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SUMMARY OF METHODS AND FINDINGS

EVALUATION OF CANCER INCIDENCE AND ENVIRONMENTAL EXPOSURES IN THE AREA OF THE NAVAL WEAPONS INDUSTRIAL RESERVE PLANT (NWIRP) AND GRUMMAN AEROSPACE SITES, BETHPAGE, NASSAU COUNTY, NEW YORK

The New York State Department of Health (NYSDOH) conducted an evaluation of newly diagnosed cancers and potential environmental exposures in the area of the Naval Weapons Industrial Reserve Plant (NWIRP) and the Grumman Aerospace (Grumman) sites in Bethpage, Nassau County. Public officials requested the evaluation because residents were concerned over possible health effects from exposures to contaminants from the sites.

The NWIRP and Grumman sites were sites of industrial activities beginning in the 1930s (Grumman) and 1940s (NWIRP). Testing and manufacturing-related operations at both sites ended in 1998. As a result of these activities, soil and groundwater at the NWIRP site were contaminated by chlorinated volatile organic compounds (VOCs). Soil, soil vapor (air spaces within the soil) and groundwater at the Grumman site were contaminated by chlorinated VOCs and other substances. Recent testing showed that contaminants had gotten into the air beneath, and in some cases inside, several homes near the two sites. Systems put in place since the contamination was discovered have successfully reduced contaminant levels inside and beneath the homes.

CANCER EVALUATION

The cancer evaluation reviewed available information for evidence of unusual cancer patterns in the area of concern.

- Community members provided the NYSDOH with information on cancers diagnosed among people who lived in the area of concern and beyond. These included a report of cancer in a resident of a home near the NWIRP site. Numbers of reported cases of brain tumors and a rare type of cancer reported to the NYSDOH appeared unusual, but these reports could not be confirmed. Breast cancers appeared to make up an unusually high proportion of the total cancers reported, but the number of breast cancer cases was not unusual given the number of people living in the area.

This information gave no evidence of unusual patterns of cancer occurrence unique to the area of concern.

ENVIRONMENTAL EVALUATION

Air inside and beneath 15 homes near the NWIRP site was collected and tested for contaminants in 2009. Air inside and beneath eight homes near the Grumman site was sampled in 2007 and 2008. The environmental evaluation reviewed the results of the sampling to determine whether people might have come into contact with unusual levels of contaminants related to the sites. The evaluation also considered what was known about the characteristics of any exposures.

- Four homes near the NWIRP site had levels of the chlorinated VOC trichloroethene (TCE) in the indoor air that were above the NYSDOH guideline of 5 micrograms per cubic meter of air. The chlorinated VOCs tetrachloroethene (PCE) and 1,1,1-trichloroethane (TCA) were found in five other homes; the levels of these chemicals *inside* these homes were similar to levels found in other homes in New York State, however two of the homes had levels of VOCs in the air *beneath* the home that represented a significant potential for exposure in the future. A total of six homes had chlorinated VOC levels in the air inside and/or beneath the home where measures to reduce or prevent human exposure were recommended. All of the homes where VOCs were found were on the same block.

- None of the eight homes tested near the Grumman site had levels of TCE above the NYSDOH guideline or levels of other site-related contaminants above levels found in other homes in New York State. Soil vapor contaminated with TCE was found beneath three homes. Levels at one of these homes required continued monitoring to make sure the air inside the home was not affected in the future.

- All the measurements were from one point in time. It is not possible to know when exposures began, what the contaminant levels were in the past, or if there might have been exposures at other homes in the past.

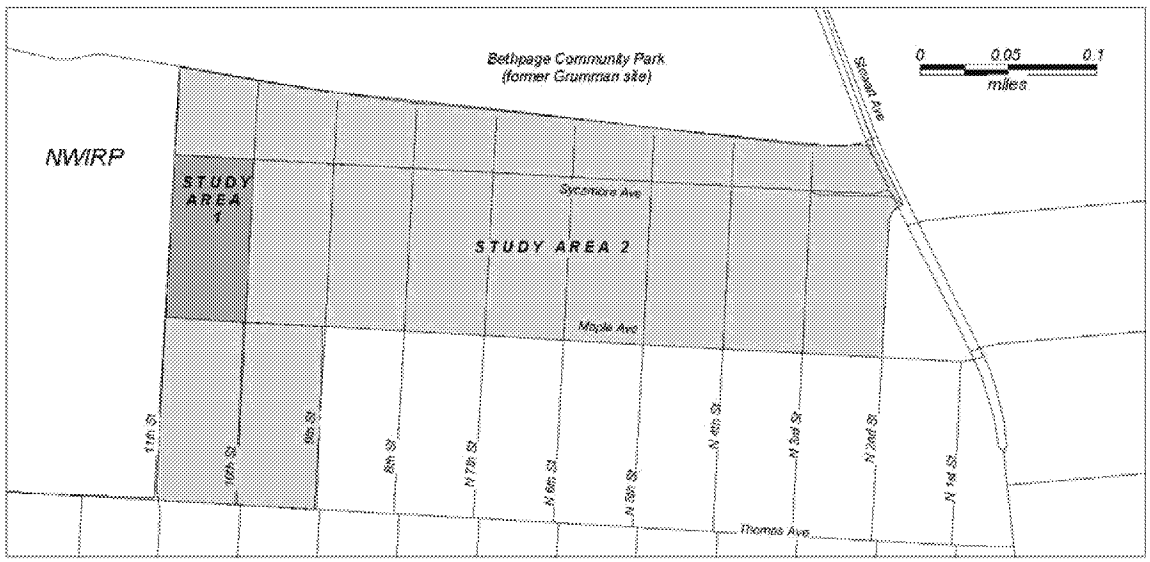
It was concluded that further investigation was indicated on the basis of the finding of completed exposure pathways in the one-block area near the NWIRP site.

ADDRESS-SPECIFIC CANCER REVIEW

The cancer review included two study areas. Study area 1 is the one-block area where some homes had documented exposures to VOCs associated with the NWIRP site. Study area 2 is made up of 19 blocks not including Study area 1. These blocks are either next to Study area 1 or next to or including blocks where contaminants associated with the Grumman site were detected in the air beneath homes (see map on next page).

The New York State Cancer Registry was used to identify all people who had been diagnosed with cancer while they were living in either of the study areas. The Cancer Registry collects reports on all persons diagnosed with cancer in New York, as required by law. The Registry is considered complete on a statewide basis beginning with cancers diagnosed in 1976. Information

from the Cancer Registry was examined to see if there were any unusual patterns in the cancers identified in residents of these areas.



- There were seven tumors identified among residents of **Study area 1** that were diagnosed since 1976. The cancers were all of different types, including the types that occur most often in adults. The cancers identified included some of the many types that have been linked or possibly linked with exposures to TCE and/or PCE. The types of cancer identified showed no clear relation with the results of environmental sampling for the homes. None of the residents with cancer were children, but none were over age 55 at the time they were diagnosed. The total number of cancers identified among residents of the block was similar to the number expected.

- There were 93 tumors identified among residents of **Study area 2** that were diagnosed in the 34 years between 1976 and 2009. As seen in most communities, the number of cancers diagnosed in any one year increased gradually during this time period. There were 22 different types of cancer. The most frequently diagnosed types of cancer were cancers of the lung (12 cases), female breast (11 cases), and prostate (11 cases). These are the types that are diagnosed most frequently among adults. There were some rare types of cancer, but there was no more than one case of any one rare cancer. The types of cancers identified included types that have been linked with exposures to TCE and PCE, although these cancers have many other known and possible causes. For the small number of homes that had been sampled, the types of cancer identified among residents of the home showed no clear relation with the results of environmental sampling for that home. The majority (86%) of people diagnosed with cancer were age 55 or older at the time their cancer was diagnosed. The total number of cancers identified was similar to the approximate number expected.

DISCUSSION

- Cancer is a common disease, more common than many people realize. It is not a single disease, but a collection of many different diseases, each with its own occurrence patterns, effective treatments, outlooks and risk factors. Although cancer can occur in younger people, it is primarily a disease of the middle-aged and elderly.

- The present study was done to determine whether the characteristics of the cancers diagnosed among residents of the area of concern were unusual. Unusual patterns of cancer may include 1) an unusually large number of cases of the same kind of cancer; 2) two or more cases of the same particularly rare cancer; 3) cancers occurring in people of ages where that cancer is not typically seen; or 4) many cases in a short time period (one or two years).

- For any substance in the environment to have an effect on human health, people have to come into contact with it. This is known as exposure. People may be exposed to a chemical substance by breathing it in, consuming it in food or water, or getting it on their skin. The risk of developing cancer upon exposure to a cancer-causing substance depends on how people are exposed to it, the amount of the substance to which they are exposed, the length of time over which they are exposed, and how often they are exposed.

- Of the contaminants related to the two sites, TCE and PCE have been classified as probable human carcinogens. In humans, exposures to TCE have been associated with cancer of the liver and bile duct, kidney cancer, non-Hodgkin lymphoma, and cancer of the esophagus. Cancers associated with exposures to PCE in humans include cancers of the esophagus and bladder, and non-Hodgkin lymphoma. PCE may also possibly be associated with cancers of the cervix, tongue, and lung. Evidence regarding the carcinogenicity of TCA is less strong than the evidence for the carcinogenicity of TCE and PCE.

CONCLUSIONS

The only thing unusual about the cancers occurring in the one-block area, defined as Study area 1, where elevated levels of contaminants related to the NWIRP site had been found in indoor air, was the relatively young average age of the people affected. Due to the limited size of this one-block area, however, these results do not provide a clear indication of an unusual pattern of cancers.

For the larger area near the NWIRP and Grumman sites, Study area 2, where no exposures were found at the time of the sampling but exposure might have occurred in the past, cancer patterns were not unusual.

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Background

The community of Bethpage, in eastern Nassau County, New York, has a history of residential and industrial development, with some residential neighborhoods bordering active and former industrial facilities. During the course of investigation of environmental contamination associated with the Grumman Aerospace (Grumman) and the Naval Weapons Industrial Reserve Plant (NWIRP) New York State Department of Environmental Conservation State Superfund Registry sites in Bethpage, public concerns arose about the possibility of health effects from exposures to contaminants from the sites. In particular, environmental sampling activities had shown that the air spaces within the soil ("soil vapor") in and around the NWIRP site were contaminated by site-related compounds. It was also found that this contaminated soil vapor had moved into the air inside a small number of homes near the NWIRP site, resulting in elevated levels of site-related contaminants. At that time, area residents were aware of what appeared to them to be a large number of residents of the nearby neighborhood who had developed cancer and other diseases.

Community residents expressed their concerns over the possible link between contamination and illnesses in the area at a public availability session in early 2009. Residents reported that a resident of one of the homes where indoor air exposures were documented had developed cancer. They also reported many other current and former residents of the larger neighborhood who had developed cancer and other diseases over the years; one resident had compiled information on almost 80 people who were believed to have been diagnosed with cancer or lupus since the early 1960s. People attending the availability session called for a health investigation, and in March of 2009, then-county legislator (current county executive) Edward Mangano sent a letter to the New York State Department of Health (NYSDOH) requesting that a "cancer survey" be conducted in the area of the NWIRP site. Specifically, County Executive Mangano requested that the NYSDOH evaluate whether soil vapor intrusion had impacted residents living in proximity to the NWIRP Former Drum Marshalling Area and the Grumman Former Settling Ponds Area, and if so, whether these residents experienced an increase in cancers. State Senator Carl Marcellino sent a similar request in April 2009.

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Upon receipt of these requests, the NYSDOH began an evaluation to determine whether further investigation of cancer occurrence in the vicinity of the sites was indicated. The evaluation considered the evidence for unusual environmental exposures in the area and evidence for unusual cancer patterns. Further investigation would be indicated if there were evidence for human exposure to unusual environmental contaminants with the potential to affect cancer risk, OR if there were evidence for an unusual pattern of cancers (or both). This report presents the results of the evaluation and the investigation of cancer incidence that was conducted as a result of its findings.

Site history The Grumman and NWIRP facilities were originally situated on 605 acres, with 105 of those acres occupied by the NWIRP. The NWIRP was a government-owned, contractor-operated facility under Grumman's direct control. Operations began at the Grumman site in the early 1930s and at the NWIRP site in 1941. Activities conducted at the facilities included engineering, administrative operations, research and development, testing, and manufacturing. All testing and manufacturing-related operations at both sites ended in 1998. Once operations were terminated, the Navy transferred 96 acres of the 105-acre NWIRP parcel to Nassau County. The remaining nine-acre parcel is being retained by the Navy for environmental investigations and remediation.

NWIRP Former Drum Marshalling Area (FDMA) The FDMA, located in the eastern portion of the Navy's nine-acre parcel, was the location of two pads used to store waste materials generated at the NWIRP facility. Above-ground storage tanks, a sanitary settling tank, and sludge drying beds were also located in this area. Use of the FDMA resulted in soil and groundwater contamination by chlorinated volatile organic compounds (VOCs), including trichloroethene (TCE), tetrachloroethene (PCE) and 1,1,1-trichloroethane (TCA). An air sparging/soil vapor extraction system operated at the FDMA between 1998 and 2002 to reduce VOC concentrations in groundwater and to minimize emissions during soil removal actions. Once these objectives were met, operation of the air sparging/soil vapor extraction system was discontinued.

Soil vapor testing conducted in January 2008 indicated that elevated concentrations of VOCs, including TCE, PCE and TCA, were present along the eastern boundary of the FDMA. These findings led to indoor air and sub-slab sample collection in 2009 from 15 homes immediately east of the FDMA. The sampling showed that six homes had chlorinated VOC levels in the air inside and/or beneath them where mitigation was the recommended course of action (1). The Navy mitigated these impacts by initially providing air purification units and subsequently installing sub-slab depressurization systems in the six homes. A soil vapor extraction containment system was then made operational at the site in January of 2010 to mitigate the source area and to move contaminated soil vapor away from the homes.

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Measurements taken during February and June of 2011 showed that the soil vapor extraction containment system was maintaining a negative pressure field underneath the impacted homes. It was determined that this negative pressure field was sufficient to perform the function of the sub-slab depressurization systems, and that those systems could be removed from the homes. The data also showed that the negative pressure field generated by the soil vapor extraction containment system included homes in an area beyond the impacted homes. The Navy has recently completed removal of the sub-slab depressurization systems from all six homes.

Grumman Former Settling Ponds Area (FSPA) The FSPA was used for the disposal of wastewater treatment sludge and used rags from Grumman operations and for fire training purposes. This use resulted in soil, soil vapor and groundwater contamination by chlorinated VOCs (TCE, cis-1,2-dichloroethene, vinyl chloride) as well as by petroleum-related VOCs, polycyclic aromatic hydrocarbons (PAHs), metals and polychlorinated biphenyls (PCBs).

Results of air sampling conducted in 2007 and 2008 for eight homes located south of the FSPA showed that none of the homes had chlorinated VOC levels in the air inside or beneath the home where mitigation would be recommended. Soil vapor contaminated with TCE was, however, detected beneath three of the homes evaluated, and one home required additional monitoring to verify that the indoor air was not impacted over time. A soil vapor extraction system was installed at the FSPA in February of 2009, and subsequent sampling at the home that required monitoring showed that soil vapor contamination beneath the home had been successfully mitigated.

Cancer evaluation

The cancer evaluation was conducted to review and assess whether there was evidence for an unusual pattern of cancers in the area. Unusual patterns may include, but are not limited to, 1) an unusually large number of cases of the same kind of cancer; 2) two or more cases of the same particularly rare cancer; 3) cancers occurring in people of ages where that cancer is not typically seen; 4) many cases in a short time period (one or two years).

To do this, citizen reports of cancer in the community were evaluated. Attempts were made to confirm the reported cancers against a source of routinely and reliably collected cancer data. The characteristics of the cancers that were reported and the cancers that were confirmed were also examined.

Methods The source of NYSDOH cancer data was the New York State Cancer Registry, which contains information on all cases of cancer diagnosed or treated in New York State. Cancer reporting has been mandated by law since 1940 for health care providers in New York State, exclusive of New York City, and since 1973 for providers in New York City. Registry files are considered complete on a statewide basis beginning with cases diagnosed in 1976.

Variation in cancer incidence among different geographic areas reflects not only true differences in cancer occurrence, but also differences in how cancer is diagnosed, treated, and recorded in different areas of the state. The completeness and accuracy of the Cancer Registry depend upon reporting from hospitals, laboratories, managed care organizations and other sources. The North American Association of Central Cancer Registries, an organization that works to improve cancer registries, has certified that the New York State Cancer Registry is over 95% complete. This means that it contains reports on over 95% of all cancers actually diagnosed in New York State residents. In addition, the Cancer Registry has received gold certification from the Association every year since 2000 (data year 1996), the highest certification given to central cancer registries (2).

One person can be hospitalized many times, at different hospitals, over a period of years for the same cancer. Each separate hospital admission is reportable to the Cancer Registry. As multiple reports on the same cancer are received, they are combined with existing information to continuously update Cancer Registry files to reflect the fullest and most accurate information available. At the time the cancer evaluation began in April 2009, cancer incidence data were considered official through 2006, meaning that reports for this year and previous years were essentially complete and the data had passed all quality assurance checks. The data also reflected all second and later reports that had been received to date on cancers diagnosed in 2006 and earlier, as well as reports on many cancers that had been diagnosed in 2007 and later.

Citizen reports of cancers in the community included a detailed list of nearly 80 one-time residents of the area with cancer or other conditions that had been provided to staff from the Navy. The list had been forwarded to the NYSDOH following the 2009 availability session. Reports also included identifying information on a person with cancer who had lived in one of the homes with indoor air contamination. (To protect confidentiality, findings of the attempt to verify this person's diagnosis will be combined with findings for the evaluation of the list.)

The information provided to the Navy included a listing of locations (streets or blocks) where people believed to have been diagnosed with different types of cancer had lived, grouped by type of cancer. The listing did not contain the names of any individuals. Most of the people referred to were noted to have attended nearby Bethpage High School in the late 1970s to early

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1980s, or to have been parents of high school attendees, and each item on the listing had information on the person's graduating class at Bethpage High School or status as a parent. The listing also indicated whether each person was alive or deceased. The cancer diagnoses were reported to have occurred since 1961, but there was no information provided on individual dates or years of diagnosis.

The listing of suspected cancer cases was accompanied by two photographs of a pin map showing the addresses of people reported to have cancer. Each pin had a label that was color-coded by the person's diagnosis. The labels included the last name, and sometimes the first name, of the person reported to have cancer; some of the names were visible in the photograph.

To confirm citizen reports on people with cancer, information provided by the citizens was compared with information from the Cancer Registry. For the small number of people whose names were visible on the pin map, attempts were made to confirm these individuals by name. Patterns in the reported cancers were evaluated by examining the detailed information reported, including information on type of cancer, address, and the person's graduating class or status as a parent. When indicated, Cancer Registry files were also searched by address to identify people diagnosed with a particular cancer who lived on a particular block.

Findings In his letter requesting an investigation, County Executive Mangano referred to a residential area east of the NWIRP site, south of the Grumman site, west of Stewart Avenue and northeast of Railroad Avenue as the area to be investigated (see Map 1). Information received from citizens indicated that their concerns involved a somewhat wider area.

From the information provided by citizens, there were 10 people with sufficient identifying information to attempt to confirm them by name. Of the 10, it was possible to confirm eight in Cancer Registry files. The eight confirmed cancers represented four different cancer types. The types of cancer confirmed most frequently included cancers of the colon or rectum, and female breast cancer. These are among the types of cancer diagnosed most frequently in adults. (To protect confidentiality, exact numbers of the different types of cancers confirmed and other details can not be provided.)

The pin map accompanying the listing of cases provided by citizens to the Navy depicted an apparent grouping of reported cases within the residential area outlined by County Executive Mangano and just to the east. Another, smaller, apparent grouping was depicted south of Railroad Avenue, in the area of Central Avenue. Other mapped cases were scattered throughout a wider area outside of the area outlined by County Executive Mangano. The address information provided in the case listing was used to assign each reported case to one

of three areas: Area A, the area outlined in County Executive Mangano's request or directly to the east of it up to Broadway; Area B, the Central Avenue area south of Railroad Avenue; and Area C, the remainder (see Map 1). Bethpage High School is located in Area A, on the east side of Stewart Avenue across from Bethpage Community Park. Patterns of the cancers reported by citizens were examined for the list as a whole and for each area separately.

For the list as a whole, there were 73 people who were reported to have developed cancer (the remainder were reported to have developed lupus). Of the 73, 25 were reported to have been diagnosed with breast cancer, including eight former students at Bethpage High School and 17 parents of students. There were 24 people who were reported to have developed cancers classified only as "Cancer in other location or throughout;" most of these were parents. The next frequently reported type of cancer was "primary brain cancer," which was reported in 11 persons, the majority of whom were former students. Other specific types of cancer reported included cancers of the colon, "aorta or heart," lung, skin (metastatic), endocrine system, eye, liver, and throat.

Although many common cancers often spread (metastasize) to the brain, tumors that start in the brain (primary brain tumors) are one of the less common cancers. Cancers of the aorta or heart are particularly rare. Due to the apparently unusual numbers of reported primary brain tumors and cancers of the "aorta or heart," further attention was given to these cancers.

Primary brain tumors that are malignant (cancerous) typically make up less than 2% of the cancers diagnosed in a community. Primary brain tumors that are benign or of uncertain behavior may make up a similar amount or more (3). Of the 73 total cancers reported, approximately 15% were primary brain tumors. The 11 people reported with primary brain tumors lived in all areas, including three in Area A, three in Area B and five in Area C. Names were visible on the pin map for a small number of the people reported as having primary brain tumors. It was possible to confirm some, but not all, of these people by name as having been diagnosed with a malignant brain tumor. Search of Cancer Registry files by address found a small number of people with brain tumors who lived on the same streets or blocks as students reported with brain tumors, however their ages were not consistent with high school attendance in the 1970s and 1980s. There were no records on people with brain tumors living on the streets or blocks listed for parents with brain tumors. People who could not be confirmed could have moved away prior to their diagnosis. They also could have had metastatic tumors to the brain, which are counted as tumors of the organ where they started. The reports of an unusual number of people with primary brain tumors therefore could not be confirmed.

Cancers of the heart or aorta are rare. Two or more *confirmed* cases of these cancers could be seen as an unusual pattern, and more than one of these cancers was reported.

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Cancer Registry files confirmed only one resident of ZIP Code 11714 who had been diagnosed with cancer of the aorta or heart since 1961. This resident did not live on any of the streets listed for the people reported to have developed cancer of the heart of aorta. Since the names of the people reported to have this type of cancer were not available, it is not known whether the resident who was confirmed was one of the people reported. It is possible that there were people with cancers of the heart or aorta who had once lived in the area but moved away prior to their diagnosis. The one confirmed case of a particularly rare cancer, however, does not constitute an unusual pattern.

The three areas on the pin map were then examined separately. There were 33 reported cases of cancer assigned to Area A, including a small number of people who lived east of Stewart Avenue. Of the 33 cancer cases, almost half, 16, were reported as breast cancer, including 10 parents and 6 members of graduating classes. Nine people were reported as having cancers with the type not specified. Other specific cancer sites reported included primary brain, lung, metastatic skin, and throat.

Breast cancer appeared to account for a greater than usual *proportion* of reported cancers in Area A. To better assess whether the 16 breast cancer cases reported represented an unusual occurrence of the disease or were more likely a result of incomplete reporting of other types of cancer, approximate *numbers* of breast cancer diagnoses expected among women in this area were calculated. To do this, the crude breast cancer incidence rate for New York State, exclusive of New York City, for 2001-2005 was applied to the population of the area outlined by County Executive Mangano. The crude breast cancer incidence rate was obtained by dividing the average number of new cases of female breast cancer diagnosed in a year in New York State, exclusive of New York City, by the average (total) population of New York State, exclusive of New York City. The population of Area A was estimated based on information from the 2000 US Census. With a crude female breast cancer incidence rate of 79/100,000 population per year and a total estimated population in Area A of 3370 persons, this gives about 2.66 cases expected in a year. About 27 cases would be expected in the past 10 years, or 125 in the 47 years since 1961. Even with uncertainties related to changes in the population and in breast cancer rates over time, the 16 cases reported for all years is still substantially less than the 27 expected for just the past 10 years. This indicates that, even if all the reported cases were confirmed, the *number* of reported breast cancer cases would not be excessive.

Many of the women reported to have developed breast cancer were former students at Bethpage High School. Former students may not have been residents of the Bethpage area at the time they developed breast cancer. The number of breast cancer cases that would have been expected among members of the various graduating classes was therefore calculated. To

do this, the number of breast cancers that would be expected to occur between the ages of 20 and 55 was estimated based on the approximate number of girls in the graduating classes between those of the earliest and the latest reported cases (1973 and 1980) (estimated from US Census data) and probabilities for developing cancers at different ages (4). With a 3.74% probability of developing breast cancer between ages 20 and 55 and an estimated 256 girls in the eight graduating classes who lived in Area A, about 10 (9.56) girls would develop breast cancer in the 35 years between the ages of 20 and 55 if they had the same risk as the national sample of women on whom the probability was based. The six cases reported is fewer than the number expected.

The resident who had compiled the listing of reported cancer cases expressed particular concern over cancers developing in people from the graduating classes of 1979, 1980 and 1981. For the classes of 1979 and 1980, which included most of the reported breast cancer cases, there would be about 64 girls total, of whom about two (2.39) would be expected to develop breast cancer by the age of 55. The five cases reported among members of these two classes is greater than the number expected. The difference, however, is not statistically significant, meaning that it could easily have occurred by chance. Thus, even if all the reported breast cancer cases in former students were confirmed, the number would not be statistically unusual.

In Area B, the Central Avenue neighborhood south of the area outlined by County Executive Mangano, there were 15 people reported to have cancer. The greatest number of these people, six, were reported to have cancers of unspecified types. Other, specific, sites of cancer reported included breast, colon, primary brain, endocrine and eye. Without additional information on specific types of cancer or on the dates of diagnosis of the cancers reported, it was not possible to determine whether the cancer pattern might be unusual.

In Area C, a large and less well defined area extending to the north, east and west of the area outlined by County Executive Mangano, there were 25 people reported to have cancer. Nine people were reported to have cancers of unspecified type. Seven people were reported to have developed breast cancer. Other cancers reported in this area included primary brain, colon, liver and "aorta or heart." The largest number of people reported to have primary brain cancers lived in Area C, but they were widely scattered throughout the area. Although this area was the largest in size of the three areas examined, it did not have the largest number of total reported cancer cases. This suggests that the higher than usual proportion of reported brain tumors may be a result of preferential reporting of this disease. Without additional information on types of cancer or on dates of diagnosis, it is not possible to evaluate further whether the cancer pattern might be unusual.

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In summary, of the 74 people reported as having been diagnosed with cancer (73 on the listing and one reported separately), due to a lack of information it was possible to confirm only eight by name. The cancers that could be confirmed by the person's name were for the most part among the most common cancers. For all the cancers for which a block or street of residence was given, there were patterns of some cancers that appeared unusual. The reports of apparently unusual numbers of primary brain tumors and cancers of the heart or aorta could not be confirmed by examining either the location of residences or the names of the people (when available). For breast cancer, which appeared to represent a greater proportion of cases than usual, calculations showed that even if all the case reports could be substantiated, there would not be an unusual occurrence of this very common cancer.

Discussion and conclusions Cancer is a common disease; it occurs in every community. Reports of people with cancer in a community do not necessarily mean that the community is experiencing a greater burden of this disease. Members of the public provided information on people known to them to have developed cancer, including a resident of a home with documented soil vapor intrusion. For most of the people reported with cancer, however, the information provided did not include their name. Names might have allowed cancers to be confirmed in some people who had moved away from the area before their diagnosis. Eight of the ten people for whom names were available were confirmed to have been diagnosed with cancer, although the types of cancers confirmed in this manner did not appear unusual.

Almost one third of the people were reported without information on type of cancer, so that reported cancer occurrence patterns by cancer type could not be fully evaluated. The reported cancers included an apparently unusual proportion of brain tumors. Most of the brain tumors could not be confirmed as primary brain tumors, and it was likely that other cancers in this area were not reported, making the proportion of brain tumors appear high. There were reports of two cases of a particularly rare cancer, but these reports could not be confirmed. The reported cancers also included an unusual *proportion* of breast cancer cases in an area approximating that outlined by County Executive Mangano, but calculations showed the *number* of breast cancers, even if they all could be confirmed, would not be unusual.

As noted above, much of the information that would have been useful for a more complete cancer evaluation was not available. The information that was available did not indicate any unusual patterns of cancer in the area of the two sites.

Environmental evaluation

The environmental evaluation was conducted to review the available evidence regarding human exposures to unusual environmental contamination related to the sites of concern. Exposure is contact. Without human exposure to a contaminant, there can be no health effects. Results of environmental sampling were examined to identify any completed pathways of exposure to unusual environmental contaminants. A completed exposure pathway has five elements: 1) a source of contaminants; 2) a way for contaminants to leave and be carried away from the source; 3) a place where people can be exposed to the contaminants; 4) a way people can be exposed to the contaminants, such as by breathing them in or consuming them in their water; and 5) people who have, or may have, been exposed to the contaminants.

Methods The environmental evaluation was based on information gathered from environmental sampling in homes near the sites. In 2009, a contractor for the Navy collected and analyzed air samples inside and beneath 15 homes east of the NWIRP FDMA in 2009 to determine levels of chlorinated VOCs. The NYSDOH and the New York State Department of Environmental Conservation conducted air sampling for chlorinated VOCs in eight homes south of the Grumman FSPA in 2007 and 2008.

Any information available about the characteristics of the exposures was then examined for any completed or potential exposure pathways that were identified. This includes information on when and for how long the exposures occurred, how much of the contaminants were present, and what geographic area was affected.

Findings *NWIRP* Sampling conducted at 15 homes east of the FDMA in 2009 showed completed pathways of exposure to TCE at levels greater than the NYSDOH air guideline of 5 micrograms per cubic meter of air (mcg/m^3) in four homes in a one-block area. Five other homes in that one-block area had detected levels of PCE and TCA in indoor air, but the concentrations there were similar to those commonly found in homes. Two of these five homes, however, had concentrations of these contaminants in the air beneath the home that represented a significant potential for exposure. In total, six homes had chlorinated VOC levels in air inside or beneath the home where mitigation was the recommended course of action according to current NYSDOH guidance (1).

Although completed pathways of exposure to concentrations of TCE greater than 5 mcg/m^3 in indoor air were found in four homes east of the FDMA, measurements of contaminants were only available for one point in time. Exposures would have effectively ended when mitigation methods were implemented, but it is not known when the exposures began, or how long the people occupying the homes were exposed to what concentrations of

contaminants. It is also not known if other homes in the area that did not require mitigation at the time of sampling may have had unusual levels of contaminants associated with the FDMA in indoor air in the past.

Grumman FSPA Air sampling inside and beneath eight homes south of the FSPA in 2007 and 2008 did not identify any completed exposure pathways to levels of TCE above the NYSDOH air guideline, or to other site-related VOCs at concentrations above those commonly found in the air inside homes. Soil vapor contaminated with TCE was detected beneath three of the homes evaluated, however, with one home requiring additional monitoring to verify that the indoor air was not impacted over time. Subsequent sampling at this home confirmed that the soil vapor extraction system installed at the FSPA had successfully reduced the soil vapor contamination.

Although unusual levels of TCE or other chlorinated VOCs were not identified for the indoor air of homes south of the FSPA, measurements were only available beginning in 2007. It is not known whether unusual levels of these contaminants may have existed in the indoor air of the sampled homes at some time prior to that. It is also not known whether other homes in the area had ever been affected by elevated concentrations of site-related VOCs.

Conclusions The environmental evaluation showed that unusual environmental exposures had occurred in a small number of homes east of the Navy FDMA. It was not known how long these exposures had been present, or if other homes may have been affected in the past. Exposures to unusual levels of contaminants may have occurred in the past in a small number of homes south of the Grumman FSPA, but it is not known whether any exposures had actually occurred, and if so, exactly when, at what levels, and in which homes. Based on the findings of a completed pathway of exposure to unusual levels of contaminants for a small number of homes in the area east of the Navy FDMA, it was concluded that additional examination of cancer occurrence was indicated.

Address-specific cancer review

Even though the information available did not indicate any unusual patterns of cancer in the area, it was concluded that further investigation of cancer occurrence in the vicinity of the sites was indicated on the basis of the findings of the environmental evaluation. Findings of the environmental evaluation were therefore used to design the resulting address-specific cancer investigation.

The environmental evaluation showed that there was a limited area where exposures to site-related contaminants had occurred. There was also another area where site-related contaminants had been found in the air beneath homes, but the levels inside the homes were not unusual at the time of sampling. It is not known whether the levels inside these homes might have been higher in the past, or whether there might have been unusual levels of contaminants inside homes in the immediate neighborhood of these homes.

Because of the small number of homes that were known to have been impacted by site-related contaminants or might have been impacted in the past, it was decided to conduct a Registry-based address-specific review. In this type of study, people diagnosed with cancer while residing at the addresses included in the study are identified from routinely collected data. Information on the identified cases is then reviewed to detect any unusual patterns. A Registry-based address-specific review can be used to study relatively small, well defined areas, such as a few streets or portions of streets. Detailed population data, which are needed to be able to determine whether the numbers of cancer cases were unusual, are often not available for these types of areas. The Registry-based address-specific review relies instead on internal comparisons and knowledge of typical cancer patterns in communities to assess whether there are any unusual patterns in cancer occurrence.

Methods For the address-specific review, the New York State Cancer Registry was used to identify cancers diagnosed in a given time frame (incident cancers) among people living on specified streets or portions of streets. Cancers that were diagnosed in residents prior to this time frame or before the residents moved into the study area (prevalent cancers) were not included.

Once incident cancers are identified, Cancer Registry data on those cancers are examined for any unusual patterns. As noted above, unusual patterns may include 1) an unusually large number of cases of the same type of cancer; 2) two or more cases of the same particularly rare cancer; 3) cancers occurring in people of ages where that cancer is not typically seen; 4) many cases in a short time period (one or two years).

The present review includes two study areas. Study area 1 is the one-block area where some homes had documented exposures to VOCs associated with the NWIRP site. Study area 2 is a 19-block area (not including Study area 1) either adjacent to Study area 1 or adjacent to or including blocks where contaminants associated with the Grumman site were detected in the air beneath one or more homes. Exposures to VOCs associated with the NWIRP or Grumman sites may have occurred in the past in these homes (see Map 2).

Because exposures may have occurred over a very long time, cases were identified dating back to diagnosis year 1976, the year reporting to the Cancer Registry is first considered

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complete on a statewide basis. At the time the review was initiated in July 2011, Cancer Registry data were official through the year 2008. An initial listing of cancer cases was generated at that time. The listing was updated in August 2012, when data were official through the year 2009. The examination of case characteristics was therefore undertaken for cases diagnosed through 2009. Registry files also included some cancer cases that were diagnosed in later years. These data were examined as well, although specific results can not be provided since the numbers for later years are not yet official.

Findings *Study area 1* - The Cancer Registry identified seven tumors that were diagnosed among residents of the one-block Study area 1 between 1976 and 2009, a period of 34 years. Of the seven tumors, six were invasive malignant tumors. (In addition to invasive malignant tumors, which have spread into adjacent tissue layers, the Registry contains reports on certain types of non-invasive [*in situ*], borderline, and benign tumors.) Dates of diagnosis of the seven tumors ranged from the late 1970s to the mid-2000s, with more of the diagnoses occurring in the second half of this time period.

Each of the seven tumors represented a different type of cancer. These types included some of the types most frequently diagnosed among adults, as well as other, less frequently diagnosed types. (To protect confidentiality, details of the diagnoses can not be provided.) The types of cancer identified included some of the many types that have been associated with or possibly associated with exposure to TCE and/or PCE.

None of the people diagnosed with cancer were children (under age 20) at the time of their diagnosis, and none were age 55 or older. All of the cancers were diagnosed at ages less than the average (median) age of diagnosis for that cancer. Some of the diagnoses occurred at ages where the cancer frequently occurs, while others occurred at much younger ages.

The seven people who developed cancer over the 33-year period lived in five of the 14 homes on the block. Results of air sampling are available for 13 of the 14 homes. People diagnosed with cancer lived in some, but not all, of the homes where mitigation was recommended to address documented or potential exposure issues. People with cancer lived in some, but not all, of the homes that had levels of contaminants that are frequently found in homes. No residents were identified who had developed cancer while living in the small number of homes that were not sampled or where contaminants were not detected in the indoor air. The types of cancer most closely associated with exposures to TCE or PCE (cancers of the esophagus, liver and bile duct, kidney and bladder, and non-Hodgkin lymphoma) were not identified more often in homes with the highest measured levels of contaminants.

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Study Area 2 - The Cancer Registry identified 93 tumors that were diagnosed among 82 residents (some residents had more than one tumor diagnosed) in the 19-block Study area 2 between 1976 and 2009. A small number of additional cases were diagnosed in years after 2009. Between zero and six cases were diagnosed in any one year. As seen in most communities, the average number of cancers diagnosed in a year increased gradually throughout the 34-year study period.

Eighty eight of the 93 tumors identified were invasive malignant tumors (or tumors of the bladder *in situ*, which are customarily grouped with invasive malignant bladder tumors); most of the remainder were tumors *in situ*. Twenty two different types of cancer were represented, not including a small number of cancers for which the primary site could not be determined. The types and numbers of cancers identified are shown in Table 1. (Only invasive malignant tumors are shown except for bladder cancer, where the total includes both invasive and *in situ* tumors.) Some of the cancer types are grouped in the table to protect patient confidentiality.

As is seen in the state as a whole, lung, breast and prostate cancers were the most frequently diagnosed types of cancer. Three of the other types of cancer identified were fairly rare, but there was no more than one case of any one of these rare types. The types of cancer identified included types that have been linked with TCE exposure (esophagus, kidney and non-Hodgkin lymphoma), types that have been linked with PCE exposure (esophagus, bladder and non-Hodgkin lymphoma), and a type that has possibly been linked with PCE exposure (lung), although there are many other known and possible causes for these cancers.

Ages of the people at the time of their diagnoses ranged from the early 20s to over 85. The majority (80, or 86%) of the people diagnosed with cancer were age 55 or over at the time of their diagnoses. The ages or ranges of ages at which the individual cancers were diagnosed were typical for the different cancers. Forty four of the cancers were diagnosed in males, and 49 in females.

As noted above, additional cancers that were diagnosed after 2009 were identified in this area. Review of these cancers showed that the numbers and characteristics were consistent with the pattern seen in previous years.

The 82 residents identified with cancer lived at 62 addresses in the 19-block area. Results of indoor air sampling for contaminants associated with the NWIRP or Grumman site are available for 10 homes in the 19-block area, including some of the homes where residents with cancer had lived. None of the homes sampled in this area had unusual levels of TCE or PCE in the indoor air at the time of the sampling. A small number of homes near the Grumman site had detectable levels of TCE in the air beneath the home; cancers were identified among

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residents of some, but not all, of these homes. One of the cancers identified in residents of these homes has been linked with TCE and/or PCE exposure. This type of cancer is not an uncommon cancer and has many other known risk factors. Cancers were also identified among residents of homes that were sampled and were not found to have site-related contaminants in the air beneath the home.

Discussion

Study findings The address-specific review was conducted because of documented exposures to environmental contaminants in a small number of homes, and the possibility of exposures on a somewhat wider scale. Although unusual patterns of cancer were not confirmed in the preliminary cancer evaluation, this evaluation was based on cancers reported by members of the community. Members of the community would likely not have been aware of all cancers diagnosed among residents of their area, so these reports were likely incomplete. In contrast, the Registry-based address-specific review was capable of focusing in on the area with the greatest potential for site-related exposures and could identify cases of which community members may not have been aware.

The Registry-based address-specific cancer review identified seven cases of cancer that were diagnosed since 1976 among residents of Study area 1. The cancers were all of different types. Some of the cancers identified among residents of Study area 1 have been associated with PCE and/or TCE exposures, but there are other, more common, risk factors for these cancers as well. Although no children were identified who had been diagnosed with cancer, residents of Study area 1 were younger than average for the types of cancer they had at the time their cancers were diagnosed. The types of cancer that were identified showed no clear relation with the results of air sampling.

As might be expected, a much larger number of cancers (93, including 88 invasive malignant tumors and bladder cancers *in situ*) were identified among the residents of the much larger Study area 2. The most frequently diagnosed types of cancer in this area were the types most frequently found in adults, and there was no more than one case of any single rare cancer type. Some cancers that were identified have been associated with PCE and/or TCE exposures, but there are other, more common, risk factors for these. As is usually found in communities, most of the people diagnosed with cancer in Study area 2 were middle aged or older. The cancers did not appear to be related to findings of any indoor air sampling that had been conducted, but the extent of sampling in this area was quite limited.

To determine whether the numbers of cancers diagnosed over the 34-year period may have been unusual, calculations were conducted of the numbers of cancers one would expect

to find in the two areas. These calculations were based on incidence rates for invasive malignant tumors for New York State, exclusive of New York City, for the period for which data were official, and population estimates for the areas.

The population estimates were derived from data provided by the US Census for individual blocks. To protect confidentiality, age-specific data provided by the Census for individual blocks do not always reflect the exact counts obtained. In addition, the Census definitions of some blocks in Study area 2 changed over time and might at one time have included people who were not living in the study area. These calculations should therefore be regarded as approximate.

In Study area 1, the calculations predicted that approximately five people would be diagnosed with (invasive malignant) cancers during the time of the study. This number is similar to the six persons actually identified with invasive malignant tumors. Numbers of specific types of cancer that were identified in the study were also similar to the numbers expected. When total numbers of cancers were examined by age group, however, the number of cancers diagnosed in people under age 55 was greater than the number expected. This difference was statistically significant, meaning that it was not likely to occur by chance.

In Study area 2, a total of 107 cases of invasive malignant cancers (including bladder cancer *in situ*) were predicted, compared with 88 actually identified. This difference was not statistically significant. When looking at individual cancer types, there were no cancers where there were significantly more cases than expected. There were significantly fewer than expected cases of lung cancer among males, and fewer than expected cases of colorectal cancer among males and females combined. As noted above, uncertainties with population estimation may have led to an overestimate of the number of cases expected. Still, the calculations provide no evidence that the total number of cancers or the number of cases of any individual cancer was greater than expected in the study areas.

Environmental considerations For any substance in the environment to have an effect on human health, people have to come into contact with it. This is known as exposure. People may be exposed to a chemical substance by breathing it in (inhalation), consuming it in food or water (ingestion), or getting it on their skin (skin absorption). The risk of developing cancer upon exposure to a cancer-causing substance depends on how people are exposed to it, the amount of the substance to which they are exposed, the length of time over which they are exposed, and how often they are exposed.

In the present study, measurements of contaminant levels in the air inside and beneath homes were available for most of the homes in Study area 1, and some of the homes in Study

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area 2. As stated above, these measurements only show contaminant levels at one point in time. They do not provide a complete history of contaminant levels. Even if someone were living in a house where there were elevated levels of contaminants levels in the indoor air, this does not tell us precisely to what extent the person was actually exposed to the contaminants. This would depend on factors including how much time they spent inside the home, and how much time they spent in its different levels and rooms.

Even when exposure to a hazardous substance occurs, not all hazardous substances cause cancer. Researchers look at different kinds of evidence to determine how likely a substance is to cause cancer. These include studies in laboratory animals, observational studies of humans exposed to a substance, and studies aimed at understanding how a substance might cause cancer. The studies also take into account the route of exposure, whether by inhalation, ingestion or skin absorption.

Of the site-related contaminants, TCE has been classified as "reasonably anticipated to be a human carcinogen" (5). This classification was based on limited evidence of carcinogenicity in humans exposed to high levels in the workplace, sufficient evidence of cancer causation in laboratory animals, and information that indicates that it causes cancer in a way that would operate in humans. In studies in humans, exposures to TCE have been associated with cancer of the liver and bile duct, kidney cancer, non-Hodgkin lymphoma, and cancer of the esophagus.

PCE (also known as perchloroethylene, tetrachloroethylene, tetrachloroethene, or "perc") has been classified as "reasonably anticipated to be a human carcinogen" (5). This classification was based on sufficient evidence of carcinogenicity in experimental animals. PCE has been shown to cause liver tumors in mice, leukemias in rats, and kidney tumors in male rats. Some studies show a slightly increased risk of some types of cancer among workers, including dry-cleaning workers, exposed to PCE and other chemicals. Cancers associated with exposures include cancers of the esophagus, bladder, and non-Hodgkin lymphoma. Cancers less clearly associated with exposures include cancers of the cervix, tongue, and lung (6).

Evidence regarding the carcinogenicity of TCA is less strong. Two agencies that evaluate the carcinogenic risks of chemicals list TCA as "not classifiable" as to its carcinogenicity in humans (7, 8) due to limited data in both humans and animals. Studies of humans exposed to high levels of TCA in the workplace have been inconsistent; some studies suggest links with multiple myeloma and cancers of the central nervous system, lung and kidney, although the numbers of workers were small and the workers were exposed to other chemicals as well. Studies in animals have been inadequate to assess carcinogenicity when

the animals ingested the substance, and did not find a link with any cancers when the animals inhaled it.

Limitations The design of the review has implications for any conclusions that may be drawn from it. The environmental evaluation identified a small area in which completed exposure pathways had been documented. This area is the area with the greatest potential for human exposures, and so the area where the greatest effect of any exposures on cancer occurrence would be concentrated. But the number of people living in this area is relatively small (for statistical purposes). Since cancer is a common disease and can occur even when there are no unusual exposures to environmental contaminants, to demonstrate any effects that might be related to exposure, a study would have to show an unusual *pattern* of cancers, not just that cancers had occurred. When numbers of people in an area are small, the numbers of cancers are much more susceptible to the effects of random variation (chance). A cancer pattern would therefore have to be markedly different from one often seen in communities for it to be distinguishable from a cancer pattern that could easily occur by chance in a small population.

To overcome difficulties associated with small numbers, the review also examined a larger area. In a larger area, effects of chance are not as important and, if there were exposures, there would be a greater likelihood of detecting any effects of these exposures. However, it is not known whether exposures to site-related contaminants ever occurred in the larger area; if they did occur, it is not possible to know exactly where, at what levels, and for how long. These factors all affect the likelihood of seeing an effect of the exposure. The greater number of people in the larger area thus comes with a greater uncertainty of exposure.

Another limitation of this review is that migration, that is, movement of people in or out of the study area, could not be taken into account. Cancers were identified among people who both resided in the study areas and were diagnosed with cancer during the period 1976 through 2009. Former residents of the study areas who may have grown up there but moved away prior to being diagnosed could not be included, while people who developed cancer shortly after moving in to the area would have been included.

This type of study is *not* capable of demonstrating any cause-and-effect relationships. Cancers were identified among people living in the study area, and the characteristics of the identified cancers were reviewed to obtain information on cancers occurring in a population that had been or might have been exposed to contaminants related to the two sites. This information, however, does not allow the determination of what might account for the cancers that were found. As discussed above, this type of study does not provide information on whether and to what degree the people who developed cancer may have actually been exposed to any contaminants from the sites. In addition, cancers have many possible causes, including

genetic, lifestyle (smoking, diet etc.), and occupational factors as well as environmental exposures. At the current level of understanding, it is not possible to separate out all possible causes to determine the role of environmental factors in causing cancers in a small geographic area.

General cancer information Cancer, unfortunately, is a common disease. Almost one of every two men and over one of every three women will develop cancer during his/her lifetime (9). The number of people with cancer is increasing in most communities because more people are living to older ages, when cancer is more common.

Cancer may result from either genetic or environmental influences or an interaction of both genetics and environment. Examples of possible environmental influences include diet, smoking, and other lifestyle factors, and occupation, as well as natural and man-made cancer-causing substances in the air, food or water. The development of cancer is usually a lengthy process. For many types of cancer, symptoms do not occur until 10 to 30 years after exposure to cancer-causing agents. An agent that promotes the uncontrolled growth of cancer cells may cause cancer symptoms to be recognized in less time.

Much more research is necessary before the causes of cancer are well understood. Current knowledge, however, suggests that the leading preventable cause of cancer is cigarette smoking. Dietary practices such as excessive alcohol consumption and the eating of high fat foods, as well as physical inactivity, are also believed to be important. In fact, tobacco use has been estimated to account for about 30% of all cancer deaths (10), and recent evidence suggests that unhealthy diet and insufficient physical activity may account for one third (11). Other avoidable risk factors include excessive exposure to sunlight, ionizing radiation, and various occupational exposures to cancer-causing agents.

It is important to realize that many cancers can be effectively treated if they are diagnosed at early stages. Screening for cancers of the breast, cervix, colon and rectum, for example, helps to identify these diseases before the onset of symptoms and at a time when they are more treatable. People can reduce their chances of developing or dying from many cancers by adopting healthier lifestyles and by visiting their physicians for cancer-related checkups.

Conclusions

In the one-block area where elevated levels of contaminants related to the NWIRP site had been found in indoor air, the cancers that were identified were all of different types. While

some of these types of cancer have been associated with some of the site-related contaminants, these were not uncommon cancers and have many known and suspected risk factors other than chemical exposures. There was no clear relationship between the occurrence of cancer or the type of cancer identified and the levels of contaminants found in the homes. The total number of cancers was similar to the approximate number expected. The only thing unusual about the cancers occurring in Study area 1 was the younger than usual ages of the people affected. Due to the limited size of this one-block area, however, these results do not provide a clear indication of an unusual pattern of cancers.

For the larger area near the NWIRP and Grumman sites, the most frequently diagnosed types of cancer in this area were the types most frequently found in adults, and there was no more than one case of any single rare cancer type. Most of the people diagnosed with cancer in Study area 2 were diagnosed at the ages where cancer occurs most frequently, and the cancers did not appear to be related to findings of the limited amount of air sampling that had been conducted. Cancer patterns in this area were therefore not unusual.

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Table 1. Cancer cases identified in Study area 2 by type, 1976-2009, Bethpage, Nassau County, NY[1]

Type of cancer	Number of cases
Colorectal	5
Other digestive system (Includes esophagus, stomach and pancreas)	6
Lung and bronchus	12
Malignant melanoma	6
Breast (female)	11
Female reproductive (Includes uterus and ovary)	7
Prostate	11
Bladder (incl. *in situ*)	7
Kidney/renal pelvis	4
Brain and other nervous system	2
Blood and blood-forming system (Includes non-Hodgkin lymphoma, multiple myeloma and leukemias)	8
Other and unknown	9
Total cancers	88

[1]Includes all invasive malignant tumors plus cancers of the bladder *in situ;* does not include five other tumors that were *in situ* tumors of other sites, or tumors of other behaviors. Source of data: New York State Cancer Registry. Registry data are official through 2009.

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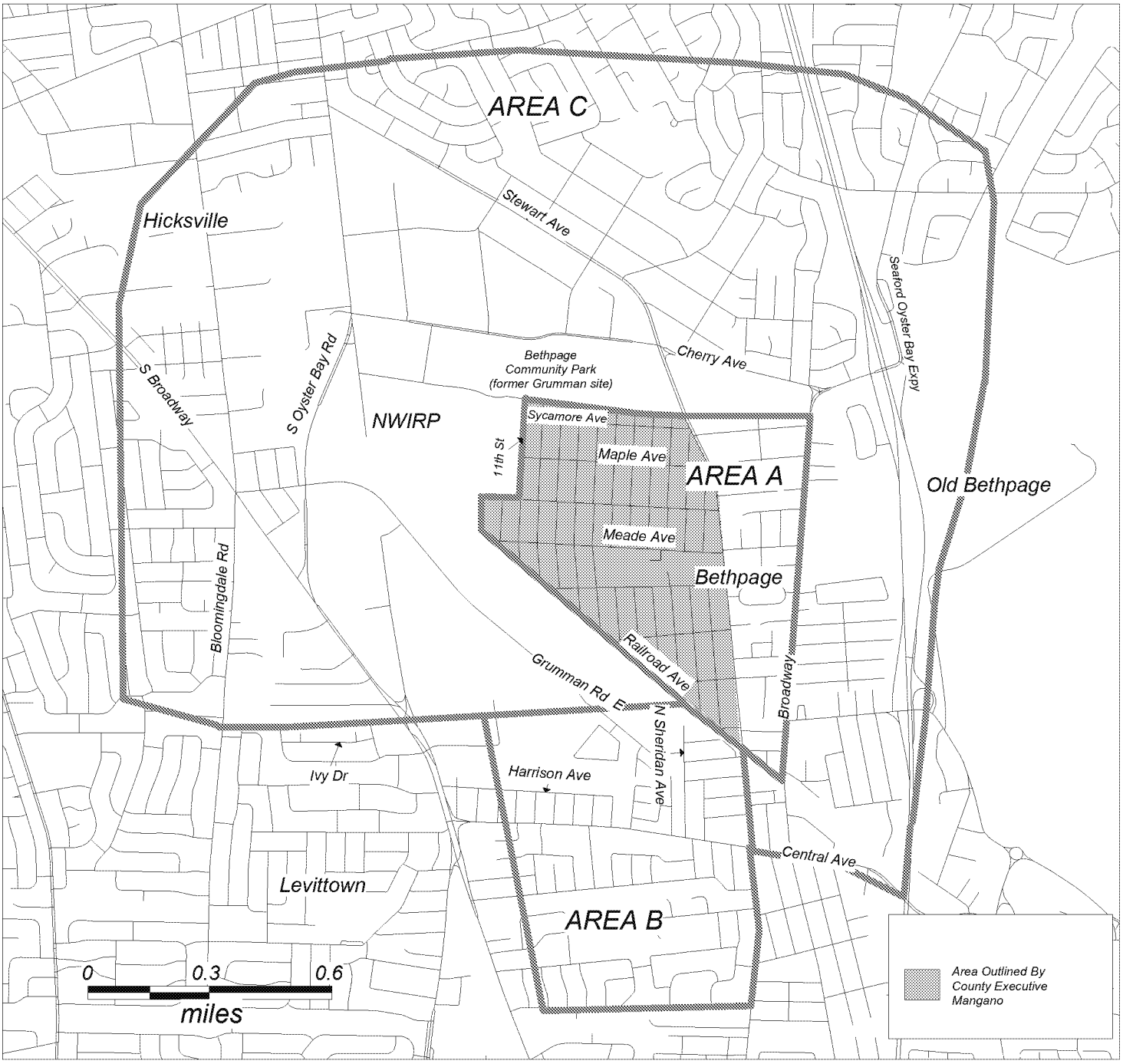
Map 1.

AREA OF CONCERN NEAR NWIRP SITE AND BETHPAGE COMMUNITY PARK NASSAU COUNTY, NEW YORK



Map 2.

STUDY AREAS
BETHPAGE, NASSAU COUNTY, NEW YORK