STONY BROOK
Health Sciences Center

School of Medicine
Department of Preventive Medicine

February 2, 1998

Kathy Geiger
Brookhaven National Laboratory
Building 460
Upton, NY 11973-5000

Dear Ms. Geiger:

Enclosed is a copy of the Suffolk County Task Force's report regarding health in communities surrounding Brookhaven National Laboratory.

Any questions or comments are welcome.

Sincerely,

Roger Grimson

Roger Grimson, PhD
Chair
BNL Environmental Task Force

RG:lm

Enclosure

State University of New York at Stony Brook
Stony Brook, New York 11794-8036
516-444-2190 fax: 516-444-7525

CONTENTS

Task Force Members

Executive Summary

1. Introduction 1

1.1 Task Force 1
1.2 The Epidemiologic Objective 1

2. Methods 2

2.1 Cancer Types Considered 2
2.2 Methods of Assessing Risk 3
2.3 Unstable Rates and Small Numbers 4
2.4 The Geographic Regions for Which Cancer Rates are Presented 4
2.5 The Time Frame for Cancer Rates 5
2.6 Comparing Cancer Rates 6
2.7 Congenital Malformation Rates 6

3. Results 7

3.1 Cancer Rates for the Investigated Regions 7
3.2 Breast Cancer Incidence and Discussion 8
3.3 Rhabdomyosarcoma Incidence and Discussion 11
3.4 Congenital Malformation Incidence and Discussion 13

4. Pathways of Exposure 13

5. Limitations 14

6. Conclusions 15

7. Recommendations 15

Acknowledgments
References
Figures 1-6
Tables 1-23
Appendix 1: Definition of Cancer Rate
Appendix 2: Stability of Rates

Task Force Members:*

Jane Alcorn, Chair Radiation Committee
Wading River, NY

G. Anders Carlson, Ph.D.
Bureau of Environmental Exposure Investigation
New York State Department of Health

William Graner, P.E., Ph.D.
School of Engineering and Technology
New York Institute of Technology

Roger Grimson, Ph.D., Chair Task Force and Chair Epidemiology Committee
Department of Preventive Medicine, H.S.C.
SUNY at Stony Brook

Amy Juchatz, M.P.H., Chair Non-Radiation Committee
Smithtown, NY

Glenn Harvey Alcalay, Ph.D. Candidate at The New School for Social Research
Social Anthropology
City College of New York and Dowling College

James C. Maloney, M.S., P.E.
Suffolk County Department of Health Services

Ronald Stanchfield, M.A., Vice Chair Task Force
East Hampton, NY

Gordon Rieckhoff
Yaphank, NY

Karim Rimawi, Ph.D.
Bureau of Environmental Radiation Protection
New York State Department of Health

Dawn Triche, M.L.S., Co-Chair Epidemiology and Non-Radiation
East Yaphank, NY

* Four additional members resigned during the 15 month tenure of the Task Force for reasons involving moving, conflict of interest and commitment.

Report to the Suffolk County Legislature
From
The Brookhaven National Laboratory
Environmental Task Force

Evaluation of Allegations of Contamination and Risk Associated with the Operation of Brookhaven National Laboratory

Part I: Epidemiology
Jan. 26, 1998

Roger Grimson, PhD
Dawn Triche, MLS

EXECUTIVE SUMMARY
of the Epidemiology Report

The Brookhaven National Laboratory Task Force, created by the Suffolk County Legislature, worked from October 1996 through January 1998 to respond to its objective of assessing allegations of harm to the environment or to the public health in communities in close proximity to Brookhaven National Laboratory (BNL), due to the operations of BNL. To address its objective, the Task Force created three subcommittees: Epidemiology for assessing cancer and congenital malformation incidence in targeted communities, and, Radiation and Non-Radiation for addressing environmental and exposure issues regarding radiation and chemicals, respectively.

For technical reasons described herein, the Task Force's report to the Legislature will be presented in three parts (epidemiology, radiation and non-radiation) within a few weeks of each other. Also under separate cover, a general executive summary and a set of recommendations from the Task Force is being prepared.

This executive summary pertains specifically to the epidemiologic work.

The Task Force studied geographic patterns of the following cancers: thyroid, leukemia, non-Hodgkin's lymphoma, brain and nervous system, female breast, prostate, liver, bone, multiple myeloma, and childhood rhabdomyosarcoma. Also, the Task Force studied geographic patterns of the following congenital malformations: major malformations (as a group), chromosome anomalies, Down's syndrome, tracheoesophageal fistula, hip dislocation, neural tube defect, anencephaly, spina bifida, microcephalus and a group of rare mutations not inherited termed the "surveillance mutation group".

The decisions regarding the kinds of cancers and malformations to investigate were reached with the assistance of medical and environmental consultants on the basis of the potential for environmental causes and feasibility. Feasibility for the cancer work was determined by time (measured in months) required for geocoding.

Each cancer was studied in the following manner. A circle of a 15 mile radius was inscribed around BNL. The reason for the choice of 15 miles is not arbitrary; it was suggested a few years ago, based on properties of radiation, by investigators who examined breast cancer incidence rates within 15 miles of BNL and it has been used by the New York State Department of Health. The choice of 15 miles is discussed further in the report. Next the circle was partitioned into four "pie-shaped" regions. These regions are oriented in north, south, east and west directions in order to have optimal concordance with predominant groundwater plume directions (south) and wind directions (east).

Next, age adjusted cancer rates for the circle (and for each of its regions), for regions east and west of the circle and for Nassau County were requested from the New York State Cancer Registry for all of the above listed cancers.

The congenital malformation data were received from the Congenital Malformations Registry on the county level because partitioning Suffolk County into smaller regions was not

possible for these data. Malformation rates were calculated for Suffolk County, Nassau County, NY City and Upstate NY (which is the rest of NY State). The congenital malformation data covered the 12 year period 1983-94, for which data are available. All malformation rates are similar between Suffolk County and the other regions for each malformation type, with the exception of congenital hip dislocation. This malformation was higher for Suffolk County than for Nassau County and NY City, but the Suffolk rate is about the same as the Upstate rate.

The conclusions of the epidemiologic cancer study are that (1) cancer rates of all types of cancers studied are not elevated near BNL and (2) there is no evidence that rates among the four sectors are significantly different from each other or are correlated with underground plume or wind directions. Also, there is no evidence that childhood rhabdomyosarcoma incidence is elevated in Suffolk County or in the circle encompassing BNL during the study period 1979-93 for which the Registry rhabdomyosarcoma data were available at the time of the request.

Interested Suffolk County residents have been identifying more recent cases of childhood rhabdomyosarcoma. This effort should be helpful in the event that an epidemiologic study of rhabdomyosarcoma will be conducted, but the data obtained so far do not comprise evidence of clustering, or of associations with BNL.

An unexpected finding is that the age adjusted female breast cancer rate on the "east end" of Long Island is significantly elevated (129 per 100,000 women) compared with rates of other areas (e.g. the Nassau County rate of 117 per 100,000 and the NY State rate of 106 per 100,000). This elevated East End rate is not attributable to BNL for reasons discussed in this report. Several informative maps pertaining to breast cancer are provided.

Specific recommendations to the Suffolk County Legislature regarding activities in the interest of public health are given at the end of the report.

1. *INTRODUCTION*

1.1 The Task Force

In August of 1996 the Suffolk County Legislature created the Brookhaven National Laboratory Task Force (Resolution Number 1726-96) for the purpose of evaluating allegations of environmental contamination and public health risk in communities surrounding Brookhaven National Laboratory (BNL) and which are associated with the operation of BNL. This legislation resulted from mounting public concern regarding environmentally harmful events occurring at BNL [DOE 90, DOE 97].

The Task Force is comprised of individuals of diverse backgrounds and interests. Over half of the members are scientists or engineers. Two are librarians. Five live within 15 miles of BNL. About one-third (four) have been involved in antinuclear work. Four are on faculties of four different Universities. Two are employed by the NY State Department of Health and one is employed by the Suffolk County Health Department.

The Task Force began its investigations in October of 1996 and is completing its work in January of 1998. The Task Force held four public hearings, held 15 open meetings, interviewed numerous Suffolk County residents and scientists and conducted scientific work and statistical analysis. The Task Force partitioned itself into three subcommittees: Epidemiology, Radiation, and Non-Radiation. Each subcommittee held numerous meetings and extended those activities described above for the Task Force. This represents an intense amount of work during the 16 month period for all members of the Task Force.

Members of the Task Force agreed that the final report to the Legislature would be structured around the three subcommittees' work, which represents a natural division of community concerns and which is reflected in the language of the legislation. Also, it was decided that each subcommittee would make recommendations to the legislature in its own part of the report but that a separate part of the report be relegated to recommendations decided by vote of the entire Task Force. This plan has been maintained but due to different dates of completion of each subcommittee's work and to the need for the Task Force to issue a timely written report after hosting a press conference regarding its epidemiologic work that was already being discussed publicly, the report is being presented, not under one cover as separate chapters, but as separate parts:

Part I:	Epidemiology
Part II:	Radiation
Part III:	Non-Radiation
	Summary and Recommendations

The findings of the epidemiology committee are presented in this part, Part I.

1.2 The Epidemiologic Objective

Epidemiology concerns patterns of disease occurring within a community of people.

The primary epidemiologic objective of the BNL Task Force is to describe cancer incidence in Suffolk County according to proximity to BNL. Incidence patterns of the types of cancers most likely to be associated with radiation and chemical exposure will be described. Of all diseases, cancer has been voiced as the disease of greatest concern regarding possible associations with BNL, and cancer was singularly mentioned in the legislation that created the Task Force.

New York State operates a cancer registry and a congenital malformations registry which enable investigators to conduct incidence studies in varied geographic settings for these health outcomes. These registries are part of the State Department of Health (NYSDH). Consequently, in addition to the more detailed analysis of cancer incidence, this report will provide information regarding incidence of certain types of congenital anomalies. Incidence patterns of other diseases which are not reportable cannot be studied in this relatively simple manner.

Mortality statistics compiled by the Vital Statistics Section of NYSDH on the basis of recorded death certificates, could be used for mortality studies of cancer and other diseases. However, for technical reasons, incidence studies are preferable to mortality studies where the objective is the identification of environmental correlates of the incidence of disease.

Epidemiology is not a science for directly determining causes of disease. Epidemiology is about determining correlates of the incidence of disease. "Correlate" (or statistical association) and "cause" have widely different meanings. However, "correlate" can be an imperfect but useful and manageable substitute for "cause" in epidemiology. Sometimes upon lengthy processes of confirmation, a correlate may come to be established as a cause (e.g. cigarette smoking and lung cancer). The use of mortality statistics in lieu of incidence statistics simply imposes another layer of obscurity on the search for cause and effect. (Section 5 on limitations further discusses rate based studies).

Several consultants and witnesses, which include local residents, contributed to the work that resulted in this report; see the Acknowledgments.

2. *METHODS*

2.1 *Cancer Types Considered*

The following list itemizes the types of cancers discussed in this report, and it provides an abbreviated rationale for their selection. Ascertainments of incidence patterns on a geographic level smaller than the county level require laborious geocoding, which underscores the importance of prudent selection of the types of cancers investigated here.

Lung cancers were not requested because information in the Cancer Registry about the predominant cause of lung cancer, cigarette smoking, is incomplete. Possible attributions to lung cancer from the environment cannot properly be assessed without controlling for the effects of smoking.

Information on cases of pituitary adenomas was originally requested, but the State Cancer Registry does not register these tumors because most are benign tumors.

The types of cancers, along with their International Classification of Disease codes (ICD 9 codes), considered in this report are:

Thyroid cancer: Association with radiation exposure, including past nuclear reactor mishaps (Chernobyl). (IDC 9 code 193).

Leukemia: Association with radiation and solvent exposure (ICD 9 codes 204-208).

Non-Hodgkin's Lymphoma: Associated with radiation exposure. Possible link with pesticide exposure. (ICD 9 codes 200 and 202).

Brain and Central Nervous System Cancer: Concern regarding possible links to certain environmental agents, including solvents, ionizing and non-ionizing radiation. (ICD 9 codes 191, 192 and 225 [benign brain]).

Female Breast Cancer: Concern regarding association with various environmental exposures. Association with radiation therapy. (ICD 9 code 174).

Prostate Cancer: Geographic correlations with breast cancer. Suspected association with exposure to environmental agents, notably solvents and heavy metals (cadmium). (ICD 9 code 185).

Liver Cancer: Animal studies and limited human studies suggest organic solvents may be a factor. (ICD 9 code 155).

Bone (osteogenic sarcomas): Association with radiation therapy, prenatal x-rays, possible viruses and chemicals. Linear dose effect. (ICD 9 code 170).

Multiple Myeloma: Rates elevated among radiologists and workers in nuclear processing plants, suggesting long-term dose exposures. (ICD 9 code 203).

Rhabdomyosarcoma (Childhood): Radiation therapy. Possible prenatal factors. Community concern. (ICD 9 morphology codes 89003, 89013, 89103, and 89203).

2.2 *Methods of Assessing Risk*

This report presents average annual age-adjusted incidence rates for each of the above listed cancers, excluding childhood rhabdomyosarcoma, for which unadjusted rates are appropriate.

Appendix 1 provides a discussion of cancer rates for readers who are unfamiliar with rates and wish to better understand them.

In addition to rates, this report presents the numbers of the cases of each cancer type studied, the population census counts on which the rates are based and other statistics as introduced in context.

2.3 *Unstable Rates and Small Numbers*

The National Center for Health Statistics (NCHS), in its reports, identifies rates that are based on fewer than 20 events, such as deaths or cases (Appendix 2). These "flagged" rates should be "interpreted with caution", meaning that they are unreliable or unstable rates. Unstable rates are flagged by the symbol "†". Most (probably all) state health departments flag rates that are based on fewer than some similar number of events. This report flags rates that are based on fewer than 20 cases. Appendix 2 provides a quantitative definition of rate stability.

The degree of stability or precision of the estimates of each rate reported here is given by a confidence interval. A definition of confidence interval is given in Appendix 1.

Rates for regions within counties that have some cases but fewer than six cases are not reported by the State, and subsequently are not reported here. This policy, sometimes referred to as the "rule of six", protects confidentiality of cancer patients. Information about cases in a community with few cases could lead to the identification of a case, thus violating State confidentiality protection policies. If in a given region no cases are diagnosed then confidentiality is not an issue and the corresponding rate of zero is reported for that region.

2.4 *The Geographic Regions for Which Cancer Rates are Presented*

Suffolk County is partitioned into seven regions for purposes of this study. These regions are constructed as follows. First, a circle of a 15-mile radius is inscribed around the approximate geographic center of BNL which is denoted by a star in Figure 1. This center also is approximately the center of Census Tract 1587.10, the census tract containing Upton, the village identification of BNL.

Drs. E.J. Sternglass and J.M. Gould argued that the greatest health effects due to external and internal doses of iodine-134 would be expected to occur within a distance of 10 miles or 15 miles of BNL [STERNGLASS 94]. The rationale is based on the half-life of iodine-134, wind velocities and other physical matters. Also, the New York State Health Department has used the 15-mile radius in unpublished maps. So use of the 15 mile radius has a history, and it is retained here for analysis; to change this distance without justification would be inappropriate.

Next, the circle is partitioned into four "pie-shaped" sectors: north, south, east and west. (See Figure 2.) These orientations correspond optimally albeit imperfectly with predominant plume flow and wind directions. Census Tract 1587.10 is denoted in Figure 2 by double boundary lines.

It is important to realize that the 15-mile circle <u>includes</u> Census Tract 1587.10 (BNL), and that, although the study objectives pertain to the circle as a whole, the circle may be invisioned as composed of the four sectors (N,S,E,W), and, Tract 1587.10 (center).

Census tracts are the smallest geographic units from which the investigated regions can reasonably be constructed. Because census tracts are of various sizes and shapes, the circle and its four sectors are approximated by tracings of boundaries of census tracts. These are represented in Figure 2 by the heavier boundary lines.

Figure 3 closely corresponds to the inscribed area and is useful in identifying townships within the 15-mile radius (30 mile diameter) circle and its sectors.

Table 1 identifies the census tracts for each of the four sectors.

The regions of Suffolk County extending to the east and to the west of the circle comprise the two Suffolk County regions furthest away from BNL.

Census Tract 1587.10, the four sectors minus this tract, and the eastern and western parts of the County, therefore, comprise the seven regions for which cancer rates are described in Suffolk. For further comparison, Nassau County rates and State rates exclusive of New York City are provided in a summary table. (Routinely, NYSDH excludes city statistics from analysis in some reports due to demographic reasons.)

For most cancer types, the "rule of six" applies to Census Tract 1587.10, the tract containing BNL, because of its relatively small population size. For these cancers, the number of cases and the population in Census Tract 1587.10 are incorporated within the western sector of the circle because it appears that most residents of 1587.10 reside on the west side of 1587.10. In fact, it makes little difference with which sector the 1587.10 cases and population are included, since the numbers of these cases and residents are very small in comparison with those of the sectors.

Table 2 lists the regions of Suffolk County for which rates are described in this report and it gives the 1990 male and female population census counts used in the calculations (denominators) of the rates.

Geocoding, which is the determination of the census tract of residence of the cases from addresses collected at the time of diagnosis by the NY State Registry, was accomplished by Registry personnel.

2.5 *The Time Frame For Cancer Rates*

Early in 1997 The Task Force requested cancer statistics covering the most recent five year period for which cancer incidence data were available, which, at that time, was the period between 1988 and 1992. At the time of this request, 1992 was the most recent year for which registry data was complete. A five-year period offers maximal stability of rates while not being too long for the required geocoding to be completed in time for completion of this report.

As the 1993 cancer incidence data file was being completed during this time, cancer registry personnel determined that the geocoding and associated computations for the 1993 data could be completed soon enough to coincide with the Task Force's schedule. Thus, the cancer

rates described in this report pertain to the most up-to-date six year period, 1988-93.

The 1990 census population counts comprise the denominators of these rates (Table 2).

2.6 *Comparing Cancer Rates*

Confidence intervals are given in the tables of results. If, when comparing rates between two regions, the two confidence intervals do not overlap, so that a range of numbers exist between them, then the prospect is raised that a significant difference exists between the rates, that is, the difference between the two rates is likely to be caused by something other than chance. Where this occurs, further testing will be conducted to assess significance at the usual $\alpha = 0.05$ level.

The following illustration may be helpful: The confidence intervals (5,10) and (8,18) overlap, and the confidence intervals (5,10) and (12,18) do not overlap. Thus the two (hypothetical) rates for whom the latter two confidence intervals belong will be set aside for further analysis.

2.7 *Congenital Malformation Rates*

The Congenital Malformations Registry of the NYSDH provided the Task Force with the data to calculate rates for select kinds of malformations. These data cover the 12-year span of time for which they were collected and processed electronically to date, 1983-94.

Average annual congenital malformation rates were calculated for four regions that together comprise the State of New York: Suffolk County, Nassau County, NY City and Upstate NY. Here, Upstate NY is the State minus New York City and Nassau and Suffolk Counties. The rates are expressed in terms of 100,000 live births.

The analysis focuses on a longer time period and larger geographic regions than does the analysis of the cancer data (except for the cancer rhabdomyosarcoma) because the frequencies of occurrence of congenital malformations are small. Compared with the cancer data, the geographic resolution of the malformation data is poor. The 15-mile radius circle could not be used; the congenital Malformations Registry is not equipped to geocode data to census tracts or to groups of census tracts. They can report zip codes for cases, but to do so for these data would have repeatedly violated the "rule of six".

Therefore, the analogous question of interest examined in the cancer data analysis, namely the question of whether malformation rates in Suffolk County are higher in communities near BNL than in communities away from it, cannot be answered.

Nevertheless, analysis of county data received from the congenital Malformations Registry will be presented in Section 3.4

The selection of malformations studied here include malformations which (1) may be associated with parental exposure to ionizing radiation [Sever 88 ab] and (2) were suggested by a

NYSDH physician as possible environmentally caused malformations. These are listed as follows, as two malformation groups and as eight specific malformations:

Major Malformations:	(a group of malformations of obvious surgical, medical or cosmetic importance.)
Chromosome Anomalies:	(ICD 9 code 758)
Down's Syndrome:	(ICD 9 code 758.0)
Tracheoesophageal Fistula:	(ICD 9 code 750.3)
Hip Dislocation:	(ICD 9 code 754.3)
Neural Tube Defect:	(ICD 9 codes 740, 741, 742.0)
Anencephaly:	(ICD 9 code 740.0)
Spina Bifida:	(ICD 9 code 741)
Microcephalus:	(ICD 9 code 742.1)
Surveillance Mutation Group:	(rare mutations not inherited, ICD 9 codes 755.55, 755.59, 756.0, 756.4)

3 *RESULTS*

3.1 *Cancer Rates for the Investigated Regions*

Tables 3 to 19 give the results for the types of cancer (excluding rhabdomyosarcoma) discussed in Section 2.1. The paramount statistics for examination are the average annual age-adjusted rates, which are the numbers of cases per 100,000 people controlling for the effects of age (Section 2.2 and Appendix 1). Average annual rhabdomyosarcoma rates are the number of cases per 1,000,000, for people less than 20 years of age; Table 21 provides these rates.

The symbol "†" denotes particularly unstable rates, that is, rates based on fewer than 20 cases.

The symbol "*" denotes unreported rates as specified by the rule of six regarding confidentiality (Section 2.3).

Table 19 summarizes the main results from the more detailed Tables 3 through 18.

Breast cancer rates are discussed in Section 3.2.

Childhood rhabdomyosarcoma is discussed separately in Section 3.3 because this cancer is so rare that a different data collection approach, discussed in Section 3.3 was required. Also, community interest has focused on rhabdomyosarcoma.

Three comparisons resulted in non-overlapping confidence intervals:

The prostate cancer rate in that region of Suffolk east of the circle (103 per 100,000) is significantly larger than the rate in Suffolk west of the circle (74 per 100,000). However, the difference reflects a low rate west of the circle, not a high rate east of it. See Tables 8 and 19. The New York State rate is 103 per 100,000 and the Suffolk County rate is 84 per 100,000 based

on the six-year period. The New York State rate excluding the city is 109 per 100,000.

From Table 14 note that within the circle the female non-Hodgkin's Lymphoma rate is relatively low (5.2 per 100,000) in the eastern sector compared with the western sector (13.8 per 100,000) and compared with that of other regions (5, and, 5 and 6 combined) that do not include the eastern sector. Again, these differences result from a singularly low, not high, rate. No similar observation pertains to males.

The age adjusted female breast cancer rate for the region of Suffolk County east of the circle (129 per 100,000) is larger than the rate west of the circle (106 per 100,000). The rate in the circle representing residents nearest to BNL is between these two (113 per 100,000). See Tables 7 and 19 for these rate comparisons. The breast cancer rate for Census tract 1587.10 containing BNL is 126 per 100,000 female population but this rate is based on only 12 cases and is flagged as unstable. (See section 2.3 regarding unstable rates.)

It is not surprising that prostate cancer and breast cancer have a somewhat similar pattern. Correlations over geographic regions for these two cancers are often observed.

3.2. *Breast Cancer Incidence and Discussion*

The reported breast cancer rate of 126 per 100,000 for Census Tract 1587.10 is flagged as unstable because the number of cases, 12, that occurred in that tract during the six-year study period is less than the NCHS requirement of 20 cases (Appendix 4.2). Yet it is reportable because it meets the criteria of confidentiality ($\geq$ 6 cases). Moreover, there are other reasons for believing this rate is inaccurate. This instability and inaccuracy are discussed below. Following that, the rate of breast cancer east of the circle will be discussed.

This instability means that a difference of only one or two cases from 12 in either direction will result in widely varying rates. For rare tumors or small geographical regions, year-to-year chance variation of a large magnitude is typical. To illustrate this effect, suppose that instead of 12, 11 women were diagnosed in that tract during the six-year period. This is about an 8% decrease. Then the unadjusted rate (113.6 per 100,000 based on numbers in Table 2) would be decreased by about 8%. If the same decrease pertains to the age-adjusted rate (Appendix 1), then the 11 cases would result in a hypothetical adjusted rate of 116 per 100,000, close to the Long Island rate. This argument lacks rigor because it ignores the effects of age that removal of the hypothetical case would have on the adjusted rate, and, in general, the rationale may become more problematic as adjusted and unadjusted rates become farther apart. Nevertheless, an 8% decrease in the number of cases (one case in this situation) produces a notable reduction in the unadjusted rate and it would be expected to produce a notable reduction in the adjusted rate.

Effects of being off by one or two cases are less sensitive for large numbers (> 20) of cases. This is why statisticians and others who are familiar with and concerned about assessments of health events using statistical methods, place little or no confidence in rates based on small numbers. (See Appendix 2.)

(Essentially, the same conclusion regarding instability of the Tract 1587.10 breast cancer

rate is inferred from the wide 95% confidence interval provided for that Tract in Table 7. Appendix 1 gives the interpretation of confidence intervals.)

The illustration provided above wherein 11 women, rather than the reported 12, are diagnosed with breast cancer is not an unrealistic scenario. Approximately 5,200 people (visitors) reside for very short periods of time at BNL each year. The average stay is less than two weeks. About 75 people (researchers, post doctoral fellows, etc.) reside in BNL site housing for a year or more. Usually, their families reside there also. Some unknown number of such temporary BNL employees reside off-site. In fact some reside in other census tracts, and list as their address a BNL PO Box number. If a woman in this latter group is diagnosed with breast cancer and no street address can be found by consulting various references, then the Cancer Registry will attribute that cancer to the BNL Tract; yet she resides in another tract. That would inflate the rate for the BNL Tract (and deflate it for her actual residential tract.)

In fact, if a woman temporarily is residing in Tract 1587.10, be it for two weeks or two years, is diagnosed with breast cancer and that cancer is therefore assigned to Tract 1587.10, then the rate, of course, will be increased. Yet, probably that woman acquired the cancer while residing at a previous address, because the induction period (the amount of time required for a specific exposure to generate a diagnosis) for breast cancer for most cases is generally thought to be between 10 and 30 years.

Circumstances of this kind have more serious statistical consequences for small areas with small populations (e.g. census tract) than for large areas (e.g. counties), especially if the small areas have institutional housing and transient populations.

The breast cancer rate of 129 per 100,000 for women residing east of the 15-mile circle (Figure 1) requires attention.

The region east of the circle is comprised of Long Island's north and south forks, Shelter Island, Gardiners Island, Fishers Island and Plum Island. This region is just east of Quogue, Flanders and Jamesport, and may include parts of these villages. Precisely, it includes all Suffolk County Census Tracts east of Tracts 1699.00, 1904.01, 1904.02 and 1905.02 (Figure 2). This region corresponds roughly with what is generally referred to as the "east end", a geographic descriptor with no formal delineation, and, evidently, with some variation from person to person. For convenience, this report refers to the Suffolk County region east of the circle as the east end.

The 1990 census count of women living on the east end is 36,478 (Table 2). The number of women living on the east end who were diagnosed with breast cancer during the six-year period 1988-1993 is 455 (Table 7). The average annual age adjusted breast cancer rate is 129 cases diagnosed per year per 100,000 women. (See Tables 7 and 19.) This rate is statistically significantly larger than the western Suffolk rate of 106 per 100,000 [NYSDH 97]. (Difference between rates = 22.9, s.e. for east = 6.48, s.e. for west = 2.04, $Z = 3.37$, $p<.001$.) For comparison, the New York State rate is 102 per 100,000 and the Nassau County rate is 117 per 100,000 [NYSDH 1997]. The Suffolk County rate is 110 per 100,000 (Table 4.19). The state rate excluding the city is 106 per 100.000.

This high rate for eastern Suffolk was not observed in an earlier study of breast cancer rates for Long Island communities [NYSDH 90].

Although environmental problems can contribute to elevated cancer rates, some demographic or population dynamic factors that also can lead to high rates could at least partially explain the high rate for the east end. First, in general, increases in mammography utilization lead to early diagnoses, grouping what would be later cases into an earlier time period along with those who would be diagnosed in the earlier period anyway. This would cause a temporary (few years) increase in breast cancer rates, followed by a leveling off or a slight drop in rates later [Feuer 92]. Evidently, patterns of mammography utilization in Suffolk County have not been described. Possibly, access to health care is more restricted on the east end than in the other more densely populated regions of Suffolk County. If that is the case then visits to health care facilities for mammography for early detection of breast cancer would occur less frequently among women residing in this region. Fewer cases would have been detected during the period of the 1970's and 1980's. Then with the introduction and accessibility of Suffolk County's mobile mammography units during the time period of breast cancer incidence observed for this study, 1988-93, more women may have had mammograms at recommended levels of frequency. This would result in earlier breast cancer detection than experienced in the region in the past, and this would be reflected as an increase in the breast cancer rates. This scenario is plausible, given the spatial and temporal pattern of breast cancer in this region. A study of records of use of the mobile mammography units should be useful in this regard.

Second, it has been observed that breast cancer rates are higher in more affluent geographic regions. Although some wealthy individuals reside on the east end, median income levels in 1980 were lower there than in other parts of Suffolk County [NYSDH 90] and a check with the 1990 census tapes indicate that this is still the case. Therefore, it is unlikely that any risk factors which coincide with affluence have elevated the east end breast cancer rate.

Third, the calculated cancer rate could be inflated by either an overcount of cases and/or an undercount of the population at risk. This could occur if individuals gave an east end address to the Cancer Registry but a different address to the U.S. Census. The notion that this mechanism of bias exists, is mitigated by the fact that the earlier study reported a low rate for the region [NYSDH 90]. It is noteworthy anecdotally that the rate of growth in terms of new permanent residences being established on the east end has increased during the past ten years. Summer residents should not be counted in the rates but to the extent that some inadvertently are, the rate will be inflated. Considering the possibility that summer residents could be included in the breast cancer enumerations, NYSDH statisticians derived the frequency of breast cancer diagnoses per month for east end residents and did not observe an unexpectedly large summertime frequency of diagnosis.

Fourth, the possibility exists that large proportions of women moving to the east end during the past ten or so years possess known non-environmental factors that modify breast cancer risk, such as affluence, genetic risk profiles, personal or familial histories of cancer, and certain reproductive characteristics. A region with an influx of large numbers of women who can be identified with some of these factors will experience increased breast cancer rates.

Generally, non-environmental factors involving aspects of migration, mammography, residential status, geocoding, diagnosis, and cancer coding affect rates, although quality control protocols designed for protecting against systematic errors in rate estimates due to coding anomalies have been followed.

3.3 *Rhabdomyosarcoma Incidence and Discussion*

Rhabdomyosarcoma is a rare cancer of the soft tissue that can originate virtually anywhere in the body and, for young people, often originates in the neck, head and genitourinary tract. It may begin to spread early and is fatal in roughly one-half of the patients within five years of diagnoses [Hawkins 87, Robbins 89].

Compared with other cancers, rhabdomyosarcoma occurs relatively more frequently among younger people (ages < 20 years) than among older people. It occurs in all ethnic and racial groups. In New York State the incidence rates for blacks and whites are similar [Polednak 86]; in other regions it varies. Rhabdomyosarcoma occurs in both sexes, with a slightly higher rate of occurrence among males. In New York State the annual incidence rate of rhabdomyosarcoma for people under 20 years of age is 5.3 per million per year based on the present analysis of incidence data covering a 15-year period; this will be discussed.

Little is known about the cause(s) of rhabdomyosarcoma. Grufferman, et al, reported an association between the occurrence of rhabdomyosarcoma in children and (1) x-ray examination (mostly of the abdomen and pelvis) of their mothers during pregnancy and (2) mothers' occupational exposures to x-rays during the year preceding birth [Grufferman 91]. Examples of such occupations are dental hygienists and radiological technicians.

Rhabdomyosarcoma occurs relatively often in children whose families have experienced other cancers. Specifically, Holleb, et al, states that rhabdomyosarcomas are often found in families whose relatives, particularly parents, have an elevated incidence of brain tumors or breast cancer at early ages [Holleb 91].

Some data suggests that rhabdomyosarcoma can cluster temporally [Grimson 92].

Otherwise, little is known about the epidemiology of this cancer.

Concern about rhabdomyosarcoma came to the attention of the Task Force during a public hearing held on December 4, 1996. The father of a young girl who recently had been diagnosed with rhabdomyosarcoma stated that he suspected the cancer was caused by something in his household water, which is supplied by Suffolk County. Further, he stated his suspicion that BNL had contaminated the water. This family lives within five miles of BNL.

Table 20 displays the data collected by this individual through networking among parents throughout Suffolk County. Diagnoses of these cases occurred after 1993.

Epidemiologically, little can be concluded with confidence from these data. The year of diagnosis of one case is unknown and is not documented for each of the others. Parents of one

case have not been contacted; information about this case is indirect. Although it is felt that the father of the index case acquired evidence of correct diagnosis for most or all cases, complete confirmation based on medical records or doctors' statements, or at least by documentation from a well-designed survey questionnaire, is a requirement for epidemiologic research.

Furthermore, the numbers are so small that rate estimates based on these numbers would be unreliable (Section 5 and Appendix 2), if indeed rates could be calculated.

Incidence rates are estimated only within the context of a geographic region and a bounded time period (e.g. a year or five-year period.) This community network data collection process has no targeted time interval for which to consider rates. The most recent full year for which diagnoses are possible is 1997, but toward the past the interval is "open ended". The seven cases for which dates of diagnoses are known to investigators (Table 20) were reportedly diagnosed in 1994, 1955 and 1996. To date, no 1997 cases have been identified but, ostensibly, the year 1997 and some unknown years prior to 1994 would comprise part of the data catchment period, that is, if cases diagnosed during these years were discovered, they would have been included in the community data base. However, even if we "make up" time periods and consider the childhood census for Suffolk County (Table 21), we derive the sense that rates from these data would <u>not</u> be elevated.

Any under reporting by this community networking effort is inadvertently likely to occur farther from BNL rather than near BNL simply because the index case lives near BNL. (This phenomenon is termed "selected bias"). Therefore, any impression from these data that cases tend to cluster near BNL is unsupported. In fact the more definitive data to be discussed (Table 21) suggests, if anything, the opposite.

Table 21 provides the data required to more rigorously assess rhabdomyosarcoma incidence for Suffolk County. These data were provided to the Task Force by the New York State Cancer Registry. They cover the 15-year period from 1979 through 1993. The first of these years is the first year for which data is readily available and the last year is the most recent year for which cancer data are available. The entire 15-year period is required in order to have sufficient numbers of cases for analysis. (Twenty-five cases occurred in Suffolk County during the 15-year period).

Of the 11 counties whose populations of people less than 20 years of age exceeded 100,000 for each of the 15 years (the 11 densely populated counties), Suffolk County has the lowest annual rhabdomyosarcoma rate: 4.1 per million. The average rate for these counties is 5.7 per million. The average for the less populated counties is 4.3 per million. The average for the State is 5.3 per million. Except for Richmond County, the City boroughs have the higher rates. Based on very small numbers the Suffolk County rates in and out of the circle are 5.2 and 2.7 respectively, but little confidence can be placed in these rates.

There are no indications that rhabdomyosarcoma cases cluster around BNL or that rhabdomyosarcoma cases occur excessively in Suffolk County. In fact, the Suffolk County incidence rates are relatively low.

3.4 *Congenital Malformation Incidence and Discussion*

Table 22 gives the congenital malformation rates for the malformations itemized in Section 2.7. The numbers of malformations and the numbers of live births occurring during the 12-year period (1983-94) in the four study regions (Suffolk, Nassau, NY City, Upstate; see Section 2.7) are provided in Table 23.

Table 22 and categorical data analysis reveal, with the exception of congenital hip dislocation, no differences in malformation rates among the four regions which could be attributable to factors other than random variation.

A congenital hip dislocation results from abnormal development of parts of the hip joint.

The congenital hip dislocation rate in Suffolk County, 27 per 100,000 live births, is significantly larger than the rate for the primary comparison region Nassau County, 22 per 100,000 ($p = <.001$, chi-square test). See Table 22. Also, it is greater than the NY City rate of 21 per 100,000 though differences in ethnicity and other demographic factors between NY City and Suffolk County cannot be accounted for in these analyses.

However, the Suffolk rate is similar to the Upstate rate of 26 per 100,000.

Congenital hip dislocations are not known to be caused by environmental factors, but the causes are unknown. Differences between the Suffolk and Nassau rates could be attributable to reporting anomalies, a rare statistical anomaly (e.g. happenstance, type I error), genetic factors, or environmental factors. However, this defect tends to recur in families [Larson 90] suggesting heredity has a role.

Ethnicity may have an effect on these rates. Congenital hip dislocations occurs 2.1 times more frequently among white infants than among black infants in New York State. Such a difference does not occur with the other malformations studied. Nassau County has a higher proportion of black residents (8.6%) than Suffolk County (6.3%) [NARIG 96]. Therefore, ethnicity may explain at least part of the difference between the Nassau and Suffolk congenital hip dislocation rates.

No evidence exists in these data linking BNL with this finding; the only conclusion that can be made from these limited data is that Suffolk County's congenital hip dislocation rate is higher than Nassau County's rate and is about the same as the Upstate rate.

4 Pathways of Exposure

Parts II and III of the report from the BNL Environmental Task Force characterize the community environment in terms of radiation and chemicals attributable to BNL operations. Pathways of exposure are discussed thoroughly in Parts II and III. However, it is informative here to summarize possible pathways of exposures and to compare the locations and directions of these pathways to local cancer rates.

The groundwater plumes containing BNL effluents move southward and the Peconic River flows eastward. Both are contained within the circle and according to Figure 4 and Tables 3 through 18, their locations generally coincide with the sectors having the lower cancer rates.

Figure 5 is a "wind rose", summarizing wind directions for the period 1979-88. BNL produces a wind rose for each of its annual site environmental reports. Occasionally BNL produces a summary wind rose that covers a number of years. The wind rose of 1979-1988 (BNL 89) is shown in Figure 5 in a reproduced format. This wind rose was selected because, of the few available, it covers a period of time that may approximate induction periods of some cancers that have occurred in the study period 1988-93. However, all wind roses are nearly identical, since prevailing winds have changed little in several decades.

The arrow heads formed by the wedges of the wind rose point in the direction that the wind moved during this time period, and the concentric circles represent the percent of time that the wind blew in the indicated directions.

Figure 6 displays the relative frequencies of the time the wind moves in the directions indicated by the arrows. These arrows simply comprise an alternative presentation of wind directions and their relative frequencies but they correspond exactly with the wind rose, pointing away from, rather than into the origin (BNL) of the graph. (The lengths of the arrows taken alone are meaningless but taken together they represent the relative frequencies of direction.)

This presentation of frequencies of wind direction (Figure 6) is placed on the Long Island map with the origin placed on BNL. Thus the arrows of Figure 6 show the major and minor directions that wind takes releases away from BNL.

Although it has been noted earlier that breast cancer rates are not elevated in the circle as compared with the control areas, and that within the circle the rates for the sectors are not significantly different from each other, it is noteworthy that the breast cancer rates correlate with the reverse order of the frequencies of wind direction; compare Figures 4 and 6. That is, within the circle, breast cancer rates are higher upwind than downwind of BNL. Also, no correlation is noted for the cancer rates and wind directions for any of the other cancers. These observations are inconsistent with speculation that airborne releases from BNL, directed to nearby communities by wind, cause cancer.

5 LIMITATIONS

Epidemiologic studies based primarily on rates can be conducted relatively quickly and inexpensively because they are based on available data. Such epidemiologic studies are referred to as ecological studies. The statistical units of observation in ecological studies are populations in geographic regions observed during specified time periods. Such studies cannot provide the same strength of evidence of an association between a putative risk factor and disease that other more detailed kinds of epidemiologic studies, such as case control studies, can provide. The latter kinds of studies have individuals, not aggregates of people, as the units of observation, and exposures are measured on the individual, not on a geographic region. In this study the putative

exposure is regional (not individual) proximity to BNL, and the health effect is the cancer rate for the population of each region, not an assessment of health of each individual in the regions.

Populations of the geographic units studied must be large enough to assure stability of rates. Rates based on census tracts, or "communities" defined in terms of census tracts and zip code zones, would be unstable for "rare" diseases such as cancer. Furthermore, the increased amount of geocoding required would introduce more error or uncertainty. Such instability and error could result in undeserved adverse consequences for a community. If inadvertent inclusions of two or three cases into a rate calculation can change a normal rate to a rate of epidemic appearance, then the population is too small for a meaningful and definitive rate assessment.

Nevertheless, for larger populations, rate studies serve a valuable purpose as a "first look" in assessing community health problems, and they may be useful in formulating hypothesis that can be explored in more detail through more definitive studies.

6 CONCLUSIONS

This investigation found that cancer rates in regions near BNL are not elevated in comparison with cancer rates farther away from BNL.

The rhabdomyosarcoma rates for Suffolk County and for regions of Suffolk near and far from BNL, in comparison with other New York counties, do not support the notion that rhabdomyosarcoma cases comprise a cluster near BNL or in Suffolk County.

The breast cancer rate for the east end, east of the circle on the map of Figure 4, is notably elevated. The reasons for this increase are not known at this time.

Congenital malformation data could not be examined for frequency of occurrence in relation to residential proximity to BNL. Nevertheless, it is noted that the Suffolk County malformation rates are not elevated. The congenital hip dislocation rate in Suffolk County is higher than that for Nassau County but it is about the same as the Upstate rate.

It is emphasized here that this study is an ecological study and therefore it inherents limitations. The reader is advised to read the previous section: Limitations.

7 RECOMMENDATIONS

Recommendations in the Epidemiologic Report (e.i. Part I) are:

1) It is understood that the Department of Energy (DOE) is beginning a cancer incidence study among BNL employees. It is recommended that the Suffolk County Legislature communicate with DOE about creating a community-based oversight group, consisting of public health professionals and local residents who are independent of BNL, to monitor and provide input to this study.

2) It is recommended that the Suffolk County Legislature ask the Suffolk County Health Department to examine the matter of the elevated breast cancer rates in the east end and to investigate, or to make recommendations regarding an investigation of, these elevated rates.

3) It is recommended that the Suffolk County Legislature, perhaps through the Suffolk County Health Department or through other appropriate public health professionals, monitor for five to ten years the annual incidence rates for breast cancer on the east end and annual rhabdomyosarcoma rates for Suffolk County.

ACKNOWLEDGEMENTS

The Task Force wishes to express its appreciation to Ms. Aura Weinstein, Director of the Cancer Surveillance Program of the Bureau of Chronic Disease and Epidemiology of the New York State Department of Health for overseeing the cancer geocoding and rate calculations for this investigation, for numerous consultations on the statistical aspects of this investigation during the Task Force's duration and for helpful comments on an earlier draft of this report.

Dr. Maria Schymura, Director of the NYS Cancer Registry and her staff provide invaluable service and advice throughout the study.

Also, the Task Force wishes to express its appreciation to Ms. Monica Sharpe Stimac of the NY State Congenital Malformations Registry, New York State Department of Health, for providing the congenital malformations data and for helpful suggestions regarding interpretations of these data.

Dr. Evelyn Bromet of the Department of Psychiatry and Behavioral Science at SUNY Stony Brook and Dr. Jay Gould of the Radiation and Public Health Project, NY participated as witnesses, regarding epidemiologic matters, for the Task Force. Mr. Randy Snell of Manorville was helpful during several discussions regarding Childhood Rhabdomyosarcoma. The contributions of these three individuals are greatly appreciated.

Drs. Joe Falco, Geoffrey Kabat and Erin O'Leary of the Department of Preventive Medicine, HSC, SUNY at Stony Brook, read earlier drafts of this report and made many helpful suggestions; these interactions are greatly appreciated. Dr. Joe Falco also provided input in the planning process.

The Task Force acknowledges and appreciates the assistance, support and advice of Legislator Michael Caracciolo, and of his Legislative Assistant Maryann Wowak who spent many hours assisting The Task Force in its duties and attending its meetings.

Finally The Task Force wishes to express its appreciation to Lola Michelini, Wanda Mocarski and Karen Henrickson for their technical assistance in the preparation of this report.

REFERENCES

[BNL 89] Site Report for the Calendar Year 1988, Safety and Environmental Protection Division, Brookhaven National Laboratory, June, 1989.

[DOE 90] Tiger Team Assessment of the Brookhaven National Laboratory, U.S. Department of Energy, June 1990.

[DOE 97] Interim Report on the Office of Environment, Safety and Health Oversight of Groundwater Tritium Plume Recovery Activities at the Brookhaven National Laboratory, office of Oversight, Environment, Safety and Health, U.S. Department of Energy, February, 1997.

[Feuer 92] Feuer, EJ and Wun, LM, "How much of the recent rise in breast cancer incidence can be explained by increases in mammography utilization?", American Journal of Epidemiology 136 (1992), 1423-1436.

[Grimson 92] Grimson, R; "Clustering in sparse data and an analysis of rhabdomyosarcoma incidence", Statistics In Medicine 11 (1992), 761-768.

[Grufferman 91] Grufferman, S; Gula, MJ; Olshan, JM; Falletta, JM; Pendergrass, TW; Buckley, J; Maurer, HM; "In utero x-ray exposure and risk of childhood rhabdomyosarcoma" (Abstract), Pediatric Prenatal Epidemiology 5 (1991), A6-A7.

[Hawkins 87] Hawkins, HK and Camacho-Velesquez, TV; "Rhabdomyosarcoma in children: correlation of form and prognosis in one institution's experience", American Journal of Surgical Pathology 11 (1987), 531-542.

[Holleb 91] Holleb, AI; Fink, DJ; Murphy, JP; Clinical Oncology, American Cancer Society, 1991.

[Larson 90] Larson, DE (ed), Mayo Clinic Family Health Book, William Morrow and Company Inc, NY, P. 999, 1990.

[NARIG 96] The Nelson A. Rockefeller Institute of Government, SUNY, 1996 New York State Statistical Yearbook, 21st Edition, 1996.

[NYSDH 90] New York State Department of Health, Bureau of Cancer Epidemiology and Division of Environmental Epidemiology and Occupational Health, Small Area Analysis of Breast Cancer Incidence Rates in Nassau and Suffolk Counties, New York, 1978-1987, October, 1990.

[NYSDH 95] New York State Department of Health, Congenital Malformations Registry, Congenital Malformations Registry Annual Report, Statistical Summary of Children Born in 1991 and Diagnosed Through 1993, 1995.

[NYSDH 97] New York State Department of Health, Bureau of Chronic Disease Epidemiology and Surveillance, Cancer Registry, Cancer Incidence and Morbidity by County, 1989-1993. May, 1997.

[Polednak 86] Polednak, AP; "Incidence of soft-tissue cancers in blacks and whites in York State', International Journal of Cancer, 38 (1986), 21-26.

[Robbins 89] Robbins, SL; Coltran, RS; Kumar, V; Pathologic Basis of Disease, 4th edition, Chapter 28, W.B. Saunders, Philadelphia, (1989)

[Sever 88a] Sever, LE; Gilbert, ES; Hessol, NA; McIntyrre, JM; "A case-control study of Congenital Malformations and occupational exposure to low-level ionizing radiation." American Journal of Epidemiology 127 (1988), 226-241.

[Sever 88b] Sever, LE; Hessol, NA; Gilbert, ES; McIntyre, JM; "The prevalence at birth of congenital malformations in communities near the Hanford site." American Journal of Epidemiology 127 (1988), 243-254.

[Sternglass 94] Sternglass, EJ and Gould, JM; "The Long Island breast cancer epidemic: evidence for a relation to the releases of hazardous nuclear wastes", CMA Occasional Papers, Issue #1, School of Public Service, Long Island University, C.W. Post Campus, July 1994.

Census Tracts in Four Sectors Within a
15 Mile Radius of Brookhaven National Laboratory
Suffolk County, New York

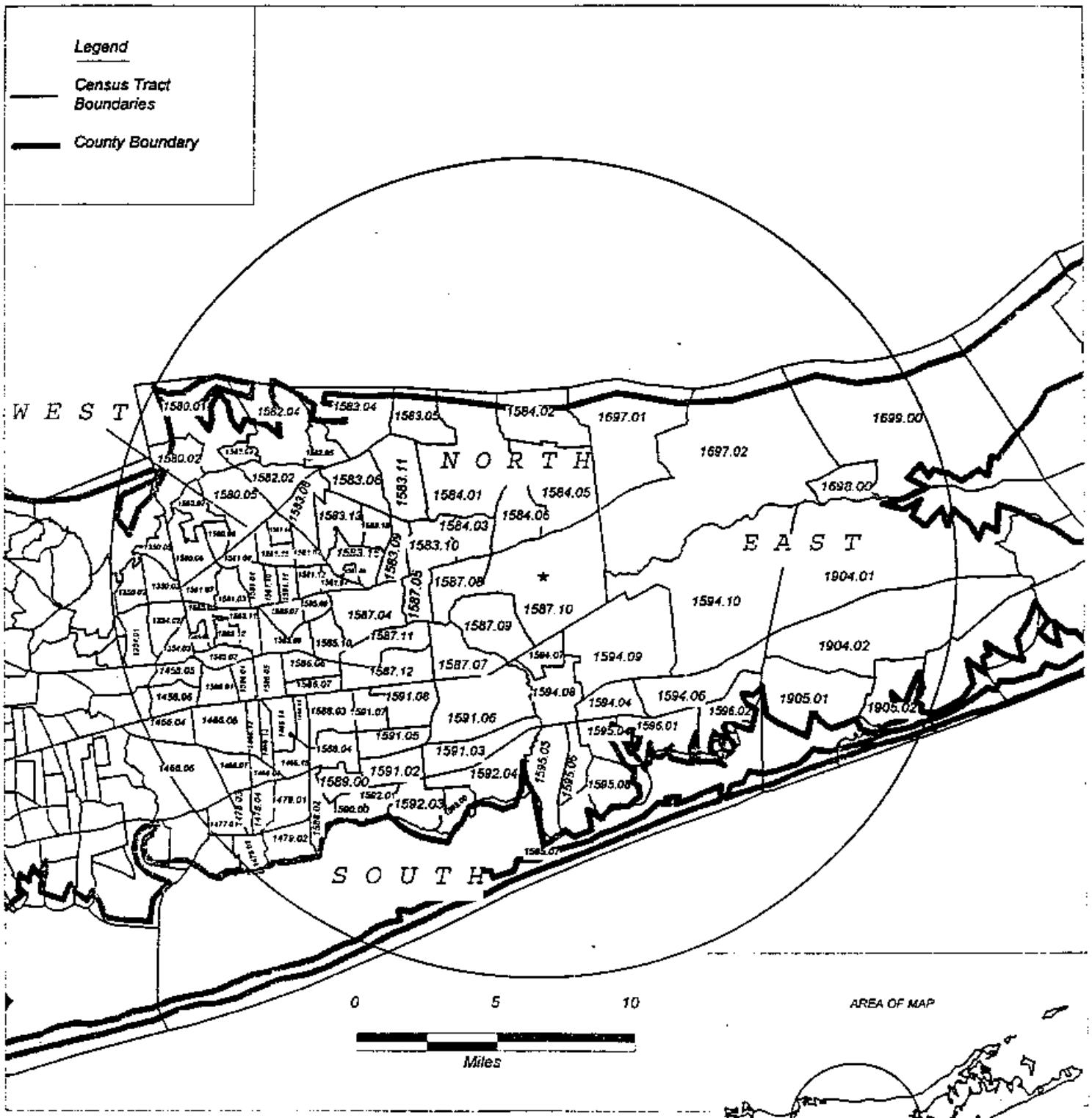


Figure 1

The Study Regions Comprised of Census Tracts

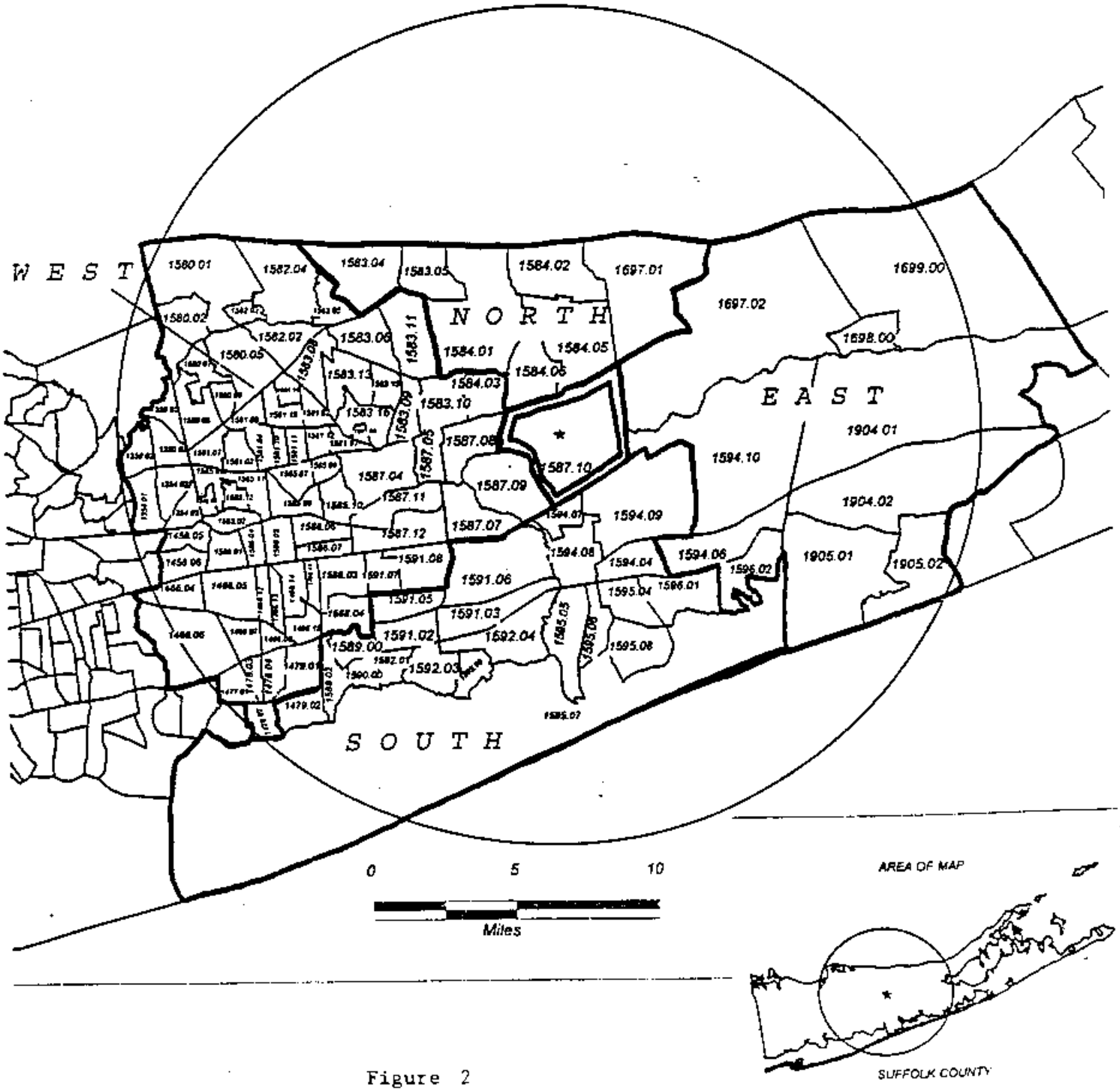


Figure 2

Communities near BNL: Compare with
Circle of Figure 4.2

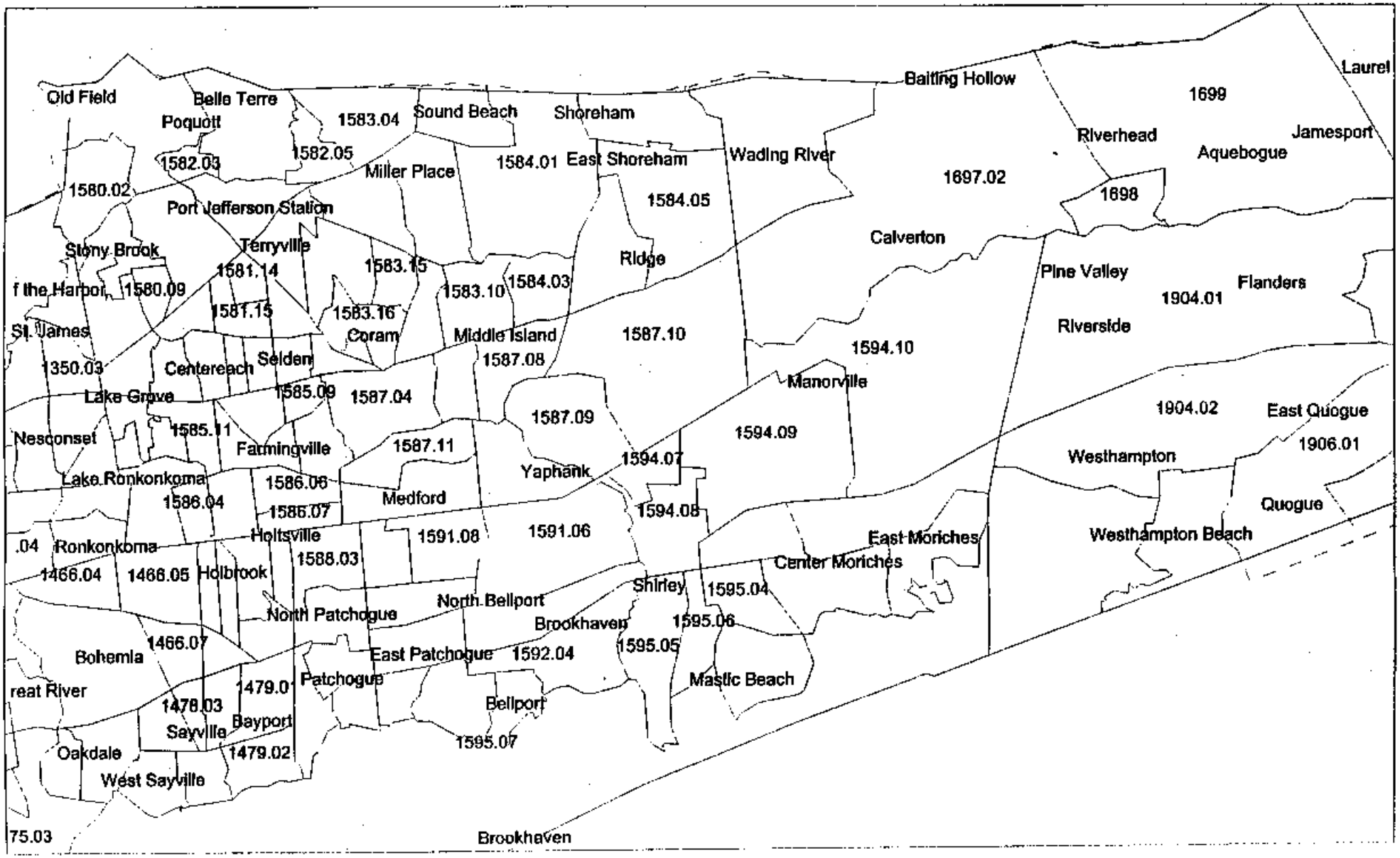


Figure 3

Average annual age adjusted breast cancer rates for the period 1988-93 for the study regions

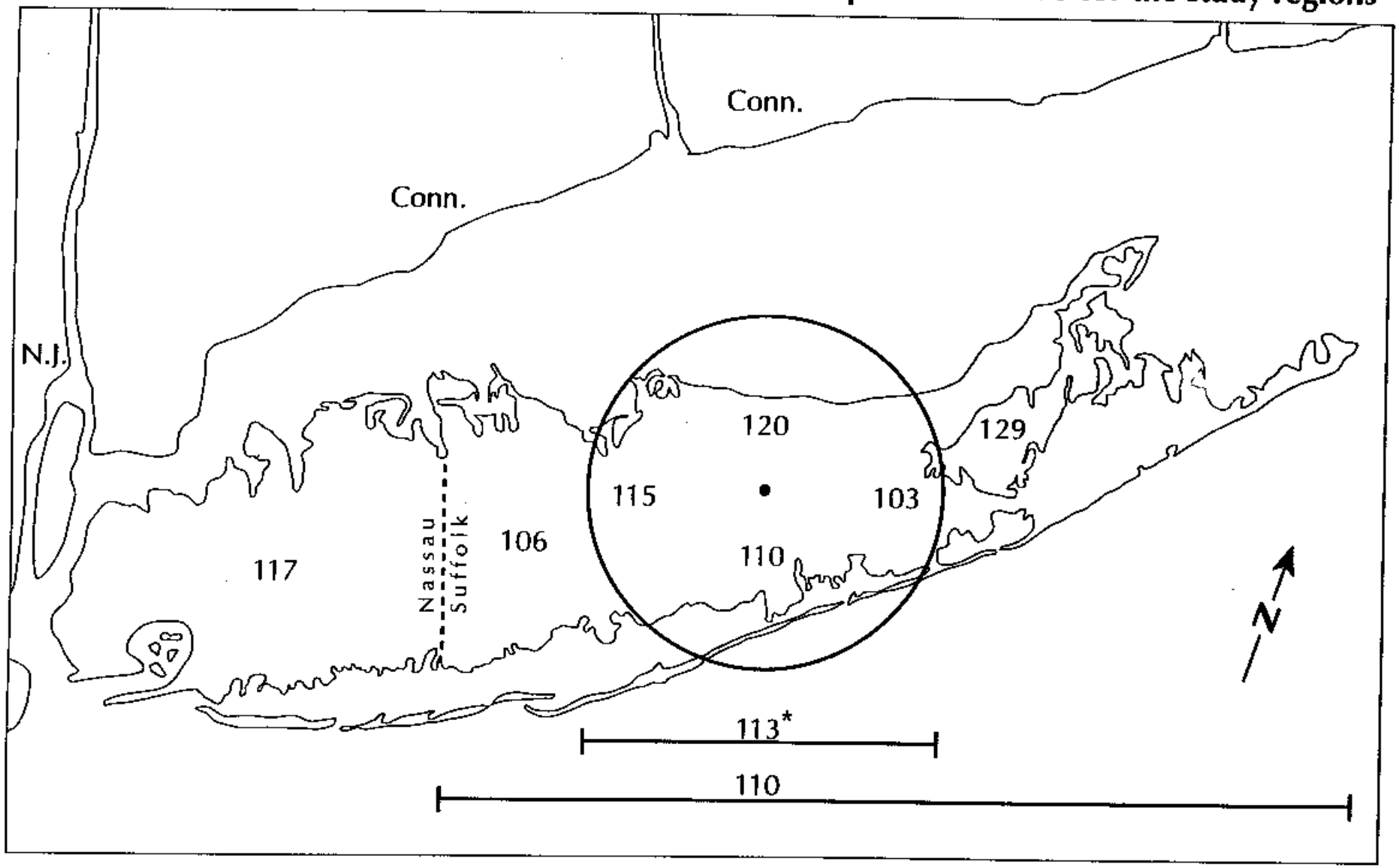


Figure 4

*Includes Census Tract 1587.10 containing BNL, discussed in Section 3.2

Average annual age adjusted breast cancer rates for the period 1988-93 for the study regions

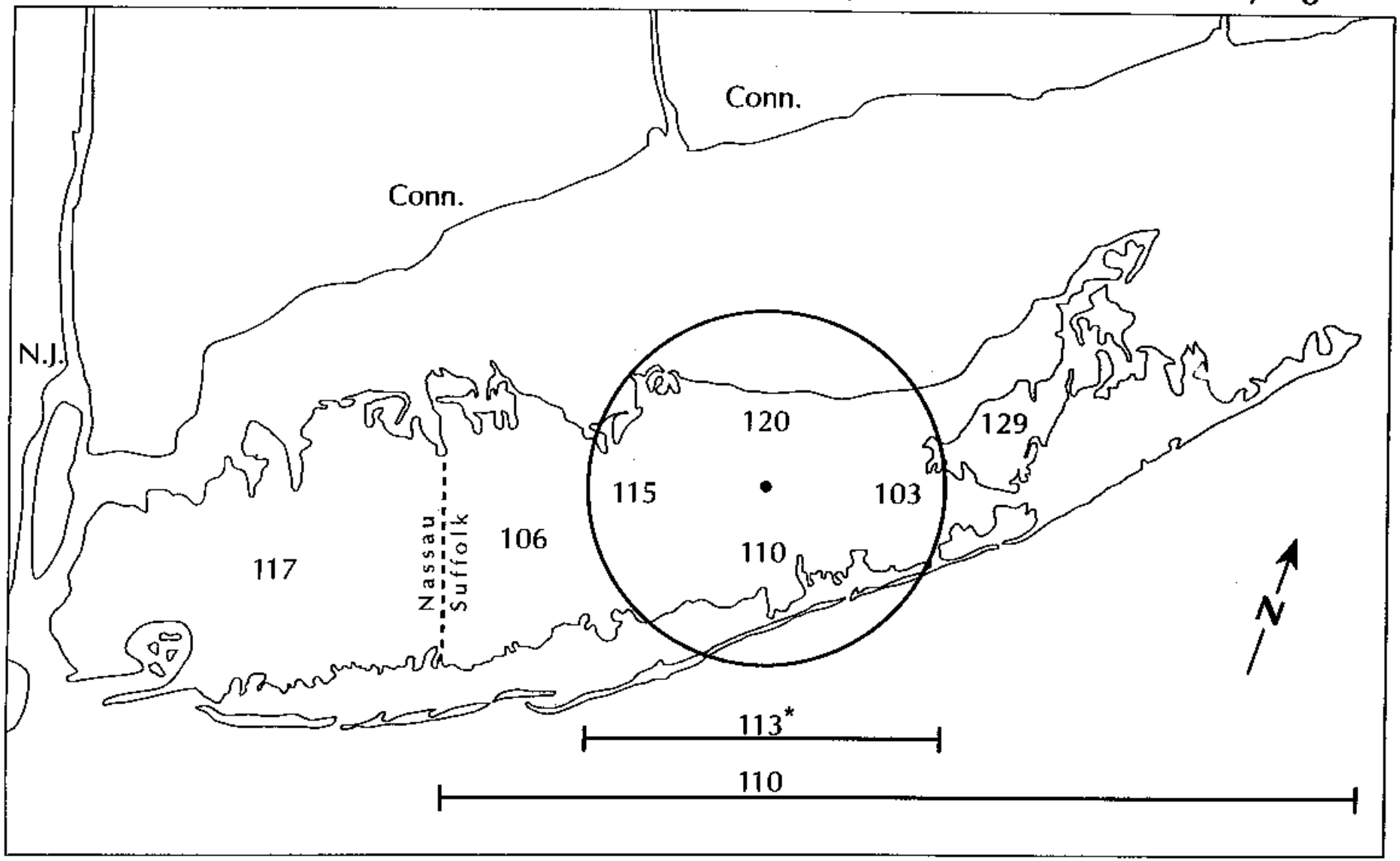
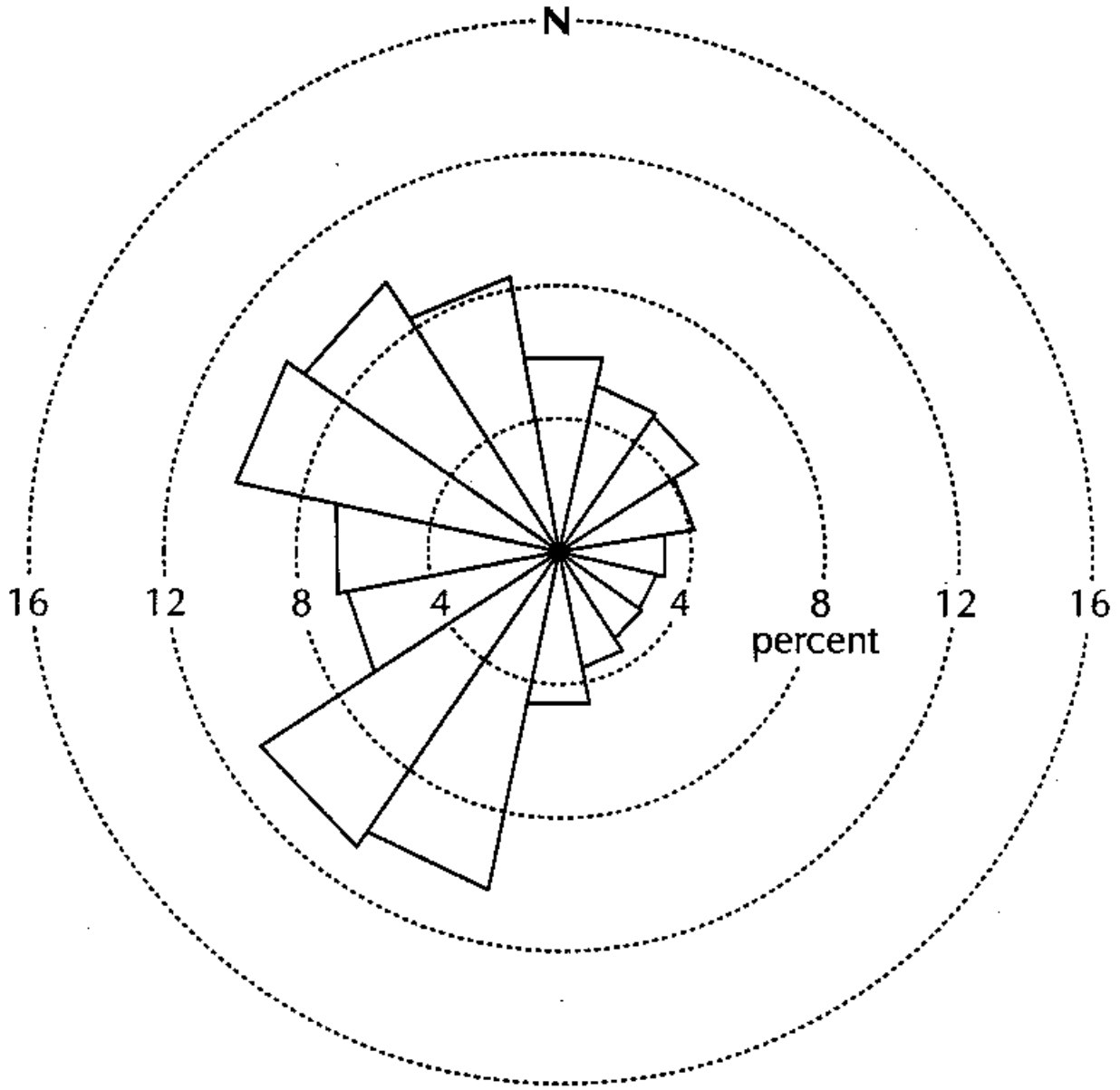


Figure 4

*Includes Census Tract 1587.10 containing BNL, discussed in Section 3.2

BNL historic wind rose for the calendar years 1979 - 1988



- The arrow heads formed by the wedges indicate the direction toward which the wind blew.
- Each concentric circle represents a 4% frequency of the time for which the wind blew in the indicated directions.
- Wind directions were measured at a height of 88 meters.

Figure 5

Wind directions for the period 1979-88 superimposed on the study regions, where the lengths of the arrows indicate relative proportions of time the wind was blowing in the indicated directions

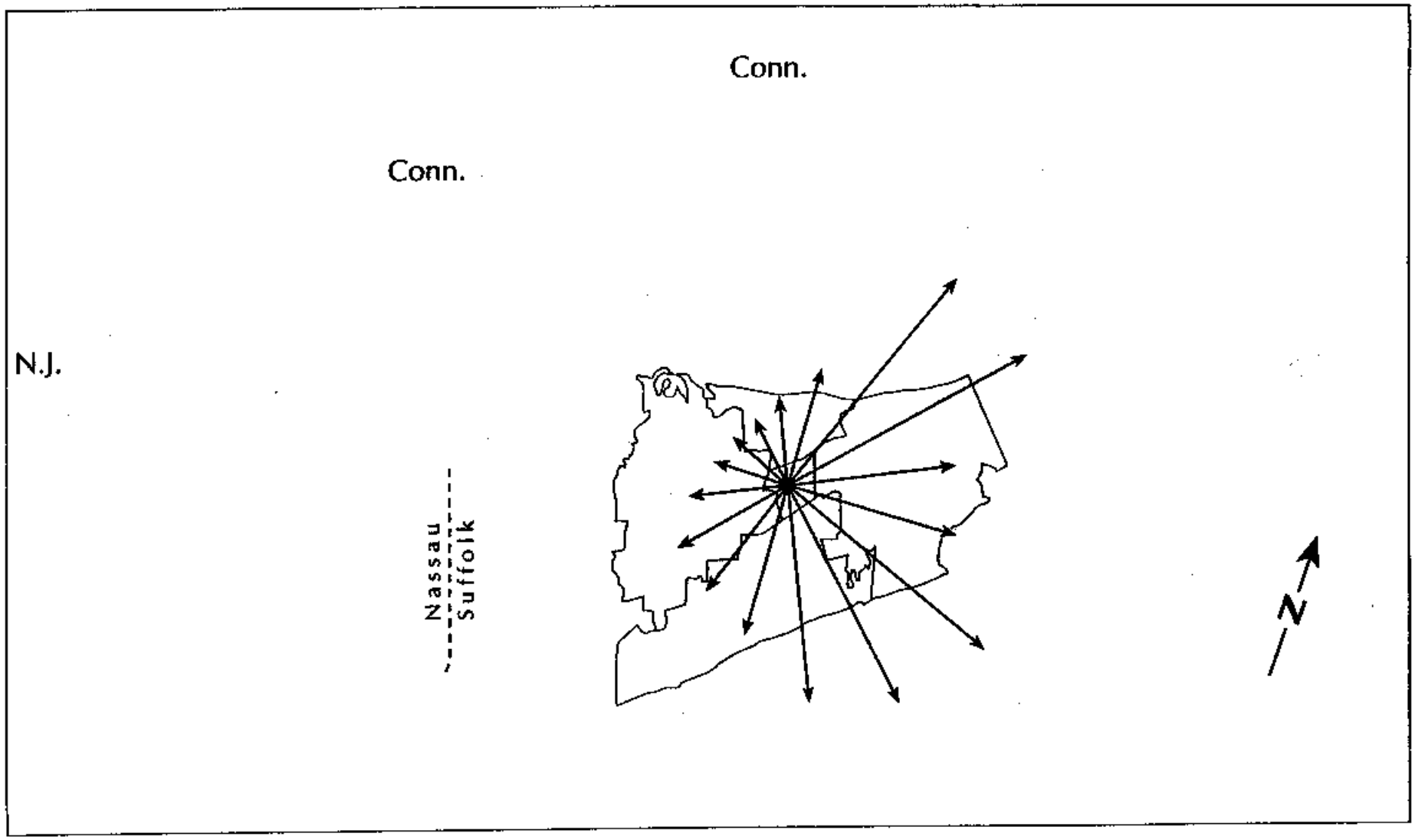


Figure 6

TABLE 1

Census Tracts in Four Sectors Within a 15-Mile Radius of BNL*

North (sector 1) n=7	East (sector 2) n=10	South (sector 3) n=22	West (sector 4) n=79	
1583.04	1594.06	1479.02	1350.02	1581.97
1583.05	1594.10	1588.02	1350.03	1581.98
1584.01	1596.02	1589.00	1350.05	1582.02
1584.02	1697.02	1590.00	1354.01	1582.03
1584.05	1698.00	1591.02	1354.02	1582.04
1584.06	1699.00	1591.03	1354.03	1582.05
1697.01	1904.01	1591.05	1458.05	1583.06
	1904.02	1591.06	1458.06	1583.08
	1905.01	1592.01	1446.04	1583.09
	1905.02	1592.03	1466.05	1583.10
		1592.04	1466.06	1583.11
		1593.00	1466.07	1583.13
		1594.04	1466.08	1583.15
		1594.07	1466.11	1583.16
		1594.08	1466.12	1584.03
		1594.09	1466.13	1585.02
		1595.04	1466.14	1585.05
		1595.05	1466.15	1585.06
		1595.06	1477.01	1585.07
		1595.07	1478.02	1585.08
		1595.08	1478.03	1585.09
		1596.01	1478.04	1585.10
			1479.01	1585.11
			1580.01	1585.12
			1580.02	1586.01
			1580.05	1586.04
			1580.06	1586.05
			1580.07	1586.06
			1580.09	1586.07
			1581.02	1587.04
			1581.03	1587.05
			1581.04	1587.07
			1581.07	1587.08
			1581.08	1587.09
			1581.10	1587.11
			1581.11	1587.12
			1581.12	1588.03
			1581.14	1588.04
			1581.15	1591.07
				1591.08

*These Tracts and the center Tract 1587.10 comprise the study region ("circle" of 15 mile radius).

TABLE 2

Total 1990 Populations, by Sector and Sex

Sector	Males	Females
North (1)	20941	22621
East (2)	19474	20602
South (3)	55728	57242
West (4)	171170	177723
BNL (0)	1822	1760
Remainder of the County to the West (5)	343811	358978
Remainder of the County to the East (6)	33514	36478
Total within 15 Miles of BNL (0-4)	269135	279948
Total Further than 15 Miles from BNL (5.6)	377325	395456
Total Sufolk County	646460	675404

TABLE 3

Male Liver Cancer Incidence Statistics for the Suffolk County Study Regions for the 6 Year Period 1988-1993

Sector	Number of Cases During 6 Years	Age Adjusted Annual Incidence Rates	95% Confidence Interv. for the Adjusted Rate
North (1)	9	5.3†	(1.8, 8.8)
East (2)	0	0†	--
South (3)	11	3.8†	(1.5, 6.1)
West (4)	30	3.8	(2.4, 5.2)
BNL (0)	*	*	*
Remainder of the County to the West (5)	84	4.4	(3.4, 5.4)
Remainder of the County to the East (6)	16	4.6†	(2.3, 6.9)
Total within 15 miles of BNL (0-4)	50	3.7	(2.7, 4.7)
Total further than 15 miles of BNL (5,6)	100	4.5	(3.6, 5.4)
Total Suffolk County	150	4.2	(3.5, 4.9)

* <6 cases were reported to the Registry.

† Rate is unstable; <20 cases were reported.

TABLE 4

Female Liver Cancer Incidence Statistics for the Suffolk County Study Regions for the 6 Year Period 1988-1993

Sector	Number of Cases During 6 Years	Age Adjusted Annual Incidence Rates	95% Confidence Interv. for the Adjusted Rate
North (1)	8	3.7†	(0.6, 6.8)
East (2)	6	2.5†	(0.4, 4.6)
South (3)	11	3.1†	(1.2, 5.0)
West (4)	19	1.8†	(1.0, 2.6)
BNL (0)	0	0†	--
Remainder of the County to the West (5)	49	1.8	(1.3, 2.3)
Remainder of the County to the East (6)	9	2.4†	(0.7, 4.1)
Total within 15 miles of BNL (0-4)	44	2.3	(1.6, 3.0)
Total further than 15 miles of BNL (5,6)	58	1.9	(1.4, 2.4)
Total Suffolk County	102	2.0	(1.6, 2.4)

† Rate is unstable; <20 cases were reported.

TABLE 5

Male Bone Cancer Incidence Statistics for the Suffolk County Study Regions for the 6 Year Period 1988-1993

Sector	Number of Cases During 6 Years	Age Adjusted Annual Incidence Rates	95% Confidence Interv. for the Adjusted Rate
North (1)	*	*	*
East (2)	*	*	*
South (3)	*	*	*
West (4)	*	*	*
BNL (0)	*	*	*
Remainder of the County to the West (5)	**	**	**
Remainder of the County to the East (6)	*	*	*
Total within 15 miles of BNL (0-4)	12	0.8†	(0.3, 1.3)
Total further than 15 miles of BNL (5,6)	30	1.3	(0.8, 1.8)
Total Suffolk County	42	1.1	(0.8, 1.4)

* <6 cases were reported to the Registry.

† Rate is unstable; <20 cases were reported.

** Not reported because the rule of 6 could be violated in the cell below by a process of subtraction.

TABLE 6

Female Bone Cancer Incidence Statistics for the Suffolk County Study Regions for the 6 Year Period 1988-1993

Sector	Number of Cases During 6 Years	Age Adjusted Annual Incidence Rates	95% Confidence Interv. for the Adjusted Rate
North (1)	*	*	*
East (2)	*	*	*
South (3)	*	*	*
West (4)	*	*	*
BNL (0)	*	*	*
Remainder of the County to the West (5)	18	0.8†	(0.4, 1.2)
Remainder of the County to the East (6)	0	0†	--
Total within 15 miles of BNL (0-4)	15	0.9†	(0.4, 1.4)
Total further than 15 miles of BNL (5,6)	18	0.7†	(0.4, 1.0)
Total Suffolk County	33	0.8	(0.5, 1.1)

* <6 cases were reported to the Registry.

† Rate is unstable; <20 cases were reported.

TABLE 7

Female Breast Cancer Incidence Statistics for the Suffolk County Study Regions for the 6 Year Period 1988-1993

Sector	Number of Cases During 6 Years	Age Adjusted Annual Incidence Rates	95% Confidence Interv. for the Adjusted Rate
North (1)	215	119.5	(102.0, 137.0)
East (2)	182	103.0	(87.0, 119.0)
South (3)	391	109.6	(98.4, 120.8)
West (4)	1236	115.1	(108.5, 121.7)
BNL (0)	12	126.1†	(43.3, 208.9)
Remainder of the County to the West (5)	2681	106.0	(102.0, 110.0)
Remainder of the County to the East (6)	455	128.9	(116.2, 141.6)
Total within 15 miles of BNL (0-4)	2036	113.2	(108.1, 118.3)
Total further than 15 miles of BNL (5,6)	3136	108.7	(104.9, 112.5)
Total Suffolk County	5172	110.3	(107.3, 113.3)

† Rate is unstable; <20 cases were reported.

TABLE 8

Prostate Cancer Incidence Statistics for the Suffolk County Study Regions for the 6 Year Period 1988-1993

Sector	Number of Cases During 6 Years	Age Adjusted Annual Incidence Rates	95% Confidence Interv. for the Adjusted Rate
North (1)	154	97.9	(81.9, 113.9)
East (2)	144	87.5	(72.9, 102.1)
South (3)	260	92.5	(81.2, 103.8)
West (4)	671	93.2	(86.1, 100.3)
BNL (0)	*	*	*
Remainder of the County to the West (5)	1354	74.4	(70.4, 78.4)
Remainder of the County to the East (6)	369	103.1	(92.4, 113.8)
Total within 15 miles of BNL (0-4)	1229	92.6	(87.4, 97.8)
Total further than 15 miles of BNL (5,6)	1723	79.2	(75.4, 83.0)
Total Suffolk County	2952	84.4	(81.3, 87.5)

* <6 cases were reported to the Registry.

TABLE 10

Female Brain and Central Nervous System Tumor Incidence Statistics for the Suffolk County Study Regions for the 6 Year Period 1988-1993**

Sector	Number of Cases During 6 Years	Age Adjusted Annual Incidence Rates	95% Confidence Interv. for the Adjusted Rate
North (1)	8	4.9†	(1.3, 8.5)
East (2)	10	7.0†	(2.2, 11.8)
South (3)	36	9.9	(6.5,13.3)
West (4)	105	9.7	(7.8, 11.6)
BNL (0)	*	*	*
Remainder of the County to the West (5)	194	8.0	(6.8, 9.2)
Remainder of the County to the East (6)	27	9.4	(5.3, 13.5)
Total within 15 miles of BNL (0-4)	159	9.0	(7.6, 10.4)
Total further than 15 miles of BNL (5,6)	221	8.1	(7.0, 9.2)
Total Suffolk County	380	8.5	(7.6, 9.4)

* <6 cases were reported to the Registry.
† Rate is unstable; <20 cases were reported.
** Includes benign tumors.

TABLE 11

Male Thyroid Cancer Incidence Statistics for the Suffolk County Study Regions for the 6 Year Period 1988-1993

Sector	Number of Cases During 6 Years	Age Adjusted Annual Incidence Rates	95% Confidence Interv. for the Adjusted Rate
North (1)	*	*	*
East (2)	*	*	*
South (3)	*	*	*
West (4)	*	*	*
BNL (0)	*	*	*
Remainder of the County to the West (5)	**	**	**
Remainder of the County to the East (6)	*	*	*
Total within 15 miles of BNL (0-4)	34	2.0	(1.3, 2.7)
Total further than 15 miles of BNL (5,6)	46	1.8	(1.3, 2.3)
Total Suffolk County	80	1.9	(1.5, 2.3)

* <6 cases were reported to the Registry.

** Not reported because the rule of 6 could be violated in the cell below by a process of subtraction.

TABLE 12

Female Thyroid Cancer Incidence Statistics for the Suffolk County Study Regions for the 6 Year Period 1988-1993

Sector	Number of Cases During 6 Years	Age Adjusted Annual Incidence Rates	95% Confidence Interv. for the Adjusted Rate
North (1)	*	*	*
East (2)	*	*	*
South (3)	*	*	*
West (4)	*	*	*
BNL (0)	*	*	*
Remainder of the County to the West (5)	125	5.0	(4.1,5.9)
Remainder of the County to the East (6)	10	3.2†	(1.1,5.3)
Total within 15 miles of BNL (0-4)	90	4.8	(3.8, 5.8)
Total further than 15 miles of BNL (5,6)	135	4.8	(4.0, 5.6)
Total Suffolk County	225	4.8	(4.2, 5.4)

* <6 cases were reported to the Registry.

† Rate is unstable; <20 cases were reported.

TABLE 13

Male Non-Hodgkin's Lymphoma Incidence Statistics for the Suffolk County Study Regions for the 6 Year Period 1988-1993

Sector	Number of Cases During 6 Years	Age Adjusted Annual Incidence Rates	95% Confidence Interv. for the Adjusted Rate
North (1)	30	22.5	(14.2, 30.8)
East (2)	26	18.7	(11.2, 26.2)
South (3)	61	18.9	(14.0, 23.8)
West (4)	167	18.7	(15.8, 21.6)
BNL (0)	*	*	*
Remainder of the County to the West (5)	321	15.2	(13.5, 16.9)
Remainder of the County to the East (6)	61	19.8	(14.7, 24.9)
Total within 15 miles of BNL (0-4)	284	18.7	(16.5, 20.9)
Total further than 15 miles of BNL (5,6)	382	15.9	(14.3, 17.5)
Total Suffolk County	666	17.0	(15.7, 18.3)

* <6 cases were reported to the Registry.

TABLE 14

Female Non-Hodgkin's Lymphoma Incidence Statistics for the Suffolk County Study Regions for the 6 Year Period 1988-1993

Sector	Number of Cases During 6 Years	Age Adjusted Annual Incidence Rates	95% Confidence Interv. for the Adjusted Rate
North (1)	27	13.8	(8.0, 19.6)
East (2)	9	5.2†	(1.4, 9.0)
South (3)	45	12.0	(8.4, 15.6)
West (4)	147	13.8	(11.5, 16.1)
BNL (0)	0	0†	--
Remainder of the County to the West (5)	297	11.8	(10.4, 13.2)
Remainder of the County to the East (6)	38	9.7	(6.4, 13.0)
Total within 15 miles of BNL (0-4)	228	12.3	(10.6, 14.0)
Total further than 15 miles of BNL (5,6)	335	11.6	(10.3, 12.9)
Total Suffolk County	563	11.9	(10.9, 12.9)

† Rate is unstable; <20 cases were reported.

TABLE 15

Male Multiple Myeloma Incidence Statistics for the Suffolk County Study Regions for the 6 Year Period 1988-1993

Sector	Number of Cases During 6 Years	Age Adjusted Annual Incidence Rates	95% Confidence Interv. for the Adjusted Rate
North (1)	11	7.8†	(3.0, 12.6)
East (2)	11	6.8†	(2.7, 8.9)
South (3)	9	3.1†	(1.1, 5.1)
West (4)	45	5.9	(4.1, 7.7)
BNL (0)	0	0†	--
Remainder of the County to the West (5)	82	4.2	(3.3, 5.1)
Remainder of the County to the East (6)	14	4.0†	(1.8, 6.2)
Total within 15 miles of BNL (0-4)	76	5.5	(4.3, 6.7)
Total further than 15 miles of BNL (5,6)	96	4.2	(3.4, 5.0)
Total Suffolk County	172	4.7	(4.0, 5.4)

† Rate is unstable; <20 cases were reported.

TABLE 16

Female Multiple Myeloma Incidence Statistics for the Suffolk County Study Regions for the 6 Year Period 1988-1993

Sector	Number of Cases During 6 Years	Age Adjusted Annual Incidence Rates	95% Confidence Interv. for the Adjusted Rate
North (1)	*	*	*
East (2)	*	*	*
South (3)	*	*	*
West (4)	*	*	*
BNL (0)	*	*	*
Remainder of the County to the West (5)	88	3.4	(2.7, 6.1)
Remainder of the County to the East (6)	9	2.2†	(0.7, 3.7)
Total within 15 miles of BNL (0-4)	65	3.4	(2.5, 4.3)
Total further than 15 miles of BNL (5,6)	97	3.3	(2.6, 4.0)
Total Suffolk County	162	3.3	(2.8, 3.8)

* <6 cases were reported to the Registry.

† Rate is unstable; <20 cases were reported.

TABLE 17

Male Leukemia Incidence Statistics for the Suffolk County Study Regions for the 6 Year Period 1988-1993

Sector	Number of Cases During 6 Years	Age Adjusted Annual Incidence Rates	95% Confidence Interv. for the Adjusted Rate
North (1)	16	10.8†	(5.3, 16.3)
East (2)	14	9.8†	(4.4, 15.2)
South (3)	32	11.0	(7.1, 14.9)
West (4)	109	13.9	(11.2, 16.6)
BNL (0)	0	0†	--
Remainder of the County to the West (5)	227	11.9	(10.3, 13.5)
Remainder of the County to the East (6)	27	10.4	(6.0, 14.8)
Total within 15 miles of BNL (0-4)	171	12.2	(10.3, 14.1)
Total further than 15 miles of BNL (5,6)	254	11.5	(10.1, 12.9)
Total Suffolk County	425	11.8	(10.7, 12.9)

† Rate is unstable; <20 cases were reported.

TABLE 18

Female Leukemia Incidence Statistics for the Suffolk County Study Regions for the 6 Year Period 1988-1993

Sector	Number of Cases During 6 Years	Age Adjusted Annual Incidence Rates	95% Confidence Interv. for the Adjusted Rate
North (1)	17	7.9†	(3.7, 12.1)
East (2)	14	7.9†	(3.2, 12.6)
South (3)	32	8.4	(5.4, 11.4)
West (4)	84	7.8	(6.1, 9.5)
BNL (0)	0	0†	--
Remainder of the County to the West (5)	172	7.2	(6.1, 8.3)
Remainder of the County to the East (6)	33	9.5	(5.4, 13.6)
Total within 15 miles of BNL (0-4)	147	7.8	(6.5, 9.1)
Total further than 15 miles of BNL (5,6)	205	7.5	(6.4, 8.6)
Total Suffolk County	352	7.6	(6.8, 8.4)

† Rate is unstable; <20 cases were reported.

TABLE 19

Summary of the 6-Year (1988-1993) Age Adjusted Cancer Incidence Rates of Tables 3-18 Rounded to the Nearest Integer for the Larger Suffolk Regions and Age Adjusted Rates for Nassau County, Suffolk County, and New York State

	New York State[1]	Nassau[1]	Suffolk County	Suffolk West of Circle	Suffolk in Circle	Suffolk East of Circle
Liver-male	5	4	4	4	4	5†
Liver-female	2	2	2	2	2	2†
Bone-male	1	1	1	*	1†	*
Bone-female	1	1	1	1†	1†	0†
Breast-female	106	117	110	106	113	129
Prostate	109	115	84	74	93	103
Brain-CNS-male**	10	11	10	9	10	10
Brain-CNS-female**	9	11	9	8	9	9
Thyroid-male	2	3	2	*	2	*
Thyroid-female	5	6	5	5	5	3†
Non-Hodgkin's - male	18	20	17	15	19	20
Non-Hodgkins - female	12	14	12	12	12	10
Multi Myeloma - male	5	5	5	4	6	4†
Multi Myeloma - female	4	4	3	3	3	2†
Leukemia-male	12	12	12	12	12	10
Leukemia-female	8	8	8	7	8	10

[1] Nassau County and New York State (excluding NY City) rates are annual age adjusted rates based on the 5-year period 1989-1993.

* <6 cases were reported to the Registry.

† Rate is unstable; <20 cases were reported.

** Includes benign tumors.

TABLE 20

Geographic Locations and Dates of Diagnoses of Childhood Rhabdomyosarcoma Cases in Suffolk County, Collected by the Father of a Case

Southhampton	June 1996
Manorville	May 1995
Mastic	June 1996
E. Setauket	1995
Stony Brook	Unknown
Selden	1994
Patchogue	1994
St. James	1994

TABLE 21

Average Annual Rhabdomyosarcoma Incidence Rates for People Less than 20 Years of Age in Counties Containing More than 100,000 People of That Age Group, for the 15 Year Period 1979-1993

County	1990 Population	Interpolated 1986 Population*	Incidence Rate Per Million
Bronx	374737.0	378964.2	4.2
Erie	255337.0	276625.8	6.5
Kings	681998.0	691584.4	7.0
Monroe	199044.0	207041.2	4.5
Nassau	317252.0	344919.6	5.6
New York	285847.0	287496.2	5.8
Onondaga	132549.0	138700.2	5.3
Queens	464666.0	475672.0	6.4
Richmond	105519.0	109061.8	4.3
Suffolk	368979.0	402654.2	4.1
Westchester	214288.0	226722.8	5.6
Total Above	3400216.0	3539442.0	5.7
In BNL Circle	159340.7	173883.1	2.7
Out BNL Circle	209638.3	228771.1	5.2
Less Populated	1403858.0	1473176.0	4.3
New York State	4804074.0	5012618.4	5.3

* The mid interval populations on which rates are based.

TABLE 22

Average Annual Congenital Malformation Incidence rates Per 100,000 Live Births for Suffolk County and for Three Comparison Regions, Rounded to the Nearest Integer*

	Suffolk	Nassau	NY City	Upstate NY
Major Malformation	252	277	225	268
Chromosome Anomalies	13	14	12	12
Down's Syndrome	9	10	8	8
Tracheoesophageal Fistula	2	2	2	2
Hip Dislocation	27	22	21	26
Neural Tube Defect	21	22	24	19
Anencephaly	0†	1	1	1
Spina Bifida	3	2	3	3
Microcephalus	5	5	6	4
Surveillance Mutation Group	0†	0†	0†	0

* Based on 12 consecutive years of data, 1983-94. Provided by the Congenital Malformations Registry, N.Y.S.D.H. Annual Rate = (number malformations x 100,000) / (number live births x 12)

† Rounds off to zero. The numbers of malformations and numbers of live births are provided in Table 23

TABLE 23

Numbers* of Congenital Malformations of the Types Considered and the Number of Live Births for the Four Study Regions for the 12 Year Period 1983-94

	Suffolk	Nassau	NY City	Upstate NY
Major Malformation	7,052	6,706	40,253	44,259
Chromosome Anomalies	352	343	2,079	2,051
Down's Syndrome	242	245	1,418	1,391
Tracheoesophageal Fistula	66	50	344	374
Hip Dislocation	748	532	3,782	4,256
Neural Tube Defect	583	543	4,226	3,118
Anencephaly	11	22	115	170
Spina Bifida	79	58	558	549
Microcephalus	138	113	1,120	640
Surveillance Mutation Group	4	5	18	20
Live Births	232,964	201,417	1,491,516	1,374,335

* Derived from information obtained by the NY Congenital Malformations Registry, NYSDH.

APPENDIX 1

Definition of Cancer Rate

A cancer incidence rate is the number of cases diagnosed in a year in a specific population, per 100,000 people. For example, if 199 people were diagnosed in 1997 with a certain type of cancer in a geographic region containing 600,500 people who could conceivably acquire that cancer, then the cancer rate for that type of cancer in that population is:

$$(199/600{,}500) \times 100{,}000 = 33.1$$

Thus, this hypothetical cancer is diagnosed at a rate of 33.1 persons for 100,000 persons per year in that population.

A disease rate provides a measure of risk. The rate of 33.1 per 100,000 may be roughly thought of as the probability of a randomly selected person acquiring the disease in a year, ignoring age, ethnicity and other factors. The raw number of cases, 199, in this example provides no information like this because it does not involve the population size. The number of cases is useful in planning, such as in planning hospital needs (needs assessment), but the rate is more important in investigating causes of disease.

A geographic region (e.g. county) contains people of both sexes, and all ages. Sometimes a rate pertains to just one sex or to a specific age group. For example, prostate cancer pertains to males so the prostate cancer rate is based on all males in the population of the region, not on all people. In this case, males comprise the "population at risk".

Sometimes specific age groups are of special interest. As a case in point, this report describes incidence rates of childhood rhabdomyosarcoma. The rates pertain only to those who are less than 20 years old.

Although most cancer rates are expressed on a per 100,000 population basis as a matter of convenience, sometimes other bases are used. In the rhabdomyosarcoma analysis, rates are expressed on a per one million population basis due to the rareness of the disease.

The kind of rate defined above is an unadjusted rate. If the unadjusted annual incidence rate for breast cancer is 100 cases per 100,000 women in one county and is 120 cases per 100,000 women in another county, and if women in the second county are on average older than the women in the first county, then one could not assert that reasons other than age created the difference between the rates, because breast cancer rates are higher among older women. For this reason, age adjusted rates are preferred. Age adjusted rates allow for comparability of rates, while excluding differences in age distributions between two populations from being a factor; it "controls for" or "adjusts" the effects of age. For instance, if the breast cancer rates, having been adjusted for age, remain different, then one may conclude that the differences in rates are not due to the differences in the respective age distributions. (The direct method of adjustment is used here and is based on nine age groups and the standard 1970 US population [NYSDH 1997].)

Ninety-five percent confidence intervals (CI's) accompany the rates in the tables of results. A reported rate is an estimate, based on statistical theory. The 95% CI for a rate is a statistically derived interval for which one is 95% certain that it contains the "real" rate. The rates given are sometimes referred to "point estimates" and the CI's are sometimes referred to "interval estimates". CI's are useful to investigators in gauging precision of rate estimates.

APPENDIX 2*

Stability of Rates

Why are rates based on fewer than 20 cases marked as being unreliable?

The National Center for Health Statistics does not publish data which do not meet their requirement for a minimum degree of accuracy. They base the accuracy requirement on a measure called the relative standard error (RSE). The RSE is the standard error as a percent of the measure itself. (This is very similar to a coefficient of variation, which is the standard deviation divided by the measure). A RSE of 50% means that the standard error is half the size of the rate.

The following calculations show that the RSE of a incidence or mortality rate is based completely on the number of cases or deaths, unlike the standard error, which is based on both the number of cases and the size of the population.

For crude incidence and morality rates, the RSE is calculated as follows:

$$\textit{Relative standard error} = \frac{\textit{standard error}}{\textit{rate}} \cdot 100$$

For crude rates, the standard error is calculated as follows:

$$SE = \frac{rate}{\sqrt{cases}}$$

so the relative standard error is:

$$RSE = \frac{rate}{\sqrt{cases}} \cdot \frac{1}{rate} \cdot 100 = \frac{1}{\sqrt{cases}} \cdot 100$$

Example:

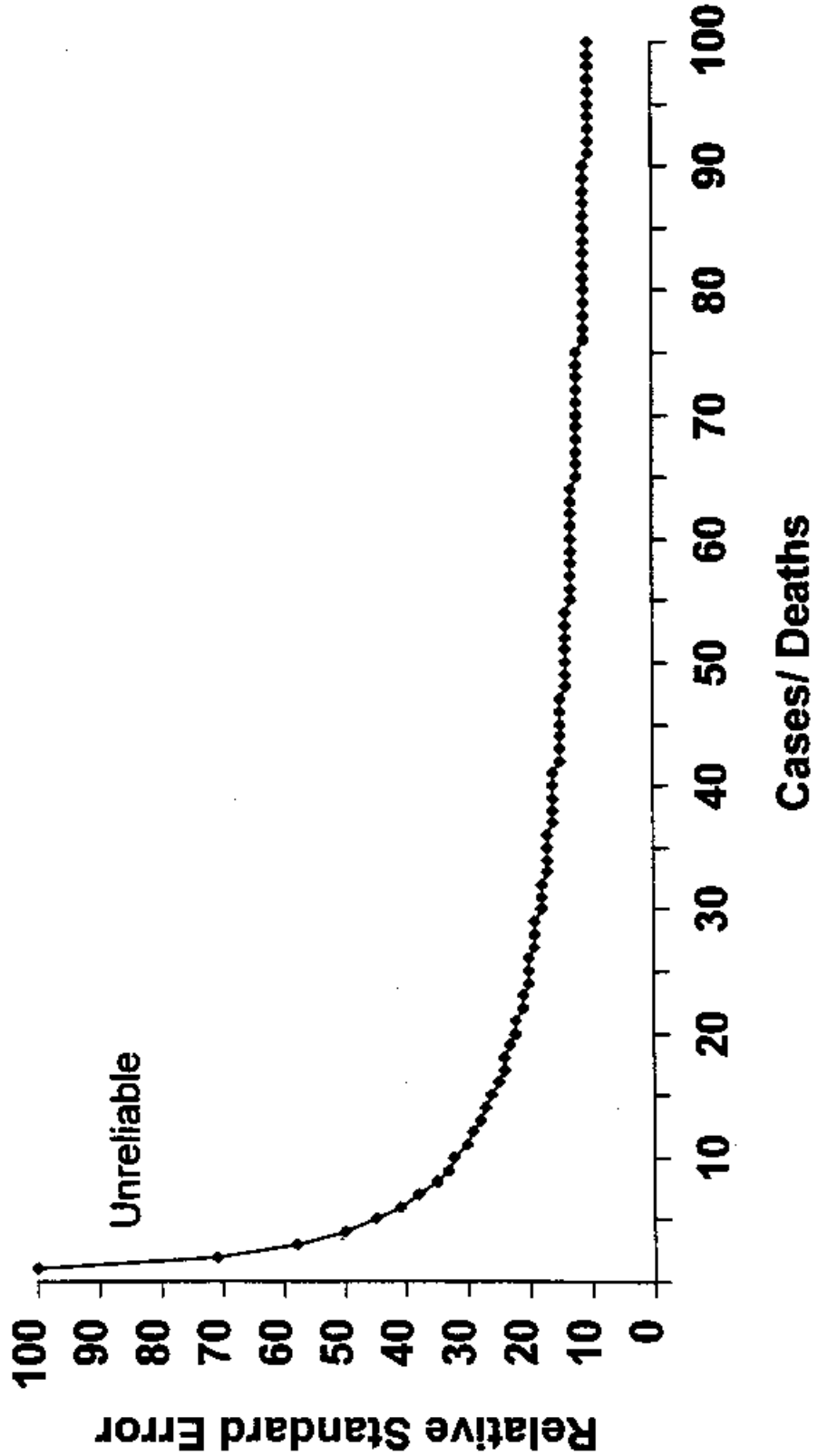
There are 20 testicular cancer deaths among males in New York State, excluding New York City every year. The rate of testicular cancer deaths is 0.4 per 100,000 males, and the standard error is 0.09. The relative standard error is 22%.

There are about 20 prostate cancer deaths among males in Orange County every year. The rate is 21.9 deaths per 100,000 males; the standard error is 4.8. Again, the relative standard error is 22%.

So even though the standard error for the testicular cancer rate is much smaller than the standard error for the prostate cancer rate, both have the same magnitude relative to the rate itself.

The NCHS does not publish numbers or rates where there are fewer than 20 cases or deaths, corresponding to a RSE of approximately 22%. This may seem arbitrary until you examine the relationship between the RSE and the number of cases/deaths, which is displayed graphically in figure 1. This is an inverse exponential function, which means that small changes in the number of deaths at the lower end of the scale have a much bigger effect than small changes at the large end of the scale: going from 10 deaths to 20 deaths reduces the RSE from 32% to 22%, while going from 60 deaths to 70 deaths reduces the RSE from 13% to 12%. It is somewhere around 20 deaths that the curve seen in figure 1 starts to level out. Hence, rates based on fewer that 20 deaths, in the steep end of the curve, are highly variable and for that reason unreliable.

*This document has been prepared by NYSDH

Figure 1

Relative Standard Error of an Incidence or Mortality Rate as a Function of the Number of Cases or Deaths