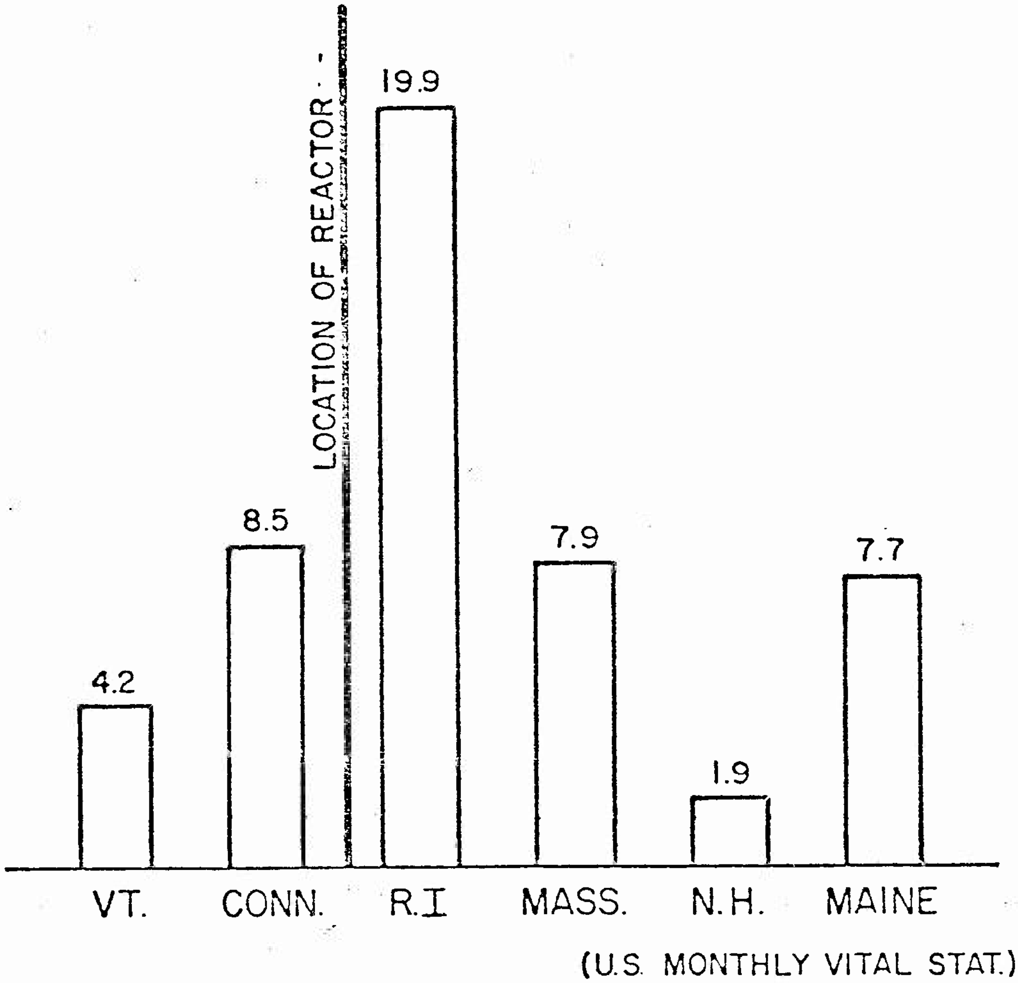


Figure 18. Geographical pattern of infant mortality changes at different distances from the Millstone Nuclear Power Station located near the border between Connecticut and Rhode Island. Note the high rate downwind from the plant in Rhode Island.