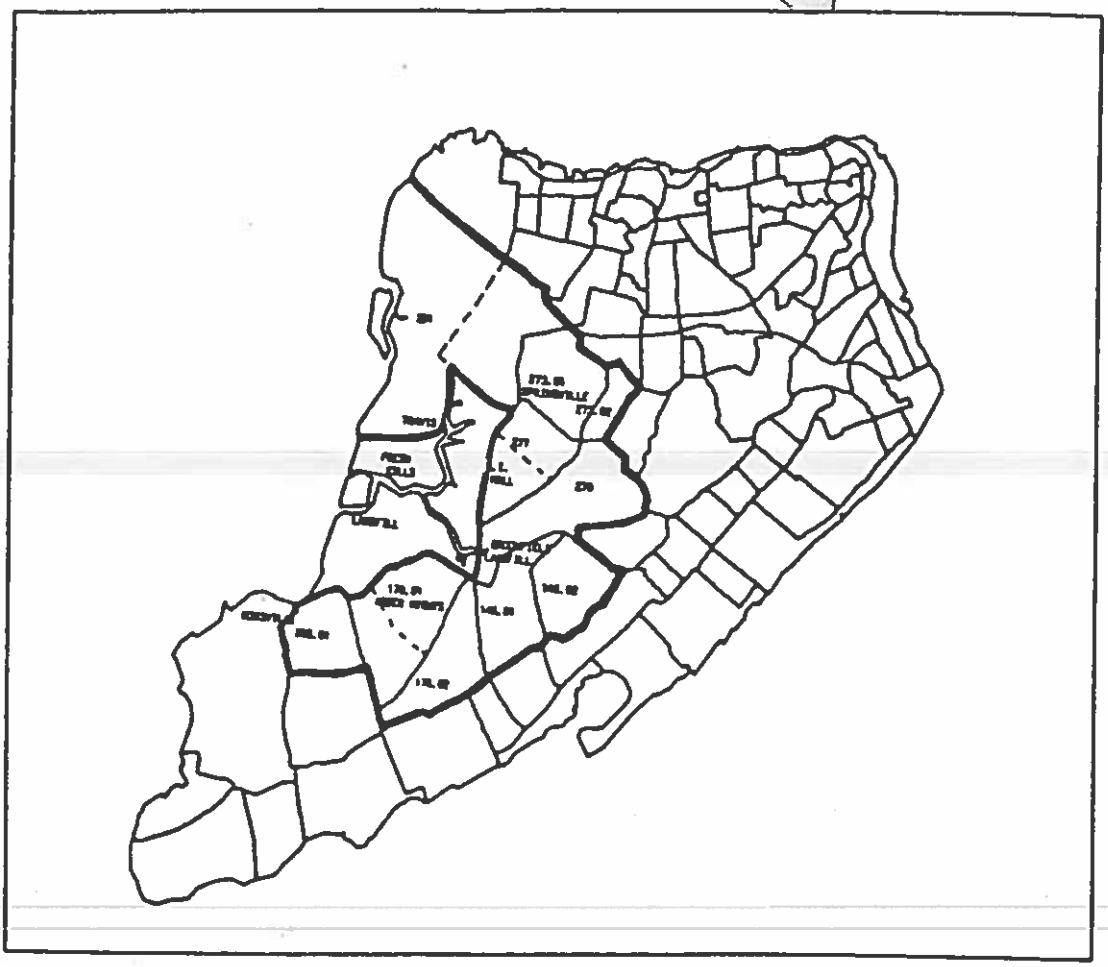
STATEN ISLAND CANCER INCIDENCE STUDY

MARCH, 1996



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I. INTRODUCTION

A. BACKGROUND

In the Spring of 1992, the New York City Department of Health (DOH) was notified by the New York State Departments of Health and Environmental Conservation that residents of Staten Island were concerned about a seemingly high incidence of cancer and other illnesses. Residents feared that the health problems were related to exposures from the two municipal waste disposal sites on Staten Island, Fresh Kills and Brookfield Avenue.

As a first step in addressing residents' concerns, DOH initiated a descriptive epidemiologic study of cancer incidence. Cancer was selected because it was one of the most frequently reported health concerns and because it was the only reported health problem for which complete surveillance data were readily available (from the NYSDOH Cancer Registry). At the time this study was initiated, Registry data were complete through the year 1988.

B. OBJECTIVES

1. To determine the **absolute burden** of selected cancers (i.e.: the exact number of cases) among residents in an area of 13 census tracts adjacent to the landfills (referred to as the Study Area) and Staten Island as a whole.

2. To assess the **relative burden** of these cancers by comparing the incidence in:

   a) the Study Area with the incidence in the rest of Staten Island

   b) the Study Area with the incidence in a demographically similar area that was not in proximity to a landfill

   c) Staten Island as a whole with the incidence in a demographically similar area that was not in proximity to a landfill

   d) Staten Island to the incidence in the rest of NYC.

3. To evaluate the results of 1 & 2 (above) to determine whether any patterns emerge that may indicate a need for further investigation or public health measures.

4. To address concerns about cancers which occurred after the period for which complete

data were available from NYSDOH (post 1988).

It must be emphasized that a descriptive study **cannot** provide conclusive information as to whether exposures from the landfills may have contributed to cancer incidence or **why** people in Staten Island developed cancer. This is partly because:

* There are currently no medical tests to determine the causes of cancer in individuals.

* There was no information available about if, when, what type, or how much exposure to cancer-causing substances occurred among residents.

* The data used for this study did not contain information about other individual exposures or risk factors for cancer.

Even though this type of study cannot define or identify the possible role of the landfills in cancer causation, it is a useful first step in documenting the numbers and types of cancers and assisting interested parties in prioritizing needs and resources for future cancer research, education, prevention, or other activities.

This study consisted of two parts. The first part concentrated on cancer incidence from 1979-1988 (the years for which complete data were available from the New York State Cancer Registry at the time the study was initiated). The second part verified citizen reports of more recent cancer cases (1989-1992).

II. CANCER INCIDENCE, 1979 - 1988

A. METHODS

Data on cancer incidence for the years 1979-1988 were provided by the New York State (NYSDOH) Cancer Registry. Fourteen types of cancer and total cancer incidence were evaluated for men and women separately. Three types of cancer and total cancer incidence were evaluated for children. The choice of cancer types studied was guided by consideration of their frequency in the general population, their possible association with environmental risk factors, and community concern.

Cancer incidence rates in the Study Area were calculated and compared to rates in the rest of Staten Island and to rates in a demographically similar neighborhood (the combined Bay Ridge and Flushing Health Districts). Cancer incidence rates for Staten Island were calculated and compared to the rates in demographically similar neighborhoods (Bay Ridge and Flushing) and also to rates in the rest of New York City. Rate ratios (RR) were calculated for each comparison. Statistical significance of the differences between the rates was evaluated by calculating 95 percent confidence intervals. Statistical power to detect differences in rates was also calculated.

B. RESULTS

Absolute Burden

* The most common types of cancer among men in both the Study Area and on Staten Island were lung, prostate, and colon cancer. Together these cancers accounted for over 40% of all cancers among men.

* The most common types of cancer among women in the Study Area and on Staten Island were breast, lung, and colon cancers. These sites accounted for at least 50% of all cancers among women.

* Leukemia was the most common cancer type among children in the Study Area and on Staten Island.

* These cancers are also the most common among men, women, and children in New York City and New York State.

Relative Burden

In the Study Area:

* Lung cancer in both men and women was the only type of cancer which was moderately and statistically significantly elevated in the Study Area compared to the Bay Ridge and Flushing Health Districts.

* Among men and women, no cancers were statistically significantly elevated compared with the rest of Staten Island; 13 out of 14 cancers were not statistically significantly elevated compared with the Bay Ridge and Flushing Health Districts.

* Among children, there were no cancer types that were statistically significantly elevated compared to either the rest of Staten Island or the combined Bay Ridge and Flushing area. The RR for lymphoma was moderately elevated, although not statistically significant.

On Staten Island:

* Slight to moderate, statistically significant elevations ranging from 12 - 36% were noted for both men and women in cancers of the lung, bladder and colon, compared to the rest of NYC. Also, compared with the rest of NYC, the rates of lymphoma and breast cancer were slightly and statistically significantly higher in women only; the rate of larynx cancer was statistically elevated in men only.

* Slight to moderate, statistically significant elevations, ranging from 10 - 55%, were

noted for both men and women in cancers of the lung and pharynx when compared to the combined Bay Ridge and Flushing Health Districts. Also, compared with Bay Ridge and Flushing, the rate of larynx cancer was statistically elevated among men and the rate of colon cancer was slightly and significantly elevated in women.

* The incidence rates of 11 out of 14 types of cancer in both men and women were not statistically elevated, compared with the Bay Ridge and Flushing Health Districts.

* The incidence rates of 10 out of 14 types of cancer in men and 9 out of 14 types of cancer in women were not statistically elevated compared with the rest of NYC.

* The following cancers ranked among the top 6 out of 30 health districts (top one-fifth or 20%) in the City: Colon (#2 in men and women), lung (#2 in men and #4 in women), bladder (#1 in men and #2 in women), nervous system (#4 in men and #6 in women), breast (#4 in women), lymphoma (#5 in women), and larynx (#6 in men and women).

* Cancer incidence ranked in the middle or lower third for 9 of 14 sites among men and 6 of 14 sites among women.

* Stomach cancer ranked among the bottom 20% of Health Districts in NYC (#29 in men and #27 in women).

* When compared to Bay Ridge/Flushing and to the rest of NYC, children had lower rates of cancer. There were no cancer types for which the incidence rates were significantly elevated compared to the two areas.

* Childhood cancers ranked in the middle (#15) or lower third for each of the childhood cancers evaluated and for total cancers combined. The Staten Island rate was lower than the NYC average rate for each type of cancer.

III. CASE VERIFICATION, 1989 - 1992

A. METHODS

In order to address concerns about the reportedly high incidence of cancers which occurred after 1988, NYCDOH solicited information and assistance from residents, local community organizations, and elected officials. Cases of cancer were reported to NYCDOH during 1992 and 1993 through a variety of methods. A local community organization (Wish is Granted) compiled information, primarily on childhood cancers, and forwarded it to DOH. A local newspaper (Staten Island Advance) ran a notice requesting residents to contact NYCDOH.

Finally, NYCDOH reached out to local community boards and elected officials, asking their constituents to report cases to NYCDOH.

Reported cases were verified through hospital records, the NYSDOH Cancer Registry, and the NYCDOH Division of Vital Statistics. Expected numbers of cases were calculated based on the overall NYC and NYS rates during the same years as cases were diagnosed.

B. RESULTS

A total of 379 cases were reported to NYCDOH via the methods described above. Of these, 138 were verified as cancer cases, diagnosed after 1988. The remaining cases were either diagnosed before 1989 (140 cases); were diseases other than cancer (55 cases); or, after repeated follow-up, could not be verified because of insufficient information (46 cases).

The majority (57%) of verified cases lived within the vicinity of the landfills. Verified cases were only a fraction of the number of cases expected during this time period based on prevailing NYC or NYS cancer rates.

IV. DISCUSSION AND CONCLUSIONS

This study represents the Department of Health's first step in evaluating citizens concerns about cancer in the neighborhoods surrounding the Brookfield and Fresh Kills landfills. Specifically the purpose was to assess patterns of cancer by examining: 1) the **absolute burden** of cancer, i.e: how many cases of each type of cancer occurred; 2) the **relative burden** of cancer, i.e.: whether there was a higher incidence of cancers in the areas around the Landfills and/or on Staten Island compared with other parts of NYC and whether noted increases were statistically significant; and 3) whether the **patterns were consistent** across different subgroups in the population (such as men and women); and 4) whether othe investigators have noted similar results. These factors, can help to provide a picture of the burden of cancer on the community and be used to help determine where further health research, education, medical, or prevention efforts should be focussed.

The results of this study show that the types of cancer with the greatest absolute burden on New Yorkers also have the greatest burden on Staten Islanders: lung and colon cancers among men and women, breast cancer among women, prostate cancer among men, and leukemia among children.

The findings do not provide any consistent evidence of an elevation in cancer incidence in the Study Area. There was consistent evidence to support a slight to moderate elevation in lung cancer and, to a lesser extent, colon, bladder, pharynx and larynx cancers on Staten Island as a whole. These findings provide support for the view that the elevations noted, particularly for lung cancer, were probably not due to normal fluctuation in cancer incidence rates, but

indicate truly higher rates of certain cancers. Further evidence is provided by previous investigations that have also noted a higher rate of lung cancer incidence or mortality on Staten Island .[5,6,7] At the same time, the data provide no direct clues as to why these elevations occurred.

It must be noted that there are several limitations that make it difficult to draw conclusions with 100% certainty about whether the incidence of certain types of cancer on Staten Island is truly elevated and if so, whether it is possible that the increase could be due to environmental exposures from the landfills or from other sources. These limitations are briefly noted below:

a) Absence of Strong Increases in Cancer Rates: Although certain cancers were significantly elevated on Staten Island, the magnitude of the increase was generally slight to moderate. Many studies of cancer near hazardous waste sites have been unable to show a relationship even with large relative risks (that is effects greater than a doubling or tripling). In no case did the cancer rate even approach a doubling compared with other areas in NYC. Slight to moderate increases are often difficult to interpret because there is no way to know whether they represent an actual increase or random variation between different neighborhoods.

b) Lack of Direct Environmental Exposure Data: No direct information on actual exposures from the landfill or other sources was available. Without knowing what substances were present in the environment, and the amount to which individuals were actually exposed, it is difficult, if not impossible, to make a link between cancer incidence and environmental exposures.

c) Latency: In adults, cancers may take, on average, more than 20 years to develop from the time a person is first exposed to a cancer-causing substance. Consequently, to prove a link between environmental exposures on Staten Island and cancer, it would be necessary to document that persons were living on Staten Island and sufficiently exposed many years ago. The issue of latency is particularly relevant where the Brookfield Landfill is concerned. Toxic dumping was alleged to have taken place at Brookfield during the late 1970's, the cancer incidence data were evaluated for 1979-1988. Given this scenario, it would appear that there was an insufficient amount of time for cancers to develop as a consequence of possible toxic exposures from this landfill.

d) Migration and Population Growth: Exposure and latency are further complicated by migration. No information was available regarding the length of time people lived in Staten Island. Theoretically, it is possible that some people were exposed to carcinogens elsewhere and moved to Staten Island only to develop cancer shortly thereafter. This issue is particularly relevant to the Study Area, where there was recently very rapid population growth.

e) Competing Risk Factors for Cancer: Cancer can be caused by many different agents--

chemical exposures, lifestyle factors, or genetic factors acting alone or in concert. For lung cancer, the major known risk factor is cigarette smoking; for colon cancer, dietary factors are thought to play a role; for breast cancer, the major known risk is genetic (family history). Unfortunately, no data on any risk factors were available for this study, and so it is difficult to evaluate the possible role that environmental vs. other (eg. lifestyle and genetic) factors may have played in cancer incidence.

V. RECOMMENDATIONS

The NYSDOH and SAC have reviewed previous drafts of this report (see appendices 1 and 10). Based on the findings of this investigation, the New York City Department of Health, in consultation with its scientific advisory committee makes the following recommendations:

1. Continue evaluation of more recent (post 1988) incidence of selected cancers in the Study Area: Although the results of this study showed that the incidence of cancer during the 10 year period from 1979-1988 was not statistically elevated, the follow-up period after possible exposure from illegal dumping (late in the 1970's) may not have been long enough for some cancers to develop. Therefore, it is recommended that the incidence of more recent (post 1988) cancers continue to be evaluated. It is further recommended that such analyses focus on childhood cancers (since this was a predominant community concern) and on those adult cancers for which a moderate (although non-statistically significant) elevation was observed in the Study Area (i.e. kidney in men; leukemia and lymphoma in women) . Because of the relatively small number of cases which occur within a single year, and the subsequent difficulties this poses for conducting meaningful statistical analyses, such analyses should only be conducted when at least four or five years worth of additional data are available (eg. 1989-1992). More recent data should be compared with data from the previous period to evaluate time trends.

2. Convene a panel of experts in cancer epidemiology to review this study and other available literature to determine whether or not an analytic epidemiologic study would provide valuable information as to the possible causes of elevated cancer incidence rates on Staten Island (lung, and possibly bladder, colon, larynx and pharynx cancers). Although the incidence of several types of cancer among residents of Staten Island was statistically significantly elevated (lung and to a lesser extent bladder, colon, larynx and pharynx cancers), this study does not provide direct clues as to why these increases occurred. In its deliberations, the panel should carefully consider such issues as: the magnitude of elevations in the above-mentioned cancers (10-55%); racial and ethnic differences in cancer patterns; the role of cigarette smoking; and the best way to obtain accurate information on possible environmental and occupational exposures. Should the panel decide that further study is necessary, they should determine the appropriate scope, and assist in the design, of such a study. The panel should also assist in the identification of potential sources of funding for such a study.

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I. INTRODUCTION

A. BACKGROUND

In the spring of 1992, the New York City Department of Health (DOH) was notified by the New York State Department of Environmental Conservation (DEC) and New York State Department of Health (NYSDOH) that residents of Staten Island believed there was a seemingly high incidence of cancer and other conditions among resident children and adults. Residents believed these conditions were due to possible exposures from the two municipal landfills on Staten Island, the Fresh Kills and Brookfield Avenue Landfills.

The Brookfield Avenue Landfill was operated by the New York City Department of Sanitation (DOS) from 1966 until it was closed in 1980. It is bounded on the north by Richmond Creek, on the East by Colonial Square Condominium Properties, on the south by Arthur Kill Road and on the West by Richmond Avenue. The Brookfield Avenue Landfill had a total area of 272 acres, however, only 150 acres of the Landfill received refuse. Brookfield Avenue Landfill had an average daily disposal capacity of 1,200 tons of municipal waste. In May of 1982, a driver/dispatcher for the Hudson Oil Refining Company, testifying before a senate committee on crime, reported that between 1974 and 1980, waste oil, sludges, metal plating wastes, lacquers and solvents were illegally disposed of at several New York City landfills, including Brookfield Avenue. During subsequent court proceedings, the probable contaminants were identified as cyanide, dichlorobenzene, dioctylphthalate, naphthalene, ethyl benzene, toluene, xylene, and alkyl phenol. The exact types, quantities and locations of the wastes were not known. However, among those landfills that were reported to have received chemical wastes, the Brookfield Avenue Landfill was alleged to be the primary disposal point.[1] There is no further information available about other illegal dumping at the landfill, so it is unknown whether toxic dumping occurred at other times. Subsequently, the Brookfield Avenue Landfill was classified as an inactive hazardous waste site by DEC. It is currently undergoing a remedial investigation by the New York City Department of Environmental Protection (DEP).

Across Richmond Avenue, to the west, is the Fresh Kills Landfill. Fresh Kills is also owned and operated by DOS. The landfill began accepting waste in 1948 and has been in continuous use since then. Fresh Kills Landfill accepts mixed solid waste, the majority of which is residential. It is the only active landfill in New York City and is in operation 24 hours a day, six days a week. Currently, Fresh Kills receives about 13,000 tons of refuse by barge and 1500 tons by truck daily.[2]

B. STUDY DEVELOPMENT

In response to concerns about childhood and adult cancer and other conditions around the landfills on Staten Island, DOH met with members of the public, elected officials, representatives from state and federal environmental and public health agencies and members of the medical and scientific community in September 1992. At this meeting, several suggestions were made as to possible health outcomes the DOH could study. Among these were studies of cancer, birth outcomes, and respiratory diseases.

In considering the various health outcomes for study, sources of health data were evaluated for data quality. For example, data on birth defects, reported on birth certificates and collected by DOH, is not considered of adequate quality since reporting is not complete. In part, this is because many birth defects are not recognized at birth, and therefore not reported on birth certificates. Consequently, the database is not comprehensive. NYSDOH reported the information they collected on birth defects is also incomplete because many defects go unreported. NYSDOH also explained that no surveillance database exists for studying the incidence of respiratory diseases other than respiratory cancers. Among the health issues of concern, cancer incidence data from the NYSDOH cancer registry was the only comprehensive data base of illnesses available.

Meeting participants acknowledged that, while there were still other health issues of interest among Staten Island residents, cancer among children and adults living near the landfills was a major health concern for which there was a comprehensive database of reported cases and that, as a first step to addressing health concerns among Staten Island residents, the NYSDOH Cancer Registry data should be analyzed to determine if residents around the Brookfield and Fresh Kills Landfills experienced an elevated rate of cancer. Since cancer information for Staten Island was available and residents living in other areas of Staten Island had expressed concern about cancer, this study also examined cancer incidence in Staten Island as a whole.

Unfortunately, there are currently no medical or scientific tests to determine why an individual develops cancer. In the absence of such information, epidemiology is one of the main tools available for evaluating disease in human populations. Meeting participants agreed that an epidemiologic assessment was the best approach to the question of whether there was an elevated rate of cancer near the landfills and/or in the rest of Staten Island.

The Staten Island Cancer Incidence Study is a descriptive epidemiologic study. This study type is generally the first step of an epidemiologic investigation. It is designed to provide information on the specific types and amounts of cancer which occurred among residents in the communities around the landfills and in residents of Staten Island as a whole. The results of this investigation can be used to determine how many cases of cancer occurred in the neighborhood near the landfills and in the rest of Staten Island. They can also be used to determine whether residents in either area experienced a higher or lower incidence of cancer than residents of other areas. The results of this investigation can be used to guide in the

formulation of public health policy, interventions, or further research questions that would be part of a subsequent investigation. Because of their many limitations (a detailed overview of the limitations is provided in the discussion), a descriptive investigation such as this one cannot answer questions pertaining to what caused a cancer or **why** a particular individual or group of individuals developed a specific type of cancer.

Meeting participants acknowledged at the outset that a descriptive study could not prove or disprove the possible role the landfills played in cancer causation--indeed, participants noted that many similar investigations of cancer incidence among people living near landfills or hazardous waste sites, including studies of Love Canal [3], have failed to provide strong and consistent evidence of a high risk for cancer. However, they also acknowledged that a descriptive investigation of cancer incidence was a necessary first step to confirm or alleviate citizen concerns about the occurrence of excess cancer in the community. A descriptive investigation was also a necessary to generate theories or hypotheses about possible causes of cancer that might be tested in future studies.

To provide guidance and oversight for the study, a Scientific Advisory Committee (SAC) was formed. Nominations to the SAC were solicited from community organizations, elected officials, universities and medical societies. Members of the SAC were selected based on their experience and expertise in the fields of environmental health, epidemiology and medicine. Selection of the SAC members was completed in early 1993 (a list of the SAC members is presented in Appendix 1). The specific role of the SAC was to review the proposed study methodology, review drafts of the study findings, and to make recommendations regarding the interpretation of data and further actions. The SAC reviewed and commented on several drafts of the proposed study methodology and the study findings and were instrumental in helping to formulate the recommendations for further study.

C. OBJECTIVES

The Staten Island Cancer Incidence Study was designed to satisfy the following objectives:

1. Determine the **absolute burden** of cancer among child and adult residents of the census tracts near the Fresh Kills and Brookfield Avenue Landfills and in Staten Island as a whole by documenting the exact number of and specific types of cancer (the "cancer incidence") during the period 1979-1988. This was the most recent time period for which complete data were available when the study was initiated.

2. Assess the **relative burden** of cancer in both the landfill neighborhoods and Staten Island as a whole to determine if cancer incidence was higher or lower in either area by:

   a) Comparing the incidence of cancer in the landfill area with cancer incidence in the rest of Staten Island.
   b) comparing the incidence of cancer in the landfill area with cancer incidence in an area demographically similar to Staten Island that was not in proximity to a landfill.
   c) comparing the incidence of cancer in Staten Island as a whole with cancer incidence in an area demographically similar to Staten Island that was not in proximity to a landfill.
   d) comparing the incidence of cancer in Staten Island to cancer incidence in the rest of NYC.

3. Evaluate the results of 1 & 2 (above) to determine whether any patterns emerge that may trigger a need for further public health interventions or investigations.

4. Address community concerns about cancers that occurred after the period for which complete data are available at the time the study was initiated (1989 to 1992).

5. Provide information to the public about other epidemiological studies that examined cancer among residents near waste sites.

6. Provide the public, government officials and agencies, and other researchers with information about the occurrence of cancer on Staten Island that could be used as a basis for further research and/or policy development.

II. CANCER INCIDENCE 1979-1988

A. METHODS

1. Study Population and Geographic Area

a. *Staten Island Populations*

This investigation evaluated the incidence of cancer in an area comprising 13 census tracts (based on the 1990 census) that surround the Fresh Kills and Brookfield Avenue Landfills (hereafter called the "Study Area") and on Staten Island as a whole. The Study Area is shown in figure 1. This area was selected in consultation with concerned residents.

b. *Comparison Populations*

The three areas selected for comparison were: 1) Staten Island minus the Study Area, 2) the combined population of the Bay Ridge, Brooklyn and Flushing, Queens Health Districts and 3) The rest of New York City (excluding Staten Island).

The Bay Ridge and Flushing Health Districts were selected because, in combination, they were demographically similar to Staten Island with regard to race and income distribution. In addition, they were not communities where a landfill had been operated. These areas are shown in figure 2.

2. Sources of Data

a. *Cancer Incidence Data*

The DOH obtained cancer incidence data (that is, reports of new cases of cancer) from the New York State Department of Health (NYSDOH) Cancer Registry. All medical facilities in New York State are legally required to report new cases of cancer to the Registry. Additionally, the NYSDOH Cancer Registry has reporting agreements with many other states, including Florida, New Jersey and Connecticut. Thus, if a resident of New York State was diagnosed with cancer in another state he/she would still be included in the NYSDOH Cancer Registry file. Surveys conducted by the NYSDOH's Bureau of Chronic Disease Epidemiology and Surveillance have concluded that cancer reporting for NYC is more than 90 percent complete[4].

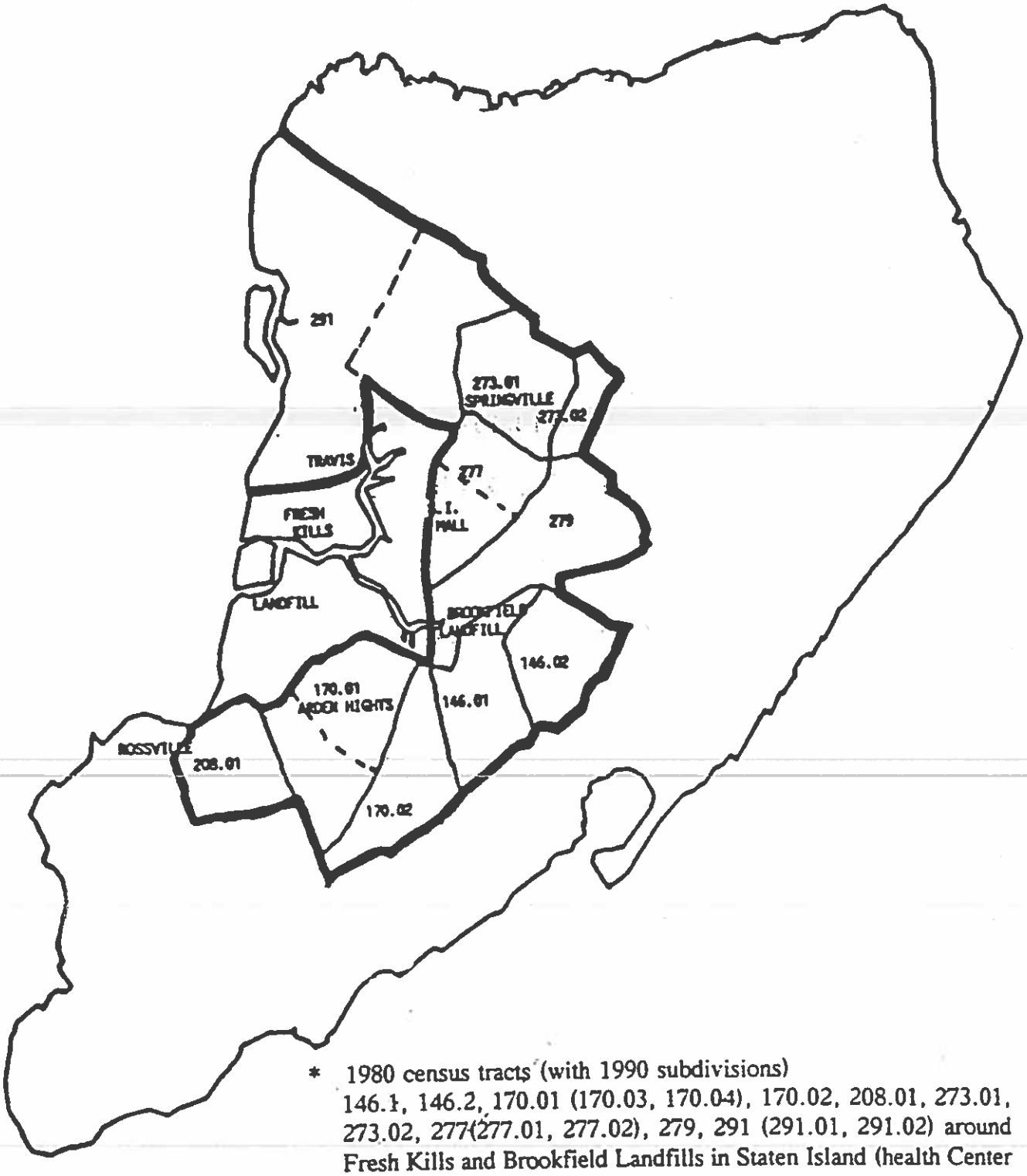
Information was obtained for all new cases of cancer that were diagnosed in residents of Staten Island and the rest of NYC during the ten year period between 1979-1988. At the time this study was initiated, this was the most recent period for which cancer reporting was considered complete for analysis of small geographic areas (ie: census tracts).

The Registry continually receives reports of new cancer cases and therefore continually

FIGURE 1

STATEN ISLAND CANCER INCIDENCE STUDY

STUDY AREA MAP*



* 1980 census tracts (with 1990 subdivisions) 146.1, 146.2, 170.01 (170.03, 170.04), 170.02, 208.01, 273.01, 273.02, 277(277.01, 277.02), 279, 291 (291.01, 291.02) around Fresh Kills and Brookfield Landfills in Staten Island (health Center District Richmond). Dashed lines indicate subdivisions of census tracts in 1990

FIGURE 2

HEALTH CENTER DISTRICTS
CITY OF NEW YORK*

* Studied area (Richmond) and compared areas (Bay Ridge and Flushing) highlighted

updates the data base. Generally, it takes 2-4 years for all reports of cancer during a given year to be filed, verified and computerized. After this process is complete, additional steps must be taken to add information such as census tract, borough, and health district for each reported cancer case so that analyses, such as those conducted for this study, can be carried out.

For each cancer case the following information was obtained: age, sex, census tract and health district at time of diagnosis, and type of cancer diagnosis. Cancer incidence data are normally coded for race (White, Black, Other) and Hispanic origin. Complete information on Hispanic origin was not reported to the NYSDOH Cancer Registry for more than 40% of NYC cancer cases, therefore, race/ethnicity information (which may relate to lifestyle or genetic risk factors) was not included in the analyses for this report.
Information about more recent (> 1988) cancer cases was obtained through neighborhood and community reporting of individual cases to DOH.

b. Demographic Data

Demographic data, including population size, age, sex, race, and income for all areas were provided by the New York City Department of City Planning and obtained from the 1980 and 1990 US Census.

3. Selection of Cancer Sites for Analysis

In this investigation, DOH evaluated the incidence of 14 different types of cancer in adults and 3 different childhood cancers. Particular cancer sites were selected for two reasons: 1) residents were concerned that there may have been an unusually high incidence; and/or 2) these cancers have been shown to be related to environmental exposures (although they may be caused by other factors as well). Information on risk factors for different types of cancers is included in appendix 2. The rates of the following types of cancer were analyzed for adults and children:

pharynx/ oral cavity	(ICD* 140-149)	prostate	(ICD 185)
		bladder	(ICD 188)
stomach	(ICD 151)	kidney	(ICD 189)
colon	(ICD 153)	CNS**√	(ICD 190-192)
liver	(ICD 155)	lymphoma √	(ICD 200-202)
pancreas	(ICD 157)	mult. myeloma	(ICD 203)
larynx	(ICD 161)	leukemias√	(ICD 204-208)
lung	(ICD 162)		
female breast	(ICD 174)	total√	(ICD 140-208)

* ICD = international classification of diseases
** CNS = central nervous system (including brain) cancers
those cancers indicated by a" √" were also evaluated in children

In this investigation we have included an assessment of total cancer incidence. From an

epidemiologic perspective, total cancer incidence is not considered useful for identifying patterns of disease or causes of disease. This is because total cancer incidence relies on the underlying frequencies of specific cancer types. For example, an elevation of a relatively common cancer like lung or breast cancer will have a large impact on the total cancer incidence rate. An elevation of a rarer form of cancer, like kidney cancer may have no impact on the total cancer incidence rate. Total cancer incidence was included here because of community interest, however, total cancer incidence should not be used when drawing conclusions about cancer incidence patterns or cancer risk either in the Study Area or on Staten Island as a whole.

4. Analysis

a. *Description of Cancer Cases*

As noted previously, the first objective in evaluating the occurrence of cancer in the Study Area and in Staten Island as a whole was to document the absolute burden of cancer, that is: Who was getting cancer? When did cancer cases occur? Where did the cancer cases live? What type and how many cancers occurred?

b. *Comparison of Cancer Incidence in Staten Island and Study Area with Other Areas*

To evaluate whether cancer incidence was unusual (i.e.: the relative burden) in these areas, four (4) comparisons were made.

1. Cancer incidence in the Study Area compared with cancer incidence in the rest of Staten Island.

2. Cancer incidence in the Study Area compared with cancer incidence in the Bay Ridge and Flushing Health Districts

3. Cancer incidence in Staten Island as a whole compared to the Bay Ridge and Flushing Health Center Districts.

4. Cancer incidence in Staten Island as a whole compared with cancer incidence in the rest of New York City

c. *Evaluating the Patterns of Results*

Taken individually, each of the comparisons (above) allow us to assess the relative burden of cancer--either in the Study Area or in Staten Island as a whole. Taken together, they allow for a more comprehensive assessment of the patterns of cancer on Staten Island, as well as for an assessment of the consistency of the findings. Both of these factors, that is: the pattern of findings and how well the findings of the individual analyses correspond to each

other (the consistency), contribute to the interpretation of the results and provide evidence for determining whether the findings support a need for further investigation, other public health interventions, or both.

For example, comparing the Study Area with the rest of Staten Island will help to establish whether the pattern of cancer in Staten Island is consistent with possible landfill exposures. A pattern in which cancer incidence in the Study Area was higher than in the rest of Staten Island and higher than in the Bay Ridge/Flushing comparison area would not prove that landfill exposures were responsible for the elevations. However, such a pattern would suggest a possible need for further analysis. Comparing both the Study Area and the rest of Staten Island to the Bay Ridge/Flushing health districts allows for a comparison of whether the patterns of cancer are similar in each area of concern--indicating that a cancer "problem" may be Island-wide. In addition, it is well established that cancer rates vary by socio-demographic factors such as income and race/ethnicity. These comparisons help to factor out some of the demographic influences on cancer risk since the Bay Ridge/Flushing area is demographically similar to Staten Island, while the rest of New York City (as a whole) is quite different. Previous investigators have noted elevations of specific cancers on Staten Island as compared to the rest of NYC[5,6,7], the comparison of Staten Island to the rest of NYC will indicate whether this trend is continuing.

d. Calculation of Cancer Incidence Rates and Rate Ratios

Ten year cumulative cancer incidence rates (the number of new cases of cancer during the ten years from 1979 to 1988 in an area divided by the population in the same area) were calculated for the Staten Island populations and the populations in the comparison area. Computation of confidence intervals and power analysis (discussed below and explained in detail in appendix 3) are based on these cumulative rates. Average annual incidence rates (cumulative rates divided by 10) were also calculated and are presented in tables accompanying this report.

Accurate calculation of cancer incidence rates depends on the accurate determination of both the number of people who developed cancer and the total number of people in the population during the same time period. The population in Staten Island and the population in the Study Area experienced an overall growth of 8% and 31% respectively during the decade of 1980 to 1990. The populations in the comparison areas also grew during the decade, but not to the same extent. Consequently, use of the 1990 or 1980 population data to calculate the cancer incidence rates would result in either an underestimate of the true rates (using 1990) or an overestimate of the cancer rates (using 1980), particularly in the Study Area. Therefore the "average" population was approximated by estimating the 1984 population (the midpoint of the study time period). This average population was used to calculate the 10 year cumulative and average annual cancer incidence rates. Since it was not possible to determine precisely when the growth in different areas occurred, the 1984 average population was estimated using simple linear interpolation. Linear interpolation assumes that the changes in the size of the population happened at a constant rate over the 10 year time period. Population change and

demographic characteristics are presented in appendix 4.

Cancer rates were calculated separately for children (≤ 14 years old) and adults. In adults, cancer incidence rates vary with age. To take into account differing age structures of the populations the adult cancer incidence rates for males and females were directly age adjusted to the 1980 New York City population. Eight age groups were used to age adjust the adult cancer rates (15-24, 25-34, 35-44, 45-54, 55-64, 65-74, 75-84, 85+). Similarly, cancer rates are influenced by other socio-demographic variables (such as race/ethnicity or socio-economic status). Failure to consider the differing racial/socio-economic conditions of different areas can cause cancer rates in one area to be comparatively high or low. As noted previously, the cancer incidence data used in this investigation are missing more than 40% of the coding for Hispanic origin. Consequently, it was not possible to race adjust. The primary analyses in this study (the Study Area compared to the rest of Staten Island and the Study Area and Staten Island as a whole compared to the combined Bay Ridge/Flushing Health Districts) were devised to deal with this issue: Since these areas are very similar with regards to race/ethnicity, the impact of race/ethnicity in any differences in cancer rates should be small. In other analyses (Staten Island compared to the Rest of NYC and the Ranking of the 30 NYC Health Districts) it was not possible to adjust for race/ethnicity. Because NYC as a whole and several of the individual Health Districts are very different with regards to racial/ethnic makeup, these analyses should be interpreted with caution. The relationship of race/ethnicity to cancer incidence rates will be addressed more fully in the discussion. Age adjustment and the issues of race adjustment in this study are also discussed in appendix 3.

Rate ratios (RR's) for all cancer types were computed by dividing the adjusted rates in Staten Island and in the Study Area by the adjusted rates in the corresponding comparison areas. The RR shows how the cancer incidence rate in one area compares to the rate in a comparison area. The RR is interpreted as follows: a RR close to 1.00 shows that the Study Area has about the same cancer incidence rate as a comparison area. A ratio over 1.00 means that the Study Area has a higher incidence rate than the comparison area. Similarly, a ratio less than 1.00 indicates that the Study Area rate is less than the comparison area's incidence rate. For example, a RR of 1.25 means that the area under investigation has a 25% higher cancer incidence rate than the comparison area. A RR of 0.80 means the Study Area has cancer rate 20% lower than the comparison area.

e. Significance Testing and Power Calculations

The statistical significance of each RR was evaluated with 95% confidence intervals. Confidence intervals for the RR's were calculated based on ten-year cumulative rates using a formula presented by Flanders[8]. If the 95% confidence interval contains the value of 1.00 within it, then the RR is not statistically significant and may be due to random variation. However, if the value of 1.00 is <u>not</u> contained within the interval then the RR is said to be statistically significant. A complete discussion of the interpretation of 95% confidence intervals is presented in appendix 3.

A counterpart to statistical significance testing is power analysis. Power refers to the ability to observe an effect of a given magnitude--in this study the size of the RR--as statistically significant. Like statistical significance testing, power is influenced by many factors, most importantly: the size of the population being studied, the number of cases, and the size of the RR. In general, 80% is considered adequate power and larger sample sizes and/or large effects (high RR's) will have adequate power.

Power analysis was performed for each set of analyses to determine whether there was adequate statistical power to recognize a true statistical difference in the rates of the Study Areas and the comparison areas. Power was determined using a computer generated model based on "Monte Carlo" simulation and standard power formulas[9]. A complete discussion of the interpretation of power is presented in appendix 3.

B. RESULTS

The results of this investigation will be presented in three (3) sections. The first section will describe the findings for the analyses of cancer incidence from 1979-1988 in the Study Area. The following section will present the findings of these analyses of Staten Island as a whole. The third section will describe the findings of the case verification for more recent cases of cancer. Throughout each section, in addition to an indication as to whether the RR 's were statistically significantly elevated, the following terms will be used to describe the magnitude of the RR: "similar to 1.00" indicates RR's that are between 0.95-1.05, "slightly" elevated indicates RR's that are between 1.06 and 1.24, and "moderately" elevated refers to RR's that are greater than or equal to 1.25. These categories were selected to simplify the presentation of the results for the reader.

The age adjusted cancer rate ratios (RR's) for each set of comparisons are summarized in tables 1-3 (pages 21-23). The summary results are presented in separate tables for adult males (table 1), adult females (table 2) and children (table 3). Across all areas, RR's for men ranged from 0.50 -- 1.55 , for women the RR's ranged from 0.48 -- 1.58 and for children the RR's ranged from 0.67 --1.38. There were no cases where a very large elevations in cancer rates was noted (i.e.: a doubling (or more) of the cancer rates; RR of greater than 2.0)

Appendix 5 (pages 63-73) presents the results in more detail. Again, they are presented in separate tables for adult men, adult women, and children. This appendix presents the number of cancer cases that occurred in each area for each cancer type investigated, the average annual age-adjusted incidence rates for each area, the RR and the 95% confidence interval for the RR.

Appendix 6 (pages 74-77) presents patterns of the rate ratios (RR's) for each area comparison. This appendix also present the results of the power analyses.

1. Cancer Incidence in the Study Area

Absolute Burden

The most common types of cancer, contributing the most to the absolute burden of cancer among men in the Study Area, were lung (221 cases), prostate (128 cases), and colon cancer (116 cases). Together these cancers accounted for 43% of all cancers in the Study Area. Among women, the most common types of cancer were breast (340 cases), lung (126 cases), and colon cancer (112 cases). These cancers accounted for 52% of all cancers among women. Leukemia (7 cases) was the most common cancer type among children. This types are also the most common in Staten Island as a whole, New York City, and New York State.

a. *Cancer Incidence in Study Area Compared to the Rest of Staten Island*

Overall, among men, women and children, cancer incidence in the Study Area for the majority of sites was lower than that in the rest of Staten Island. However, the pattern of results noted among men and women was slightly different from one another. That is, women in the Study Area experienced elevations in the same cancers that men experienced a deficit in and vice versa. The results of these analyses are discussed in detail below.

Relative Burden

Men:

Rate ratios ranged from 0.50 for multiple myeloma to 1.31 for kidney cancer. There were no cancer rates that were statistically significantly elevated in the Study Area when compared to the rest of Staten Island. Kidney cancer was moderately elevated among men in the Study Area (RR 1.31). This difference was not statistically significant; however, there was only good power to evaluate a RR of 1.6 or more (appendix 6). Cancer rates for men in the Study Area were similar to or lower than (RR's 0.50-1.04) the cancer rates for the rest of Staten Island for 13 of 14 different sites and total cancers combined (table 1 and appendix 5 table 1a). The rates of pharynx cancer and multiple myeloma were significantly lower in Study Area men.

Women:

Rate ratios ranged from 0.48 for pharynx cancer to 1.24 for leukemia. As with men, there were no cancer rates that were statistically significantly elevated in the Study Area when compared to the rest of Staten Island. Women had slightly higher rates of leukemia, lymphoma and cancers of the bladder, stomach, and lung when compared to the rest of Staten Island (see table 2 and appendix 5 table 2a). These elevations were not statistically significant and the absolute magnitude of the elevation for any given site was relatively small (8% - 24%). This investigation only had good statistical power to evaluate RR's greater than 1.3 or 1.4 in cancer rates in this small population (see appendix 6). Cancer incidence among women in the Study Area for the majority of sites (9 of 14 and total cancers combined) was similar to or lower than (RR's of 0.48-1.01) cancer incidence in the rest of Staten Island. Among women, the incidence of pharynx and nervous system cancers was statistically significantly lower in the Study Area than in the rest of Staten Island.

Children:

Rate ratios ranged from 0.80 for leukemias to 1.38 for lymphomas. There were no cancer types for which the rate ratios were statistically significantly elevated. While the RR for lymphoma was not statistically significant, there was also very low power to detect this moderate elevation. There was only adequate statistical power to detect a quadrupling of the rate (ie: a RR of 3.8, see appendix 6).

b. ***Cancer Incidence in the Study Area Compared to the Combined Bay Ridge and Flushing Health Districts***

Overall, there was a somewhat similar pattern of findings among men and women when the Study Area was compared to the combined Bay Ridge/Flushing area. Exceptions to this were in leukemia and lymphoma, where women experienced a slight increase and men experienced a slight deficit. Cancer rates among children were generally lower in the Study Area.

Men:
The average annual incidence rate ratios among men in the Study Area compared to men in the Bay Ridge and Flushing area ranged from 0.58 for multiple myeloma to 1.46 for larynx cancer (table 1). The moderate elevation noted for lung cancer (RR 1.32) was statistically significant as was the slight elevation in total cancer incidence (RR=1.09) (see appendix 5 table 1b). Six other sites had RR's that were greater than 1.00 (RR's 1.04-1.46). Moderate elevations that were not statistically significant were noted for liver (RR of 1.26) and larynx cancer (RR of 1.46). The remaining 4 sites with RR > 1.00 represented only slight elevations or RR's that were very close to 1.00. None of these remaining elevations were statistically significant. However, there was very poor power to detect significant elevations for these slight or moderately elevated RR's (see appendix 6). Seven of 14 sites evaluated had RR's less than 1.00. The RR for multiple myeloma was significantly lower in the Study Area compared to the combined Bay Ridge and Flushing Health Districts (appendix 5 table 1b).

Women:
Among women, the RR's ranged from 0.64 for central nervous system to 1.58 for larynx cancer (table 2). The RR for lung cancer (1.32), was statistically significant. There were 5 other types of cancer with a rate ratio slightly or moderately elevated (RR 1.11-1.58). As with the results for men (above) the statistical power was very low and there was only adequate statistical power to detect differences larger than a 50-75% elevation in rates (appendix 6). The remaining sites had RR's that were similar to, or less than, 1.00. The RR for CNS cancers (RR=0.64) was significantly lower among women in the Study Area when compared to women from the Bay Ridge/Flushing comparison area.

Children:
Cancer incidence RR's among children ranged from 0.67 for leukemias to 1.10 for lymphoma. There were no types of cancer for which there was a statistically significant elevation or deficit in the RR's. There was only adequate statistical power to detect a doubling or tripling in the rate of lymphoma (appendix 6).

2. Cancer Incidence on Staten Island

Absolute Burden

The three cancer types that contributed the most to the absolute burden of cancer among men in Staten Island were lung (1,575 cases), prostate (875 cases), and colon (762 cases) cancer. Overall these three cancer types represented 47% of all male cancers in Staten Island. Among women, the three most common cancer types (accounting for 50% of all female cancers) were breast (1,975 cases), colon (839 cases), and lung (755 cases) cancer. As noted previously, these cancer types are also the three most common types among men and women in NY State and the U.S. Leukemia (31 cases), the predominant cancer type in children in the City, State and the U.S., was also the most common cancer among children in Staten Island.

Relative Burden

a. *Cancer Incidence on Staten Island Compared to the Combined Bay Ridge and Flushing Health Districts*

The pattern of results noted in this comparison was similar to that noted for the comparison of the Study Area to the Bay Ridge Flushing Health District. Men and women in Staten Island as a whole experienced elevations or deficits in the same cancer sites at more or less the same magnitude as men and women in the Study Area when compared to men and women in Bay Ridge and Flushing, The only notable exception are the findings for cancers of the pharynx. The results for each sex are discussed in more detail below.

Men:
RR's for cancer among men ranged from 0.89 for stomach cancer to 1.55 for larynx cancer (Table 1). Moderate, statistically significant elevations were observed for cancers of the pharynx, larynx, and lung. The slight elevation noted in total cancers (RR of 1.14) was statistically significant. Liver cancer was moderately elevated (RR = 1.27). This elevation was not statistically significant. For most cancer types, there was good power to detect statistically significant differences, however, there was only 50% power to detect a statistically significant difference for liver cancer. Cancer incidence in 6 of the 14 cancer sites investigated was similar to or lower than cancer incidence in the Bay Ridge/Flushing area. Slight elevations, representing differences in rates of between 7% and 9%, were noted for cancers of the colon, bladder and nervous system. These elevations were not statistically significant.

Women:
As shown in table 1b, the RR's for Staten Island women as compared to women from the Bay Ridge and Flushing Health Districts ranged from 0.92 for kidney cancer to 1.56 for larynx cancer. Statistically significant elevations were noted for cancers of the pharynx, colon, and lung. Total cancer incidence was also statistically significantly elevated, though the RR (1.04) was very close to 1.00. There was fairly good power (approximately 80%, see appendix 6) to

detect a statistically significant RR for larynx cancer (RR = 1.56), so we can be relatively confident that the moderate elevation noted for this site does not indicate a true elevation in the rate of larynx cancer in this population. Conversely, for liver cancer (RR = 1.24), power was very low (20%) and it is not clear whether this moderate elevation represents a truly elevated rate or simply represents normal variation in the rates of cancer. There were five other cancer types with RR's greater than 1.00, most of these represent slight elevations. There were five cancer types for which the incidence was similar or lower on Staten Island compared to the Bay Ridge and Flushing area (RR's 0.92-0.98). There were no cancer types for which the incidence rates were significantly lower on Staten Island than in the comparison area.

Children:
When compared to Bay Ridge/Flushing, the children on Staten Island had lower rates of cancer. The RR's ranged from 0.77 to 0.89 (table 3). There were no cancer types for which the incidence rates were significantly different for the two areas.

b. ***Cancer Incidence on Staten Island Compared to the Rest of NYC***

The pattern of results noted here was somewhat similar to the pattern noted in the previous comparison. That is, the patterns of results noted among men and women were similar (appendix 6) to one another and elevations were noted in the same cancer sites. The magnitude of the elevations for specific cancer sites was similar among men and women. The only exception was the rate of lymphoma for men which was about the same or lower in Staten Island as in the rest of NYC while for women the rate on Staten Island was slightly higher (RR 1.17) than in the rest of NYC. The RR for lymphoma among females was statistically significant.

The results for each sex are discussed in more detail below.

Men:
The RR's ranged from 0.83 for stomach cancer to 1.36 for lung cancer. Four cancer types (colon, lung, bladder, larynx) had incidence rates which was statistically significantly higher than the rates in the rest of NYC. These represent slight to moderate elevations of 12%-36%. The incidence of all cancers combined was also slightly but significantly higher on Staten Island than in the rest of NYC (RR = 1.10). There was good power to detect very slight elevations in the rates for most cancer sites. The only exception was the RR for CNS cancers (RR 1.23), where there was only good power to detect an RR of 1.3 to 1.4.
There were 9 types of cancer for which the incidence was similar to or lower than the rest of NYC (RR's 0.83-1.04). Of these, the incidence rates for stomach and prostate cancers were significantly lower on Staten Island than the rest of NYC (table 1 and appendix 5 table 1d)

Women:
As shown in table 2, the RR's for the different types of cancer ranged from 0.85 for multiple

myeloma to 1.30 for larynx cancer. Five cancer sites (colon, lung, breast, bladder, and lymphoma) had incidence rates that were slightly or moderately elevated and statistically significantly higher than the incidence rates in the rest of NYC (RR's 1.14-1.25). The slight elevation (RR of 1.09) in total cancer incidence was also significantly higher among Staten Island women. A moderate elevation (30%) noted for cancers of the larynx was not statistically significant. However, there was only good power to detect an RR of 1.5 or more for larynx cancer (see appendix 6). There was also inadequate statistical power (55%) to evaluate the slight elevation noted in pharynx cancer (RR = 1.18) and CNS cancers (RR 1.16, power approximately 40%). There were 6 types of cancer for which the incidence on Staten Island was similar to (RR's 0.85-1.04) or lower than that in NYC. (appendix 5, table 2d).

Children:
Table 3 presents the incidence rates for the 3 different types of childhood cancer evaluated and for total cancers combined. In all types, the rates on Staten Island were lower than the rates in the rest of NYC. Rate ratios ranged from 0.84-0.93.

c. ***Cancer Incidence on Staten Island Compared with Other NYC Health Districts***

The incidence rate of specific types of cancer was calculated for each of the 30 Health Districts in NYC. Health Districts were then ranked from 1 to 30 for each cancer type according to the results. A ranking of #1 means a Health District had the highest incidence rate for that specific type of cancer, whereas a ranking of #30 means a Health District had the lowest incidence rate.

For specific types of cancers among men, women and children, appendix 7 (pages 78-81) shows where Staten Island (Richmond HD) ranked among the 30 Health Districts, the age-adjusted incidence rate for specific types of cancer, the range of rates among all 30 NYC Health Districts and the incidence rate for New York City as a whole.

Rates are presented as number of cases/100,000 populations. Results of the Health District (HD) ranking for men, women, and children are presented below:

Men:
Staten Island ranked among the top 20% of Health Districts for 5 of 14 types of cancers in men- colon (#2), lung (#2), bladder (#1), nervous system (#4) and larynx (#6). Staten Island ranked in the middle (a rank between 10-20) or lower (a rank between 21-30) for 9 of 14 different types of cancer. Staten Island ranked among the bottom 20% of Health Districts in NYC for stomach cancer (#29).

Among the types of cancers for which Staten Island ranked in the top 20% of Health Districts, the range of rates varied from less than a doubling to a tripling between the HD

with the lowest rate and the HD with the highest rate. For example, for colon cancer among men, there was less than a doubling between the HD with the lowest rate of 55.96/100,000 and the HD with the highest rate of 81.84/100,000. The NYC rate of 72.05/100,000 is not that different from the HD with the highest rate of 81.84/100,000 nor the Staten Island rate of 80.59/100,000. However, for other cancer types, such as lung cancer among men, there was a wider range of rates among the health districts. For lung cancer, the lowest health district rate was 85.74/100,000 while the highest health district rate was 202.69/100,000. There was also a large difference between the average NYC rate and Staten Island rate (118.82/100,000 vs. 159.43/100,000).

Women:
Staten Island ranked among the top 20% of health districts for 7 of 14 types of cancers - colon (#2), lung (#4), breast (#4), bladder (#2), lymphoma (#5), larynx (#6) and CNS (#6). Staten Island ranked in the middle (rank between 10-20) or lower (rank of 21-30) for 6 of 14 types of cancer. Again, Staten Island ranked among the bottom 20% health districts for stomach cancer (#27).

For women, among the types of cancers for which Staten Island ranked in the top 20%, there was less variance in the range of rates than for men. For colon cancer in which Staten Island ranked #2, both the Staten Island rate of 59.10/100,000 and the highest rate of 60.17/100,000 were very close to the NYC rate of 52.30/100,000. For bladder cancer (rank #2), there was a slightly wider range of rates among the health districts with a doubling between the HD with the lowest and HD with the highest rate. The Staten Island rate was 14.82/100,000 cases while the NYC rate was 11.98/100,000.

Children:
Staten Island ranked in the middle (#15) or lower for each of the childhood cancers evaluated and for total cancers combined. The Staten Island rate was lower than the NYC average rate for each type of cancer.

3. Case Verification

As noted earlier, at the time that the cancer incidence study began, complete and computerized cancer case information was not available from the NYSDOH Cancer Registry for the time period after 1988. However, residents of Staten Island, particularly residents living near the landfills, were concerned about cancers that had occurred more recently. To address these concerns, the NYCDOH asked people to report more recent cancer cases. These cases were then medically verified. The case verification results are discussed below. Appendix 8 (pages 82-87) presents the methods of verifying reported cases of cancer and shows the results in tabular form.

A total of 379 cases were reported to NYCDOH for verification. One hundred thirty eight

(138) of the 379 cases were confirmed as cancer cases (table 1 in appendix 8). Over two thirds of the cancer cases were less than 55 years of age at the time of their diagnosis. There was a higher percentage of female cases reported (60%) than male cases (40%) (table 2 in appendix 8).

Table 3 in appendix 8 presents the cases according to cancer site. Twenty four different cancer types were reported. Breast cancer was the most frequently reported (30%) cancer. Leukemia (15%) and lymphoma (12%) are the next most frequently reported cancers. Only one case of childhood leukemia and 2 cases of childhood lymphoma were reported. Eleven lung cancer cases were also reported (8% of the total) (table 3 in appendix 8).

Ninety-nine percent (99%) of the cases were diagnosed between 1989 and 1992. This is not surprising since the case verification was publicized during late 1992. For both 1993 and 1994 one case was diagnosed.

The 138 cancer cases were grouped according to their location with respect to the Fresh Kills and Brookfield Avenue Landfills. Over half (57%) of the cancer cases lived in the Study Area, while a lesser portion (36%) lived in other parts of Staten Island. Exact address information was not available for 7% of the reported cases. Census tracts with the highest number of verified, self reported cases were 146.01 (17 cases), 277.00 (13 cases), and 170.02 (11 cases), all of which are located within the Study Area.

Expected numbers of cancer cases, for 1989-1992 were calculated for total cancers, leukemias and lymphomas using cancer rates in NYC and NYS as reference rates. Using the NYC cancer incidence rate as the reference, 879 cases of cancer were expected to occur in the Study Area while 3339 cases were expected in other parts of Staten Island. Using the NYS rate, 910 cases were expected in the Study Area and 3518 total cancer cases were expected in other parts of Staten Island. This information is presented in table 4 in appendix 8.

Seventy percent (14 of 20) of the reported leukemia cases lived in the Study Area. In the entire Study Area, 20 (NYC) or 24 (NYS) cases of leukemia were expected to occur. In other parts of Staten Island, 66 (NYC) and 84 (NYS) leukemia cases were expected.

Forty seven percent (8 of 17) of the reported lymphoma cases lived in the Study Area. Using NYC and NYS as the references, the numbers of lymphoma cases expected to occur in the Study Area was 51 (NYC) and 50 (NYS). For other parts of Staten Island 165 (NYC) and 164 (NYS) lymphoma cases were expected to occur.

It is important to note that the data used to calculate rates for NYC and NYS up through 1992 were not yet finalized and expected rates will change slightly in the future. In addition, this analysis of post-1988 cancer cases relied on community reports of cancer cases and therefore the reported and verified number of cases probably does not reflect the complete and exact number of cases that occurred.

TABLE 1

MEN
SUMMARY OF AGE-ADJUSTED CUMULATIVE RATE RATIOS(RRs)[1]
FOR STATEN ISLAND[2] AND STUDY AREA[3]
1979-1988

Rate Ratios (RR) & 95% CI	**Study Area/Rest S.I.[6]**	**Study Area /Bay Ridge & Flushing**	**S.I./ Bay Ridge & Flushing[5]**	**S.I./Rest of NYC[4]**
Range of Rate Ratios (14 Sites & Total Cancers)	0.50-1.31	0.58-1.46	0.89-1.55	0.83-1.36
# of Sites RR Similar to 1.00 (0.95-1.05)	7	3	2	5
# of Sites RR Slightly Elevated (note) (1.06-1.24)	0	3 Total Cancer*	5 Total Cancer*	3 Total Cancer* Colon*
# of Sites RR Moderately Elevated (note) (1.25 and greater)	1	2 Lung*	4 Pharynx* Lung* Larynx*	3 Lung* Bladder* Larynx*
# of Sites with Significant Deficit	2: Pharynx Multiple-Myeloma	1: Multiple-Myeloma	0	2: Stomach Prostate

1 Cumulative rate ratio (RR) is the ten year cancer incidence rate in a Study Area divided by the ten year cancer incidence rate in a comparison area. Rates are age adjusted to the NYC adult population, based on the 1984 estimated population.
2 Health Center District (HD) Richmond
3 1980 census tracts (with 1990 subdivisions) 146.01, 146.02, 170.01 (170.03 and 170.04), 170.02, 208.01, 273.01, 273.02, 277(277.01, 277.02), 291 (291.01, 291.02) around the Fresh Kills and Brookfield Landfills.
4 NYC excluding HD Richmond
5 (HD) Bay Ridge (Brooklyn) and Flushing (Queens) combined
6 HD Richmond excluding above census tracts
* Rates statistically significantly elevated. A rate ratio (RR) is considered to be significantly elevated if the lower limit of the 95% CI is greater than 1.00.
Note: not all slightly or moderately elevated RR's were statistically significant

TABLE 2

WOMEN
SUMMARY OF AGE-ADJUSTED CUMULATIVE RATE RATIOS[1]
FOR STATEN ISLAND[2] AND STUDY[3]
1979-1988

Rate Ratios (RR) & 95% CI	**Study Area /Rest of SI[6]**	**Study Area /Bay Ridge & Flushing**	**S.I./ Bay Ridge & Flushing[5]**	**S.I/Rest of NYC[4]**
Range of Rate Ratios (14 Sites & Total Cancers)	0.48-1.24	0.64-1.58	0.92-1.56	0.85-1.30
# of Sites RR Similar to 1.00 (0.95-1.05)	3	3	5 Total Cancers*	4
# of Sites RR Slightly Elevated (note) (1.06-1.24)	5	3	6 Colon* Lung*	7 Total Cancers* Colon* Lung* Breast* Lymphoma*
# of Sites RR Moderately Elevated (note) (1.25 and greater)	0	3 Lung*	2 Pharynx*	2 Bladder*
# of Sites with Significant Deficit	2: Pharynx Nervous-System	0	0	0

1 Cumulative rate ratio (RR) is the ten year cancer incidence rate in a Study Area divided by the ten year cancer incidence rate in a comparison area. Rates are age adjusted to the NYC adult population, based on the 1984 estimated population.
2 Health Center District (HD) Richmond
3 1980 census tracts (with 1990 subdivisions) 146.01, 146.02, 170.01 (170.03 and 170.04), 170.02, 208.01, 273.01, 273.02, 277(277.01, 277.02), 291 (291.01, 291.02) around the Fresh Kills and Brookfield Landfills.
4 NYC excluding HD Richmond
5 (HD) Bay Ridge (Brooklyn) and Flushing (Queens) combined
6 HD Richmond excluding above census tracts
* Rates statistically significantly elevated. A rate ratio (RR) is considered to be significantly elevated if the lower limit of the 95% CI is greater than 1.00.

note: not all slightly or moderately elevated RR's were statistically significant

TABLE 3

CHILDREN (Ages 0-14)
SUMMARY OF AGE-ADJUSTED CUMULATIVE RATE RATIOS[1]
FOR STATEN ISLAND[2] AND STUDY AREA[3]

Rate Ratios (RR) & 95% CI	Study Area/Rest of SI[6]	Study Area /Bay Ridge & Flushing	S.I./ Bay Ridge & Flushing[5]	S.I/Rest of NYC[4]
Range of Rate Ratios (3 Sites & Total Cancers)	0.80-1.38	0.67-1.10	0.77-.89	0.84-.93
# of Sites RR Similar to 1.00 (0.95-1.05)	0	0	0	0
#of Sites RR Slightly Elevated (1.06-1.24)	1	1	0	0
# of Sites RR Moderately Elevate (1.25 and greater)	1	0	0	0
# of Sites with Significant Elevation or Deficit[7]	0	0	0	0

1 Cumulative rate ratio (RR) is the ten year cancer incidence rate in a Study Area divided by the ten year cancer incidence rate in a comparison area. Rates are age adjusted to the NYC adult population, based on the 1984 estimated population.
2 Health Center District (HD) Richmond
3 1980 census tracts (with 1990 subdivisions) 146.01, 146.02, 170.01 (170.03 and 170.04), 170.02, 208.01, 273.01, 273.02, 277 (277.01, 277.02), 291 (291.01, 291.02) around the Fresh Kills and Brookfield Landfills.
4 NYC excluding HD Richmond
5 (HD) Bay Ridge (Brooklyn) and Flushing (Queens) combined
6 HD Richmond excluding above census tracts
7 A rate ratio (RR) is considered to be significantly elevated if the lower limit of the 95% CI is greater than 1.00.

C. DISCUSSION

This study represents a first step in responding to citizen concerns and documenting the extent and patterns of cancer in the neighborhoods surrounding the Brookfield and Fresh Kills Landfills. The purposes were:

1) To assess the patterns of cancer based on available data, specifically focussing on:

a) How many people were affected by different types of cancer in the area surrounding the landfills and on Staten Island as a whole (also called the "absolute burden" of cancer);

b) How much greater the incidence of cancer was in the area surrounding the landfills and on Staten Island, compared with other neighborhoods in New York City (or "relative burden" of cancer);

c) Whether cancer patterns were consistent for subgroups (men, women and children).

2) To explore the need and set priorities for further studies or other public health measures.

Below, the patterns of cancer found in this study and the implications for future studies are critically evaluated.

1. Patterns of Cancer in the Study Area and on Staten Island

Absolute Burden

Cancers that occur most frequently in a population have the greatest "burden" on that population. In this study, the most common types of cancer -- both in the Study Area and on Staten Island as a whole -- were lung, prostate, and colon cancer in men, and breast, lung, and colon in women. Among children, leukemia was the most frequently diagnosed cancer. These are also the most common types of cancer in men, women, and children, respectively in New York City, New York State, and in the United States.

Relative Burden

Cancers with the highest incidence rates in one population as compared with another population are those that have the greatest relative burden. In this study, the Rate Ratio (RR) was used to measure the relative burden of cancer in an area compared with another.

a. *Study Area*

Although residents of Staten Island were very concerned about the incidence of childhood cancers, particularly in areas around the landfills, the incidence of most childhood cancers was lower in the Study Area (around the landfills) than on the rest of Staten Island or in the

Bay Ridge and Flushing Health Districts. There were no cancer sites that were statistically significantly elevated when the Study Area was compared to the rest of Staten Island. Lung Cancer was statistically significantly elevated among both men and women in the Study Area when compared to Bay Ridge/Flushing . With few exceptions, the incidence of cancer among people living near the landfills was similar to or lower than the incidence among people living in the rest of Staten Island and in demographically similar communities (Bay Ridge/Flushing). As noted previously, even where elevations occurred, the magnitude was, at most, slight to moderate.

b. ***Staten Island***

Of the 14 cancer sites evaluated for men and women, slight to moderate, statistically significant elevations were noted for both genders in lung, bladder, and colon cancers when Staten Island was compared to the rest of NYC and in lung bladder and pharynx when compared to the combined Bay Ridge and Flushing Health Districts. As noted in the results, slight to moderate statistically significant elevations were also noted in 1 or 2 other cancer sites for either males or females.

Cancer rates for children were generally lower in Staten Island than elsewhere in the city.

Consistency of Results

The more consistent the findings of an elevated cancer incidence rate are for different subgroups in a population (e.g.: men and women) and the more consistent they are with results of previous studies, the more compelling the evidence of a cancer problem.

a. ***Study Area***

In the comparison of the Study Area to the rest of Staten Island, there was little evidence of a consistent pattern of findings. There were no types of cancer that were elevated in both men and women.

There was particular concern among residents regarding the incidence of leukemia and lymphoma. A minor elevation (RR=1.24) was noted for leukemia among women in the Study Area. This elevation was not statistically significant. However, in this analysis there was very poor power to detect, as statistically significant, anything less than a 70% (RR=1.70) elevation in the rate of leukemia. To put this finding into context, the moderate elevation noted for leukemia in women was not noted for children or men in the Study Area. In fact, men and children in the Study Area had lower rates of leukemia than the rest of Staten Island or the Bay Ridge/Flushing Health Districts. The lack of consistency in these findings provides some assurance that the rate observed for women in the Study Area may be due to random fluctuation in the cancer rates.

Minor elevations were noted in the Study Area for adult female lymphoma and childhood

lymphoma. The slight elevations noted in both women and children in the Study Area were due primarily to a higher rate of non-Hodgkins lymphoma. Among children, this elevation was based on a very small number of cases. The rate of lymphoma among men was lower in the Study Area than on the rest of Staten Island. As with leukemia, the interpretation of these findings is confounded by a lack of statistical power to detect anything less than a 50-70% elevation in rates of lymphoma in women and anything less than a tripling or quadrupling in children.

Since this was the first study of cancer incidence near the Brookfield and Fresh Kills Landfills, there are no previous studies with which to compare the results.

b. *Staten Island*

The findings are more consistent for the comparisons of Staten Island to NYC or Bay Ridge/Flushing. There were slight to moderate statistically significant elevations in four types of cancer, (colon, lung, bladder, and larynx) in both men and women when Staten Island was compared to the rest of NYC. These same types of cancer were also elevated when Staten Island was compared to the Bay Ridge/Flushing area. Additionally, this pattern was seen when the Study Area was compared to Bay Ridge/Flushing, but was not seen when comparing the Study Area to the rest of Staten Island. The consistency of these findings for specific cancer types (in particular, lung cancer) provides more support for the view that the elevations noted in these cancers were probably not due to normal fluctuation in cancer incidence rates, but indicate truly higher rates of certain cancers. Further evidence for consistency is provided by previous investigations that have also noted higher rates of lung cancer incidence or mortality on Staten Island .[5,6,7]

In the ranking of the 30 NYC Health Districts (HD), for both men and women, Richmond HD (Staten Island) ranked among the top 20% of Health Districts for colon, lung, and bladder cancers. This is consistent with the results that show that for both men and women, the rates of lung, colon, and bladder cancer were statistically significantly higher for Staten Island residents than for residents of the rest of NYC combined.

As noted in the Methods section and discussed subsequently, because race and Hispanic origin could not be adjusted for, the findings of some of these analyses (notably the analyses of Staten Island compared to the rest of NYC and the Health District rankings) should be interpreted with caution as race/ethnicity is a major influence in the rates of several cancers. A full discussion of the consequences of not adjusting for race and Hispanic origin is presented later in this section.

2. <u>Evaluating the Results to Determine the Priorities for Further Study</u>

This study represents a first step in identifying cancer patterns on Staten Island. It is typical for epidemiological studies to be carried out in a series of steps, first to identify disease patterns and then to evaluate the findings to determine if additional studies are warranted

which would further specify these patterns or try to evaluate their causes.

Evaluating the absolute burden and/or relative burden and the consistency of results together can help to set priorities for further research or public health interventions. Those types of cancers that have both a high absolute burden (i.e. affect a large number of people), and/or a high relative burden (the incidence was greater than in other areas), and for which the pattern is consistent for males and females, should be given priority when considering further evaluation or study.

In summary, at this time there do not appear to be elevations in cancer rates among children or adults that are specific to the landfill area. In the comparison of the Study Area with the rest of Staten Island, there were no cancers which had a high absolute impact, a high relative impact, and consistent patterns among both men and women. The rates of most common types of cancer in the Study area -- lung, colon, prostate and breast cancers -- were all about the same or slightly lower compared to the rest of Staten Island (all RR's < 1.00). In other words, because they are more common, these cancers had a high absolute burden, but not a high relative burden. At the same time, there were some cancers that had a low absolute burden but a high relative burden. For example, among men in the Study Area the rate of kidney cancer was 31% higher (RR=1.31) compared to the rest of Staten Island (i.e. high relative burden), even though it accounted for only 3% of the total cancer cases (35 people) -- far fewer than the number of colon, prostate or lung cancer cases (i.e. low absolute burden).

For Staten Island, most cancer types did not have either a high absolute or relative impact, and consistent patterns for both men and women. The exceptions were lung cancer, and to a lesser extent, larynx and bladder cancer. Lung cancer was the most common cancer in men and the second most common cancer in women in the Staten Island and in the Study Area. There was a consistent pattern of results noted for both cancer types across genders and geographic areas. The RR's for lung and larynx cancer for each comparison were almost all statistically significant. A similar magnitude of elevations was noted in many comparisons and in both genders.

There was also a consistent pattern of results seen for bladder cancer where the rate among adults was higher on both Staten Island and in the Study Area compared to the rest of NYC and/or Bay Ridge/Flushing However, for bladder cancer the RR's, overall, were of smaller magnitude (ranging from 1.08-1.34) and the differences in rates were statistically significant for only one comparison - Staten Island compared to the rest of NYC. Again, as discussed later, the overall magnitude of several of the RR's was likely to have been influenced by demographic differences in the study and comparison populations. As noted earlier, for lung, larynx, and bladder cancers, these findings do not appear to be related to residence near the landfills since the rates in the Study Area and the rest of Staten Island are similar.

Overall, the strength of association is rather low for the analysis of Staten Island as a whole when compared to either the rest of New York City or the Bay Ridge/Flushing Health

Districts (none of the RR's were greater than 1.56). However, compared to the results observed in the Study Area the strength of association was slightly stronger for many cancer types. This is due, in part, to better statistical power for these analyses, which aids in the interpretation of the RR (ie: for most of the analyses there was very good power to detect statistically significant differences, and statistically significant RR's were noted for seven different cancer types in men and/or women).

These findings do not provide any consistent evidence of an elevation in cancer incidence among communities surrounding the landfills. There is, however, consistent evidence to support a slightly to moderately elevated incidence of lung cancer and, to a lesser extent, larynx and bladder cancer incidence on Staten Island as a whole. There is no evidence from these data to indicate why the elevations noted for Staten Island as a whole might have occurred. Because of the patterns noted, these cancers should be given greater priority in determining what further studies should be undertaken. It is important to note, however, that the data contain several limitations that make it difficult to draw conclusions about cancer incidence either around the landfills or in the rest of Staten Island with 100% certainty. These limitations are discussed below.

a. ***Estimation of Cancer Rates***

The relative burden of cancer was based on calculating cancer rates (# of cases in the populations divided by the population size) and comparing them to the rates in other populations.

As noted in appendix 4, the cancer rates calculated for the Study Area may be slightly higher than the actual rates presented in this study because the interpolated population may represent an underestimate of the actual population. In other words, cancer might actually be "less" of a problem in the Study Area. In comparison, the cancer rates for Staten Island as a whole are, most likely, relatively accurate since the population of Staten Island as a whole only changed by 8%.

b. ***Magnitude of the Relative Risk***

A second factor in evaluating the relative burden is the magnitude of the Relative Risk (RR). In general, the "larger" the RR (that is, the "stronger" the association), the greater the evidence of a "cancer problem". In this study, most of the RR estimates were not elevated (i.e. the numerical values were close to 1.00). Even for those relative risk values which were somewhat elevated, the magnitude of elevations were, at best, modest (between 1.10 and 1.58). Modestly elevated relative risks such as these do not provide definitive proof that a particular community has a higher rate of cancer. Depending on the number of people involved, RR values of at least 2.0, and often at least 3.0 or 4.0 (if the populations are very small) are generally required in community environmental studies to demonstrate compelling evidence of an elevated rate of disease.

Another reason why it is difficult to interpret modest RR's is low statistical power. This is especially true in the analysis of the Study Area where statistical power was often 30% or

less to detect statistically significant associations for most types of cancer. Because of this, it is uncertain whether the elevated RR's are in fact indicative of an elevation in the rate of cancer or simply due to random (unexplained) fluctuation often seen in small populations.

In spite of these limitations, these findings support the conclusion that there was not a major elevation in the cancer rate around the landfills (i.e. doubling or tripling). If there was an elevation in particular types of cancer among certain subgroups in the population, it was very small. The lack of consistency in RR's for men and women, coupled with the lack of strong associations, and the lack of statistical significance provides some reassurance that the slight elevations that occurred were likely due to random fluctuation rather than a true difference in rates.

Based on these findings, further analyses of these data for this time period and for this population are unlikely to reveal any information about possible associations between cancer incidence and the landfills.

c. ***Assessment of Possible Environmental Exposures***

A basic concern of Staten Island residents was that environmental pollution near the landfills and on Staten Island may have contributed to cancer. Do the patterns of lung, larynx, and bladder cancers on Staten Island suggest an environmental connection? What else could be done to pinpoint the problem and evaluate whether the cancers are due to environmental pollution? Are these feasible tasks?

To show a link between cancer cases and specific environmental hazards is an extremely difficult task because the necessary data are not always available. Some of the specific reasons are discussed below:

In order to show that the cancers around the landfills and on Staten Island were due to carcinogenic exposures from the landfills and/or other carcinogenic environmental exposures, it is necessary to show that people who developed cancer had been exposed to carcinogenic substances.

In the current study, no direct information on individual exposures was available. In the absence of such direct information, this investigation evaluated cancer incidence using residential distance from the landfills as an indirect or "proxy" measurement of exposure to the landfills. This approach is based on the assumption that people who lived closer to the landfills would be more likely to have been exposed to any contaminants from them -- for example, when breathing the air or if children played near, or on, the soil at the landfills. Based on this measure there was no evidence that people living near the landfills experienced a higher incidence of cancer. However, this method is not as precise as obtaining direct exposure measurements.

Is it possible to design a study that would better document possible environmental exposures?

In order to know whether residents who developed cancer during the study period (1979-1988) had been exposed to cancer causing substances from the landfills, it would have been necessary to conduct biological or environmental monitoring twenty years earlier and to demonstrate a series of events: First, that cancer causing toxins were present at one or both landfills; second, that there was a pathway through which these substances reached the public; and third, that individuals were actually exposed to sufficient quantities to produce illness. The fact that cancer-causing substances were illegally dumped into the landfill does not automatically "prove" that the people who developed cancer were exposed to them.

Unfortunately, no historical information on environmental monitoring exists for the Brookfield or Fresh Kills Landfills. Also, there are very few biomarker tests that can assess whether someone was exposed to a chemical in the past. Finally, it would be very difficult to learn the time frame for a person's exposure.

These facts present a serious and important deficiency in the ability for this or any future study to directly link the occurrence of previous cancers in the Study Area with previous exposures from the landfills. In other words, accurately evaluating historical exposure in future studies is probably an impossible task.

Fortunately, there are several exposure monitoring programs that are planned or have begun at the landfills. Although the results of these programs cannot be used to determine exposures in the past or to make a link with cancers that occurred in the past, they will be important in determining current and future exposures and the need for future monitoring of cancer rates in the area.

Furthermore, making a link between environmental exposures and cancers not only requires evaluating exposures to environmental carcinogens (i.e.: those present at a given hazardous waste site and to which people are exposed), but also documenting a full exposure history to other potential carcinogens (for example, workplace exposure to toxic chemicals and lifestyle risk factors such as smoking and drinking alcohol). How these "competing" risk factors interact is complicated. This is because in addition to not knowing what people were exposed to, the mechanisms of carcinogenesis are complex. First, there are conditions or toxins that create changes that can change a normal, healthy cell into a cancerous one, thereby initiating the cancer process. Such substances are called "initiators". There are also substances that cause the damaged cells to multiply, thereby promoting tumor growth. Such substances are called "promoters".

Initiation of cancer cells may result from a limited exposure to a carcinogen, for example asbestos fibers and some components of tobacco smoke are thought to be tumor initiators. Initiation can occur rapidly (sometimes with only one exposure) and is thought to be irreversible. In the absence of further exposure to other toxins, initiated cells may not develop into tumors.

Tumor promoters act only after there has been exposure to a tumor initiator. Promoters can

cause tumor development even if there has been a long interval between exposure to an initiator and exposure to the promoter. However, exposure to a promoting substance in the absence of, or prior to, initiation of cells will not result in tumor growth. In addition, promotion may require numerous exposures to a promoting agent at regular intervals. If there are long intervals between exposures, then promotion may be reversible. It is thought some substances, for example ultraviolet radiation, can both initiate and promote tumor growth[10]

How the issue of initiators and/or promoters could effect potential cancer risk around the landfills is probably impossible to evaluate, but may offer a theoretical explanation as to why some persons go on to develop cancer very rapidly while others develop cancer very slowly. Theoretically, if a person with prior cancer cell initiation were continuously exposed to promoters from the landfills, over a sufficient period of time, then that person may go on to develop clinically apparent cancer in a shorter period of time than a similar individual without such exposure.

d. ***Latency***

In adults, many cancers take at least 20 years to develop from the time a person is first exposed to a cancer-causing substance (or the cancer process begins) and the time when cancer can be medically detected. The average time lag, or latency period, varies, depending upon the type of cancer and individual factors such as a person's genetic predisposition, lifestyle, and/or toxic exposures. For example, childhood cancers -- such as certain leukemias -- are thought to have shorter latency periods; whereas some adult cancers -- such as lung cancer -- are thought to have much longer latency periods of 20, 30, or 40 years. As noted above, tumor initiators or tumor promoters may also play a role in the speed at which cancer develops. Unfortunately, the exact degree to which so-called initiators or promoters may influence the pace of cancer development is poorly understood. Whether the differing latent periods are due to different types of initiator-promoter relationships is not clear.

As noted previously, in order to show that a person developed cancer as a result of exposure to carcinogenic substances from the landfills or other environmental exposures on Staten Island it would be necessary to show that there was both a route of exposure to these substances and that persons were sufficiently exposed well in advance of their cancer diagnosis.

The Fresh Kills Landfill has been in use since 1948. There are no allegations or evidence of large scale toxic dumping at the Fresh Kills Landfill. The Brookfield Avenue Landfill was in operation from 1966 to 1980. Toxic dumping there occurred allegedly throughout the 1970's, and mostly in the late 1970's.

This study examined the incidence of cancers that occurred from 1979 through 1988 among residents of the communities abutting the landfills. It follows that the latency period for this study ranges from a minimum of less than one year to a maximum of twenty-two years for exposures from the Brookfield site and 1 year - 49 years for the Fresh Kills site.
Overall, the findings of similar rates of cancer in the Study Area and the rest of Staten Island

are reassuring and do not suggest that the Fresh Kills Landfill contributed to the development of cancer in the area. Since Fresh Kills opened 49 years ago, people who already lived in the area 20, 30 or 40 years ago could have developed cancer by the 1980's from being exposed to it, assuming the landfill released cancer-causing toxins and assuming these toxins reached them. On the other hand, if people moved into the area later or started to be exposed to cancer causing substances from the Brookfield Avenue Landfill in the late 1970's or early 1980's and also developed cancer in the 1980's, it is less likely that these cancers were related to exposure to toxins from the landfill.

e. ***Migration and Population Growth***

In addition to establishing previous exposure and adequate latency, documenting the period in which individuals moved into or out of an area relative to their developing cancer is also important. Migration has consequences for both possible landfill exposures and latency related to those exposures. The cancer data available for this study contained information about people who lived in Staten Island, the Study Area, or the comparison areas at the time they were diagnosed with cancer. People who may have been exposed to carcinogens in an area and subsequently moved e.g.: from the rest of Staten Island into the Study Area, from Queens to Staten Island, or from Staten Island to another community, and then became ill, were not counted as cancer cases where they were exposed, but rather where they were diagnosed. There is no way to re-create the residential history of each cancer case using cancer registry data. Therefore, there was no way of accounting for persons who may have left Staten Island and then developed cancer or persons who moved to Staten Island and went on to develop cancer shortly thereafter.

f. ***Competing Risk Factors for Cancer***

Cancers can be caused by many different agents -- chemical exposures, lifestyle and genetic factors, each acting alone or in concert with others. To determine the extent to which cancers on Staten Island are due to environmental exposures, it would also be necessary to know something about an individual 's personal risk factors and exposures.

For example, the strongest and most consistent finding throughout Staten Island was observed for lung cancer. But this, by itself, does not necessarily suggest an environmental source. The major cause of lung cancer is a history of cigarette smoking. In fact, more than 80% of lung cancers among men in the United States are reportedly due to smoking [11,12]. Although many workplace or environmental exposures have been shown to increase the risk of lung cancer -- such as asbestos, radon, nickel -- for the population in general, the contribution of these substances to the overall lung cancer burden is thought to be much less.

In the present study, no information on cigarette smoking was evaluated. The NYSDOH Cancer Registry does collect information on cigarette smoking for reported cases of cancer. However, reporting may not be complete enough to determine whether the elevated rates of lung cancer observed in Staten Island and the Study Area could have been due only to cigarette smoking. There is no reason to suspect that the population of Staten Island smoked more than the population of Bay Ridge/Flushing or the rest of NYC. However, smoking is the

primary risk factor for lung cancer, and the role of smoking must be evaluated in any future studies of lung cancer on Staten Island.

In the absence of data for cigarette smoking, is it still possible to "rule out" smoking as the sole reason for the moderate elevation in lung cancer rates? Small differences in the prevalence of cigarette smoking from place to place are one reason lung cancer rates vary from place to place. For example, since smoking is so closely tied to lung cancer, if there were historically more persons who were smokers in community "A" than there were in community "B", then one would expect that the current lung cancer rates in community "A" would be higher than in community "B". How differences in smoking prevalence effect lung cancer rates has been estimated by researchers. Certain researchers indicate that RR estimates of over 2.0 are less likely to be due to differences in smoking since it is unlikely that smoking rates would vary enough between two areas to observe a difference in lung cancer rates this large. These same researchers report that moderately elevated RR's (1.25-2.0), like those observed for lung and laryngeal cancer in Staten Island, could result from small differences in smoking prevalence patterns between study and comparison populations [13].

The RR's observed in this study were between 1.22-1.58. Therefore, it is possible that these elevated risks may be due to differences in smoking habits between the Staten Island population and the comparison area populations. In addition, the same pattern of elevations was also noted for cancers of the larynx and bladder, both of which are associated with cigarette smoking. These patterns support the idea that smoking may explain the elevated RR's. On the other hand, the same patterns of elevated RR's were <u>not</u> noted for kidney and pancreatic cancers. Since these types of cancers are also associated with smoking (though somewhat less strongly), if smoking were responsible for the observed elevations in lung, larynx and bladder cancers we might expect to see an elevation in these other cancer sites as well. However, given the small magnitude of the RR's for cancer of the lung, larynx and bladder, if differences in smoking prevalence <u>were</u> responsible for the elevations observed, these differences may not have been large enough to affect the rates of pancreatic or kidney cancer. Another possibility is there may be other, stronger, risk factors for kidney and pancreatic cancers present in the comparison populations that were not present in the Staten Island population.

Given the small magnitude of the RR's it is not possible to rule out smoking as a possible explanation for the elevations. To do so it would be necessary to evaluate smoking trends in the Staten Island population and the comparison areas. In addition to smoking, other known or suspected risk factors for bladder cancer include obesity, exposure to fabric dyes, and chemicals used in foam and resin processes. Other risk factors for larynx cancer include heavy alcohol consumption and exposure to asbestos and the metal, nickel.

A slight to moderate elevation in lymphoma was noted for both women and children in the Study Area. Lymphomas are types of cancers that affect white blood cells in the immune system. Lymphomas are categorized into two broad types, Hodgkins disease and non-Hodgkins lymphoma (NHL). Each type has a somewhat different etiology. There is some

evidence that NHL may run in families, however, it is not clear whether this is due to genetic or environmental influences. Certain viruses such as EBV and HIV increase the risk for NHL. Occupational studies have indicated a possible association with phenoxyacetic acid and chlorophenol herbicides [11]. However, most studies of toxic agents as risk factors have been inconclusive.

Genetic, lifestyle and socio-demographic factors, acting alone or in combination are thought to cause many types of cancer. Although not all of the specific factors in cancer causation have been identified by medical researchers, one convincing piece of evidence is the fact that cancer rates are different for men and for women, for different race and ethnic groups, and for different age groups. Because there may be wide variation in cancer rates among different gender, race, ethnicity, and age groups, it is important to take these factors into account when comparing cancer rates in two or more different populations. In this study, gender and age were taken into account in the analysis. However, available data were inadequate to directly account for race/ethnicity. This fact presents an important limitation to the interpretation of some of the analyses in this report. A brief summary of some of the cancers that can differ by racial/ethnic group is presented below.

Cancer Type	*How Distributed in U. S. Population*
Bladder Cancer	Twice as high in White populations compared to Black populations
Prostate Cancer	40% higher in Black men than in White men
Pancreas Cancer	40% higher in Black populations than in White
Larynx Cancer	Higher in Blacks and Asian Indians than in Whites
Lymphoma	Higher in White populations, especially high in Jewish populations
Lung Cancer	Higher in Black men than in White; Black and White women have similar rates
Colon Cancer	Historically higher in White populations; White and Black women have similar rates
Breast Cancer	Higher in White Women than in Black
Stomach Cancer	Higher in Black Populations than in White; also high among Asian and Eastern European Ethnic Groups

NYC as whole and many of the Health Districts, are considerably different from Staten Island in racial/ethnic makeup. Clearly, given this fact and the information presented above, a comparison of two areas with strikingly different racial/ethnic backgrounds could result in RR's that are elevated (or depressed) primarily because of the differences in cancer rates for

different race/ethnic groups. Because of this, the role of differing racial/ethnic distributions should be carefully considered in the interpretation of those analyses that compare Staten Island to either the rest of NYC or the 30 HD's.

For example, as noted above, White populations have higher rates of bladder cancer than Black populations. The analyses comparing Staten Island to the rest of NYC showed that the rate of bladder cancer among Staten Island men was 34% higher (RR=1.34) and the rate among women was 25% higher (RR=1.25) than the rate in the rest of NYC. Both of these findings were statistically significant. However, the population of Staten Island was more than 80% White (7% Black) during the period under investigation and the population of the rest of New York City was less than 50% White (25% Black). Based on these demographic characteristics alone we would expect Staten Island to have a comparatively "high" rate of bladder cancer relative to the rest of NYC--simply because Staten Island has a higher proportion of Whites than the rest of NYC.

Indeed, when Staten Island was compared to the demographically similar communities of Bay Ridge and Flushing (both of which have approximately the same proportion of Whites as Staten Island) , the elevation in the RR for bladder cancer among both men and women depreciates considerably (RR of 1.09 among men and 1.10 among women) and is no longer statistically significant (see excerpt from appendix 5, pg. 36).

The analysis of cancer in the 30 HD's provides another illustration of the influence of race on the relative ranking of cancer rates. Individual Health Districts in NYC vary in racial/ethnic composition from 93% Black in Central Harlem to 93% White in Kips Bay/Yorkville. Again, bladder cancer can serve as an example: Staten Island men and women ranked #1 and #2 in the City for bladder cancer relative to the rest of the HD's. The remaining five HD's that ranked in the top 20% for bladder cancer among both men and women had populations that were, on average, over 80% White. Conversely, the HD's that ranked in the bottom 20% had populations that were, on average, less than 20% White. Similar findings--meaning predominantly White HD's ranked in the top 20% of Health Districts and predominantly Black HD's ranked in the bottom 20% were noted for cancers of the breast, CNS and lymphoma for women, and colon and CNS for men.

This is not to say that race is the sole reason that Staten Island ranks among the top 20% for these particular cancers, but that race played a significant role in determining both the ranking of cancer incidence rates in NYC and in the magnitude of the RR for these cancers when Staten Island was compared to the rest of NYC. Based on the results of this investigation it appears that the rates in Staten Island are higher (in particular for bladder and colon cancers) even in comparison to other predominantly White HD's, however, the magnitude of the difference in rates among the HD's with similar racial makeup is slight (among males it ranges from less than 1%-19%, among women the magnitude was less). As noted below, this is clearly illustrated when the findings of the analyses of Staten Island compared to Bay Ridge/Flushing (a more comparable comparison area) are viewed along side the analyses of Staten Island compared to the rest of NYC.

Staten Island also ranked in the top 20% of Health Districts for cancers of the lung and larynx for both men and women. As shown in the table above, these cancers predominate in Black populations, especially among men. That Staten Island ranks in the top 20% for these cancers is the opposite of what one would expect to find if differences in cancer rates from place to place were related primarily the racial/ethnic differences in those places (as appeared to be the fact for bladder, colon, breast, CNS and lymphoma-see appendix 6). This fact underscores the importance of these particular findings (i.e.: the lung and larynx elevations) for Staten Island. To reiterate, the remaining HD's which ranked in the top 20% for lung cancer had populations that were, on average 23% White. In comparison, Staten Island is more than 80% White. Those HD's that ranked in the in the bottom 20% had populations that were, on average, 75% White. As seen below, when Staten Island was compared to a demographically similar area, the RR's for lung cancer became even more pronounced. The findings for larynx cancer were similar, though the overall differences in race/ethnic makeup between the top 20% of HD's and the bottom 20% of HD's was less pronounced. Again, comparing the RR's from the two Staten Island analyses (Staten Island compared to NYC and Staten Island compared to Bay Ridge/Flushing) underscores these findings:

	RR's AMONG MEN		
	LUNG	LARYNX	BLADDER
SI/Rest of NYC	1.36	1.30	1.34
SI/Bay Ridge Flushing	1.44	1.55	1.09

The findings for women were also less pronounced with regard to the impact of differences in race/ethnicity between Health Districts on the magnitude of difference in rates, though this is not surprising given that Black and White women have similar incidence rates for lung cancer.

Bay Ridge/Flushing was selected for a comparison area because it was demographically similar to Staten Island. As illustrated here, demographic differences can greatly influence cancer rates--when Staten Island was compared to Bay Ridge/Flushing the RR for bladder cancer, colon cancer, breast cancer and CNS cancer decreased as compared to the analysis of Staten Island and the rest of NYC. The opposite was seen for lung and larynx cancers. Since Bay Ridge/Flushing is more similar to Staten Island, the results of those analyses should carry greater weight than those where race/ethnicity has a larger influence when determining recommendations for future study and priority cancer "problems".

As alluded to in the preceding paragraphs, genetic, medical and dietary factors also may play

a role in the development of certain cancers. Similarly, underlying differences in the prevalence of these factors could play a role in the differences noted in the cancer incidence rates between areas. The combined Bay Ridge and Flushing Health Districts were selected for a comparison population because their combination was very similar to Staten Island for a variety of socio-demographic factors, including income and race/ethnicity. Populations that are socio-demographically similar are often similar with regard to other lifestyle factors that may influence cancer risk (e.g.: diet). Use of a socio-demographically similar population for comparison helps to control for some of these underlying factors. However, there are still many population differences that may affect cancer rates, which cannot be adjusted for or which are insufficiently known to estimate their effect. Information on individual dietary, genetic, or other lifestyle risk factors (outside of smoking) are not collected by the NYSDOH and were not available for analysis. There is no way to be sure how much these factors may have influenced cancer risk on either Staten Island or in the comparison areas.

3. Weighing the Evidence

It is helpful to assess all of the evidence presented in the results collectively to see if the two components of this study (ie: the analyses of the Study Area and the analyses of Staten Island as a whole) indicate a need for further investigation or other public health intervention. Our discussion of the criteria in the preceding pages indicates several factors that should be considered when evaluating this study's results. As noted before, the more of the specific criteria that are met, the better the evidence for future investigations. Several of these criteria are similar to the factors that epidemiologists use to evaluate study results: "Strength of Association" asks us to consider the magnitude of the RR or the relative burden of cancer. "Consistency" evaluates the patterns of cancer and whether other researchers found similar results. "Dose/Response" asks us to evaluate whether persons with higher exposure to toxins have higher rates of cancer . "Time Sequence" is somewhat similar to evaluating latency, in other words, were people exposed to environmental carcinogens well before they were diagnosed with cancer. "Biologic Plausibility" asks us to evaluate if there is a known biologic mechanism by which the environmental toxins present (e.g.: from the landfills) could cause the diseases under investigation (in this case 14 different types of cancer). The table on page 38 characterizes the weight of the evidence in the current study and whether or not additional information would be available for future studies. Each cell in the table has either a " +" indicating positive evidence, a "-" indicating negative evidence or a "?" indicating that the parameter could not be evaluated at all. If the evidence was equivocal, a combination of symbols was used.

CRITERIA	STUDY AREA	STATEN ISLAND
Absolute Burden	+	+
Strength of Association/ Relative Burden	-	+
Consistency	-	+
Dose/Response	?/-	?
Time Sequence	?	?
Biologic Plausibility	?	?

In summary, the results of this investigation do not provide strong clues that cancer near the landfills is elevated. However, they do provide evidence of a modest elevation for certain types of cancer on Staten Island as a whole.

4. Case Verification

Case verification revealed that 138 of 379 potential cancer cases reported to DOH were actual cases diagnosed between 1989 and 1992. Over 15 different types of cancer were reported. The areas with the greatest number of reported cases were neighborhoods closest to the landfills: Arden Heights (census tract {CT} 170)--south of Fresh Kills; Heartland Village (CT 277)--east of Fresh Kills; and the northern part of Great Kills (CT 146) south of Brookfield Avenue Landfill. This is not surprising. The areas closer to the landfills were also the areas where community concern was greatest and case finding efforts were concentrated.

Lymphoma and leukemia were the cancer types of chief concern and the types most often reported among men and second most often reported--after breast cancer--for women. Even in areas where reporting was greatest, there were no indications of pockets or clusters of these cancer types. The total number of cancer cases, and the number of lymphoma and leukemia cases reported by residents were only fractions of what would have been expected if the Study Area had the same rates as New York State or New York City.

The results of the case verification should be interpreted with caution since the number of cases of cancer reported to the NYCDOH probably represents an under-reporting of the actual number of cancer cases that occurred in the Study Area or Staten Island during that period, and differential case finding efforts throughout Staten Island.

5. Other Investigations of Cancer Near Landfills

It is often difficult to draw definitive conclusions about cancer risk resulting from residence near a landfill or hazardous waste site. In order to put the findings of this investigation in perspective, a review of published studies of cancer in populations living in close proximity to hazardous waste sites was conducted. Eight investigations, published between 1981 and 1992, were reviewed. A summary of these studies is presented in appendix 9 (page 88).

All of these investigations suffer from many of the same limitations as this investigation. Namely, latency, migration, exposure, and other cancer risk factors often cannot be documented or addressed. In addition, the statistical power of many of these investigations was quite low.

Overall, there was no consistent pattern of findings in these investigations. In four of the investigations [3,14,15,16] no significant excess in cancer incidence and/or mortality was observed in populations living near the sites. Two of the remaining investigations found significant excesses in incidence or mortality in only one site or all cancers combined [17,18]. Only one investigation found significant excesses in multiple cancer sites [19]. The remaining investigation evaluated a statistically significant increase in childhood leukemia [20].

Since different chemicals were present at different sites the lack of a consistent pattern of findings may not be surprising. Even so, several of the investigators documented RR's that represented a doubling or tripling in either cancer incidence or mortality rates. However, even with RR's much higher than those found in Staten Island, no investigators were able to document a consistent pattern of results that indicated cancer risk was related either to residence near the site or to contact with the site.

These findings, while based on a limited number of somewhat similar studies, suggest that, given the limits of current epidemiologic and medical methods, cancers are difficult diseases to evaluate in connection with landfills and hazardous waste sites. This is particularly true when exposure in the population is not, or is poorly, documented.

D. CONCLUSIONS and RECOMMENDATIONS

1. CONCLUSIONS

Descriptive investigations are a necessary first step to evaluate the distribution of disease in a community. This investigation allowed us to determine how many and what types of cancer occurred in a population within a specified time period. It also allowed an assessment of whether cancer incidence is different in the Staten Island population as compared to other populations. However, the investigation did not allow for a determination of the causes of cancer either in the population or in individuals.

In summary, the results show:

* The most common types of cancer among men in both the Study Area and on Staten Island were lung, prostate, and colon cancer. Together these cancers accounted for over 40% of all cancers among men.

* The most common types of cancer among women in the Study Area and on Staten Island were breast, lung, and colon cancers. These sites accounted for at least 50% of all cancers among women.

* Leukemia was the most common cancer type among children in the Study Area and on Staten Island.

* These types are also the most common cancers in New York City and New York State.

In the Study Area:

* Lung cancer in both men and women was the only type of cancer which was moderately and statistically significantly elevated in the Study Area compared to the Bay Ridge and Flushing Health Districts.

* Among men and women, no cancers were statistically significantly elevated compared with the rest of Staten Island; 13 out of 14 cancers were not statistically significantly elevated compared with the Bay Ridge and Flushing Health Districts.

* Among children, there were no cancer types were statistically significantly elevated compared to either the rest of Staten Island or the combined Bay Ridge and Flushing area. The RR for lymphoma was moderately elevated, although not statistically significant.

On Staten Island:

* Slight to moderate, statistically significant elevations ranging from 12 - 36% were noted for both men and women in cancers of the lung, bladder, and colon, compared to the rest of NYC. Also, compared with the rest of NYC, the rates of lymphoma and breast cancer were slightly and statistically significantly higher in women only; the rate of larynx cancer was statistically elevated in men only.

* Slight to moderate, statistically significant elevations, ranging from 10 - 55%, were noted for both men and women in cancers of the lung and pharynx when compared to the combined Bay Ridge and Flushing Health Districts. Also, compared with Bay Ridge and Flushing, the rate of larynx cancer was statistically elevated among men and the rate of colon cancer was slightly and significantly elevated in women.

* The incidence rates of 11 out of 14 types of cancer in both men and women were not statistically elevated, compared with the Bay Ridge and Flushing Health Districts.

* The incidence rates of 10 out of 14 types of cancer in men and 9 out of 14 types of cancer in women were not statistically elevated compared with the rest of NYC.

* The following cancers ranked among the top 6 out of 30 health districts (top one-fifth or 20%) in the City: colon (#2 in men and women), lung (#2 in men and #4 in women), bladder (#1 in men and #2 in women), nervous system (#4 in men and #6 in women), breast (#4 in women), lymphoma (#5 in women), and larynx (#6 in men and women).

* Cancer incidence ranked in the middle or lower third for 9 of 14 sites among men and 6 of 14 sites among women.

* Stomach cancer ranked among the bottom 20% of health districts in NYC (#29 in men and #27 in women).

* When compared to Bay Ridge/Flushing and to the rest of NYC, children had lower rates of cancer. There were no cancer types for which the incidence rates were significantly elevated compared to the two areas.

* Childhood cancers ranked in the middle (#15) or lower third for each of the childhood cancers evaluated and for total cancers combined. The Staten Island rate was lower than the NYC average rate for each type of cancer.

Overall:

* Study data provide no clear-cut evidence linking cancer incidence to residence near the landfills.

B. RECOMMENDATIONS

Based on the findings of this investigation, the New York City Department of Health, in consultation with its scientific advisory committee makes the following recommendations:

1. Continue evaluation of more recent (post 1988) incidence of selected cancers in the Study Area: Although the results of this study showed that the incidence of cancer during the 10 year period from 1979-1988 was not statistically elevated, the follow-up period after possible exposure from illegal dumping (late in the 1970's) may not have been long enough for some cancers to develop. Therefore, it is recommended that the incidence of more recent (post 1988) cancers continue to be evaluated. It is further recommended that such analyses focus on childhood cancers (since this was a predominant community concern) and on those adult cancers for which a moderate (although non-statistically significant) elevation was observed in the Study Area (i.e. kidney in men; leukemia and lymphoma in women) . Because of the relatively small number of cases which occur within a single year, and the subsequent difficulties this poses for conducting meaningful statistical analyses, such analyses should only be conducted when at least four or five years worth of additional data are available (eg. 1989-1992). More recent data should be compared with data from the previous period to evaluate time trends.

2. Convene a panel of experts in cancer epidemiology to review this study and other available literature to determine whether or not an analytic epidemiologic study would provide valuable information as to the possible causes of elevated cancer incidence rates on Staten Island (lung, and possibly bladder, colon, larynx and pharynx cancers). Although the incidence of several types of cancer among residents of Staten Island was statistically significantly elevated (lung and to a lesser extent bladder, colon, larynx and pharynx cancers), this study does not provide direct clues as to why these increases occurred. In its deliberations, the panel should carefully consider such issues as: the magnitude of elevations in the above-mentioned cancers (10-55%); racial and ethnic differences in cancer patterns; the role of cigarette smoking; and the best way to obtain accurate information on possible environmental and occupational exposures. Should the panel decide that further study is necessary, they should determine the appropriate scope, and assist in the design, of such a study. The panel should also assist in the identification of potential sources of funding for such a study.

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APPENDIX 1

STATEN ISLAND CANCER INCIDENCE STUDY SCIENTIFIC ADVISORY COMMITTEE

Appendix 1

STATEN ISLAND CANCER INCIDENCE STUDY
SCIENTIFIC ADVISORY COMMITTEE MEMBERS

The following 11 people were nominated and selected to be members of the Scientific Advisory Committee (SAC) based on their experience in the fields of cancer epidemiology and environmental health:

PERSON	POSITION	AFFILIATION
Michael Buccigrossi, DrPH	Environmental Scientist	U.S. Environmental Protection Agency
Barbara Warren Chinitz, BSN, MS	Project Coordinator Officer	Consumer Policy Institute Staten Island Citizens for Clean Air
Joseph G. Feldman, DrPH	Prof., Dept. of Preventive Medicine & Community Health	State Univ. of NY Health Science Cent at Brooklyn
Thomas Forlenza, MD	Chief of Oncology	St. Vincent's Medical Center
Donna Birch Gerstle, MA, MS	Assistant Director Center for Environmental Science	College of Staten Island, CUNY
Morton Israel, MA, EdD	Research Scientist	NYC Human Resources Administration
George Friedman Jiminez, MD	Medical Director, Occupational & Environmental Health Clinic	Bellevue Hospital Center
Philip J. Landrigan, MD	Chair, Dept. of Community Med.	Mount Sinai Medical Center
Gilbert S. Lederman, MD	Director, Radiation Oncology	Staten Island University Hospital
David Michaels, PhD, MPH	Assoc. Professor of Epidemiology	City University of NY Medical School
Roy Shore, PhD, DrPH	Head, Env. Epidemiology Unit	New York University Medical School

THE CITY UNIVERSITY OF NEW YORK MEDICAL SCHOOL
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February 14, 1996

Margaret Hamburg, MD
Commissioner
New York City Department of Health
125 Worth Street
New York, New York 10013

Dear Dr. Hamburg,

The members of the Staten Island Cancer Study Scientific Advisory Committee have reviewed the Staten Island Cancer Incidence Study Final Report and agree that the study's methods reflect sound epidemiologic principles. The presentation and discussion of the results, the conclusions and recommendations in the Final Report are reasonable and represent an accurate incorporation of many of the comments and suggestions made by the Scientific Advisory Committee. Within the constraints posed by the available data and methods, the Report advances our understanding of cancer incidence on Staten Island.

We strongly urge that further research be done to investigate causes of cancer on Staten Island.

Your very truly,

David Michaels
On behalf of the Staten Island Cancer Study Scientific Advisory Committee

APPENDIX 2

SELECTED CANCER RISK FACTORS

SELECTED CANCER RISK FACTORS*

Please note that even when there is a strong association between a risk factor and a disease, this does not mean that all individuals with the risk factor will develop the disease, nor does it mean that those without the risk factor will not develop the disease.[1]

Included in this table are risk factors that have not been firmly established. In those instances, a question mark in parenthesis (?) follows the risk factor. Future research may reveal a stronger, weaker or no association between some of these risk factors and their respective cancer sites

CANCER SITE	GENETIC/MEDICAL CONDITIONS	LIFESTYLE/MEDICAL TREATMENTS	OCCUPATIONAL	ENVIRONMENTAL
Bladder	*Gender (males) *Age (over 65)	*Cigarette smoking	*Truck drivers, leather workers, machinists, and plumbers; *Exposure to aromatic amines ? , dye & rubber	*Living in urban areas
Brain	*Head trauma *Genetic factors may be related to other tumors (?)		*Synthetic rubber manufacturing, polyvinyl chloride production, oil refinery and petrochemical production and the nuclear industry (?)	*Some studies suggest an association between electromagnetic fields and brain cancer, others do not (?)
Breast	*Early menarche (before 12) *Late menopause *Personal or family history of breast cancer *Age (over 40)	*High fat diet (?) *Late age at first live birth (over 30) *Nulliparity *Higher education and socio-economic status		*Exposure to radiation *Exposure to PCB's/DDE (?) *Electromagnetic fields (?) *Heterocyclic amines in cooked meats (?) *Higher rates in NE & mid- Atlantic US states
Cervix (Uterus)	*Infection with human papillomavirus	*Early age at first intercourse *Cigarette smoking *Multiple sex partners		
Colon and Rectum	*Inflammatory bowel disease *Personal or family history of cancer or polyps of the colon or rectum	*High fat and/or low fiber diet (?)	*Workers in metals, paper, dry cleaning, & rubber industries *Exposure to asbestos	

CANCER SITE	GENETIC/MEDICAL CONDITIONS	LIFESTYLE/MEDICAL TREATMENTS	OCCUPATIONAL	ENVIRONMENTAL
Lung		•Cigarette smoke •Secondhand smoke •X-radiation exposure	•Coke oven workers, iron ore miners, workers in isopropyl alcohol production, roofers who smoke, some rubber workers, uranium miners (?) •Exposure to arsenic, asbestos, beryllium, chloromethyl ether, chromium, carbon compounds, hydrocarbons, mustard gas, nickel, vinyl chloride, radiation, radon	•Asbestos •Radiation •Radon
Lymphoma (Hodgkin's & non-Hodgkin's)	•HIV and HTLV-I viruses associated with increased risk for non-Hodgkin's •Reduced immune function		•Exposure to herbicides, industrial solvents, vinyl chloride (?)	
Ovary	•Age (over 40; high risk ages 65 - 84; highest risk) •Rare genetic disorders •Family history of ovarian cancer •Obesity •Personal history of breast cancer	•Nulliparity		•Highest incidence rates are found in industrialized nations
Pancreas	•Age (over age 50, most cases occur between 65-79) •History of chronic pancreatitis, diabetes, and cirrhosis (?)	•High fat diet •Smoking	•Rubber and furniture workers (?)	

CANCER SITE	GENETIC/MEDICAL CONDITIONS	LIFESTYLE/MEDICAL TREATMENTS	OCCUPATIONAL	ENVIRONMENTAL
Endometrium (Uterus)	•Early menarche •Failure to ovulate •Family history of endometrial cancer •Infertility •Late menopause •Obesity	•Tamoxifen or estrogen therapy for more than two years without taking progesterone		
Kidney	•Gender (males) •Age (over 50) •overweight (?)	•Cigarette smoking (smokers are twice as likely to get the disease than nonsmokers) •Long term use of phenacetin	•Coke oven and asbestos workers •Exposure to cadmium and gasoline	
Leukemia	•Certain genetic abnormalities (ex. Down Syndrome) •Certain retroviruses •HTLV virus	•Treatment with some chemotherapy drugs for cancer	•Rubber workers and farmers •Exposure to benzene and ethylene oxide	•Ionizing radiation •There is some association between electromagnetic fields and leukemia in numerous countries (?); further investigation has been suggested
Liver	•Chronic HBV infection	•Aflatoxins •Ethanol •Slightly increased risk with the use of oral contraceptives and anabolic steroid hormones	•Agricultural, coke oven, rubber, and printer workers •Exposure to vinyl chloride monomer, arsenical pesticides	•Exposure to chlorinated hydrocarbons

CANCER SITE	GENETIC/MEDICAL CONDITIONS	LIFESTYLE/MEDICAL TREATMENTS	OCCUPATIONAL	ENVIRONMENTAL
Prostate	•Age (over 65) •Race (African American) •Family history (?) •Hormones (?)	•High fat diet	•Farmers, metal workers, repairmen and mechanics •Exposure to Cadmium	•Environmental factors are suspected in playing a major role •Radiation (?)
Skin	•Fair complexion esp. those with red or blond hair •Genetic factors are assoc with cutaneous malignant melanoma •Tendency toward developing nevi (?) •Children or teens who have suffered severe sunburns •Presence of a birthmark, certain moles, xeroderma pigmentosa or family members with melanoma	•Boating, sunbathing, & participating in a lot of outdoor sports •X-ray treatment for acne & other conditions	•People who work outdoors--ex. farming and construction •Exposure to coal tar, pitch creosote, arsenic compounds or radium, ionizing radiation	•Overexposure to sunlight (ultraviolet radiation)
Stomach	•Gender (males) •Stomach acid imbalances caused by pernicious anemia or atrophic gastritis	•Lower socioeconomic status •Diets high in starch, smoked, salted, pickled, salt-cured, and fried foods and low in fresh fruits and vegetables •Nitrates in foods(?)	•Workers in rubber, wood & paper products industries •Coal mine dust together with cigarette smoke (?) •Exposure to asbestos and general dust	
Testes	•Undescended testes (risk increases five times for males with this condition)			

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APPENDIX 3

Age Adjustment
Interpretation of Confidence Intervals
Interpretation of Power Analysis

Why is Age Adjustment Necessary?

Among adults, cancer incidence varies across age groups (most types of cancer are more common in older adults than in younger adults). Therefore, when comparing the incidence rates from two areas it is important to take into account any differences in the age structure of the two populations by adjusting the rates for differences in the underlying age structures. Age adjustment has the effect of "forcing" different areas to have the same proportional age distribution. With an age adjusted rate, any differences in cancer rates between two areas are due to factors other than differences in the age of the population. Adjusted rates are not "actual" rates, but are rates used for comparison purposes to determine if one community has a higher burden of cancer than another. As noted, these are rates that would occur given certain assumptions--in this case that the areas being compared have an identical age distribution. In this study, the rate calculated for each comparison is a rate that would occur using the estimated 1984 populatio and assuming that each area had the same age distribution as NYC. Adjusted rates are used so we may compare cancer incidence in one area to cancer incidence in another without the effect of age differences in each population.

A corollary to the influence of age on cancer rates is the influence of other sociodemographic variables (such as race/ethnicity or socio-economic status). For example, White populations generally have higher rates of bladder cancer while Black populations have comparatively higher rates of prostate cancer. Failure to take into account the differing racial/socio economic conditions of different areas can cause certain areas to look artificially high (or low) in comparison to each other. This fact presents a problem in the interpretation of some of the analyses in this investigation. The cancer incidence data used in these analyses were missing the indicator for "Hispanic Origin" for more than 40% of the cases. As such, in this investigation we were unable to adjust the cancer rates for race/ethnicity with any certainty. To help to take into account the influence of race/ethnicity we chose to compare the Study Area and Staten Island to a comparison area that was very similar with regard to race/ethnicity and income. Using this comparison population helps to remove any effects of race in the comparison of cancer rates (much like age adjustment removes the effects of the differing age structures of two populations). In other analyses (Staten Island compared to the rest of NYC and the Ranking of the 30 NYC Health Districts) there was no attempt to adjust for race/ethnicity, therefore, these analyses should be interpreted with caution.

What are 95% Confidence Intervals and What is Statistical Significance?

Ninety-five percent (95%) confidence intervals were used to assess the likelihood that observed differences between the rates in the different comparisons were due to random fluctuation or were statistically meaningful. Although the RR may be over 1.00, this does not mean the difference is statistically significant. Many times an observed increase in a cancer rate is due to random fluctuation or normal variation. For example, cancer rates vary over time (like from year to year) and place (like from neighborhood to neighborhood)--so, when we say that during 1979-1988 the average annual rate for some cancer was 20 cases for every 100,000 persons in a given area we don't mean that every year exactly 20 cases of cancer were diagnosed for every 100,000 persons; what we mean is that in some years the rate was 21 or 22 per 100,000 persons and in other years it was 18 or 19 per 100,000 persons, but, on average, the rate was 20 cases per 100,000 persons. Similarly, cancer rates may be different from place to place--indicating this same type of variability. Statistics allow us to assess whether the difference or variability in rates is occurring within some normal parameters--like normal fluctuation--or whether it represents

we would expect under normal fluctuation.

Most scientists and epidemiologists consider a value "unusual" or "outside the range of normal fluctuation" when it occurs 5% of the time or less. If a RR is statistically significantly elevated or statistically significantly lower, it means that one would only expect to see a RR as extreme or more extreme 5% of the time or less.

As noted above, we call something statistically significant or "unusual" if it happens 5% of the time or less. Confidence intervals provide a range of "usual" values for the RR estimate we calculated. If that range of usual values doesn't include the RR of 1.00 (a RR of 1.00 means the rates of cancer in two areas are identical) then we can say that 95% of the time 1.00 is not among the "usual" values for the RR. Therefore, the RR we calculated is statistically significantly different from 1.00. If the confidence interval is very wide, it means that the estimate of the RR is not very precise--this usually happens when we have very small samples or very rare cancers. Very narrow confidence intervals indicate a very precise estimate. Therefore, 95% confidence intervals tell us two things: how precise or variable our RR is and whether it is statistically significant.

For example, when we calculate the RR for a cancer as 1.03, with a 95% confidence interval of 0.94-1.13, we mean that the best single estimate for the ratio is 1.03, and we are 95% sure that the true RR is somewhere between .94 and 1.13, meaning anything within this range is a possible value. Since the ratio of 1.00 (signifying that the rates in the 2 areas are the same --neither an increased or decreased risk) is included within the 95% confidence interval of 0.94-1.13 we cannot rule out the possibility that the RR for that particular type of cancer is 1.00 (i.e.: no different than in the comparison area). Since the RR of 1.00 is a possible value, we say that the RR is not statistically significant.

On the other hand, if the RR for a cancer is 1.17 and the 95% confidence interval ranges from 1.10-1.23, then, as above, we can say that the best single estimate for the RR is 1.17 and we are 95% confident that the true RR is contained within the range of 1.10-1.23. Since the RR of 1.00 is not included in the range, then 1.00 is not a likely value for the RR and we can conclude that the RR of 1.17 is different, statistically speaking, than 1.00, or we say the RR is statistically significant.

However, there is still an element of uncertainty in these analyses. Since, statistically speaking, we are only 95% "confident", there is also a probability of observing RR's that appear to be "statistically significant" (that is: they have confidence intervals that do not include 1.00) 5% of the time purely by chance alone. What this means is that 5% of the time we will call the RR statistically significant when it is not.

Generally, the smaller a population and the rarer a disease, the wider a confidence interval for a given RR will be.

What is Meant by 'Power Analysis'? Why is it Necessary?

The concept of "power" is similar to the concept of "detection limits." A detection limit is the minimum level at which a measuring device can begin to count a quantity. Most measuring devices have detection limits. For example, a scale which measures in pounds has a detection limit of about half a pound. If you

weigh a heavy quantity -- say 100 pounds -- the scale will be able to accurately measure it. However, if you weigh a quantity of two or three ounces, the scale will register zero. This does not mean that the quantity has no weight, it just means that it is too small to be measured on that scale. Similarly, devices used to measure environmental contaminants have detection limits. The results will say "ND" or "non detectable" if the levels are below the detection limits. By analogy, the available tool or scale for measuring cancer rates was quite good for measuring total cancers and common types of cancer and for evaluating large differences between Staten Island and New York City. But this tool was not sensitive enough to say for sure whether the small differences noted between some of the areas were meaningful differences or just due to the expected random fluctuation in the rates of cancer.

Another analogy can be drawn with the concept of evidence in a court of law. Under our legal system, it is the duty of the jury to evaluate the evidence of the prosecution and the defense to determine whether the defendant is guilty or not guilty. In order to find the defendant guilty, the evidence must be convincing "beyond a reasonable doubt." If there is not enough evidence or if the evidence is very weak, the jurors are instructed to find the defendant "not guilty". It is very important to note that "not guilty" does not always mean the same thing as "innocent". It can also mean that the evidence just isn't very convincing. Because our standard for convicting a defendant is very rigorous, there is a risk that a guilty person could be set free.

Similarly, in epidemiology we need strong evidence to detect a statistical association. In the case at hand we are seeking evidence that living near the Fresh Kills and Brookfield Avenue Landfills or living in Staten Island in general is associated with an increased rate of cancer. Strong or "powerful" evidence of a statistically significant difference between the two rates occurs when 1) groups of people are small but the differences in rates are very large or 2) groups are large and the differences in rates are very small. If the groups are small and the differences are small, the study method is too weak to detect a difference. The results of the power calculations showed that for certain types of cancer, we did not have enough "evidence". That is, there were too few people and the cancer rates were not substantially higher. In other words, we didn't have enough evidence or "power" to determine whether or not the RR's were truly different than 1.00.

Power is especially important when evaluating results that are not statistically significant. Analogous to the 5% error noted above for 95% confidence intervals (ie: that 5% of the time we will call a RR statistically significant "by mistake"), power allows us to evaluate the opposite situation: how likely are we to miss a statistically significant result or call a RR "not statistically significant" and be mistaken.

A good illustration of how statistical tests and power are related is to consider flipping a coin to determine whether the coin is "fair". In a fair coin we would expect that 50% of our flips would result in "heads" and 50% would result in "tails". However, it is very rare that this is the case--especially when we only flip the coin a small number of times. Even tossing the coin ten times doesn't necessarily give us half heads, but in a long enough series of flips it will happen. Only if the coin is flipped 1000 or 10,000 times would we expect to find a nearly even outcome. This example shows that by chance alone we can get either noticeably more heads or fewer heads than the expected value, and such outcomes are more likely the less times a coin if flipped. However, if the coin is flipped a sufficiently large number of times, the result is likely to be the expected one. When a coin is flipped, we know what to expect on the average. However.

when we look at other situations, such as cancer incidence in a community, it is not as clear what the "average" should be. For most types of cancer the rates observed are not exactly the same as the rates in the comparison area. The concepts of "statistical significance" and "power" are used to help determine whether the differences in rates between two areas are due to normal fluctuations alone, or some other difference between the communities.

APPENDIX 4
POPULATION CHARACTERISTICS AND GROWTH

TABLE 1

STATEN ISLAND CANCER INCIDENCE STUDY
POPULATION CHARACTERISTICS OF STATEN ISLAND, THE STUDY AREA, AND THE COMPARISON AREAS [1]

Comparison Areas	Staten Island [2]	Rest of New York City [3]	Bay Ridge and Flushing combined [4]	Study Area [5]	Rest of Staten Island [6]
Total Population 1980 1990	352,017 378,977	6,719,512 6,943,587	691,463 694,821	75,433 99,008	276,584 279,969
Percent Growth	8	3	0	31	1
Ages	1980 1990	1980 1990	1980 1990	1980 1990	1980 1990
0-14	23% 21%	20% 19%	16% 16%	28% 23%	22% 20%
15-34	34% 32%	33% 33%	31% 30%	37% 33%	33% 32%
35-54	23% 27%	22% 26%	22% 25%	24% 30%	23% 26%
55+	19% 20%	24% 22%	30% 28%	11% 14%	21% 22%
Ethnicity	1980 1990	1980 1990	1980 1990	1980 1990	1980 1990
Hispanic	5% 8%	21% 25%	7% 11%	3% 5%	6% 9%
White Nonhispanic	85% 80%	50% 41%	85% 71%	94% 89%	83% 77%
Black Nonhispanic	7% 7%	25% 26%	3% 3%	1% 1%	9% 10%
Other	2% 5%	4% 7%	6% 15%	2% 6%	2% 4%
Range of Median Family Income in	Health Areas	Health Areas	Health Areas	Census Tracts	Census Tracts
1979	$18,430-$26,170	$ 3,750-$ 67,025	$14,090-$30,190	$26,051-$28,278	$ 5,417-$38,762
1989	$37,168-$58,081	$ 7,811-$135,944	$30,773-$60,467	$43,393-$62,995	$16,141-$76,333

1 1980 and 1990 US Census, data provided to NYCDOH by NYC Department of City Planning
2 Health center district (HD) Richmond
3 New York City excluding HD Richmond
4 HDs Bay Ridge (Brooklyn) and Flushing (Queens) combined
5 1980 census tracts (with 1990 subdivisions) 146.01, 146.02, 170.01 (170.03 and 170.04), 170.02, 208.01, 273.01, 273.02, 277 (277.01 and 277.02),279, 291 (291.01 and 291.02) around Brookfield and Fresh Kills Landfill
6 HD Richmond excluding above census tracts

Growth of Populations During the Decade 1980-1990

Demographic information for the population of the Study Area, Staten Island, the rest of NYC and the Bay Ridge/Flushing comparison area is presented in Table 1. There were 75,433 persons living in the Study Area according to the 1980 census. During the 1980's the population grew 31% in size to a total of 99,008 persons in 1990. In comparison, the rest of Staten Island grew only one percent during the same time period. The combined Bay Ridge and Flushing Health Districts grew less than one percent over the decade and the NYC population grew by approximately 3%

Since the population in the Study Area grew very rapidly during the ten-year period, the pattern of growth was examined to determine when and where the bulk of the growth took place. By assessing the pattern of growth, we were better able to determine whether the 1984 population estimated by linear interpolation was a good estimate of the area's actual population and, therefore, the cancer rates calculated were representative of the actual average rates of cancer in the Study Area. Four of the ten census tracts in the Study Area experienced rapid growth. These are presented in table 2. Of the remaining six census tracts, four grew between 1% and 18%. The population in two census tracts declined 4% and 9% respectively.

Table 2

POPULATION CHANGE FROM 1980 TO 1990 IN THE FOUR STUDY AREA[1] CENSUS TRACTS WITH THE GREATEST CHANGE[2]

Census Tract	1980	1990	Difference	Comment
146.02	4,437	8,604	+ 4,167 (+ 94%)	Main growth at **beginning** of decade
170.01 (170.03+170.04)	15,220	20,535	+ 5,315 (+ 35%)	Main growth at **beginning** of decade
208.01	385	4,983	+ 4,598 (+1194%)	Main growth at **e n d** of decade
277.00 (277.01+277.02)	8,363	16,017	+ 7,654 (+ 92%)	Main growth at **beginning** of decade

1 Study Area comprised of 1980 census tracts (with 1990 subdivisions) 146.1, 146.2, 170.01 (170.03, 170.04), 170.02, 208.01, 273.01, 273.02, 277 (277.01, 277.02), 279, 291 (291.01, 291.02) around Fresh Kills and Brookfield Landfills in the Richmond Health Center District.

2 US census 1980 and 1990, records STF2, information provided by the NYC Dept. of City Planning

3 Information gathered from aerial photographs taken in 1984 and 1988

The pattern of growth was assessed by looking at aerial photographs of the Study Area over the decade from the New York City Department of City Planning. The aerial view allowed us to evaluate whether housing development was in progress, had been completed recently, or was established at least several years ago. Housing development in progress can be distinguished by incomplete housing, visible construction machinery, or wide areas of property recently bulldozed. New housing is usually surrounded by areas of exposed soil. Conversely, fully developed gardens and good sized bushes and trees indicate housing built at least several years ago.

Only one out of the four census tracts, tract 208.01, showed large areas of housing development either in progress or only completed late in the decade (1988). Very early in the decade there were almost no established housing units in this census tract. The New York City Department of City Planning estimated that by 1984 only 25% of final development in this census tract was complete and that between 1984 and 1988 an additional 50% to 70% had been completed.

The other three census tracts appeared to have experienced the bulk of their development earlier in the 1980's. Census tracts 146.02 and 170.03 were probably fully developed by 1986. Census tract 170.04 was 90% developed by 1988. In census tract 277.00 half of the new housing was probably fully developed by the middle of the decade, and most new housing was completed by 1988.

Based on these growth patterns, the interpolated 1984 population would appear, on average to be an acceptable estimate of the actual Study Area population. Since the true intercensus population was impossible to know, however, this estimate also represents a somewhat conservative estimate and, since most development appears to have taken place prior to the middle of the decade, may actually underestimate the 1984 population. An underestimate of the population would make cancer rates in the Study Area appear higher than they actually were.

Age

In the Study Area, 28% of the population were aged 0-14 in 1980. In 1990, the proportion of children decreased slightly to 23%. On Staten Island as a whole, the percentage of population aged 0-14 was 23% in 1980 and 21% in 1990, while in 1980 and 1990 only 16% of the Bay Ridge/Flushing area population were in this age group. The Staten Island population (both in the Study Area and in the rest of Staten Island), is proportionally a much younger population than the Bay Ridge and Flushing comparison area with an age distribution close to that of New York City.

Race/Ethnicity

Staten Island as a whole and the Bay Ridge/Flushing comparison area have a large, though decreasing, white non-Hispanic majority. Overall, Staten Island's population was 85 percent white non-Hispanic in 1980 and 80 percent white non-Hispanic in 1990. There was a higher proportion of white non-Hispanics in the Study Area (94% in 1980, 89% in 1990) than in the rest of Staten Island (83% in 1980, 77% in 1990). The white non-Hispanic population in Bay Ridge/Flushing declined 14% during the decade to 71% white non-Hispanic in 1990. In contrast, the rest of New York City's population was 50% white non-Hispanic in 1980 and

41% white non-Hispanic in 1990. Staten Island and the Bay Ridge/Flushing area both have small, but growing Hispanic and black non-Hispanic populations.

Income

Median family incomes in Staten Island Health Areas ranged from $18,430 to $26,170 in 1980 and from $37,168 to $58,081 in 1990. Wider variation was noted in the Bay-Ridge/Flushing area, however, the incomes in this area appear to be on a par with those in Staten Island. Incomes in the Study Area appear, on average, higher than in the rest of Staten Island or the Bay Ridge/Flushing area.

APPENDIX 5

Cancer Incidence Rates, Rate Ratios and 95% Confidence Intervals

Table 1a: Men in Study Area compared to Men in Rest of Staten Island
Table 1b: Men in Study Area compared to Men in Bay Ridge/Flushing
Table 1c: Men in Staten Island compared to Men in Bay Ridge/Flushing
Table 1d : Men in Staten Island Compared to Men in the Rest of NYC

Table 2a: Women in Study Area compared to Women in Rest of Staten Island
Table 2b: Women in Study Area compared to Women in Bay Ridge/Flushing
Table 2c: Women in Staten Island compared to Women in Bay Ridge/Flushing
Table 2d : Women in Staten Island Compared to Women in the Rest of NYC

Table 3a: Children in Study Area compared to Children in Rest of Staten Island
Table 3b: Children in Study Area compared to Children in Bay Ridge/Flushing
Table 3c: Children in Staten Island compared to Children in Bay Ridge/Flushing
Table 3d : Children in Staten Island Compared to Children in the Rest of NYC

Table 1A

CANCER INCIDENCE 1979-88
STUDY AREA [1] COMPARED TO REST OF STATEN ISLAND [2]
MEN (AGES 15 +)

SITE	No. of Cases 1979-88		Average Annual Rates [3]		RATIO OF RATES	95% CONFIDENCE INTERVAL
	Study Area	Rest of S.I.	Study Area	Rest of S.I.		
PHARYNX	28	248	15.78	27.91	0.57 -	0.44 - 0.72
STOMACH	32	173	20.36	21.53	0.95	0.64 - 1.39
COLON	116	646	78.79	81.01	0.97	0.79 - 1.19
PANCREAS	30	156	20.06	19.28	1.04	0.68 - 1.60
LUNG	221	1,354	146.21	162.83	0.90	0.78 - 1.03
PROSTATE	128	747	94.47	98.76	0.96	0.79 - 1.15
BLADDER	97	473	58.36	58.37	1.00	0.79 - 1.27
KIDNEY	35	139	20.92	16.01	1.31	0.78 - 2.18
LYMPHOMA	60	252	24.84	26.54	0.94	0.70 - 1.26
LEUKEMIA	21	126	13.44	15.28	0.88	0.57 - 1.37
LIVER	13	65	7.81	7.88	0.99	0.52 - 1.89
LARYNX	31	175	18.79	20.22	0.93	0.63 - 1.36
NERVOUS SYSTEM	19	92	8.60	10.14	0.85	0.54 - 1.34
MULTIPLE MYELOMA	7	61	3.73	7.47	0.50 -	0.33 - 0.75
TOTAL CANCERS	1,078	5,767	660.43	696.96	0.95	0.89 - 1.01

1 1980 census tracts (with 1990 subdivisions) 146.1, 146.2, 170.01 (170.03, 170.04), 170.02, 208.01, 273.01, 273.02, 277(277.01, 277.02), 279, 291 (291.01, 291.02) around Fresh Kills and Brookfield Landfills.
2 Health District Richmond excluding above census tracts
3 Age-adjusted rates per 100,000 persons
* Indicates statistically significant elevation of RR
\- Indicates statistically significant decrease of RR

Table 1B

CANCER INCIDENCE 1979-88
STUDY AREA [1] COMPARED TO BAY RIDGE & FLUSHING COMBINED [2]
MEN (AGES 15 +)

SITE	No. of Cases 1979-88		Average Annual Rates [3]		RATIO OF RATES	95% CONFIDENCE INTERVAL
	Study Area	BayRidge/ Flushing	Study Area	BayRidge/ Flushing		
PHARYNX	28	486	15.78	17.38	0.91	0.62 - 1.34
STOMACH	32	660	20.36	24.50	0.85	0.61 - 1.18
COLON	116	2.064	78.79	75.16	1.05	0.85 - 1.29
PANCREAS	30	534	20.06	19.26	1.04	0.69 - 1.57
LUNG	221	3,100	146.21	110.96	1.32 *	1.09 - 1.60
PROSTATE	128	2,676	94.47	98.74	0.96	0.80 - 1.14
BLADDER	97	1,489	58.36	53.85	1.08	0.85 - 1.38
KIDNEY	35	499	20.92	17.67	1.18	0.77 - 1.83
LYMPHOMA	60	764	24.84	27.74	0.90	0.69 - 1.17
LEUKEMIA	21	432	13.44	15.83	0.85	0.57 - 1.27
LIVER	13	171	7.81	6.21	1.26	0.58 - 2.75
LARYNX	31	363	18.79	12.84	1.46	0.82 - 2.62
NERVOUS SYSTEM	19	258	8.60	9.23	0.93	0.58 - 1.50
MULTIPLE MYELOMA	7	177	3.73	6.39	0.58 -	0.37 - 0.93
TOTAL CANCERS	1,078	16,673	660.43	604.23	1.09 *	1.02 - 1.18

1 1980 census tracts (with 1990 subdivisions) 146.1, 146.2, 170.01 (170.03, 170.04), 170.02, 208.01, 273.01, 273.02, 277(277.01, 277.02), 279, 291 (291.01, 291.02) around Fresh Kills and Brookfield Landfills in Health District (HD) Richmond
2 HDs Bay Ridge (Brooklyn) and Flushing (Queens)
3 Age-adjusted rates per 100,000 persons
* Indicates statistically significant elevation of rate ratio
- Indicates statistically significant decrease of rate ratio

Table 1C

CANCER INCIDENCE 1979-88
STATEN ISLAND [1] COMPARED TO BAY RIDGE AND FLUSHING COMBINED [2]
MEN (AGES 15 +)

SITE	No. of Cases 1979-88		Average Annual Rates[3]		RATIO OF RATES	95% CONFIDENCE INTERVAL
	S.I.	BayRidge/ Flushing	Staten Island	Bay Ridge/ Flushing		
PHARYNX	276	486	25.76	17.38	1.48 *	1.19 - 1.85
STOMACH	205	660	21.37	24.05	0.89	0.77 - 1.02
COLON	762	2,064	80.59	75.16	1.07	0.98 - 1.17
PANCREAS	186	534	19.33	19.26	1.00	0.85 - 1.19
LUNG	1,575	3,100	159.45	110.96	1.44 *	1.32 - 1.57
PROSTATE	875	2,676	98.43	98.74	1.00	0.92 - 1.08
BLADDER	570	1,489	58.66	53.85	1.09	0.98 - 1.21
KIDNEY	174	499	16.67	17.67	0.94	0.80 - 1.11
LYMPHOMA	312	764	26.18	27.74	0.94	0.83 - 1.07
LEUKEMIA	147	432	14.92	15.83	0.94	0.79 - 1.13
LIVER	78	171	7.87	6.21	1.27	0.90 - 1.79
LARYNX	206	363	19.84	12.84	1.55 *	1.18 - 2.02
NERVOUS SYSTEM	111	258	9.91	9.23	1.07	0.84 - 1.37
MULTIPLE MYELOMA	68	177	6.94	6.39	1.09	0.80 - 1.48
TOTAL CANCERS	6,845	16,673	690.45	604.23	1.14 *	1.11 - 1.18

1 Health District (HD) Richmond
2 HDs Bay Ridge (Brooklyn) and Flushing (Queens)
3 Age-adjusted rates per 100,000 persons
* Indicates statistically significant elevation of RR

Table 1D

CANCER INCIDENCE 1979-88
STATEN ISLAND [1] COMPARED TO REST OF CITY [2]
MEN (AGES 15 +)

SITE	No. of Cases 1979-88		Average Annual Rates[3]		RATIO OF RATES	95% CONFIDENCE INTERVAL
	S.I.	Rest of N.Y.C.	S.I	Rest of N.Y.C.		
PHARYNX	276	5,687	25.76	25.16	1.02	0.90 - 1.16
STOMACH	205	5,466	21.37	25.66	0.83 -	0.74 - 0.94
COLON	762	15,038	80.59	71.66	1.12 *	1.03 - 1.22
PANCREAS	186	4,180	19.33	19.59	0.99	0.85 - 1.14
LUNG	1,575	25,317	159.45	117.06	1.36 *	1.27 - 1.46
PROSTATE	875	22,545	98.43	109.56	0.90 -	0.84 - 0.96
BLADDER	570	9,204	58.66	43.76	1.34 *	1.19 - 1.51
KIDNEY	174	3,485	16.67	16.02	1.04	0.88 - 1.22
LYMPHOMA	312	6,357	26.18	27.55	0.95	0.85 - 1.06
LEUKEMIA	147	3,400	14.92	15.64	0.95	0.81 - 1.12
LIVER	78	1,870	7.87	8.58	0.92	0.74 - 1.13
LARYNX	206	3,386	19.84	15.26	1.30 *	1.08 - 1.57
NERVOUS SYSTEM	111	1,848	9.91	8.06	1.23	0.97 - 1.57
MULTIPLE MYELOMA	68	1,763	6.94	8.24	0.84	0.68 - 1.04
TOTAL CANCERS	6845	135,387	690.45	627.67	1.10 *	1.07 - 1.13

1 Health District (HD) Richmond
2 New York City excluding HD Richmond
3 Age-adjusted rates per 100,000 persons
* Indicates statistically significant elevation of RR
- Indicates statistically significant decrease of RR

Table 2A

CANCER INCIDENCE 1979-1988
STUDY AREA [1] COMPARED TO THE REST OF STATEN ISLAND [2]
WOMEN (AGES 15 +)

SITE	No. of Cases 1979-88		Average Annual Rates [3]		RATIO OF RATES	95% CONFIDENCE INTERVAL
	Study Area	Rest of S.I.	Study Area	Rest of S.I.		
PHARYNX	12	126	5.21	10.79	0.48 -	0.36 - 0.65
STOMACH	26	139	13.05	11.42	1.14	0.70 - 1.86
COLON	112	727	55.12	59.91	0.92	0.76 - 1.11
PANCREAS	26	178	13.36	14.86	0.90	0.62 - 1.31
LUNG	126	629	58.61	53.81	1.09	0.88 - 1.35
BREAST	340	1,635	134.62	138.40	0.97	0.86 - 1.10
BLADDER	33	175	15.81	14.61	1.08	0.72 - 1.63
KIDNEY	13	83	5.86	7.08	0.83	0.50 - 1.36
LYMPHOMA	62	245	24.71	20.94	1.18	0.84 - 1.66
LEUKEMIA	25	114	11.74	9.48	1.24	0.72 - 2.14
LIVER	7	43	3.41	3.49	0.98	0.45 - 2.14
LARYNX	9	44	3.86	3.82	1.01	0.48 - 2.13
NERVOUS SYSTEM	9	78	3.84	6.72	0.57 -	0.38 - 0.86
MULTIPLE MYELOMA	8	62	3.66	5.16	0.71	0.41 - 1.22
TOTAL CANCERS	1,108	5,972	475.76	504.00	0.94	0.89 - 1.01

1 1980 census tracts (with 1990 subdivisions) 146.1, 146.2, 170.01 (170.03, 170.04), 170.02, 208.01, 273.01, 273.02, 277(277.01, 277.02), 279, 291 (291.01, 291.02) around Fresh Kills and Brookfield Landfills in Health District (HD) Richmond
2 HD Richmond excluding above census tracts
3 Age-adjusted rates per 100,000 persons
* Indicates statistically significant elevation of rate ratio
\- Indicates statistically significant decrease of rate ratio

Table 2B

CANCER INCIDENCE 1979-88
STUDY AREA [1] COMPARED TO BAY RIDGE AND FLUSHING COMBINED [2]
WOMEN (AGES 15 +)

SITE	No. of Cases 1979-88		Average Annual Rates [3]		RATIO OF RATES	95% CONFIDENCE INTERVAL
	Study Area	Bay Ridge/ Flushing	Study Area	Bay Ridge/ Flushing		
PHARYNX	12	269	5.21	7.11	0.73	0.47 - 1.14
STOMACH	26	516	13.05	12.49	1.04	0.69 - 1.59
COLON	112	2,211	55.12	53.67	1.03	0.84 - 1.25
PANCREAS	26	633	13.36	15.36	0.87	0.62 - 1.23
LUNG	126	1,701	58.61	44.28	1.32 *	1.04 - 1.69
BREAST	340	5,273	134.62	141.34	0.95	0.85 - 1.06
BLADDER	33	548	15.81	13.45	1.18	0.77 - 1.79
KIDNEY	13	298	5.86	7.52	0.78	0.50 - 1.22
LYMPHOMA	62	827	24.71	22.32	1.11	0.82 - 1.50
LEUKEMIA	25	353	11.74	8.99	1.31	0.76 - 2.25
LIVER	7	112	3.41	2.79	1.22	0.48 - 3.11
LARYNX	9	92	3.86	2.45	1.58	0.52 - 4.81
NERVOUS SYSTEM	9	215	3.84	5.99	0.64	0.41 - 1.00
MULTIPLE MYELOMA	8	187	3.66	4.58	0.80	0.45 - 1.44
TOTAL CANCERS	1108	18,372	475.76	478.45	0.99	0.93 - 1.06

1 1980 census tracts (with 1990 subdivisions) 146.1, 146.2, 170.01 (170.03, 170.04), 170.02, 208.01, 273.01, 273.02, 277(277.01, 277.02), 279, 291 (291.01, 291.02) around Fresh Kills and Brookfield Landfills in Health District (HD) Richmond
2 HDs Bay Ridge (Brooklyn) and Flushing (Queens)
3 Age-adjusted rate per 100,000 persons
* Indicates statistically significant elevation of rate ratio

Table 2C

CANCER INCIDENCE 1979 - 88
STATEN ISLAND [1] COMPARED TO BAY RIDGE & FLUSHING COMBINED [2]
WOMEN AGES 15+

SITE	No. of Cases 1979-88		Average Annual Rates [3]		RATIO OF RATES	95% CONFIDENCE INTERVAL
	S.I.	Bay Ridge/ Flushing	S.I	Bay Ridge/ Flushing		
PHARYNX	138	269	9.85	7.11	1.39 *	1.04 - 1.85
STOMACH	165	516	11.57	12.49	0.93	0.79 - 1.09
COLON	839	2,211	59.10	53.67	1.10 *	1.01 - 1.20
PANCREAS	204	633	14.54	15.36	0.95	0.81 - 1.10
LUNG	755	1,701	54.48	44.28	1.23 *	1.11 - 1.37
BREAST	1,975	5,273	137.83	141.34	0.98	0.93 - 1.03
BLADDER	208	548	14.82	13.45	1.10	0.92 - 1.32
KIDNEY	96	298	6.91	7.52	0.92	0.74 - 1.14
LYMPHOMA	307	827	21.58	22.32	0.97	0.85 - 1.10
LEUKEMIA	139	353	9.69	8.99	1.08	0.87 - 1.33
LIVER	50	112	3.46	2.79	1.24	0.82 - 1.88
LARYNX	53	92	3.81	2.45	1.56	0.92 - 2.65
NERVOUS SYSTEM	87	215	6.24	5.99	1.04	0.80 - 1.35
MULTIPLE MYELOMA	70	187	4.92	4.58	1.08	0.80 - 1.45
TOTAL CANCERS	7,080	18,372	499.32	478.54	1.04 *	1.01 - 1.07

1 Health District (HD) Richmond
2 HDs Bay Ridge (Brooklyn) and Flushing (Queens)
3 Age-adjusted rates per 100,000 persons
* Indicates statistically significant elevation of rate ratio.

TABLE 2D

CANCER INCIDENCE 1979-88
STATEN ISLAND [1] COMPARED TO THE REST OF NEW YORK CITY [2]
WOMEN (AGES 15 +)

SITE	No. of Cases 1979-88		Average Annual Rates [3]		RATIO OF RATES	95% CONFIDENCE INTERVAL
	S.I.	Rest of N.Y.C.	S.I	Rest of N.Y.C.		
PHARYNX	138	2,619	9.85	8.36	1.18	0.96 - 1.44
STOMACH	165	4,378	11.57	13.09	0.88	0.77 - 1.01
COLON	839	17,252	59.10	51.93	1.14 *	1.05 - 1.23
PANCREAS	204	4,856	14.54	14.65	0.99	0.86 - 1.14
LUNG	755	14,125	54.48	44.72	1.22 *	1.11 - 1.33
BREAST	1,975	39,266	137.83	124.88	1.10 *	1.05 - 1.16
BLADDER	208	3,917	14.82	11.85	1.25 *	1.05 - 1.49
KIDNEY	96	2,264	6.91	7.08	0.98	0.80 - 1.19
LYMPHOMA	307	5,830	21.58	18.40	1.17 *	1.02 - 1.34
LEUKEMIA	139	3,220	9.69	9.87	0.98	0.83 - 1.16
LIVER	50	1,090	3.46	3.33	1.04	0.77 - 1.40
LARYNX	53	896	3.81	2.93	1.30	0.91 - 1.87
NERVOUS SYSTEM	87	1,678	6.24	5.40	1.16	0.90 - 1.49
MULTIPLE MYELOMA	70	1,888	4.92	5.80	0.85	0.69 - 1.04
TOTAL CANCERS	7080	146,122	499.32	457.43	1.09 *	1.06 - 1.12

1 Health Center District (HD) Richmond
2 New York City excluding HD Richmond
3 Age-adjusted rates per 100,000 persons
* Indicates statistically significant elevation of rate ratio

TABLES 3A and 3B

CANCER INCIDENCE 1979-1988
CHILDREN (AGES 0-14)

STUDY AREA [1] COMPARED TO REST OF STATEN ISLAND [2]

SITE	No. of Cases 1979-88		Average Annual Rates [3]		RATIO OF RATES	95% CONFIDENCE INTERVAL
	Study Area	Rest of S.I.	Study Area	Rest of S.I.		
LYMPHOMA	*	*	*	*	1.38	0.26 - 7.19
LEUKEMIA	7	24	3.24	4.04	0.80	0.41 - 1.58
NERVOUS SYSTEM	*	*	*	*	0.92	0.36 - 2.32
TOTAL CANCERS	28	71	12.98	11.95	1.09	0.68 - 1.75

STUDY AREA COMPARED TO BAY RIDGE & FLUSHING COMBINED [4]

SITE	No. of Cases 1979-88		Average Annual Rates [3]		RATIO OF RATES	95% CONFIDENCE INTERVAL
	Study Area	Bay Ridge/ Flushing	Study Area	Bay Ridge/ Flushing		
LYMPHOMA	*	*	*	*	1.10	0.34 - 3.62
LEUKEMIA	7	55	3.24	4.87	0.67	0.39 - 1.13
NERVOUS SYSTEM	*	*	*	*	0.73	0.37 - 1.44
TOTAL CANCERS	28	155	12.98	13.72	0.95	0.65 - 1.38

* NYCDOH confidentiality laws do not allow disclosure of an exact number of cases in areas where there are fewer than six cases. Although this law applies only to the study area, numbers in other areas that would have allowed calculation of numbers in the study were also suppressed.

1 1980 census tracts (with 1990 subdivisions) 146.1, 146.2, 170.01 (170.03, 170.04), 170.02, 208.01, 273.01, 273.02, 277(277.01, 277.02), 279, 291 (291.01, 291.02) around Fresh Kills and Brookfield Landfills in Health Center District (HD) Richmond

2 HD Richmond excluding above census tracts

3 Per 100,000 children

4 HDs Bay Ridge (Brooklyn) and Flushing (Queens)

Tables 3C and 3D

CANCER INCIDENCE 1979-1988
CHILDREN (AGES 0-14)

STATEN ISLAND COMPARED TO BAY RIDGE & FLUSHING [4]

SITE	No. of Cases 1979-88		Average Annual Rates [3]		RATIO OF RATES	95% CONFIDENCE INTERVAL
	S.I.	BayRidge/ Flushing	S.I	BayRidge/ Flushing		
LYMPHOMA	*	*	*	*	0.88	0.47 - 1.67
LEUKEMIA	31	55	3.83	4.87	0.79	0.56 - 1.11
NERVOUS SYSTEM	*	*	*	*	0.77	0.51 - 1.18
TOTAL CANCERS	99	155	12.22	13.72	0.89	0.71 - 1.12

STATEN ISLAND [1] COMPARED TO REST OF NEW YORK CITY [2]

SITE	No. of Cases 1979-88		Average Annual Rates [3]		RATIO OF RATES	95% CONFIDENCE INTERVAL
	S.I.	Rest of N.Y.C.	S.I	Rest of N.Y.C.		
LYMPHOMA	*	*	*	*	0.93	0.54 - 1.60
LEUKEMIA	31	579	3.83	4.32	0.89	0.64 - 1.22
NERVOUS SYSTEM	*	*	*	*	0.84	0.58 - 1.23
TOTAL CANCERS	99	1909	12.22	14.24	0.86	0.72 - 1.02

* NYCDOH confidentiality laws do not allow disclosure of an exact number of cases in areas where there are fewer than six cases. Although this law applies only to the study area, numbers in other areas that would have allowed calculation of numbers in the study were also suppressed.

1 Health Center District (HD) Richmond
2 New York City excluding Health Center District Richmond
3 Per 100,000 children
4 HDs Bay Ridge (Brooklyn) and Flushing (Queens)

APPENDIX 6

PATTERNS IN RR'S and POWER CALCULATIONS

APPENDIX 6

STATEN ISLAND CANCER INCIDENCE STUDY
RATE RATIOS (RR) FOR SPECIFIC CANCER TYPES
ACTUAL POWER TO ASCERTAIN A STATISTICALLY SIGNIFICANT DIFFERENCE AND RR REQUIRED FOR AT LEAST 80% POWER FOR EACH COMPARISON
MEN (AGES 15 AND OLDER)

STUDIED AREA/ COMPARED AREA	PHARYNX	STOMACH	COLON	PAN-CREAS	LUNG	PROS-TATE	BLADDER	KIDNEY	LYM-PHOMA	LEU-KEMIA	LIVER	LARYNX	NERVOUS SYSTEM	MULTIPLE MYELOMA	TOTAL CANCER
Study Area[1]/ Rest of S.I.[2]															
RR	0.57	0.95	0.97	1.04	0.90	0.96	1.00	1.31	0.94	0.88	0.99	0.93	0.83	0.50	0.95
% Power								30							
RR for 80% Power								1.7							
Study Area/Bay Ridge+Flushing[3]															
RR	1.91	1.05	1.01	1.04	1.31*	0.96	1.08	1.10	0.90	1.05	1.36	1.66	0.93	0.58	1.08*
% Power			15		95		20	15			15	35			80
RR for 80% Power			1.3				1.3-1.4	1.6			2.1	1.7			
S.I.[2]/Rest of NYC[5]															
RR	1.02	0.83	1.12*	0.99	1.36*	0.90	1.34*	1.04	0.95	0.95	0.92	1.30*	1.23	0.84	1.10*
% Power			80-90		>95		>95					90	50		>90
RR for 80% Power													1.3-1.4		
S.I./Bay Ridge+ Flushing[3]															
RR	1.48*	0.89	1.07	1.00	1.44*	1.00	1.09	0.94	0.94	0.94	1.27	1.88*	1.07	1.09	1.14*
% Power	>95		60		>95		45				50	>95	10	10	>95
RR for 80% Power			1.2 to >95				1.2 to >95				1.4-1.5		1.3-1.4	1.4-1.5	

* Indicates statistically significant difference between studied and compared area (level of significance <0.05).
1 1980 census tracts (with 1990 subdivisions) 146.1, 146.2, 170.01 (170.03, 170.04), 170.02, 206.01, 273.01, 273.02, 277(277.01, 277.02), 279, 291 (291.01, 291.02) around Fresh Kills and Brookfield Landfills.
2 Health District (HD) Richmond excluding above census tracts
3 HDs Bay Ridge (Brooklyn) and Flushing (Queens) combined
4 HD Richmond
5 New York City excluding Health Center District Richmond

STATEN ISLAND CANCER INCIDENCE STUDY
RATE RATIOS (RR) FOR SPECIFIC CANCER TYPES
ACTUAL POWER TO ASCERTAIN A STATISTICALLY SIGNIFICANT DIFFERENCE AND RR REQUIRED FOR AT LEAST 80% POWER FOR EACH COMPARISON FOR EACH COMPARISON

WOMEN (AGES 15 AND OLDER)

STUDIED AREA/ COMPARED AREA	PHARYNX	STOMACH	COLON	PANCREAS	LUNG	BREAST	BLADDER	KIDNEY	LYMPHOMA	LEUKEMIA	LIVER	LARYNX	NERVOUS SYSTEM	MULTIPLE MYELOMA	TOTAL CANCERS
Study Area[2]/Rest of S.I.[2] RR % Power RR for 80% Power	0.48	1.14 < 5 1.7	0.92	0.90	1.09 15 1.3	0.97	1.08 5 1.6	0.83	1.16 20 1.4-1.5	1.24 15 1.7-1.8	0.98	1.01	0.57	0.71	0.94
Study Area/Bay Ridge + Flushing[4] RR % Power RR for 80% Power	0.73	1.04	1.03	0.87	1.31* 75 1.4 to 90	0.95	1.18 20 1.6-1.7	0.78	1.11 10 1.4-1.5	1.31 25 1.7-1.8	1.22 5 2.5	1.58 30 2.5	0.64	0.80	0.99
S.I./Rest of NYC[5] RR % Power RR for 80% Power	1.18 55 1.3 to 90	0.88	1.14* 80	0.99	1.22* >95	1.10* >95	1.25* 90	0.98	1.17* 85	0.98	1.04	1.30 40 1.5	1.16 40 1.3-1.4	0.83	1.09* >95
S.I./Bay Ridge + Flushing RR % Power RR for 80% Power	1.39* 90	0.93	1.10* 65 1.2 to >95	0.95	1.23* >95	0.98	1.10 15 1.2-1.3	0.92	0.97	1.08 15 1.3	1.24 30 1.6	1.56 80	1.04	1.08 10 1.4-1.5	1.04*

* Indicates statistically significant difference between studied and compared area (level of significance <0.05).

1 1980 census tracts (with 1990 subdivisions) 146.1, 146.2, 170.01 (170.03, 170.04), 170.02, 208.01, 273.01, 273.02, 277(277.01, 277.02), 279, 291 (291.01, 291.02) around Fresh Kills and Brookfield Landfills.

2 Health District (HD) Richmond excluding above census tracts

4 HDs Bay Ridge (Brooklyn) and Flushing (Queens) combined

5 HD Richmond

4 New York City excluding Health Center District Richmond

APPENDIX 6

STATEN ISLAND CANCER INCIDENCE STUDY
RATE RATIOS (RR) FOR SPECIFIC CANCER TYPES
ACTUAL POWER TO ASCERTAIN A STATISTICALLY SIGNIFICANT DIFFERENCE AND RR REQUIRED FOR AT LEAST 80% POWER FOR EACH COMPARISON

CHILDREN (AGES 0 - 14)

STUDIED AREA/COMPARED AREA	LYMPHOMA	LEUKEMIA	NERVOUS SYSTEM	TOTAL CANCERS
Study Area[1]/Rest of S.I.[2] RR % Power RR for 80% Power	1 38 10 3 8	0 80	0 92	1 09 5 1 7-1 8
Study Area/Bay Ridge+ Flushing[3] RR % Power RR for 80% Power	1 10 5 3 1-3 2	0 67	0 73	0 93
S.I.Y/Rest of NYC[4] RR % Power RR for 80% Power	0 93	0 89	0 84	0 86
S.I./Bay Ridge+Flushing RR % Power RR for 80% Power	0 88	0 79	0 77	0 89

* Indicates statistically significant difference between studied and compared area (level of significance <0 05)

1 1980 census tracts (with 1990 subdivisions) 146.1, 146.2, 170.01 (170.03, 170.04), 170.02, 208.01, 273.01, 273.02, 277(277.01, 277.02), 279, 291 (291.01, 291.02) around Fresh Kills and Brookfield Landfills.

2 Health District (HD) Richmond excluding above census tracts

3 HDs Bay Ridge (Brooklyn) and Flushing (Queens) combined

4 HD Richmond

5 New York City excluding Health Center District Richmond

APPENDIX 7

RANKING OF THE 30 NYC HEALTH DISTRICTS

Appendix 7

STATEN ISLAND CANCER INCIDENCE 1979 - 1988
RANK AMONG THE THIRTY NEW YORK CITY HEALTH CENTER DISTRICTS

MEN

CANCER SITE	AGE-ADJUSTED AVERAGE ANNUAL RATES PER 100,000 PERSONS			
	RANK	STATEN ISLAND	RANGE OF RATES AMONG N.Y.C. HEALTH DISTRICTS	NEW YORK CITY
PHARYNX	15	25.76	14.79 - 57.56	25.15
STOMACH	29	21.37	16.00 - 43.43	25.46
COLON	2	80.59	55.96 - 81.84	72.05
PANCREAS	16	19.33	14.67 - 27.82	19.57
LUNG	2	159.43	85.74 - 202.69	118.82
PROSTATE	24	98.43	79.86 - 208.59	109.09
BLADDER	1	58.66	21.89 - 58.66	44.43
KIDNEY	11	16.67	9.40 - 19.73	16.06
LYMPHOMA	11	26.18	19.79 - 40.26	27.50
LEUKEMIA	18	14.92	9.37 - 18.14	15.60
LIVER	19	7.87	5.37 - 16.98	8.55
LARYNX	6	19.84	10.97 - 28.89	15.44
NERVOUS SYSTEM	4	9.91	3.42 - 10.47	8.14
MULTIPLE MYELOMA	24	6.94	5.12 - 14.62	8.17
TOTAL CANCER	4	690.77	566.90 - 918.00	630.21

Appendix 7

STATEN ISLAND CANCER INCIDENCE 1979 - 1988
RANK AMONG THE THIRTY NEW YORK CITY HEALTH CENTER DISTRICTS

WOMEN

		AGE-ADJUSTED AVERAGE ANNUAL RATES PER 100,000 PERSONS		
CANCER SITE	RANK	STATEN ISLAND	RANGE OF RATES AMONG N.Y.C. HEALTH DISTRICTS	NEW YORK CITY
PHARYNX	8	9.85	4.95 - 17.85	8.42
STOMACH	27	11.57	9.52 - 18.72	13.03
COLON	2	59.10	38.78 - 60.17	52.30
PANCREAS	16	14.54	11.36 - 18.28	14.65
LUNG	4	54.48	33.68 - 58.12	45.12
BREAST	4	137.83	84.74 - 162.08	125.45
BLADDER	2	14.82	7.03 - 15.44	11.98
KIDNEY	14	6.91	4.36 - 10.19	7.07
LYMPHOMA	5	21.58	10.21 - 23.22	18.54
LEUKEMIA	13	9.69	6.82 - 11.91	9.86
LIVER	12	3.53	1.97 - 5.22	3.33
LARYNX	6	3.81	1.82 - 7.39	2.97
NERVOUS SYSTEM	6	6.24	2.33 - 7.05	5.43
MULTIPLE MYELOMA	23	4.92	3.68 - 12.65	5.76
TOTAL CANCER	3	499.52	381.85 - 510.58	459.16

Appendix 7

STATEN ISLAND CANCER INCIDENCE 1979 - 1988
RANK AMONG THE THIRTY NEW YORK CITY HEALTH CENTER DISTRICTS

CHILDREN

		AVERAGE ANNUAL RATES PER 100,000 CHILDREN		
CANCER SITE	RANK	STATEN ISLAND	RANGE OF RATES AMONG N.Y.C. HEALTH DISTRICTS	NEW YORK CITY
LYMPHOMA	15	1.48	0.56 - 3.17	1.58
LEUKEMIA	21	3.83	2.32 - 7.70	4.29
NERVOUS SYSTEM	20	2.47	1.52 - 4.95	2.91
TOTAL CANCER	22	12.22	10.06 - 20.01	14.13

APPENDIX 8

Case Verification (1988-1992)

A. METHODS

At the time that this study began, complete and computerized cancer case information was available from the New York State Department of Health (NYSDOH) Cancer Registry through 1988. However, residents of Staten Island, particularly residents living near the Landfills, were concerned about cancers that had occurred more recently. To address these concerns, the New York City Department of Health (DOH) verified and tabulated cancer cases that had occurred after 1988 and had been reported to the DOH. Information on these more recent cancer cases was obtained by the following methods: a health survey initiated by the offices of Congresswoman Susan Molinari and Borough President Guy Molinari, reporting by concerned community groups, an article in a local newspaper encouraging people to call the DOH, and announcements at community board meetings. Outreach efforts were concentrated on areas surrounding the Landfills, however, cancer cases reported from other areas in Staten Island were also included in the verification of cases. Persons with cancer may have been unaware of NYCDOH's study or unwilling to report to the DOH, therefore self-reporting of cancer cases does not provide a complete count of all cases that occurred after 1988.

The process of case verification and ascertainment was ongoing and was conducted on several levels. Cases that were reported with sufficient information for verification (i.e. last name, first name, date of birth, diagnosis, diagnosis date and/or address) were sent to the NYSDOH Cancer Registry for verification. Those who had not reported sufficient information for a case were contacted via telephone and/or mailed letters for additional information. In the event that telephone, address and/or personal contact information were missing, local telephone directories were searched in an attempt to find the case. After obtaining sufficient information, these cases were also verified. In many instances, verification was sought simultaneously from the Cancer Registry and from hospitals. If a case was verified by review of hospital records, additional verification by the Cancer Registry was not requested.

Information from hospitals could only be obtained when date of diagnosis and the hospital were known. In these cases hospitals were contacted and asked to retrieve selected charts. Charts were then reviewed by DOH to ascertain medical diagnosis and date of diagnosis. Pathology and physical examination reports were also reviewed in order to document information pertaining to the patient's diagnosis, date at which he or she initially was diagnosed with cancer, the cell type, and International Classification of Disease Code (ICD) for the particular cancer. For those with more than one hospital admission, the date of diagnosis was based on the earliest admission for cancer. Duplicate case reports were eliminated.

Verification through death certificate was performed for cases which could not be confirmed through the Cancer Registry or hospital records review. After all verification procedures were completed, cases were classified into one of four categories:

1) **Verified Cancer Cases** - Those cases that were verified using one of the above named procedures.

2) **Non-cancer Cases** - Those cases that were 1) diagnosed with diseases other than cancer, 2) not living on Staten Island at the time of the diagnosis 3) diagnosed with a benign rather than malignant (or cancerous) tumor.

3) **Cases Diagnosed before 1989** - Those cases reported with diagnosis dates before 1989, and therefore should be included in the 1979-1988 cancer incidence data.

4) **Unverified Cases** - Those cases that could not be verified; information necessary for verification (e.g.: date of birth, diagnosis, diagnosis date, hospital) was missing or inaccurate, and attempts to obtain this information were unsuccessful.

The number of cases reported were compared to the number of cancer cases which would have been expected to occur if the population in the Study Area and the rest of Staten Island had the same rate of cancer as New York City (NYC) and New York State (NYS). Expected numbers of cancer cases were calculated for total cancers, leukemias and lymphomas. Calculation of the expected numbers was done using the cumulative cancer incidence rates for the years 1989 through 1992 in NYC and New York State NYS.

B. Limitations of Case Verification

The incidence rates that were calculated for the time period 1979-1988 were based on data from the NYSDOH Cancer Registry. Since complete data for more recent cancer cases (after 1988) was not yet available, verification of cancer cases that were reported to the DOH by the community was done and the number reported ("observed") was compared to the number expected to occur if the population had the same rate as either NYC or NYS. There is limited information that can be drawn from this analysis. This is due to the fact that it is not possible to determine whether all the cases that occurred in the population were actually reported to the DOH for verification. Given the small number of cases reported compared to the numbers that would be expected to occur, under-reporting of cases appears very likely. Case reporting was voluntary and depended on people to report more recent cases of cancer. Reporting in different areas could have been biased by whether there was a high level of concern about cancer in one neighborhood compared to another, whether residents were aware that a study was being conducted, and depending on where they live on the Island. For example, questionnaires were especially targeted for people who lived near the two Staten Island Landfills. These limitations make it difficult (if not impossible) to draw any conclusions about more recent cases of cancer that occurred among Staten Island residents.

C. Tables of Verification Results

A total of 379 cases were reported to NYCDOH for verification. One hundred thirty eight (138) of the 379 cases were confirmed as cancer cases. The number of cases reported and the first method by which each was verified is presented in Table 1. The age and sex distribution of the 138 cancer cases is presented in Table 2. The types of cases reported is presented in Table 3. Table 4 shows the number of cases reported compared to the number expected to have occurred for total cancers, lymphoma and leukemia.

Table 1. Status of Community Reports of Cancer & Verification Methods

Category	#	Verification Method	#
Verified cases	138	NYS Cancer Registry	46
		Hospital records	86*
		Death certificates	6
Non-cancer cases	55		
Unverifiable	46		
Pre-1989	140		
Total	379		

* Fifteen of these cases were also verified by the NYS Cancer Registry.

Table 2. Cases Grouped By Gender and Age of Diagnosis

Age	Females	Males	#
0-14	4	4	8
15-34	10	9	19
35-54	49	18	67
55 & up	20	24	44
Total	83	55	138

Table 3 Cases by Cancer Type

		Year of Diagnosis						
Type	**ICD**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**#**
Lung	162	1	2	4	4	0	0	11
Breast	173-174	12	10	11	8	0	0	41
CNS	190-192	0	2	1	2	0	1	6
Colon	153	3	2	2	1	0	0	8
Prostate	185	0	0	2	1	0	0	3
Bladder	188	0	0	3	0	0	0	3
Kidney	189	1	0	2	2	0	0	5
Leukemias	204-208	4	5	6	4	1	0	20
Pharynx	140-149	0	0	0	2	0	0	2
Lymphoma	200-202	5	2	5	5	0	0	17
Other		5	2	13	2	0	0	22
Total		31	25	49	31	1	1	138

Table 4. Community-Reported and Expected [1] Numbers of Total Cancer, Leukemia, and Lymphoma in the Study Area and the Rest of Staten Island 1989-1992.

Area	Total Reported	Total Expected (Based on NYC Rates)	Total Expected (Based on NYS Rates)
Study Area	78	879	910
Other Parts of Staten Island	50	3339	3518
Exact Location on Staten Island not known	10	-	-
Total	138	4218	4428
Area	**Leukemia Reported**	**Leukemia Expected (Based on NYC Rates)**	**Leukemia Expected (Based on NYS Rates)**
Study Area	14	20	24
Other Parts of Staten Island	3	66	84
Exact location on Staten Island not known	3	-	-
Total	20	86	108
Area	**Lymphoma Reported**	**Lymphoma Expected (Based on NYC Rates)**	**Lymphoma Expected (Based on NYS Rates)**
Study Area	8	51	50
Other Parts of Staten Island	9	165	164
Exact Location in Staten Island not known	-	-	-
Total	17	216	214

1 Based on cumulative Rates 1989-1992 for New York City and New York State

APPENDIX 9

SUMMARY OF INVESTIGATIONS OF HEALTH EFFECTS ASSOCIATED WITH HAZARDOUS WASTE LANDFILLS

Appendix 9

HEALTH EFFECTS ASSOCIATED WITH HAZARDOUS WASTE SITES
Cancers

LOCATION/AUTHOR	SITE DESCRIPTION	EXPOSURE	POTENTIAL	METHODS	OUTCOME	FINDINGS
Niagara County, NY Love Canal Site Janerich, et al. 1981 Journal	Site History: Waste burial commenced in 1920's and ceased in 1953. Contaminants: Over 80 chemicals originally identified with more since then. Chemicals of concern include benzene and halogenated hydrocarbons.	Residence near site	Air Groundwater Soil	Incidence study of cancer in 25 census tracts of Niagara Falls for years 1955 to 1977; New York State cancer registry data used; 142 cases among population of 4,987.	All cancers (10 types)	No significant increases related to residence near love canal; excess of respiratory cancers noted but not statistically significant; elevated rate of respiratory cancers in Niagara Falls county as a whole.
North Tonawanda Niagara County, NY Occidental Chemical Durez Plastics Plant NYSDOH 1990 Government Document	Site History: Plastics plant; not specified. Contaminants: Unspecified industrial wastes.	Residence near site	Surface water	Incidence and mortality study in 1989 of cancer utilizing 1976-85 NYS cancer registry data. 306 observed cases compared with 386 expected cases in incidence study; 198 observed cases compared with 186 expected cases in mortality study.	All cancers (16 types)	Significant excess in brain cancer mortality in males and females combined; no significant increase in cancer incidence.
Niagara County, NY Nine census tracts in Niagara County, NY Polednak, et al. 1989 Journal	Site History: 9 census tracts with 12 toxic dumpsites with known and/or suspected lung carcinogens. Sites operated on various dates ranging from early 1900's to mid-1950's. Contaminants: Chromium, asbestos, tar, nickel, arsenic, vinyl chloride and ionizing radiation.	Residence near site	Air Groundwater Soil	Matched case-control study of 209 deceased persons diagnosed with respiratory cancers between 1978-81 and 417 non-respiratory controls; data obtained from NYS Cancer Registry and death certificate review.	Respiratory cancers Mortality	No significant increases.

Appendix 9 (CONT.)

HEALTH EFFECTS ASSOCIATED WITH HAZARDOUS WASTE SITES

Cancers

LOCATION/AUTHOR	SITE DESCRIPTION	EXPOSURE	POTENTIAL	METHODS	OUTCOME	FINDINGS
Woburn, MA Superfund EPA Hazardous Waste Site Cutler, et al. 1986 Journal	Site History: History of textile, leather, & and paper industries; contaminated wells used intermittently between 1964 and 1979. Contaminants: Lead, arsenic, decomposed animal hides, slaughterhouse wastes, chloroform, TCE, PCE.	Residence near site	Air Groundwater Surface Water	Case-control study involving interview survey of parents of 12 leukemia cases diagnosed between 1969 and 1979, and 24 controls. Cases identified via review of mortality file of Massachusetts Department of Public Health (MDPH) and pathology reports. Demographic data taken from 1970 census and MDPH population estimate for 1975.	Childhood leukemia	Statisically significant increased rate of childhood leukemia (RR=2.3); 6 of 12 cases lived in same census tract

HEALTH EFFECTS ASSOCIATED WITH HAZARDOUS WASTE SITES
Cancers and Other Health Endpoints

LOCATION/AUTHOR	SITE DESCRIPTION	EXPOSURE	POTENTIAL PATHWAY	METHODS	OUTCOME	FINDINGS
Riverside County, CA Stringfellow & Pyrite Channel Hazardous Waste Disposal Site Baker, et al. 1988 Journal	Site History: Hazardous waste site in operation between 1956 and 1972; altogether, 33 million gallons of industrial wastes dumped. Contaminants: Mostly acids and caustics; also organic solvents, pesticides, cyanides and metal compounds.	Residence near site	Air Groundwater Surface- water Soil	Incidence, mortality, and cross-sectional study conducted in 1980 of 403[1] households versus comparison group of 203; questionnaires, birth certificates and medical records utilized as data sources.	All cancers Mortality Pregnancy outcomes Self reported health complaints	No significant increase in mortality, cancer incidence or pregnancy outcomes. Significant increases in 2 (RR=1.73-2.21) of 19 self reported diseases and 9 (RR=1.44-2.36) of 23 self reported complaints for Stringfellow site; West Glen Avon group had significant increases in 1 (RR=2.15) of 19 and 4 (RR=1.78-2.26) of 23 self reported symptoms.
Lockhaven, PA Drake Chemical Storage Site (NPL Site) Budnick, et al. 1984 Journal	Site History: Chemical storage site in operation since 1950s; cleanup underway since February 1982; a Superfund/NPL site. Contaminants: Benzene, B-napthylamine and benzidine.	Residence near site	Not noted	Cancer mortality study using National Center for Health Statistics and Census data (1950-59, 1960-69, and 1970-79); 4 counties compared with 1970 US population; annual birth defect rates reviewed for years 1973-78 in Clinton County.	Cancer mortality (30 types for male & 31 types for females) Birth defects	*Significant increase in bladder cancer mortality among males (RR=1.7) in* Clinton County (1970-79) and for females (RR=2.4)of Union County (1970-79); 9 (RR=1.3-5.0) other types had significant increases in mortality in Clinton county; for other counties 12 types in significant excess; no significant clusters of birth defects.
Yukon & Cokeburg, PA Mill Services Landfill ATSDR 1990 Government Document	Site History: Hazardous waste disposal site in operation between 1963 and present time (as of 1990). Contaminants: Inorganic wastes, including acids and dissolved metals; cyanide and sulfide wastes also processed.	Residence near site	Air Groundwater Surface- water	Cross-sectional study conducted in 1986 of self reported health symptoms from a study group of 579 versus a comparison group of 317.	Self reported health complaints and diseases, including cancers.	*Significant excess in 6 (OR=1.72-4.55) of 38 self reported diseases and 18 (OR=1.74-24.5) of 47 self reported complaints.*

[1]Study group consisted of the following two categories: 302 households living alongside Stringfellow site and 101 households living with miles of the site (West Glen Avon group) who were judged to be potentially exposed.

Appendix 9 (cont.)

HEALTH EFFECTS ASSOCIATED WITH HAZARDOUS WASTE SITES
Cancers and Other Health Endpoints

LOCATION/AUTHOR	SITE DESCRIPTION	EXPOSURE	POTENTIAL PATHWAY	METHODS	OUTCOME	FINDINGS
South Hope, ME Union Chemical Waste Site ATSDR 1992 Government Document	Active Site: Chemical site in operation between 1967 and 1987. Site cleanup begun in 1984 with subsequent EPA National Priorities List (NPL) classification in 1985. Contaminants: Petrochemical based solvents possibly including PCBs, dioxins, furan, heavy metals, radioactive and biological wastes.	Residence near site	Groundwater Surface water Soil Air Ingestion via food	Mortality study of persons who had lived within 1 mile vicinity of site between 1967 and 1987; data source included death certificates; 35 deaths occurred among 444 people.	Mortality (Cause Specific Deaths and Total Deaths)	No significant increases.

APPENDIX 10

LETTER OF CONSENSUS FROM NYSDOH

STATE OF NEW YORK
DEPARTMENT OF HEALTH

Office of Public Health Corning Tower The Governor Nelson A. Rockefeller Empire State Plaza Albany, New York 12237

Barbara A. DeBuono, M.D., M.P.H.
Commissioner

Karen Schimke
Executive Deputy Commissioner

February 27, 1996

Susan Klitzman, Dr.P.H.
Director, Environmental &
Occupational Epidemiology Unit
New York City Health Department
125 Worth Street, Room 618, Box 34C
New York, NY 10013

Dear Dr. Klitzman:

This letter is to attest that staff from the Bureau of Chronic Disease Epidemiology and Surveillance (formerly the Bureau of Cancer Epidemiology) have been involved with the New York City Department of Health's investigation of cancer incidence on Staten Island since its inception. We have supplied data from the New York State Cancer Registry, and reviewed study design and drafts of the investigation report. The analysis was accomplished using appropriate methods in accordance with sound epidemiologic principles, and we concur with the findings. We have seen the final version of the report, and approve its release.

Signed,

Mark S. Baptiste, Ph.D.
Director, Bureau of Chronic Disease
Epidemiology and Surveillance

Maria J. Schymura, Ph.D.
Director, NYS Cancer Registry

Aura L. Weinstein, M.P.H.
Director, Cancer Surveillance Program

Patricia E. Wolfgang, M.S.
Research Scientist, NYS Cancer Registry