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Assessment of Cancer Incidence in Weymouth, Abington, Hingham, and Rockland, Massachusetts 1982-1998

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Assessment of Cancer Incidence in Weymouth, Abington, Hingham, and Rockland, MA 1982-1998

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I. EXECUTIVE SUMMARY

A. Background

At the request of Senator Michael Morrissey, the Weymouth Board of Health, and concerned residents of Weymouth, Abington, Hingham, and Rockland, MA, the Community Assessment Unit (CAU), a division of the Bureau of Environmental Heath Assessment within the Massachusetts Department of Public Health (MDPH), evaluated cancer incidence in the four towns that abut the South Weymouth Naval Air Station (SWNAS). This evaluation was initiated based on concerns over possible exposures from environmental contamination present at the SWNAS. The SWNAS is a federal facility that was operated by the U.S. Navy from 1941 to 1997 (ATSDR 1999a). The SWNAS property abuts four communities and extends into the town of Weymouth to the north, Abington to the southwest, Rockland to the southeast and borders Hingham to the west.

The report on this evaluation provides a descriptive analysis of the occurrence of cancer in the towns of Weymouth, Abington, Hingham, and Rockland as well as in the census tracts that geographically subdivide the towns for the years 1982 through 1998. Eight cancer types were included in this evaluation: cancers of the bladder, brain, kidney, liver, lung, and pancreas, leukemia, and non-Hodgkin's lymphoma (NHL). The report provides a comparison of the incidence of the selected cancer types in these communities with the incidence of cancer in the state of Massachusetts as a whole. The state of Massachusetts is used as a comparison to provide a stable, standard population to calculate and compare cancer incidence rates. Additionally, available information about risk factors related to the development of these cancers, including possible exposures from the SWNAS and other environmental factors, was evaluated.

To determine whether elevated rates of cancer occurred in the four towns or their census tracts, 17 years of cancer incidence data were obtained from the Massachusetts Cancer Registry and evaluated by age group and gender. The observed number of cancer cases was compared to the number of cases that would be expected based on statewide cancer rates. Standardized incidence ratios (SIRs) were calculated for three smaller time periods within the years 1982-1998 (e.g., 1982-1986, 1987-1994, and 1995-1998) for each of the eight primary cancer types for each town as a whole and the census tracts within each town.

B. Summary of Results

In general, the results of this analysis indicate that the majority of cancer types evaluated in Weymouth, Abington, Hingham, and Rockland during the 17 years 1982-1998 occurred at or near the expected rates in the four towns and their census tracts. Moreover, with the exception of lung cancer, review of the geographic distribution of cancer in Weymouth, Abington, Hingham, and Rockland revealed no apparent spatial patterns at the census tract level that are not likely attributed to factors such as areas of higher population density (e.g., the presence of multiunit complexes or nursing homes). In general, the distribution of cases seemed to coincide closely with the pattern of population in these towns.

However, statistically significant elevations in the incidence of some cancer types were noted in some towns during certain time periods. In the town of Weymouth as a whole, the incidence of lung cancer was statistically significantly elevated during the 1987-1994 and 1995-1998 time periods. Although a statistically significant elevation in the incidence of leukemia was observed town-wide during the 1987-1994 time period, this cancer occurred at approximately the rates expected during both the earlier time period 1982-1986 and the more recent time period 1995-1998. Finally, despite a statistically significant elevation of pancreatic cancer during the earliest time period 1982-1986, this cancer occurred statistically significantly less often than expected between 1987-1994 and was about as expected in Weymouth during 1995-1998.

In Abington, a statistically significant elevation in the incidence of lung cancer was observed among males and females combined during the earliest time period 1982-1986. During 1987-1994 and the more recent time period 1995-1998, the rates of lung cancer remained elevated but were not statistically different from the expected rates.

During 1982-1998, residents of Hingham generally experienced cancer approximately at or below the expected rates for the eight cancer types evaluated. For example, the rate of lung cancer in this town was lower than expected during the earliest time period 1982-1986 and statistically significantly lower than expected during 1987-1994 and the most recent time period 1995-1998.

In Rockland, with the exception of lung cancer during more recent years (i.e., 1995-1998), no statistically significant elevations were observed town-wide for any of the eight cancer types evaluated in this report during 1982-1998.

When all four towns were evaluated together, the most consistent trend was observed for lung cancer. Analysis of lung cancer rates by smaller time period suggests that the incidence of lung cancer in both Weymouth and Rockland may be increasing over time relative to the state rate. In Abington, the incidence of lung cancer town-wide was significantly higher than expected during the earliest time period 1982-1986. During the later two time periods 1987-1994 and 1995-1998, lung cancer continued to be elevated in Abington, particularly among males. However neither of these elevations were statistically significant.

In contrast to trends observed in Weymouth, Abington, and Rockland, lung cancer incidence rates in Hingham were statistically significantly lower than expected during 1982-1998. Moreover, analysis of SIRs for smaller time periods suggests that the incidence of lung cancer may be continuing to decline in Hingham.

Statistically significant elevations in the incidence of lung cancer were also observed in some census tracts in certain time periods. Specifically, lung cancer occurred significantly more often than expected in Weymouth CTs 4222, 4223, 4225, 4227, and 4228; Abington CT 5202.02; and Rockland CTs 5021 and 5022 during one or more time periods evaluated. Lung cancer appears to be increasing over time in some of these census tracts particularly in areas near the SWNAS.

While leukemia occurred at about the rate expected in the town of Weymouth during the earliest time period, 1982-1986, a statistically significant elevation was noted in the incidence of leukemia during the middle time period 1987-1994. This elevation was primarily due to an increase in diagnoses among males in Weymouth, who also experienced statistically significant increases in incidence during this time period. However, analysis of more recent data (i.e., 1995-1998) shows that the incidence of leukemia was slightly lower than expected. Therefore, it appears that the rate of leukemia in Weymouth has decreased in more recent years.

During 1982-1998, some individual census tracts in Weymouth, Abington, Hingham, and Rockland also displayed statistically significant elevations in the incidence of certain cancer types during one or more time periods. However, these predominantly represented isolated elevations and analysis revealed, with the exception of lung cancer, no consistent trends of cancer incidence at the census tract level throughout the 17-year time period evaluated. For example, although kidney cancer occurred at about the expected rate for the town of Weymouth as a whole during the more recent time period (1995-1998), a statistically significant elevation was noted in the incidence of this cancer type in Weymouth CT 4221, which borders the SWNAS property. This is in contrast to trends observed for this census tract during 1982-1986 and 1987-1994, during which fewer individuals were diagnosed with kidney cancer than expected based on the state rates.

For some cancer types and census tracts, calculated rates were based on small numbers of observed cases and should be interpreted with caution. Because of the instability of rates based on small numbers of cases, it is difficult to determine whether the observed elevations reflect true trends in the pattern of these cancers (e.g., true increases) in Weymouth, Abington, Hingham, and Rockland CTs or are the result of random variation in cancer rates.

In general, review of the patterns of cases according to age and gender, as well as risk factor information related to smoking and occupation, did not reveal any inconsistent patterns for those cancer types that experienced statistically significant elevations within the four communities of Weymouth, Abington, Hingham, and Rockland between 1982-1998. Although an initial review of trends over time indicated an increasing rate of lung cancer in areas close to the SWNAS site, analysis of environmental and non-environmental risk factors as well as an evaluation of the geographic distribution of cases, did not reveal a clear pattern suggesting that environmental exposures from the base contributed to the incidence of this cancer type. For example, smoking is the primary risk factor for the development of lung cancer. Among those diagnosed with this cancer type, a majority reported being a current or former smoker at the time of diagnosis. This information suggests that smoking likely played a role in the incidence of lung cancer as well as in the incidence of bladder, kidney, and pancreatic cancers in these communities.

With regard to specific environmental concerns evaluated at the base, no unusual geographic concentrations of cases were observed in neighborhoods close to the SWNAS property. None of the cancer types evaluated were unusually concentrated in proximity to private drinking water wells identified by a well survey conducted by ATSDR, and no unusual geographic concentrations of cases were observed in neighborhoods along the Old Swamp River or French's Stream, downstream from the base. Although results of recent investigations at the Mill River tributary in the northwest corner of the base were unavailable at the time of this evaluation, none of the cancer types were unusually concentrated in this area of South Weymouth. No clear relationship between the distribution of cancer and historical flight paths was observed in any of the four towns surrounding the base. When cancer incidence was evaluated in relation to other specific community environmental concerns in the towns of Weymouth and Hingham, again, no unusual patterns of cases were observed. This evaluation included a review of the geographic distribution of each cancer type in relation to 21E sites (i.e., hazardous release sites reported to the Massachusetts Department of Environmental Protection) in the four towns.

C. Conclusions and Recommendations

Based on the health and environmental information reviewed in this evaluation, as well as available environmental data specific to the SWNAS, it does not appear that environmental exposures related to the base are likely to have played a major role in the pattern of cancer incidence in Weymouth, Abington, Hingham, and Rockland during the 17-year time period 1982-1998. However, very little historical data on contaminant concentrations both on and off the base were available to evaluate the potential for base-related exposures in the past. In addition, data from ongoing investigations at the base were not available at the time of this analysis.

Despite the environmental data gaps, other than lung cancer, there was no consistency in the types of cancers for which incidence rates were statistically significantly elevated in census tracts or neighborhoods immediately surrounding the SWNAS. An overall review of the geographic patterns of cancer in the neighborhoods and towns abutting the SWNAS, including Rockland, did not indicate concentrations of any of the cancer types evaluated. For most cancer

types, the geographic distribution of cancer cases was away from the base boundary and was consistent with the population density in these areas. Moreover, with the exception of lung cancer, no one area of any of the four towns displayed cancer incidence patterns that looked remarkably different from other areas of the towns.

When interpreting information related to patterns of cancer in the four towns, it is also important to consider the role of other risk factors that were not available for evaluation in this report. This investigation was not able to evaluate the possible role that other non-environmental risk factors (e.g., diet, exercise, and heredity) may have contributed to the pattern of cancer incidence in these communities. As a result of trends observed in the incidence of lung cancer, the MDPH plans to further investigate lung cancer in these communities in relation to individual length of residence, particularly among non-smokers, to determine whether a clearer pattern related to environmental or other risks for this cancer may emerge. The MDPH also recommends that the Boards of Health in Weymouth, Abington, Hingham, and Rockland consider the results of this analysis in the planning of prevention and intervention strategies to evaluate potential health impacts in these communities in the future. In addition, based on information regarding the incidence of lung cancer and smoking in Weymouth, Abington, and Rockland, the MDPH recommends that tobacco control efforts be focused accordingly. Through the use of the Massachusetts Cancer Registry, the MDPH will continue to monitor cancer incidence in the towns of Weymouth, Abington, Hingham, and Rockland.

II. INTRODUCTION

At the request of Senator Michael Morrissey, the Weymouth Board of Health, and concerned residents of Weymouth, Abington, Hingham, and Rockland, MA, the Community Assessment Unit (CAU), a division of the Bureau of Environmental Heath Assessment within the Massachusetts Department of Public Health (MDPH), evaluated cancer incidence in the four towns. This evaluation was initiated based on concerns over possible exposures from environmental contamination present at the South Weymouth Naval Air Station (SWNAS). The SWNAS is a federal facility that was operated by the U.S. Navy from 1941 to 1997 (ATSDR 1999a). The SWNAS property is adjacent to four communities and extends into the town of Weymouth to the north, Abington to the southwest, Rockland to the southeast and borders Hingham to the west. Refer to Figure 1 for the location of the SWNAS.

This report reviews cancer incidence in the towns of Weymouth, Abington, and Hingham at the town level and for the census tracts that geographically subdivide the towns. Particular emphasis was placed on those census tracts immediately surrounding the SWNAS. Refer to Figure 1 for the location of census tracts surrounding the SWNAS. The CAU conducted a review of cancer incidence in the town of Rockland presented in a previous report (MDPH 2000). The results of the cancer incidence evaluation in the town of Rockland as they relate to possible exposures from the SWNAS are considered in this report. The full Rockland report is included as Appendix A.

III. OBJECTIVES

This report provides a descriptive evaluation of the occurrence of cancer in the towns of Weymouth, Abington, Hingham, and Rockland (Appendix A). It provides a comparison of the incidence of selected cancer types in these communities with the incidence of cancer in the state of Massachusetts as a whole. The state of Massachusetts is used as a comparison to provide a stable, standard population to calculate and compare cancer incidence rates. Additionally, available information about risk factors related to the development of cancer, including environmental factors, was evaluated.

The evaluation described in this report is a descriptive analysis of cancer incidence data and therefore, cannot be used to establish a causal link between a particular risk factor and the development of cancer. In addition, this analysis cannot determine the cause of any one individual's cancer diagnosis. However, the results can be useful in identifying common patterns or trends in a geographic context, to determine if a common cause or etiology is possible, and can serve to identify areas where further public health investigations or actions may be warranted. Descriptive analyses may also indicate that an excess of known risk factors associated with a disease exists in a certain geographic area. Despite their limitations, descriptive studies can help identify patterns that may indicate an environmental exposure is related to a pattern of cancer. The purpose of this evaluation is to report the findings on patterns of cancer in these communities and discuss them in the context of the available information to determine whether recommendations for further public health action are warranted.

The specific objectives of this investigation were as follows:

- To further evaluate the incidence of cancer in Weymouth, Abington, Hingham, and Rockland by smaller geographic areas within the towns (i.e., census tracts) to determine if certain areas have higher or lower cancer rates, in particular the census tracts surrounding the SWNAS;

- To evaluate the geographic distribution of individual cases of cancer in Weymouth, Abington, Hingham, and Rockland to determine whether any indication of a pattern of cases exists in certain areas of the towns;

- To review available descriptive information as reported by the Massachusetts Cancer Registry (MCR) for individuals diagnosed with cancer in Weymouth, Abington, Hingham, and Rockland related to risk factors for developing this disease;

- To evaluate the opportunity for exposure to contaminants from the SWNAS in relation to the pattern of cancer incidence in the four communities that surround the SWNAS (Weymouth, Abington, Hingham, and Rockland);

- To evaluate the pattern of cancer incidence relative to other environmental concerns within Weymouth, Abington, Hingham, and Rockland including a review of available data from the Massachusetts Department of Environmental Protection (MDEP) on reported hazardous waste site locations in the four towns; and

- To discuss the results of this evaluation in the context of the available scientific and medical literature on cancer to determine whether further investigation or public health action is warranted.

IV. METHODS

A. Case Identification/Definition

Cancer incidence data (i.e., new diagnoses of cancer cases) were obtained for the towns of Weymouth, Abington, Hingham, and Rockland from the Massachusetts Cancer Registry (MCR) of the MDPH. The MCR is a population based surveillance system that began collecting information on Massachusetts residents diagnosed with cancer in the state in 1982. All newly diagnosed cancer cases among Massachusetts residents are required by law to be reported to the MCR within six months of the date of diagnosis (M.G.L. c.111s.111B).

At the initiation of this investigation, the thirteen-year time period 1982-1994 constituted the period for which the most recent and complete cancer incidence data were available from the MCR. However, in October of 2001 more recent data (e.g., for the years 1995-1998) have become available from the MCR. An evaluation of more recent cancer incidence data (i.e., 1995-1998) is included as Appendix B and summary results from this time period are included in the main text of this report. The observed number of cancer cases reported for each time period in this evaluation was defined as cases reported to the MCR as a primary cancer diagnosed among a resident of Weymouth, Hingham, Abington, or Rockland. Cases were selected for inclusion based on the address reported to the hospital or reporting medical facility at the time of diagnosis.

The term "cancer" is used to describe a variety of diseases associated with abnormal cell and tissue growth. Epidemiology studies have revealed that different types of cancer are

individual diseases with separate causes, risk factors, characteristics and patterns of survival (Berg 1996). Cancers are classified by the location in the body where the disease originated (the primary site) and the tissue or cell type of the cancer (histology). Therefore, each of the cancer types reviewed in this report was evaluated separately. Cancers that occur as the result of the metastasis or the spread of a primary site cancer to another location in the body are not considered as separate cancers and therefore were not included in this analysis.

Eight primary cancer types were evaluated in this investigation. These include cancers of the bladder, brain, kidney, leukemia, liver, lung, pancreas and non-Hodgkin's lymphoma (NHL). These cancer types were selected for evaluation based on elevations observed in a preliminary review of cancer rates in the four towns surrounding the SWNAS (Weymouth, Abington, Hingham, and Rockland) and resident concern over suspected elevations in some of these cancer types (MDPH 1996). It should be noted that the MCR collects data on cancerous and some non-cancerous tumors of the brain and central nervous system as one group. This report reflects only those tumors (cancerous and non-cancerous) that occurred in the brain.

Occasionally, the MCR data file may contain duplicate reports of cases. The data discussed in this report have been controlled for duplicate cases by excluding them from the analyses. However, reports of an individual with multiple primary cancers were included. Duplicate cases are additional reports of the same individual with a primary site cancer. A multiple primary cancer case is defined by the MCR as a report of a new tumor in a different primary site, or a new tumor of the same histology (cell type) as an earlier cancer, if diagnosed in the same location in the body more than two months after the initial diagnosis (MCR 1996). Therefore, duplicate reports of an individual diagnosed with cancer were removed from the analyses whereas individuals who were diagnosed with more than one primary site cancer were included as separate cases. The decision that a case was a duplicate report and should be excluded from the analyses was made by the MCR after consulting with the hospital or reporting facilities and obtaining additional information regarding the histology and/or pathology of the case. For the eight cancer types evaluated in the towns of Weymouth, Abington, Hingham, and Rockland between 1982-1994, fourteen duplicate reports were identified and excluded from the analysis.

B. Calculation of Standardized Incidence Ratios (SIRs)

To determine whether elevated numbers of cancer cases occurred in the four towns or their census tracts, cancer incidence data were tabulated by age group and gender to compare the observed number of cancer cases to the number that would be expected based on the statewide cancer rate. Standardized incidence ratios (SIRs) were calculated for the period 1982-1994 for each of the eight primary cancer types for each town as a whole and the census tracts (CTs) within each town. SIRs were also calculated in each area for two smaller time periods, 1982-1986 and 1987-1994, and for the more recent time period 1995-1998 in order to evaluate patterns or trends in cancer incidence over time.

In order to calculate standardized incidence ratios, it is necessary to obtain accurate population information. The population figures used in the 1982-1994 analysis were interpolated based on 1980 and 1990 U.S. census data for each CT in Weymouth, Abington, Hingham, and Rockland (U.S. DOC. 1980, 1990). As presented in Appendix B, U.S. census data for the years 1990 and 2000 were used in the 1995-1998 analysis (U.S. DOC. 1990, 2000). Midpoint population estimates were calculated for each time period evaluated. To estimate the population between census years, an assumption was made that the change in population occurred at a constant rate throughout the ten-year intervals between each census.

Because accurate age group and gender specific population data are required to calculate SIRs, the CT is the smallest geographic area for which cancer rates can be accurately calculated. Specifically, a CT is a smaller statistical subdivision of a county as defined by the U.S. Census Bureau. CTs usually contain between 2,500 and 8,000 persons and are designed to be homogenous with respect to population characteristics (U.S. DOC. 1990).

According to the 1980 U.S. Census, the town of Weymouth was subdivided into eight census tracts while the towns of Abington and Hingham were comprised of three census tracts (U.S. DOC. 1980). During the 1990 U.S. Census, the Census Bureau further divided two Weymouth CTs (4223 and 4225) and one Hingham CT (5012). The split in these census tracts produced a total of ten census tracts in Weymouth (4221, 4222, 4223.01, 4223.02, 4224, 4225.01, 4225.02, 4226, 4227, and 4228) and four census tracts in Hingham (5011.01, 5011.02, 5012.01, and 50120.2). In order to evaluate cancer incidence by census tract over time, 1990

population data were combined for the split CTs in Weymouth and Hingham to remain consistent with the 1980 population data and CT designations. The town of Abington did not experience a split among any of the three census tracts that subdivide the town. Therefore, for the purpose of this evaluation SIRs were calculated according to the 1980 census tract designations for eight Weymouth census tracts (4221, 4222, 4223, 4224, 4225, 4226, 4227, and 4228), three Abington census tracts (5201, 5202.01, and 5202.02), and three Hingham census tracts (5011.01, 5011.02, and 5012). The town boundaries and census tract locations for Weymouth, Hingham and Abington are illustrated in Figures 1 through 4. See Appendix A, Figures 2 and 3 for census tract designations in Rockland.

The SWNAS is located within three CTs in the towns of Weymouth, Abington and Rockland. These include CT 4222 in Weymouth, CT 5202.01 in Abington and CT 5022 in Rockland. CT 5012 in the southern portion of Hingham is adjacent to the SWNAS (see Figure 1).

C. Interpretation of a Standardized Incidence Ratio (SIR)

An SIR is an estimate of the occurrence of cancer in a population relative to what might be expected if the population had the same cancer experience as a larger comparison population designated as "normal" or average. Usually, the state as a whole is selected to be the comparison population. Using the state of Massachusetts as a comparison population provides a stable population base for the calculation of incidence rates.

Specifically, an SIR is the ratio of the observed number of cancer cases in an area to the expected number of cases multiplied by 100. The population structure of each town is adjusted to the statewide incidence rate to calculate the number of expected cancer cases. The SIR reflects a comparison of the number of cases in the town compared to the statewide rate, using the specific age/sex structure of the statewide rate as the weights to determine the expected number of cases in each town. Therefore, because each community has different population characteristics, town-to-town or census tract comparisons are not possible.

An SIR of 100 indicates that the number of cancer cases observed in the population being evaluated is equal to the number of cancer cases expected in the comparison or "normal"

population. An SIR greater than 100 indicates that more cancer cases occurred than expected and an SIR less than 100 indicates that fewer cancer cases occurred than expected. Accordingly, an SIR of 150 is interpreted as 50% more cancer cases than the expected number; an SIR of 90 indicates 10% fewer cancer cases than expected.

Caution should be exercised, however, when interpreting an SIR. The interpretation of an SIR depends on both the size and the stability of the SIR. Two SIRs can have the same size but not the same stability. For example, an SIR of 150 based on four expected cases and six observed cases indicates a 50% excess in cancer, but the excess is actually only two cases. Conversely, an SIR of 150 based on 400 expected cases and 600 observed cases represents the same 50% excess in cancer, but because the SIR is based upon a greater number of cases, the estimate is more stable. It is very unlikely that 200 excess cases of cancer would occur by chance alone. As a result of the instability of incidence rates based on small numbers of cases, SIRs were not calculated when fewer than five cases were observed for a particular cancer type.

D. Calculation of the 95% Confidence Interval

To help interpret or measure the stability of an SIR, the statistical significance of each SIR was also assessed. The statistical significance of an SIR was assessed by calculating a 95% confidence interval (95% CI) for each SIR to determine if the observed number of cases is "significantly different" from the expected number or if the difference may be due solely to chance (Rothman and Boice 1982). Specifically, a 95% CI is the range of estimated SIR values that have a 95% probability of including the true SIR for the population. If the 95% CI range does not include the value 100, then the study population is significantly different from the comparison or "normal" population. "Significantly different" means there is less than a 5% chance that the observed difference (either increase or decrease) is the result of random fluctuation in the number of observed cancer cases.

For example, if a confidence interval does not include 100 and the interval is above 100 (e.g., 105-130), then statistically this means there is a significant excess in the number of cancer cases. Similarly, if the confidence interval does not include 100 and the interval is below 100 (e.g., 45-96), then statistically this means that the number of cancer cases is significantly lower than expected. If the confidence interval range includes 100, then the true SIR may be 100, and

it cannot be concluded with sufficient confidence that the observed number of cases is not the result of chance. In this case it cannot be determined with certainty that the difference between the observed and expected number of cases reflects a real cancer increase or decrease. It is important to note that statistical significance does not necessarily imply public health significance. Determination of statistical significance is just one tool used to interpret SIRs.

In addition to the range of the estimates contained in the confidence interval, the width of the confidence interval also reflects the stability of the SIR estimate. For example, a narrow confidence interval (e.g., 103-115) allows a fair level of certainty that the calculated SIR is close to the true SIR for the population. A wide interval (e.g., 85-450) leaves considerable doubt about the true SIR, which could be much lower than or much higher than the calculated SIR. This would indicate an unstable statistic. Again, due to the instability of incidence rates based on small numbers of cases, statistical significance was not assessed when fewer than five cases were observed.

E. Evaluation of Risk Factor Information

Available information reported to the MCR related to risk factors for cancer development was reviewed and compared to known or established incidence patterns for the cancer types evaluated in this report. This information is collected for each individual at the time of cancer diagnosis and includes age at diagnosis, stage of disease, smoking status and occupation. One or even several factors acting over time can be related to the development of cancer. For example, tobacco use has been linked to lung and bladder cancers. Other cancer risk factors may include lack of crude fiber in the diet, high fat consumption, alcohol abuse, and reproductive history. Heredity, or family history, is an important factor for several cancers. To a lesser extent, some occupational exposures, such as jobs involving contact with asbestos, have been shown to be carcinogenic (cancer causing). Environmental contaminants have also been associated with certain types of cancer. The available risk factor information from the MCR was evaluated for cancers that were elevated in Weymouth, Abington, Hingham, and Rockland. However, information about personal risk factors (e.g., family history, hormonal events, diet, etc.) which may also influence the development of cancer is not collected by the MCR and was therefore not evaluated in this investigation.

F. Determination of Geographic Distribution

Address at the time of diagnosis for each cancer case was mapped using a computerized geographic information system (Environmental Systems Research Institute 1998). This allowed for the assignment of census tract location for each case as well as an evaluation of the spatial distribution of individual cases at a smaller geographic level within census tracts (i.e., neighborhoods). The geographic distribution was determined using a qualitative evaluation of the point pattern of cases within the towns and their individual census tracts. In instances where the address information from the MCR was incomplete (i.e., did not include specific streets or street numbers), efforts were made to research those cases using telephone books and town residential lists issued within two years of an individual's diagnosis. Address locations were also confirmed by site visits to the area. For confidentiality reasons, maps of the location of individual cancer cases are not provided in this report.

V. RESULTS OF CANCER INCIDENCE ANALYSIS

A. Cancer Incidence in the Town of Weymouth

In the town of Weymouth, during the period 1982-1994, five of the eight cancer types evaluated occurred less often than expected overall. These included cancers of the bladder, brain, kidney, liver, and NHL. The occurrence of bladder cancer and NHL were both lower than expected rates overall by nearly twelve cases each. The decreases observed in the incidence of these cancer types were primarily the result of lower than expected incidence among females in Weymouth. Approximately six fewer kidney cancer cases were observed among males and females combined than expected (64 cases observed versus 71.8 cases expected). The incidence of pancreatic cancer was approximately as expected. The incidence of leukemia and lung cancer was elevated in Weymouth during the 13 year time period 1982-1994. The elevation in leukemia was a statistically significant increase from the expected number of cases (79 cases observed versus 60 cases expected). This increase in the town overall was primarily due to a statistically significant elevation observed in leukemia among males (48 cases observed versus 33.1 cases expected). While the incidence of female leukemia was also elevated for the time period 1982-

1994, the elevation was not statistically significant (31 cases observed versus 26.9 cases expected).

The incidence of lung cancer was statistically significantly elevated in Weymouth overall between 1982-1994. When lung cancer in the town was evaluated for males and females separately, both experienced similar statistically significant elevations. Among males, a 14% increase was observed (324 cases observed versus 284.7 cases expected). Among females, a 16% increase in lung cancer was observed (218 cases observed versus 187.5 cases expected). These data are summarized in Table 1A.

Review of cancer incidence in the town during the two smaller time periods (1982-1986 and 1987-1994) showed that the pattern of cancer in Weymouth was similar to that observed during the overall time period 1982-1994. With a few exceptions, the majority of cancer types occurred less than or equal to what would be expected. These data are summarized in Table 1B. During the earlier time period, the incidence of pancreatic cancer was statistically elevated among males and females combined (39 cases observed versus 26.3 cases expected) primarily due to an increase among females (24 cases observed versus 14.2 cases expected). However, an increase of approximately five cases was also observed among males during this time period (15 cases observed versus 12.0 cases expected). The increase in pancreatic cancer observed among Weymouth males was not statistically significant. While these increases were observed in the earlier time period for pancreatic cancer, during the later time period 1987-1994, the incidence of this cancer type was lower than expected in Weymouth overall (30 cases observed versus 41.6 cases expected). This decrease was predominantly due to a lower incidence among females (14 cases observed versus 22.1 cases expected). Among males, approximately four cases less than expected were observed during the later time period (16 cases observed versus 19.5 cases expected).

Also, in Weymouth during the later time period 1987-1994, the number of leukemia cases was statistically significantly elevated among males and females combined (55 cases observed versus 37 cases expected). This is primarily the result of an increased incidence among males, which was also significantly elevated above the expected number of cases (36 cases

observed versus 20.7 cases expected). A slight increase of approximately three cases was observed among females (19 cases observed versus 16.3 cases expected).

Lung cancer incidence was elevated above expected rates overall, and among males and females during both the smaller time periods. The elevation observed in the earlier time period is the result of increases observed among both males (121 cases observed versus 106.9 cases expected) and females (72 cases observed versus 61.2 cases expected). In the later 1987-1994 period lung cancer incidence was statistically significantly elevated among males and females combined (349 cases observed versus 304 cases expected). When males and females were evaluated separately between 1987-1994, both experienced nearly statistically significant elevations in lung cancer (SIR=114 and SIR=116, respectively). With the exception of leukemia and lung cancer, all other cancer types occurred less than the expected rates during 1987-1994.

As indicated in Appendix B, the incidence of cancer in Weymouth for more recent years (i.e., 1995-1998) was approximately as expected. However, lung cancer occurred significantly more often than expected during this time period (223 cases observed vs. 166.5 expected, SIR=134, 95% CI=117-153). It appears that the incidence of this cancer type in Weymouth may be increasing over time.

B. Cancer Incidence in Weymouth Census Tracts

1) Census Tract 4221

CT 4221 is located in South Weymouth and is adjacent to the SWNAS. During the 13-year time period 1982-1994, the majority of cancer types evaluated in this census tract were at or below the expected rate. An increase of leukemia cases was observed overall in this area, but the elevation was not statistically significant. The increase was due to a statistically significant elevation observed among males (7 cases observed versus 2.8 cases expected). No other statistically significant elevation was observed in CT 4221 during the 13 years evaluated. An elevation in the incidence of NHL was also observed overall during 1982-1994 due to increases among both males (7 cases observed versus 4.7 cases expected) and females (8 cases observed versus 4.4 cases expected). While brain cancer incidence was above the expected rate by approximately two cases for this time period, the incidence of the other five cancer types

evaluated were below what would be expected as compared to statewide rates for these cancers (see Table 2A).

When cancer incidence in this census tract was evaluated for the smaller time periods 1982-1986 and 1987-1994, no statistically significant elevations were observed (see Table 2B). In the earlier 1982-1986 time period, SIRs were not calculated for brain, leukemia, or pancreatic cancer due to the small number of observed cases (i.e., less than five). However, expected numbers were calculated to determine whether excess numbers of cases were occurring. Of these three cancer types, only brain cancer was slightly elevated above the expected number of cases (4 cases observed versus 1.4 cases expected). Slight elevations were also observed during this time period for the three other cancer types evaluated (i.e., bladder, lung, and NHL). No cases of kidney or liver cancer were observed in the earlier time period. During the later time period 1987-1994, both leukemia and NHL incidence were slightly greater than expected in this census tract. Lung cancer incidence during the later time period was below the expected rate by approximately four cases (21 cases observed versus 25.3 cases expected). Although SIRs were not calculated for the five remaining cancer types evaluated between 1987-1994 (bladder, brain, kidney, liver, and pancreas), the incidence was equal to or below the rates expected.

Appendix B describes the incidence of the eight cancer types in CT 4221 for more recent years. During the 1995-1998 period, the majority of cancer types evaluated occurred approximately at or near the expected rates in this census tract. However, the incidence of kidney cancer and pancreatic cancer was greater than expected in this area of Weymouth. Although these elevations were statistically significant, the small number of cases and relatively wide confidence intervals suggest that the increased SIRs during this time period are somewhat unstable.

2) Census Tract 4222

CT 4222 is also located in South Weymouth and contains a large portion of the SWNAS. With a few exceptions, the majority of cancer types in this census tract occurred less frequently than expected. Lung cancer incidence during the 13-year period 1982-1994 was statistically significantly elevated above the expected rate overall (79 cases observed versus 61.2 cases expected). The increase of approximately 18 cases was predominantly due to an increase among

females (34 cases observed versus 23.7 cases expected). In addition, male lung cancer incidence was elevated by approximately eight cases during the 1982-1994 time period (45 cases observed versus 37.5 cases expected). While the increase in lung cancer cases overall was statistically significant in this area of town, the increases observed among males and females separately were not significantly elevated during the 13-year period. Leukemia incidence overall in CT 4222 was elevated by approximately six cases (14 cases observed versus 8.1 cases expected). This was primarily the result of an increase observed among males (9 cases observed versus 4.6 cases expected). Neither of these elevations was statistically significant. Lower than expected incidence was observed overall for bladder cancer, NHL, and pancreatic cancer. SIRs were not calculated for brain or liver cancer due to the small number of cases that occurred (i.e., less than five). However, brain cancer occurred less often than expected (2 cases observed versus 6.2 cases expected), and liver cancer occurred slightly more often than expected (3 cases observed versus 2 cases expected).

During the 1982-1986 time period, no significant elevations in cancer incidence were observed in CT 4222. Lung cancer incidence in this census tract was elevated by approximately four cases overall (27 cases observed versus 22.6 cases expected). Three additional cases of lung cancer occurred among males (18 cases observed versus 14.5 cases expected). Among females in this area of Weymouth, lung cancer was slightly greater than expected during 1982-1986. One additional case of lung cancer occurred among females during this time period (9 cases observed versus 8.1 cases expected).

During the later time period 1987-1994, lung cancer was elevated overall (52 cases observed versus 38.7 cases expected) and was statistically significantly elevated among females (25 cases observed versus 15.5 cases expected). Male lung cancer incidence was elevated by approximately four cases (27 cases observed versus 23.1 cases expected) but the elevation was not statistically significant. When the incidence of leukemia was evaluated among males and females separately between 1987-1994, small elevations of approximately three cases were observed. These slight increases resulted in a statistically significant elevation in leukemia overall in the later time period (11 cases observed versus 4.9 cases expected). However, this elevation should be interpreted with caution as it is based on a relatively small number of observed cases and the width of the confidence interval indicates that this is a somewhat unstable

SIR (95% CI = 112-401). Overall, all other cancer types evaluated for this time period in CT 4222 occurred below expected rates. Refer to Tables 3A and 3B for a summary of these data.

Appendix B presents the cancer incidence analysis for CT 4222 during the more recent period 1995-1998. As observed town-wide, a statistically significant elevation in the incidence of lung cancer was noted for CT 4222 overall during this time period. No other statistically significant elevations were observed.

3) Cancer Incidence in Weymouth CT 4223 through CT 4228

During the 13-year time period 1982-1994, the majority of SIRs in the six remaining census tracts in Weymouth were either not able to be calculated due to small numbers of observed cases (i.e., less than five) or indicated cancer incidence rates less than or equal to that which would be expected based on the statewide cancer rates. Complete cancer incidence results for census tracts 4223 through 4228 are presented in Tables 4A through 9B.

Several elevations in lung cancer were observed in CTs 4223 through 4228. In some census tracts or time periods, these elevations were statistically significant. In CT 4225, lung cancer was statistically elevated among females (48 cases observed versus 32.1 cases expected, SIR=149) as well as among males and females combined (101 cases observed versus 79.1 cases expected, SIR=128) between 1982-1994. This elevation was mainly due to statistically significantly elevated rates in lung cancer in the earlier time period 1982-1986 observed among females (18 cases observed versus 10.2 cases expected, SIR=176) and males and females combined (39 cases observed versus 27.4 cases expected, SIR=143). In CT 4227, lung cancer was statistically significantly elevated between 1982-1994 among males and females combined (62 cases observed versus 39 cases expected, SIR=159), and also in the later time period 1987-1994 among males and females combined (41 cases observed versus 25.2 cases expected, SIR=163). In CT 4226, 71 cases of lung cancer were observed whereas approximately 60 cases were expected. This elevation was not statistically significant. However, lung cancer was statistically significantly elevated in CT 4226 among males (22 cases observed versus 13.7 cases expected, SIR=161) between 1982-1986.

Brain cancer was statistically significantly elevated among males and females combined in CT 4227 between 1982-1994 (9 cases observed versus 3.8 cases expected, SIR=239). A statistically elevated rate of brain cancer was also observed in CT 4227 among males and females combined in the earlier time period 1982-1986 (5 cases observed versus 1.3 cases expected, SIR=383).

Leukemia was slightly elevated in CT 4224 (13 cases observed versus 10.7 cases expected), CT 4225 (12 cases observed versus 10.2 cases expected), CT 4226 (12 cases observed versus 7.2 cases expected), and CT 4228 (9 cases observed versus 5 cases expected) between 1982-1994. However, none of these elevations were statistically significant. During the later time period 1987-1994, leukemia experienced a statistically significant increase in CT 4224 among males (8 cases observed versus 3.2 cases expected, SIR=253). Non-statistically significant elevations among males and females were observed in CT 4226 (9 cases observed versus 4.5 cases expected) and CT 4228 (7 cases observed versus 3.1 cases expected).

Pancreatic cancer was slightly elevated in CT 4224 (20 cases observed versus 13.4 cases expected) and CT 4227 (7 cases observed versus 5.4 cases expected). Although not statistically significantly elevated in CT 4224 between 1982-1994, pancreatic cancer was statistically significantly elevated among females (9 cases observed versus 3.4 cases expected, SIR=264) and males and females combined (11 cases observed versus 5.4 cases expected, SIR=204) in the earlier time period 1982-1986.

Kidney cancer generally occurred less than or approximately equal to the rates expected in census tracts 4223 through 4228. Slight elevations among males were observed in CT 4225 (10 cases observed versus 7.1 cases expected, SIR=140) between 1982-1994 and in CT 4228 (6 cases observed versus 2.8 cases expected, SIR=214) between 1987-1994. Liver cancer was slightly elevated in CT 4223 (4 cases observed versus 2.3 cases expected) and CT 4226 (3 cases observed versus 1.9 cases expected), although SIRs were not calculated because the number of observed cases were less than five. NHL was slightly elevated in CT 4228 (14 cases observed versus 9.2 cases expected), but occurred less than or equal to expected in all other census tracts.

Appendix B shows the pattern of cancer incidence in census tracts 4223-4228 during the more recent years 1995-1998. Statistically significant elevations were observed for lung cancer

among males and females combined in CTs 4223 and 4228, lung cancer among females in CT 4223, and NHL among males in CT 4224.

C. Cancer Incidence in the Town of Abington

In the town of Abington during the 1982-1994 time period, cancer incidence overall was equal to or less than expected rates for six of the eight cancer types evaluated. Elevations were observed in the town overall for brain cancer (15 cases observed versus 11 cases expected) and lung cancer (128 cases observed versus approximately 107 cases expected). The elevations in these two cancer types were mainly due to increases observed among males in Abington and neither elevation was statistically significant. Among Abington males, 9 cases of brain cancer occurred during 1982-1994 versus approximately 6 cases expected (SIR=153). This increase was not statistically significant. However, the increase in lung cancer among Abington males was statistically significantly elevated. Among males during this time period, 81 cases of lung cancer were observed where approximately 64 cases were expected (SIR=127). These data are presented in Table 10A.

Cancer incidence rates in Abington during the two smaller time periods (1982-1986 and 1987-1994) followed a similar pattern to those observed in the 13-year time period 1982-1994. During the earlier time period 1982-1986, kidney cancer, NHL and pancreatic cancer in Abington occurred less often than expected. The majority of cancer types during this time period were approximately equal to or slightly above expected rates with the exception of lung cancer. An elevation was observed among lung cancer cases overall during the earlier time period (50 cases observed versus 36.2 cases expected). This increase was statistically significantly elevated from the expected number of cases. When the incidence of lung cancer during this time period was examined separately for Abington males and females, increases were observed in both groups. Although similar increases in lung cancer were observed among males and females, unlike the increase observed in Abington overall, the elevations did not represent a statistically significant difference from the expected number of cases. Among males, 31 cases of lung cancer occurred during this time period where approximately 23 were expected (SIR=135). Among females, 19 cases of lung cancer occurred where approximately 13 cases were expected (SIR=144). Refer to Table 10B for a summary of these data.

During the 1987-1994 time period, most cancer types in Abington were below or equal to expected rates. None of the increases observed during the later time period were statistically significantly different from the expected number of cases. With the exception of lung cancer, no cancer type that was elevated showed an increase of more than three cases above the expected number. Cancers of the bladder, brain, and NHL displayed slight increases. Among males and females combined, 10 cases of brain cancer were observed whereas approximately 7 cases were expected. Both bladder cancer and NHL were slightly elevated among females in this time period. Lung cancer was elevated overall with an increase of approximately eight cases. Among males in Abington between 1987-1994, 50 cases of lung cancer were observed versus approximately 41 cases expected (SIR=123). Neither elevation was statistically significant. Cancer incidence rates in Abington during 1987-1994 are presented in Table 10B.

Appendix B presents more recent cancer incidence data for the period 1995-1998 for the town of Abington. Cancer incidence during recent years was lower than or approximately equal to the expected rates for six of the eight cancer types evaluated. Bladder cancer and lung cancer occurred slightly more often than expected, however, neither of these elevations was statistically significant.

D. Cancer Incidence in Abington Census Tracts

1) Census Tract 5201

CT 5201 is located in the southern portion of the town of Abington and adjacent to the town of Whitman (see Figure 3). Most cancer types in this census tract occurred less than or equal to the rate expected with a few exceptions. During the overall time period 1982-1994, lung cancer was elevated above the expected rate among males and females combined (55 cases observed versus approximately 48 cases expected). This increase was mainly due to an elevation in lung cancer in this area of Abington among males (37 cases observed versus 29.2 cases expected). However, neither the increase overall nor among males was statistically significantly elevated. Lung cancer among females in this census tract occurred approximately as expected (18 cases observed versus approximately 19 cases expected) between 1982-1994. Female lung cancer occurred less often than expected in the later time period 1987-1994 where 8 cases were observed versus approximately 13 cases expected. Lower than expected rates were also

observed in CT 5021 in the incidence of bladder cancer, kidney cancer, leukemia, NHL, and pancreatic cancer.

In Abington CT 5201, during the years 1995-1998, cancer occurred about as expected based on state rates. Slight increases in the rates of bladder cancer, breast cancer, and kidney cancer were observed during 1995-1998, however, none of these elevations was statistically significant (refer to Appendix B for a summary of these data).

2) Census Tract 5202.01

CT 5202.01 is located in the northwest portion of the town of Abington and contains a portion of the SWNAS property (see Figure 3). Overall cancer incidence in this census tract was approximately equal to or slightly above expected rates during the 13-year period 1982-1994. With the exception of bladder and pancreatic cancer among females, the cancer types that showed increases were based on less than three additional cases. A statistically significant elevation was observed in bladder cancer incidence among females in this census tract (6 cases observed versus 1.8 cases expected, SIR=330). Also, among females, five cases of pancreatic cancer were observed whereas 1.8 cases were expected. However, the elevation in pancreatic cancer was not statistically significant. No kidney cancer cases were observed in this census tract.

During the earlier 1982-1986 time period, lung cancer incidence overall in CT 5202.01 was lower than expected (5 cases observed versus 9.6 cases expected). Although SIRs were not calculated for the seven remaining cancer types due to the small number or absence of observed cases, the incidence of these cancers was generally less than or equal to the expected number of cases.

In the later time period (1987-1994), lung cancer incidence overall in CT 5202.01 was above the expected rate (21 cases observed versus 17.4 cases expected). This was the result of a slight increase observed among females (10 cases observed versus 7 cases expected). Bladder cancer also occurred slightly more often than expected during the later time period. Among males and females combined, five cases of bladder cancer occurred where approximately four cases were expected (SIR=121). Among females, bladder cancer occurred more often than

expected, but unlike the elevation observed during the overall time period 1982-1994, the increase was based on three additional cases and did not represent a statistically significant increase from the expected rate. Also, during the later time period, most of the six remaining cancer types in this census tract occurred approximately equal to or less than the expected rate. These data are summarized in Tables 12A and 12B. Appendix B shows the pattern of cancer incidence in CT 5202.01 during the period 1995-1998. In general, cancer incidence was lower than or approximately equal to expected rates.

3) Census Tract 5202.02

CT 5202.02 is located southwest of CT 5202.01 in the western portion of Abington and borders the city of Brockton (see Figure 3). Again, in this census tract, the majority of the eight cancer types occurred at about expected rates. Lung cancer incidence was elevated in this census tract during the 13-year period 1982-1994 and the earlier time period 1982-1986. Both of these increases were statistically significantly elevated above the expected number of cases. The elevations were primarily the result of a significant increase in lung cancer incidence among males during the earlier time period 1982-1986. Among males in this area, 13 cases of lung cancer occurred during 1982-1986 where approximately 6 cases were expected (SIR=217). Lung cancer was also elevated in this census tract among females overall and during the earlier time period 1982-1986. Although the increase in the number of lung cancer cases among females was more than twice the expected number of cases, it was not statistically significantly different than the expected rate. Males in this census tract also experienced an increase in lung cancer incidence during the later time period 1987-1994. The elevation was based on approximately four additional cases and was not significantly elevated. For a summary of cancer incidence rates in CT 5202.02 refer to Tables 13A and 13B.

Although not statistically elevated, more cases of brain cancer were observed in CT 5202.02 than expected between 1982-1994 (6 cases observed versus 3.2 cases expected, SIR=188). This elevation can be attributed to slight elevations in brain cancer incidence observed among both males and females in the later time period 1987-1994, where one additional case occurred among males and two additional cases occurred among females.

Cancer incidence data for the years 1995-1998 shows that the majority of cancer types evaluated occurred less often than expected in CT 5202.02. Some cancer types occurred slightly more often than expected, however, with the exception of lung cancer among males in this census tract, none of the observed elevations were statistically significant. A detailed summary is provided in Appendix B.

E. Cancer Incidence in the Town of Hingham

In the town of Hingham during the 13 years 1982-1994, cancer incidence rates were approximately equal to or below the expected rate for seven of the eight cancer types reviewed. Brain cancer incidence in Hingham was slightly elevated overall (20 cases observed versus 17.1 cases expected) and among females (12 cases observed versus 7.7 cases expected). Although a slight elevation was observed in the incidence of lung cancer among females, (70 cases observed versus 66.4 cases expected), a statistically significant decrease in the incidence of this cancer occurred during the 13 years overall. A statistically significant decrease in pancreatic cancer was also observed in the town overall during 1982-1994. The decreases were predominantly the result of lower than expected rates for these two cancer types among males in Hingham. Both lung and pancreatic cancer among Hingham males were statistically significantly lower then expected during 1982-1994. For males, lung cancer was 31% lower than expected (SIR=69) and pancreatic cancer was 58% lower than expected (SIR=42) based on the statewide rates of these cancers. For lung cancer, 75 cases occurred among males in Hingham where approximately 109 were expected (SIR=69). For pancreatic cancer, 5 cases occurred among Hingham males where approximately 12 cases were expected (SIR=42). Pancreatic cancer also occurred less often than expected among females in Hingham (9 cases observed versus 12.5 cases expected). However, the lower rate observed among females was not statistically significantly different from the expected number of cases. Cancer incidence rates in the town of Hingham during 1982-1994 are presented in Table 14A.

When cancer incidence was evaluated in Hingham for the two smaller time periods (1982-1986 and 1987-1994), the patterns observed were similar to those observed during the 13-year time period 1982-1994. In both smaller time periods, the majority of cancer types were again at or below expected rates based on the statewide incidence of these cancers. None of the

elevations that were observed were statistically significantly elevated above the expected number of cases for any of the cancer types in either time period. During 1982-1986, a slight elevation was observed in the incidence of brain cancer in the town of Hingham overall (8 cases observed versus 5.8 cases expected). The elevation was the result of small increases above the expected rate (i.e., one additional case) among both males and females in Hingham. During the later time period 1987-1994, brain cancer was somewhat elevated among females (8 cases observed versus 5.1 cases expected). The increase was due to a small number of additional cases (approximately three) and was not statistically significantly higher than the expected rate. Refer to Table 14B for a summary of these data.

Lung cancer incidence was also elevated among females in Hingham during the earlier time period 1982-1986. During this time, 31 cases of lung cancer occurred among females in Hingham where approximately 21 cases were expected based on the statewide rates (SIR=147). Among males in Hingham during 1982-1996, lung cancer was statistically significantly lower than expected (26 cases observed versus 39 cases expected). In the later time period 1987-1994, lung cancer incidence was less than expected among both males and females in the town. For males, the decrease in lung cancer was again statistically lower than expected (49 cases observed versus approximately 69 cases expected). The lower rates among both males and females resulted in a statistically significantly lower rate in lung cancer incidence in the town overall during the later time period. Table 14B presents cancer incidence rates in Hingham for the two smaller time periods 1982-1986 and 1987-1994.

Appendix B presents the cancer incidence data in Hingham for the years 1995-1998. These data indicate that in Hingham overall, cancer incidence was approximately at or near the expected rates for the majority of cancer types evaluated. The exceptions included lung cancer, which occurred significantly less often than expected, and melanoma, which was significantly elevated among males and females combined and among males in this town.

F. Cancer Incidence in Hingham Census Tracts

1) Census Tract 5011.01 and 5011.02

CTs 5011.01 and 5011.02 are located in the northern portion of Hingham along the coastal areas of the town. CT 5011.01 borders the town of Cohasset to the east and CT 5011.02 borders the town of Weymouth to the west (see Figure 4B). With the exception of bladder cancer among males, all of the cancer types evaluated in CT 5011.01 were at or below the expected rate. For many of the cancer types in this census tract, the number of cases that occurred were relatively small (i.e., less than five) and therefore could not be evaluated statistically. No statistically significant increases or decreases were observed for any cancer type in this census tract. Although a slight elevation in bladder cancer was observed among Hingham males in this area during the 13-year period 1982-1994, the increase was due to less than two additional cases (8 cases observed versus 6.5 cases expected, SIR=123). However, when the incidence of this cancer was reviewed in this area by smaller time period, one case occurred among males during the earlier time period 1982-1986. During the later time period 1987-1994, bladder cancer was elevated among males in this area with 7 cases observed and approximately 4 cases expected (SIR=173).

In CT 5011.02, the pattern of cancer incidence was somewhat different from the other two census tracts in Hingham. Whereas in CT 5011.01 and CT 5012 almost all cancer types were below expected rates, in CT 5011.02 females generally experienced higher rates of cancer of the brain, lung, NHL and pancreas. For three of these cancer types (i.e., brain, NHL, and pancreas), the increases were based on a small number of cases and were not statistically significantly elevated above the expected number of cases. While brain cancer incidence among females was slightly elevated during all three time periods evaluated, the increase in this area was based on a total of three additional cases and was not significantly elevated. Lung cancer incidence was statistically significantly elevated among females during the 13-year period 1982-1994 (37 cases observed versus 23.4 cases expected, SIR=158). Also, further evaluation of lung cancer incidence among females in CT 5011.02 showed a pattern of increase during both smaller time periods 1982-1986 and 1987-1994. However, the elevated incidence during the earlier time period 1982-1986 was statistically significantly greater than expected. Among females, 18 cases

of lung cancer were observed in this census tract during 1982-1986 where approximately 8 cases were expected (SIR=237). The increase in female lung cancer incidence during the later time period was based on approximately three additional cases (19 cases observed versus 15.8 cases expected, SIR=120). Small increases were also observed in the incidence of NHL and pancreatic cancer among females in this census tract. However, the increases were based on approximately two additional cases and were not statistically significantly elevated. No cases of kidney cancer were reported among females in this census tract. Cancer incidence rates for Hingham CT 5011.02 are presented in Tables 16A and 16B.

With the exception of leukemia, males in CT 5011.02 generally experienced lower cancer rates than expected for the seven cancer types evaluated. Although the incidence of leukemia among males in this area was not statistically significantly elevated, during 1982-1994, 6 cases occurred where approximately 4 cases were expected (SIR=142). When examined by smaller time period, leukemia incidence was approximately equal to the expected rate during the earlier time period 1982-1986 and slightly greater than expected during the later time period 1987-1994 (4 cases observed versus 2.7 cases expected). The incidence of bladder cancer overall in this area was statistically significantly lower than expected (7 cases observed versus 16 cases expected, SIR=44) during the 13 years evaluated. Specifically, this was the result of a lower than expected incidence of bladder cancer among males in this census tract (4 cases observed versus approximately 12 cases expected). These data are summarized in Table 16A and 16B.

As previously mentioned, Appendix B provides more recent cancer incidence data for the years 1995-1998. In Hingham CTs 5011.01 and 5011.02, some cancer types occurred less frequently than expected while others occurred more frequently than expected. However, none of the observed increases or decreases in these census tracts were statistically significant.

2) Census Tract 5012

In CT 5012, the Hingham census tract abutting the SWNAS, nearly all cancer types reviewed during the 13-year time period 1982-1994 were below expected rates based on the statewide incidence of these cancers. There were no statistically significantly elevated rates of any of the seven cancers evaluated. An increase of slightly more than three cases was observed in the incidence of NHL among males in this area of town (13 cases observed versus

approximately 10 cases expected). Among females in this census tract, a slight increase was observed in brain cancer incidence (5 cases observed versus approximately 4 cases expected, SIR=138). The increase was due to one additional case and did not indicate a statistical elevation from the expected number of cases. Lung cancer incidence in this census tract was statistically significantly lower than expected overall (54 cases observed versus 82.3 cases expected, SIR=66). The decrease in lung cancer in this area was primarily the result of a statistically significantly lower rate than expected among males in this area (30 cases observed versus 51.6 cases expected, SIR=58), although females also experienced a lower than expected incidence of this cancer.

Review of cancer incidence rates in CT 5012 for the two smaller time periods again indicated that most cancer types occurred below expected rates. There were no statistically significant elevations observed for any cancer types in either of the smaller time periods 1982-1986 or 1987-1994. During the earlier time period 1982-1986, the only increase observed in CT 5012 was in the incidence of bladder cancer among males. This was the result of one additional case above the expected number (7 cases observed versus approximately 6 cases expected, SIR=120). All other cancer types occurred at or below the expected incidence in this census tract during 1982-1986. Also, no cases of kidney, liver, or pancreatic cancer were observed in CT 5012 during 1982-1986.

Review of cancer incidence rates in CT 5012 during the later time period 1987-1994 indicated lower than expected rates for six of the eight cancer types evaluated. Lung cancer occurred significantly less often than expected among males and females combined in this area as well as among males (20 cases observed versus approximately 33 cases expected, SIR=60). Lung cancer also occurred less often than expected among Hingham females in CT 5012 during this time period. However, among females, the difference between the observed and expected number of cases was not statistically significantly lower as observed for males. Slight increases were observed during the later time period in the incidence of kidney cancer and NHL. The increase in NHL was observed among males (10 cases observed versus 6.9 cases expected, SIR=145). A slight increase in kidney cancer was observed among females in Hingham CT 5012 (5 cases observed versus 3.3 cases expected). When both kidney cancer and NHL were

evaluated statistically, the increases were not significantly greater than the expected rates. These data are presented in Tables 17A and 17B.

A review of more recent cancer incidence data shows that for the years 1995-1998 in CT 5012, the cancer types evaluated occurred approximately at or near the expected rates (see Appendix B). Although some cancer types occurred slightly more often than expected, none of the observed elevations were statistically significant.

G. Cancer Incidence in the Town of Rockland

Cancer incidence results for the years 1982-1994 for the town of Rockland are presented in Appendix A, Section IV. However, kidney cancer was not evaluated as part of this previous report. For the town of Rockland as a whole, kidney cancer was lower than the rate expected between 1982-1994 and during the two smaller time periods. Among males and females combined, 14 cases of kidney cancer were observed in Rockland whereas approximately 19 were expected between 1982-1994. Kidney cancer results for the town of Rockland are presented in Table 18.

When kidney cancer was evaluated in Rockland census tracts, this cancer type generally occurred at or below the rates expected. A slight elevation was observed in CT 5021 among males and females combined during the time period 1987-1994, however this elevation was based on less than two cases (9 cases observed versus 7.4 cases expected, SIR=121).

VI. REVIEW OF CANCER RISK FACTOR INFORMATION

As previously mentioned, cancer is not just one disease but is a term used to describe a variety of different diseases. As such, studies have generally shown that different cancer types have different causes, patterns of incidence, risk factors, latency periods (i.e., period between exposure and development of disease), characteristics and trends in survival. Information available from the MCR related to age and gender patterns, as well as other factors related to the development of cancer (e.g., smoking and occupation), were reviewed for those cancer types that had statistically significant elevations in Weymouth, Abington, and Hingham, with particular emphasis on those census tracts near the SWNAS. A review of risk factor information for the

cancer types evaluated in the town of Rockland is presented in Appendix A, Section IV. Cancer types that were statistically significantly elevated in the town of Weymouth as a whole or in one of its census tracts between 1982-1994 or one of the smaller time periods included lung cancer, leukemia, pancreatic cancer, and brain cancer. The town of Abington experienced a statistical elevation of lung cancer town-wide among males and in CT 5202.02. A statistically elevated rate of bladder cancer was also observed among females in Abington CT 5202.01. In Hingham, lung cancer was statistically elevated among females in CT 5011.02. Information for each of these cancer types was compared to known or established incidence trends to assess whether any unexpected patterns exist among these cases. More complete risk factor information for each of the eight cancer types evaluated in this report is included in Appendix C.

A review of risk factor information available from the MCR for all four towns and census tracts where a statistically significant elevation was observed during the 1995-1998 time period is presented in Appendix B, Section V.

A. Age/Gender Distribution

1) Lung Cancer

During the period 1982-1994, lung cancer was statistically significantly elevated town-wide in Weymouth and in CTs 4222, 4225, and 4227. Lung cancer was also statistically significantly elevated among Abington males town-wide and in CT 5202.02, and among females in Hingham CT 5011.02. Lung cancer in Rockland CT 5021.01 was also elevated during 1987-1994, most notably among females, who experienced a statistically significant increase in the number of cases. According to epidemiological literature, the incidence of lung cancer increases sharply with age peaking at about age 60 to 70. Only two percent of lung cancers occur before the age of 40. Also, lung cancer incidence is generally observed more often among men than women, however, an increase in smoking among women has produced lung cancer incidence rates among females similar to those experienced by males (Blot and Fraumeni 1996, MCR 1997, 2000).

Lung cancer cases in Weymouth displayed an age and gender distribution that was as expected based on the known pattern for this cancer type. Among all individuals diagnosed with

lung cancer in Weymouth during 1982-1994, 4 (1%) were diagnosed before age 40. Those individuals who were diagnosed before age 40 resided in different census tracts. When male and female lung cancer were evaluated separately in the town of Weymouth, both were statistically significantly elevated. However, generally more males (60%) than females (40%) were diagnosed with lung cancer in the town as a whole. In Weymouth CTs 4221 and 4222, the CTs adjacent to SWNAS, all individuals diagnosed with lung cancer were over age 40 at diagnosis. Also, the majority of cases diagnosed in both census tracts were male (54% in CT 4221 and 57% in CT 4222). The age distribution for lung cancer in all other Weymouth census tracts was as expected for this cancer type.

In Abington, lung cancer cases also revealed an age and gender distribution that was as expected based on the known patterns of this disease. Overall, males accounted for 63% of all cases diagnosed in the town, while females accounted for 37%. Review of the age distribution among both males and females revealed the majority of cases were diagnosed between the ages of 40 and 70 (85% and 91%, respectively). In Abington CT 5202.01, a slightly different gender distribution was observed than in the town. While males accounted for a lower percentage of lung cancer cases in this census tract (approximately 58%) as compared to the town of Abington as a whole (63 %), the age distribution of both males and females was as would be expected based the known pattern of this disease. A very similar age and gender distribution was observed among lung cancer cases in CT 5202.02, where a statistical elevation among males was observed between 1982-1994 and 1982-1986.

When the age distribution was reviewed for lung cancer cases in Hingham overall, 98% of cases were diagnosed after age 40 with males (52%) experiencing a slightly greater percentage of cases than females (48%). Also, 72% of individuals with lung cancer in the town were diagnosed in their 60s and 70s. In CT 5011.02 where lung cancer was statistically elevated among females between 1982-1994, 100% of cases were diagnosed after the age of 40 and 76% were between the ages 60-70.

2) Leukemia

Statistically significant elevations in leukemia were observed in the town of Weymouth as a whole as well as in CTs 4221, 4222, and 4224. There are four major types of leukemia.

These types have different risk factors suspected to be associated to their development and occur with different frequency among adults and children. Acute lymphocytic leukemia (ALL) occurs predominantly among children. An elevation in the incidence of ALL is also seen among older individuals, which typically begins at approximately 40-50 years of age and peaks at about age 85 (Linet M.S. and Cartwright R.A. 1996). The age distribution of the ALL type of leukemia in Weymouth was as expected based on what is known about the age distribution and development of this cancer. The majority (i.e., 69%) of ALL cases were diagnosed among individuals prior to age fifteen. Chronic lymphocytic leukemia (CLL) is chiefly an adult disease. Ninety percent of individuals diagnosed with CLL are over the age of 50 (Miller et al. 1990). In Weymouth, 93% of CLL cases were diagnosed after the age of 50. The incidence of acute myelocytic leukemia (AML) increases slightly in childhood and levels off through middle age. A rapid increase in the incidence of AML is observed after about age 55 (LSA 1999). The incidence of AML in Weymouth was consistent with the pattern for this cancer type. While 36% of individuals diagnosed with AML were diagnosed below age 55, the majority of individuals diagnosed with this type of leukemia (64%) were over age 55. Chronic myelocytic leukemia (CML) can occur at any age, however it is not often observed in childhood and is most frequently observed after age 50 (LLS 2001). All individuals diagnosed with CML in Weymouth were age 50 or above.

3) Pancreatic Cancer

The occurrence of pancreatic cancer is extremely rare before the age of thirty and the median age observed at diagnosis is 71. It has been observed that the occurrence of pancreatic cancer is almost 50% higher among males than females (Anderson et al. 1996).

Pancreatic cancer was statistically significantly elevated in the town of Weymouth as a whole and in CT 4224 in the earlier time period 1982-1986 when compared with the state rate for this cancer. While no cases of pancreatic cancer in Weymouth were diagnosed before the age of 30, a slightly different gender distribution was observed among the cases than would be expected based on the epidemiologic literature. Twenty-four (62%) of the 39 pancreatic cancer cases observed in the town overall between 1982-1986 were female whereas 38% of cases were diagnosed among males during this time. This unexpected pattern was also observed in CT 4224 between 1982-1986 where pancreatic cancer occurred more often among females (81%) than

males (18%). Age-specific incidence rates in CT 4224 indicate that the elevation in pancreatic cancer incidence between 1982-1986 was primarily the result of women diagnosed after the age of 65.

4) Bladder Cancer

During 1982-1994, bladder cancer was statistically significantly elevated among females in Abington CT 5202.01, located adjacent to the SWNAS. Bladder cancer accounts for 6% of all cancers diagnosed in the United States among men and 2% among women. White males have the highest prevalence of bladder cancer among all racial groups. A male to female ratio of approximately four to one has been observed among whites, while a slightly lower male to female ratio of three to one has been observed among most other racial groups. Further, the occurrence of bladder cancer rises with increasing age; approximately two-thirds of all bladder cancer cases occur in persons age 65 and over. There has been little or no association between socioeconomic status and the development of bladder cancer (Silverman et al, 1996).

Review of available data for bladder cancer cases in Abington revealed that the majority of cases diagnosed in the town were male (62%) and were also diagnosed at age 60 or above (77%). While the pattern in the town overall is consistent with what would be expected based on the literature for this disease, in CT 5202.01 the age distribution was as expected but the gender distribution was not. While the majority of cases in this census tract were 60 years of age or above (63%) at the time of diagnosis, most of the bladder cancer cases diagnosed in CT 5202.01 were female (75%).

5) Brain Cancer

A statistically significant elevation in brain cancer was observed among males and females in CT 4227, located in the northern part of Weymouth. According to the epidemiological literature, brain tumor incidence (cancerous and non-cancerous) declines after a peak in childhood (under ten years of age), then increases from age 25 to age 75, and levels off after age 75 (Preston-Martin and Mack 1996). Males are almost twice as likely than females to develop a brain tumor of any type (i.e., cell type) (Bondy and Wrench 1996). Certain types of brain tumors are more likely to develop in children and others are more typically seen in adults

(Black 1991, NCI 1996). The review of age and gender patterns among brain cancer cases in Weymouth revealed that the majority of individuals were male (58%) and that the age at diagnosis for all cases was consistent with the pattern expected for brain cancer. In CT 4227 where a statistical elevation was observed among males and females combined, the age at diagnosis was also consistent with what would be expected. All but one of the individuals diagnosed with brain cancer were diagnosed prior to age ten or after age 25.

B. Histology

1) Lung

Lung cancer is often divided into two main types: small cell lung cancer and non-small cell lung cancer. Non-small cell lung cancer is sub-divided into three types: squamous cell carcinoma, adenocarcinoma, and large-cell undifferentiated carcinoma. The different types of lung cancer occur with different frequencies in the population. The American Cancer Society estimates that approximately 40% of all lung cancers are adenocarcinomas, 30% are squamous cell carcinomas, 20% are small cell cancers, and 10% of cases are large cell carcinomas (ACS 2000a).

An expected histologic distribution pattern was observed in the town of Weymouth where lung cancer was statistically elevated among males and females combined between 1982-1994. Thirty-two percent of lung cancer cases in the town of Weymouth were adenocarcinomas, 26% were squamous cell carcinomas, 16% were small cell cancers, and 14% were large cell carcinomas. A slightly different pattern was observed among specific types of lung cancer in CT 4222 where a statistical elevation was observed. Thirty-seven percent of lung cancer cases were adenocarinomas, 25% were small cell cancers, 16% were squamous cell carcinomas, and 13% were large cell cancers. Weymouth CTs 4225 and 4227 showed histology type distribution patterns that were consistent with the current literature.

A slightly different histologic distribution pattern was observed in the town of Abington, where male lung cancer rates were statistically elevated town-wide between 1982-1994. Twenty-seven percent of male lung cancer cases in Abington were squamous cell carcinomas, 25% were adenocarcinomas, 20% were small cell cancers, and 11% were large call carcinomas.

In Abington CT 5202.02, where a statistical elevation was also observed among males in this time period, the frequencies of lung cancer types were more typical of what would be expected. Thirty-one percent of male lung cancer cases were adenocarcinomas, 24% were squamous cell carcinomas, 10% were small cell cancers, and 17% were large cell carcinomas.

A statistical elevation in lung cancer was also observed among females in Hingham CT 5011.02 between 1982-1994. Of the lung cancer cases in this census tract, 32% of cases were adenocarcinomas, 22% were squamous cell carcinomas, 11% were small cell cancers, and 11% were large cell carcinomas.

2) Leukemia

As previously stated, there are four major types of leukemia, ALL, CLL, AML, and CML. Available information regarding the expected distribution of leukemia by histology types can vary considerably depending on coding methods, making comparisons of type-specific incidence rates from different cancer registries difficult (Linet and Cartwright 1996). In the state of Massachusetts during the time period 1982-1994, 29% of all leukemia cases were AML, 25% were CLL, 14% were ALL, 11% were CML, and 21% were other histology types. Among leukemia cases in the town of Weymouth during the same time period, AML (32%) occurred most often, followed by CLL (19%), ALL (16%), and CML (11%), while 21% of Weymouth leukemia cases were other forms. A statistical elevation of leukemia was observed among Weymouth males in CT 4221 between 1982-1994. Leukemia was also statistically significantly elevated among males and females combined in CT 4222 and among males in CT 4224 in the later time period 1987-1994. Within these census tracts and time periods the breakdown of leukemia by histology type was similar to that observed both state- and town-wide, with AML occurring most often, followed by CLL. While there is some suggestion that the occurrence of AML can be associated with external or environmental factors such as benzene or high dose radiation exposures, these factors are not thought to play a role in the development of CLL (Linet 1985, Linet and Cartwright 1996, LSA 1999, NCI 1995).

3) Brain Cancer

Primary brain tumors (i.e., brain cancer) mainly comprise two types: gliomas and malignant meningiomas. Gliomas are a general classification of brain cancer that also include a variety of different types. Astrocytomas and medulloblastomas, which are types of gliomas, are the most common brain cancers occurring in children (Black 1991). In adults, the most frequent types of brain tumors are astrocytic tumors, a type of glioma (mainly astrocytomas and glioblastoma multiforme) and meningiomas. Among brain cancer cases in CT 4227 in Weymouth, where a statistically significant elevation was observed among males and females combined, all of the cases were gliomas, and of these approximately half were astrocytomas and half were glioblastomas. Among children and adults within this census tract, all of the cases were of a histology type most commonly expected for the age at which they were diagnosed.

C. Smoking Status

Cigarette smoking is a known or suggested causal risk factor in several types of cancer. Lung and bladder cancers are strongly associated with a history of smoking (Schottenfeld and Fraumeni 1996). In addition, a positive smoking history is the most documented risk factor related to the development of pancreatic cancer (NCI 1996).

1) Lung Cancer

Smoking is the most important cause of lung cancer in the United States, and it is estimated that 87% of lung cancer cases among men and women are caused by smoking (ALA 2001). An increase in cigarette smoking among women has produced lung cancer incidence rates that more closely resemble those which are experienced by males. Female lung cancer incidence in Massachusetts increased more than 46% between the years 1982-1994 (MCR 1997). Among Massachusetts males during this same time period, lung cancer decreased by approximately 3% (MCR 1997). The risk of developing lung cancer depends on the intensity of ones smoking habits (i.e., duration of habit, amount smoked, tar yield of cigarette, and filter type).

In the town of Weymouth, statistical elevations in lung cancer were observed town-wide, and in CTs 4222, 4225, and 4227 between 1982-1994. Between 1982 and 1996, lung cancer was

also statistically elevated among males in CT 4226. During the 13-year time period 1982-1994, the smoking status of lung cancer cases in Weymouth revealed that the majority of individuals were current or former smokers (82%). This was very similar to the percentage of lung cancer cases in Massachusetts who were current or former smokers (81%). Refer to Figure 5a.

Review of the smoking status of lung cancer cases in the later time period 1987-1994 when lung cancer was also statistically significantly elevated, revealed a smoking distribution among cases in Weymouth that was also very similar to Massachusetts. During this time period, 85% of Weymouth lung cancer cases (n=296) were current or former smokers at the time of diagnosis. In comparison, 83% of lung cancer cases in Massachusetts were current or former smokers. The percentage of lung cancer cases in Weymouth that reported never having smoked was also very similar to that observed among state cases between 1987-1994. In Weymouth, 5% of lung cancer cases reported never having smoked, while in Massachusetts a slightly higher percentage (7%) was observed. Refer to Figure 5b.

In CT 4222, 90% (n=71) of lung cancer cases between 1982-1994 were current or former smokers at diagnosis. Only three percent of cases (n=2) reported never having smoked, while 8% (n=6) reported an unknown smoking status. In CT 4225, 77% (n=37) of those diagnosed with lung cancer reported themselves as current or former smokers. Six percent (n=3) reported never having smoked and 17% (n=5) had an unknown smoking status. Eighty-one percent (n=50) of lung cancer cases in CT 4227 were current or former smokers. Eight percent (n=5) were non-smokers and 11% (n=7) had an unknown smoking status. Refer to Figure 6 for the distribution of smoking status among lung cancer cases in these three CTs and the state. Among males in CT 4226 diagnosed with lung cancer between the earlier time period 1982-1986, 18 (82%) were current or former smokers at the time of diagnosis.

In the town of Abington, lung cancer was statistically elevated town-wide among males and in CT 5202.02 among males as well as among males and females combined. Elevations were noted for lung cancer during 1982-1994 and the 1982-1986 time period. The distribution of smoking status among lung cancer cases in Abington was reviewed for both time periods. Review of these data revealed that the distribution of smoking status among lung cancer cases town-wide and in CT 5202.02 was very similar to that observed among lung cancer cases in

Massachusetts. Refer to Figures 7a and 7b for the smoking distribution of lung cancer cases in Abington and Massachusetts. In both time periods 1982-1994 and 1982-1986, the majority of cases reported a smoking status as current or former smoker (i.e., 86%). While smoking status data were comparable during these time periods, the percentage of lung cancer cases that reported their smoking status as current or former smoker was higher in Abington (86%) and even higher in CT 5202.02 (89%) than in the state as a whole (81%).

The distribution of smoking status among male lung cancer cases in Abington, CT 5202.02 and the state between 1982-1994 are presented in Figure 8a. The percentage of male lung cancer cases who were current and former smokers in Abington was approximately equal to the state (84% in Abington versus 83% in Massachusetts), whereas in CT 5202.02, the percentage of lung cancer cases that were current and former smokers was higher than the state (86% in CT 5202.02 versus 83% in Massachusetts).

During the 1982-1986 time period, the percentage of male lung cancer cases who were current or former smokers was higher in Abington (84%) than the state (81%). Among male lung cancer cases in CT 5202.02, less reported themselves as current or former smokers (77%) when compared with the state (81%) (see Figure 8b).

In Hingham CT 5011.02, lung cancer was statistically significantly elevated among females during the 13-year period evaluated and the earlier time period 1982-1986. The distribution of smoking status was reviewed for female lung cancer cases in this census tract and compared to the distribution in Massachusetts during these two time periods (refer to Figures 9a and 9b). During the overall time period 1982-1994, the percentage of current or former smokers among females diagnosed with lung cancer in CT 5011.02 was 8% higher than females with lung cancer in the state (86% in CT 5011.02 versus 78% in Massachusetts). The percentage of females with lung cancer that reported never having smoked was 8% lower in this census tract than in Massachusetts (3% in CT 5011.02 versus 11% in Massachusetts). Smoking status was unknown for 11% of females diagnosed with lung cancer in CT 5011.02.

During the earlier time period 1982-1986, the percentage of current or former smokers was 15% greater for females with lung cancer in Hingham CT 5011.02 than females diagnosed with lung cancer in Massachusetts (89% in CT 5011.02 versus 74% in Massachusetts). The

percentage of females diagnosed with lung cancer that never smoked was 6% lower in CT 5011.02 than in the state (6% and 12%, respectively). Refer to Figure 9b.

Smoking induces lung cancers of all the major histologic types. The strongest associations are for squamous cell and small cell carcinomas, but dose-response relationships for adenocarcinomas and other cell types have also been reported (Blot and Fraumeni 1996). Once considered minimally related to cigarette smoking, adenocarcinomas have become the most common type of lung cancer in the United States. Histology data were also examined in an effort to describe the distribution of different histology types and their possible relationship with smoking status. A review of Weymouth lung cancer cases whose smoking status was known revealed that for those types of lung cancer most associated with smoking (small cell lung cancer and squamous cell carcinoma), 94% reported being a current or former smoker. Within those Weymouth census tracts where statistically significantly elevated rates of lung cancer were observed, the percentages of small cell lung cancer and squamous cell carcinoma cases with a known smoking status who were current smokers ranged from 89% to 100%. Of males in Abington diagnosed with small cell lung cancer and squamous cell carcinoma with a known smoking status, 100% reported themselves as current or former smokers. In Hingham CT 5011.02, where lung cancer was statistically significantly elevated among females, 91% of small cell lung cancer and squamous cell carcinoma cases with a known smoking status reported being current or former smokers.

2) Pancreatic Cancer

The most consistent and only established risk factor for pancreatic cancer is cigarette smoking (Anderson et al 1996). According to the American Cancer Society, approximately 30% of all pancreatic cancer cases are thought to result directly from cigarette smoking (ACS 2000b). Studies have estimated that the risk of pancreatic cancer is two to six times greater in heavy smokers than in non-smokers (Anderson et al 1996).

The smoking status of female pancreatic cancer cases in Weymouth as a whole and in CT 4224 in the 1982-1986 time period were reviewed due to statistically significant elevations observed among females during this time (see Figure 10). In Weymouth, 42% (n=10) of female pancreatic cancer cases were current or former smokers at the time of diagnosis. While 29%

(n=7) of cases reported never having smoked, 29% (n=7) also reported an unknown smoking status. When compared with the state, 10% more female pancreatic cancer cases in Weymouth reported being current or former smokers at the time of diagnosis than the state (32% in Massachusetts versus 42% in Weymouth during the same 1982-1986 period). In CT 4224 between 1982-1986, 22% of female pancreatic cancer cases reported themselves as current or former smokers. Smoking status was unknown for four of the nine females (44%) diagnosed with pancreatic cancer during this time period.

3) Bladder Cancer

Bladder cancer was statistically significantly elevated among females in Abington CT 5202.01 between 1982-1994. When the percentage of females with bladder cancer from CT 5202.01 who smoked was compared to that of female bladder cancer cases in Massachusetts, the percentage of current and former smokers was 26% higher in this area than the state (67% in CT 5202.01 versus 41% in Massachusetts). Also, the percentage of females with bladder cancer who reported never having smoked was 18% lower in this census tract than in the state (17% in CT 5202.01 versus 35% in Massachusetts). The distribution of smoking status among female bladder cancer cases in Abington, CT 5202.01 and Massachusetts is presented in Figure 11.

D. Occupation

Occupational information as reported to the MCR was reviewed for cancer types that have been associated with exposures in specific occupations. This information was reviewed to determine whether occupational factors might have contributed to the development of certain cancers in Weymouth, Abington, Hingham, and Rockland. It should be noted, however, that the occupational information reported to the MCR is generally limited to job title and often does not include specific job duty information that could further define exposure potential for individual cases. In addition, occupational information is often incomplete in that a number of individuals have a reported occupation as "unknown" or "retired."

Occupational exposures to certain chemicals have been associated with the development of certain cancers. Industrial workers often have more intense and prolonged exposures to chemicals than does the general population particularly in the past when standards and

regulations for worker protection were not established or enforced. A number of chemicals in the workplace that are considered carcinogenic or probably carcinogenic have been identified. These include metals (e.g., arsenic, chromium, nickel and cadmium), solvents (e.g., benzene, styrene, carbon tetrachloride, dichloromethane), organic and inorganic dusts (e.g., leather or wood dusts, asbestos, silica), chemicals used to construct polymers, and pesticides (e.g., ethylene oxide, amitrole, chlorophenoxy herbicides, DDT, toxaphene) (NCI 1996).

1) Lung Cancer

Several occupational exposures have been identified as playing a role in the development of lung cancer. Occupations such as underground miners, chemical workers, paper and pulp workers, carpenters, butchers and meat packers, and shipyard workers are some of the occupations associated with increased risk of developing lung cancer. This is a result of exposure to a number of substances that may be found in these workplaces such as arsenic, asbestos, chloromethyl ethers, chromium, vinyl chloride, and ionizing radiation. In addition, occupational exposure to such compounds in conjunction with cigarette smoking can dramatically increase the risk of developing lung cancer (Blot and Fraumeni 1996).

Review of occupational information for lung cancer cases in the town of Weymouth revealed that 35% of cases reported their occupation as retired or unknown. Only seven percent (n=37) of lung cancer cases reported an occupation that could possibly be associated to the development of this cancer (i.e., shipyard worker). For the remaining individuals (i.e., 58%) the occupational information either indicated a job title not associated with known exposures to potential lung carcinogens or was not specific enough to determine whether the occupation may be associated with exposures that could increase the risk of lung cancer.

In the town of Abington, 28% of individuals diagnosed with lung cancer reported their occupation as retired or unknown. Of the 128 individuals with lung cancer, 10 (8%) reported occupations that may have had exposures related to an increased lung cancer risk. In CT 5202.02 where a statistical elevation of lung cancer was observed, 36% (n=17) of individuals reported their occupation as retired or unknown. Four individuals (9%) in this census tract reported occupations that may have exposures related to an increased risk of developing lung cancer.

While occupation was reported as retired or unknown for 27% (n=39) of individuals diagnosed with lung cancer in Hingham, 9% (n=13) reported occupations that could be associated with increased risk of developing this disease. In CT 5011.02, where a statistical elevation in lung cancer was observed among females, four (6%) individuals reported an occupation that may have exposures related to an increased risk of lung cancer (i.e., carpenter).

2) Leukemia

Some occupational exposures to particular chemicals are thought to increase the risk of developing certain kinds of leukemia. Exposure to ionizing radiation, chronic, high-dose exposure to pesticides, and other chemicals such as benzene, are all thought to increase the risk of developing certain types of this disease (Linet and Cartwright 1996, LSA 1999, NCI 1996). Chronic occupational exposure to benzene has been established as a cause of AML. High doses of irradiation are associated with an increased incidence of AML, CML, and ALL, but no association has been established for lower doses such as when used in medical diagnostics (LLS 2001).

In the town of Weymouth, occupation was reported for only 43% of leukemia cases. Of the 34 adults with leukemia for which an occupation was reported, two individuals had an occupation in which exposure to some of the chemicals listed above may have been possible. One of these individuals resided in CT 4221 where a statistically significant elevation in leukemia was observed among males.

3) Pancreatic Cancer

Numerous occupations have been investigated for their potential role in the development of pancreatic cancer, but studies have not produced consistent results. Since the 1970's almost 100 studies have been completed looking at occupations ranging from asbestos workers to office clerks and a relationship to this cancer. Working with ionizing radiation, asbestos, fossil fuel products, and various other chemicals (including DDT and its derivatives) has been suggested as associated with pancreatic cancer in some studies, still other contrasting studies have found no link between these possible agents and pancreatic cancer (Anderson et al 1996). Many of the studies mentioned previously have a sample population that is too small to be able to give

consistent meaningful results. This is due to the fact that the incidence of pancreatic cancer is relatively low, especially when classified by job title.

Information related to occupation was reviewed for pancreatic cancer cases in Weymouth, 55% reported an occupation that was unknown or retired. While less than 30% of pancreatic cancer cases in Weymouth reported an occupation, only 3% listed occupations that have been suspected in some studies to be associated to this cancer type. Among females diagnosed with pancreatic cancer between 1982-1986, where a statistical elevation of this cancer was observed, 10 (42%) reported an occupation as "retired" or "unknown," and six (25%) reported their occupation as "at home." None of the females in this time period reported an occupation that has been suggested to be associated with development of pancreatic cancer.

4) Brain Cancer

Various studies on worker exposure to vinyl chloride and chemicals in the petrochemical industry have had conflicting results as to the association between these chemicals and the development of brain tumors. Studies investigating the possible association between occupational exposure of parents (in particular, paper or pulp-mill, aircraft, rubber, and electric workers) and the onset of brain tumors (cancerous and non-cancerous) in their children have also provided inconsistent results (Preston-Martin and Mack 1996).

Among adults in Weymouth diagnosed with brain cancer, an occupation was reported for 23 individuals (61% of all cases). None of the individuals reported occupations where exposures to the chemicals listed above were likely to have occurred. For children diagnosed with brain cancer, occupational information was available for only one parent to evaluate this potential risk factor. The occupation reported was not one that has been suggested as being possibly associated with development of brain tumors in children.

VII. COMMUNITY ENVIRONMENTAL CONCERNS AND GEOGRAPHIC DISTRIBUTION OF CANCER

The primary purpose of this report is to provide a summary of possible off-site environmental exposures near the SWNAS and to assess whether patterns of cancer exist that

may suggest environmental factors related to the base could have played a role in the incidence of cancer. In addition to determining census tract-specific incidence ratios for each cancer type, a qualitative evaluation was conducted to determine whether any specific cancer type appeared to be concentrated in any of the four towns of Weymouth, Abington, Hingham, and Rockland or their census tracts.

During the course of conducting the SWNAS cancer incidence investigation, the MDPH was also contacted by members of the community who had concerns about suspected increases in cancer in other areas of the four towns unrelated to the base. This section also addresses the geographic patterns of cancer in relation to potentially hazardous waste sites (21E Sites) within the four towns, the Weymouth Neck Landfill and in other specific neighborhoods located in Weymouth and Hingham. As presented in Appendix A, other community environmental concerns in Rockland included the Suburban Auto site, neighborhoods along French's Stream, and two landfills in town. Review of the geographic distribution of cancer for the years 1982-1998 in these areas did not reveal any unusual patterns or concentrations.

As previously mentioned, cancer is one word that describes many different diseases. Therefore, for the purposes of this evaluation, the geographic distribution of each cancer type was evaluated separately to determine whether an atypical pattern of any one type occurred. The geographic distributions of some specific cancer types were also evaluated together because they may have similar etiologies (i.e., leukemia and NHL in children). In addition, cancers that may be associated with specific environmental exposures of concern were also evaluated geographically to determine whether any atypical patterns of cases exist that may suggest an association with an environmental factor.

Place of residence at the time of diagnosis was mapped for all cancer types to assess any possible geographic concentration of cases. In general, when the geographic distribution of each cancer type was reviewed for all four towns together, no apparent spatial patterns at the neighborhood level were observed. The patterns that were observed indicated that the pattern of cancer in the four towns was consistent with the population distribution and areas of higher population density. For example, although statistically significant elevations of lung cancer were observed in Weymouth CTs 4222, 4225, 4226, and 4227, the distribution of cases within

each of these census tracts seemed to coincide closely with the pattern of population in these areas. This same pattern was observed in areas where other cancer types were statistically significantly elevated.

A. South Weymouth Naval Air Station (SWNAS)

Community environmental concerns expressed to MDPH regarding the SWNAS have largely focused on whether base activities have had an impact on nearby residents, and in particular, whether there is any relationship to a pattern of increased cancer incidence in neighborhoods of the four towns surrounding the former air base. Several specific environmental concerns have been raised by the community including potential exposures associated with off-site migration of base contaminants via movement of contaminated groundwater, the Old Swamp River, French's Stream, and flight patterns of aircraft used at the base. To address most of these environmental exposure concerns, the MDPH reviewed information on off-site migration presented in several reports including a Public Health Assessment for the SWNAS completed by the Agency for Toxic Substances and Disease Registry (ATSDR), and the SWNAS Phase I Environmental Baseline Study (ATSDR 1999a, Stone and Webster 1996). In addition, MDPH reviewed information on aircraft flight patterns from a NAS South Weymouth Master Plan provided by the U.S. Navy (U.S. Navy 1990). This section is not intended to provide a comprehensive evaluation of all environmental data and investigations associated with the SWNAS. Results of subsequent investigations that further characterize the potential for off-site contaminant migration, particularly in the northwest corner of the base, were not available at the time of these analyses and therefore could not be fully evaluated as part of this cancer incidence evaluation.

In response to public health issues at the base, the ATSDR released a final Public Health Assessment (PHA) for the SWNAS in September 1999. This PHA was a review of environmental data and investigations conducted to evaluate potential human exposures including exposure to on-site and off-site groundwater, on-site and off-site surface water, and both surface and sub-surface soils associated with the SWNAS. Based on ATSDR's review of potential exposure pathways using environmental sampling data available at the time, the PHA concluded that potential past and current exposures at the base posed no apparent public health

hazards (ATSDR 1999a). However, virtually no off-site sampling data were available to fully evaluate off-site exposures, particularly potential past exposures that may indicate a possible relationship to cancer incidence. In addition, a review of cancer incidence data in relation to possible exposures from the SWNAS was not conducted as part of the PHA.

As a whole, the geographic distribution of cancer in the four communities surrounding the base did not present a pattern that would suggest the existence of a common environmental exposure pathway related to the SWNAS. As previously noted, several cancer types showed statistically significant elevations in census tracts adjacent to the base. However, when the geographic distribution of these cancers were evaluated at a smaller geographic level, the patterns of cases did not appear to be unusually clustered close to the base. Bladder cancer was statistically elevated among females in Abington CT 5202.01 between 1982-1994, however the majority of cases were located in the more populated areas of this census tract along the southern portion of the census tract. Although statistically significant elevations in leukemia were observed in Weymouth CTs 4221 and 4222 abutting the SWNAS, none of the cases were unusually concentrated in any one area within these two census tracts. Although lung cancer was statistically elevated in CT 4222 among males and females combined between 1982-1994, the distribution of cases closely matched the distribution of population in the census tract. Between 1995 and 1998, kidney and pancreatic cancer were statistically significantly elevated in Weymouth CT 4221, and lung cancer was statistically elevated in both Weymouth CT 4222 and Rockland CT 5022 adjacent to the base. However, none of these cancers displayed a geographic pattern that would suggest an association with a common environmental risk factor or exposure pathway from the SWNAS.

1) Potential Off-Site Contaminant Migration

A number of factors need to be considered when evaluating the potential for actual human exposure. An exposure pathway is the process through which a person is exposed to contaminants from a particular source (ATSDR, 1993a). In order for actual human exposure to occur, five elements must be present: a source of contamination, transport of contamination through an environmental medium, a point of exposure or human contact, a route of human exposure (e.g. inhalation, ingestion, dermal contact), and an exposed population.

The ATSDR PHA identified potential off-site exposures that could result from contaminant transport in both groundwater and surface water (French's Stream and the Old Swamp River). These potential exposure pathways are described below. Environmental contamination identified at the SWNAS is largely associated with past operations and maintenance of aircraft, as well as the use, management, and disposal of hazardous materials (ATSDR, 1999a). The sampling and clean-up of specific contamination areas within the base are being overseen by both federal and state environmental agencies. As a result, environmental sampling data evaluated in the PHA was collected at specific contamination areas within the base and at select locations along the base boundary. Refer to Figure 12 for the location of the contamination areas mentioned throughout this section.

It should be noted that more recent investigations are currently being conducted at the Mill River tributary located near the Main Gate in the northwest corner of the SWNAS to address community concerns about arsenic exposure (see Figure 12). It is not clear whether this tributary is another possible source of off-site contaminant migration at the base, and results of sampling conducted in this area were not available at the time of this evaluation (MDEP 2001). However, as presented above, of the cancer types evaluated, none were unusually concentrated in areas close to the base, including the northwest corner where this new area of environmental investigation is located.

(a) Groundwater

There are several areas on the base where groundwater contamination was detected, however the PHA concluded that there is currently no evidence that off-site migration of groundwater is occurring (ATSDR 1999a). In general, groundwater at the SWNAS, flows into one of two major drainage basins whose border divides the base in a northwest/southeast direction (ATSDR 1999a). Water on the western portion of the base drains to the southwest and eventually discharges into the aquifer underlying French's Stream. Water on the eastern portion of the SWNAS drains to the northeast into the aquifer beneath the Old Swamp River.

The PHA evaluated 48 groundwater samples collected at the seven federally regulated contamination areas on the base and samples from six monitoring wells installed at or near perimeter locations around the base boundary. Groundwater contaminants identified above

ATSDR comparison values for drinking water in these areas on the base include metals, pesticides, and one semi-volatile organic compound (SVOC). Several metals were detected above ATSDR comparison values in five of the six perimeter wells including aluminum, arsenic, beryllium, iron, lead, manganese, and vanadium. The PHA noted that metals naturally occur in the environment and the presence of these metals may be attributed to natural soil processes and may not be related to base contamination (ATSDR 1999a). In addition, the PHA noted that perimeter wells containing elevated metals were located in areas where groundwater is migrating on-site, rather than off-site. No off-site groundwater monitoring has been conducted at the SWNAS (Barney 2001).

Additional areas on the base where groundwater contamination was identified include the Fuel Tank Farm, Building 8, Quarters A and Quarters F, the Jet Fuel Pipeline, and at the US Coast Guard (USCG) Buoy Depot. In most cases, contamination at these locations consisted of fuel oil and/or VOC vapors and is undergoing remediation (ATSDR 1999a). A groundwater plume containing chlorinated volatile organic compounds (VOCs) was also identified beneath the Building 81 site, located off Shea Memorial Drive, in the central portion of the base (see Figure 12). The plume contains VOCs at levels that exceed ATSDR comparison values for drinking water, including perchloroethylene (PCE), and BTEX (Benzene, Toluene, Ethylbenzene, Xylene). However, according to the ATSDR PHA, no private off-site drinking water wells are located within or near the plume, and based on available groundwater monitoring to date, the plume does not appear to be migrating off the base (ATSDR 1999a).

Although there are no drinking water supply wells located on the base, some private wells have been identified in residential neighborhoods near the base. To address community concerns about potential drinking water exposures, the ATSDR conducted a survey in 1999 in all four towns to identify the location and use of private wells in the vicinity of the SWNAS. The survey was conducted to determine who has wells and for what they are used (ATSDR 1999b). The survey was based on ATSDR's review of well registration lists and used well information provided by the Weymouth, Hingham, Rockland, and Abington Boards of Health. The survey was conducted for those streets identified as being close to the SWNAS and identified a total of 61 private wells located on 37 streets near the base. No private wells on the nearby streets in Weymouth, Rockland, or Abington were identified as confirmed drinking water wells. Six wells

located near the base in Hingham CT 5012 were confirmed as drinking water wells. Thirty-two wells in the area had household use other than drinking water (i.e., for gardening or to fill a swimming pool), and two homeowners located within a half mile of the base in Rockland were considering installing a well at the time the survey was conducted. The remaining 21 wells identified by the well survey were used for monitoring or other unidentified purposes that may include household use. With the exception of one private well located west of the base in Weymouth, no private well sampling data were available. Because there were high concentrations of lead in soil at the USCG Buoy Depot, one private irrigation well located near the Buoy Station was sampled and tested for lead by the Weymouth Board of Health (Nolan 2001). No lead was detected in the water sample from this well. The ATSDR well survey did not include information on past use of private wells for drinking water purposes. In addition, any unregistered wells would not be included in the well survey.

The PHA concluded that it is unlikely that nearby residents are being exposed to contaminated groundwater detected on the base because information indicated base-related contaminants are located within the site boundaries and are not migrating off-site (ATSDR 1999a). There are little to no off-site groundwater sampling data (Barney 2001). In addition, information regarding private drinking water well use in the past was not available.

The MDPH evaluated cancer incidence patterns relative to the locations of private wells identified by the ATSDR survey, particularly those in Hingham CT 5012 where drinking water wells were identified near the base. Review of cancer incidence data between 1982 and 1998 indicated that none of the cancer types were statistically significantly elevated in this census tract and the majority of cancer types occurred less often than expected. None of the eight cancer types evaluated were unusually concentrated in the vicinity of those wells identified as being used for drinking water or other household use.

(b) Surface Water - Old Swamp River

The Old Swamp River flows from south to north and traverses the eastern portion of the base near the end of runway 08/26 (see Figure 12). Contaminated areas on the base that could potentially impact this river include the Rubble Disposal Area and the Small Landfill, and several drainage ditches that discharge to the river. According to the PHA exposure evaluation,

the Old Swamp River is considered a recreational water body where activities such as wading may take place (ATSDR 1999a). The river flows north through residential and commercial neighborhoods in Hingham and Weymouth after leaving the base.

No off-site samples were taken to evaluate whether base contaminants detected on-site are also present in off-site surface water or sediment of Old Swamp River (ATSDR 1999a, Barney 2001). The PHA reviewed sampling data from the Old Swamp River at the Rubble Disposal Area and a few nearby base areas. Several contaminants were identified including antimony, arsenic, iron, manganese and thallium in surface water, and PAHs, pesticides, arsenic and iron in sediment. According to the PHA, sampling of Old Swamp River at the base boundary downstream of the Rubble Disposal Area and Small Landfill showed manganese in surface water, and arsenic and iron in sediment above ATSDR comparison values for drinking water and soil exposure (ATSDR 1999a). Because no comparison values exist for surface water and sediment, the PHA used drinking water comparison values for surface water and soil comparison values for sediment. This represents a more conservative comparison because drinking water and soil comparison values assume more frequent exposures.

As presented in the PHA, adults and children who visit or play in the Old Swamp River downstream from the base could potentially be exposed to base contaminants if they come in contact with water or sediments downstream, where contamination may have migrated off-site. However, no off-site sampling data were available to confirm that off-site contamination exists downstream from the base.

The PHA also considered exposure through consumption of fish caught in the Old Swamp River. It was concluded that if contaminants are present in fish tissue, the concentrations are expected to be low since fish are stocked annually and therefore are not in the river long enough to accumulate contaminants that may be present in water and sediments (ATSDR 1999a). No sampling of fish from the Old Swamp River downstream from the base has been conducted. Therefore no data were available to evaluate whether fish tissues contain contaminants associated with the base (ATSDR 1999a, Barney 2001).

Approximately two and a half miles north and downstream of the SWNAS, the Old Swamp River discharges to South Cove in Whitman's Pond. According to the PHA, recreational

activities that may take place in Whitman's Pond include swimming and fishing. There is a sluice gate between South Cove and Whitman's Pond which separates the two water bodies (MDEP 2002). In addition, water from the South Cove area is sometimes pumped to Great Pond, a primary municipal water supply for the town of Weymouth. Historically this water from South Cove has been estimated to contribute approximately 10% to 20% to the Weymouth municipal water supply. Recent estimates indicate however that water from South Cove may have contributed as much as 25% of the municipal supply over the last three years (MDEP 2002). The PHA concluded that it is unlikely that base contaminants would impact the municipal water supply such that levels might exceed drinking water standards because concentrations detected in on-site surface water at the base only slightly exceeded levels of health concern, and the Old Swamp River supplies only a small portion of Weymouth's total water supply (ATSDR 1999a). However, as a result of more recent environmental concerns related to the SWNAS additional sampling in several areas in South Weymouth is being conducted.

ATSDR concluded in the PHA that the potential health impacts to those who visit or play in the Old Swamp River, ingest fish caught in the river, or drink Weymouth municipal water would be expected to be minimal. However, no off-site surface water, sediment, or fish-tissue sampling data were available to further evaluate potential off-site migration of base contaminants. To address community cancer concerns, the BEHA reviewed the pattern of cancer incidence between 1982 and 1998 in the towns of Hingham and Weymouth along the Old Swamp River downstream from the base. As noted previously, several compounds were detected above drinking water and soil comparison values in the surface water and sediment of the Old Swamp River including PAHs, some pesticides, arsenic, and manganese. Cancer types that have shown some association with human exposure to some of these contaminants include cancers of the lung, liver, bladder, and kidney (ATSDR 1992a, 1992b, 1993b, 1995, 1997). Although a statistically significant elevation of lung cancer was observed in CT 4222 in Weymouth, no unusual patterns were observed for any of these cancer types in Hingham and Weymouth neighborhoods along the Old Swamp River for any time period evaluated.

(c) Surface Water - French's Stream

French's Stream is located on the southwestern portion of the SWNAS and flows from north to south along runway 17/35 and through residential neighborhoods in Rockland and Abington after leaving the base (ATSDR 1999a). Drainage ditches and surface water run-off comprise the headwaters of the stream. Some of the contaminated areas on the base that eventually discharge to French's Stream include the West Gate Landfill, the Fire Fighting Training Area, the Sewage Treatment Plant, the Abandoned Bladder Tank Fuel Storage area, and the Tile Leach Field. French's Stream discharges to Reed's Pond (also known as Studley's Pond), located approximately one and a half miles south of the base in Rockland. According to the PHA, the stream is used for wading and boating, and Reed's Pond may be used for both swimming and fishing (ATSDR 1999a). Neither the stream nor the pond is used as a source of drinking water. The frequency of fishing at French's Stream is unknown.

ATSDR reviewed surface water and sediment sampling results for French's Stream as well as drainage ditches that discharge to the stream collected at several contamination areas on base. The PHA identified bis(2-ethylhexyl)phthalate, pesticides (i.e., DDD, DDT), polychlorinated biphenyls (PCBs), and metals in surface water above comparison values for drinking water (ATSDR 1999a). Polycyclic aromatic hydrocarbons (PAHs), the pesticide dieldrin, and metals including arsenic, beryllium, and iron in sediment were above comparison values for soil. Samples taken from French's Stream at the base perimeter as it leaves the SWNAS detected manganese in surface water and arsenic in sediment at concentrations above drinking water and soil comparison values (ATSDR 1999a).

Little or no off-site sampling data were available to evaluate whether contamination detected in French's Stream on the base is also present in surface water or sediment downstream from the SWNAS. The PHA noted one off-site surface water and sediment sample that was collected near Spruce Street, located downstream near the southern SWNAS property line, in September 1997 by the Rockland Sewer Department and analyzed for metals. No metals were detected in surface water and metals detected in sediment at this location were below ATSDR's health comparison values for soil (ATSDR 1999a).

The PHA concluded that past and current exposures to surface water and sediment in French's Stream through recreational use are not likely to result in adverse health effects (ATSDR 1999a). This is based on the low contaminant concentrations detected in surface water and sediment samples collected at the site boundary and at Spruce Street, as well as the low frequency of exposure expected to occur through the recreational use of French's Stream (ATSDR 1999a). In addition, based on the concentrations of contaminants identified in on-site surface water and sediment, and the expected frequency of fish consumption from French's Stream and Reed's Pond, the PHA determined that it is unlikely that adverse health impacts would result from this potential exposure pathway. No known fish tissue sampling was conducted in French's Stream or Reed's Pond (ATSDR 1999a).

In December of 1986, a fuel storage tank was overfilled and approximately 6,000 gallons of jet fuel flowed over land, some of which entered a storm drain that discharged to French's Stream (Stone and Webster 1996). Fuel from this spill traveled through French's Stream off-site to Rockland and Abington and migrated approximately three miles where it was discovered and reported by a Rockland resident. Soil at the SWNAS property was excavated and removed, and fuel was recovered from downstream surface water with a vacuum truck. The U.S. Environmental Protection Agency (EPA) determined that off-site areas impacted by the spill were adequately remediated, however no further information related to the clean up was available (Stone and Webster 1996). Although this spill was not specifically addressed in the PHA exposure assessment, past exposure to fuel from human contact with surface water is unlikely because the spill occurred in December when recreational uses of French's Stream such as wading would be limited.

To address community concerns regarding potential exposures to base contaminants that may have migrated off-site through French's Stream, cancer distribution patterns in Rockland and Abington were reviewed for the years 1982-1994. As previously stated, several compounds in surface water and sediment of French's Stream were detected above comparison values for drinking water and soil including specific pesticides, PAHs, arsenic, beryllium, cadmium, lead, and manganese. Those cancer types that may be associated with human ingestion and/or dermal contact with some of these contaminants include cancers of the lung, bladder, kidney, liver, pancreas, and non-Hodgkin's lymphoma (ATSDR 1992a, 1992c, 1993b, 1993c, 1995, 1999c,

1999d). No unusual geographic concentrations of these cancer types were noted in Rockland and Abington near the base or in the neighborhoods along French's Stream or at Reed's Pond. Updated analyses for the 1995-1998 period were similar in that, although census tracts in Rockland displayed statistically significant elevations in lung cancer, no unusual patterns of cases were observed near the base within these census tracts.

2.) Base Flight Patterns

Another community concern raised was whether flight patterns at the SWNAS have any relationship to the patterns of cancer within the four surrounding towns. No studies in the scientific literature investigating health outcomes such as cancer associated with specific aircraft flight patterns were able to be located. Several studies have attempted to evaluate potential health impacts associated with existing or proposed airports and/or aircraft emissions. The majority of these assessments have either evaluated emissions and/or ambient air quality in the vicinity of airports, or attempted to estimate whether an increased public health risk exists for those who live near an existing or proposed airport. Most studies that estimated airport emissions or took ambient air or soot measurements found contaminant concentrations in the vicinity of airports to be typical of urban areas (van den Anker et al 1991; KM Chng Environmental 1997; KM Chng Environmental 1999; Illinois State Environmental Protection Agency 2000). Two studies that estimated people's risk of getting cancer as a result of living near an airport found the level of risk to be consistent with risk associated with living in a typical urban environment (ViGYAN, Inc. 1993; CH2M Hill 1999). Another study estimated the risk of getting cancer was 5-fold greater at locations downwind of an airport, compared with the risk of getting cancer based on "background" air concentrations (Environ 2000). However, no association has been established between airport operations and a specific cancer type. Although take-off and landing of aircraft occurred at the SWNAS, the base never functioned as a commercial airport and therefore past flight frequencies are expected to have been significantly less than at those airports on which the literature is based.

In order to evaluate cancer concerns in relation to flights at the SWNAS, MDPH reviewed information from an updated NAS South Weymouth Master Plan provided by the U.S. Navy regarding the frequency and direction of flights to and from the base (U.S. Navy 1990).

The frequency of flight times at the base varied greatly on a daily and weekly basis. Some days had little or no activity and other days were quite busy. Information provided from the U.S. Navy on aircraft flight patterns on an average busy day indicates that the majority (more than 60%) of operations at SWNAS were by helicopters (U.S. Navy 1990). Runway 08/26 was considered the primary runway and is 6,000 feet long and 175 feet wide. It stretches from east to west in the middle of the SWNAS and was the preferred runway for touch-and-go operations (see Figure 12). During times of increased/maximum flight activity, fixed wing aircraft accounted for more than 25% of base operations. Runway 17/35 was designated the secondary runway (or crosswind runway) and is 7,000 feet long and 200 feet wide. It is oriented in a north south direction on the western side of the base and was the primary runway used for jet (fixed wing) operations.

Modeled take-off and landing patterns were mapped and reviewed along with touch-and-go operation flight tracks for both fixed wing and rotary wing aircraft (i.e., helicopter) at the SWNAS. The majority of flight tracks were in a north/northwest direction over southern parts of Weymouth and in a south/southwest direction over Abington and western parts of Rockland. Flight tracks were also concentrated over northern parts of Rockland near the end of Runway 08/26. Although no research indicating an association between patterns of cancer and specific aircraft flight patterns could be located, cancer incidence data were evaluated together with flight path information to address community concerns. No clear pattern of cancer in relation to any flight path was observed for any of the cancer types evaluated within the four towns between 1982-1994. Between 1995 and 1998, none of the cancer types displayed a geographical pattern that would suggest a relationship to flight patterns at the base.

In addition to flight track patterns, the DPH reviewed three years of meteorological data for the SWNAS to evaluate potential downwind effects that may be associated with aircraft emissions. The prevailing wind direction at the SWNAS is from the south-southwest, towards the general direction of Hingham CT 5012 and Weymouth CT 4222 (NRCC 2000). For the seven cancer types evaluated between 1982-1994, none were statistically elevated in Hingham CT 5012. The majority of cancers in this census tract occurred less than the rates expected and a statistically significant decrease in lung cancer was observed. A slight elevation in NHL was observed between 1982-1994. In Weymouth CT 4222, lung cancer was statistically significantly

elevated among males and females combined between 1982-1994 and among females in the time period 1987-1994. Leukemia was also statistically significantly elevated among males and females in the later time period 1987-1994. However, none of the cancer types evaluated displayed a geographic distribution pattern that would suggest an association with aircraft emissions downwind from the base. For example, in Hingham CT 5012, few cases were located in the less populated southern portion of the census tract closest to the base. Both lung cancer and leukemia cases in Weymouth CT 4222 seemed to follow a pattern closely matched with population distribution in this census tract. With the exception of lung cancer in Weymouth CT 4222, none of the cancer types evaluated between 1995 and 1998 were statistically significantly elevated in the two census tracts downwind from the base. During this more recent time period, lung cancer in CT 4222 did not display a geographic pattern suggesting any downwind effects associated with operations at the SWNAS. In particular, the residences of non-smokers diagnosed with lung cancer were not located in the area of the census tract downwind from the base.

B. Potentially Hazardous Waste Sites (21E Sites)

To evaluate whether cancer incidence between 1982 and 1998 in Weymouth, Abington, Hingham, and Rockland may potentially be associated with the locations of spills or releases (not including those that occurred on the SWNAS), information regarding disposal sites reported to the MDEP prior to 1993 was obtained and reviewed. The MDEP is responsible for the monitoring, assessment, and clean up of releases at disposal sites (the locations where environmental spills or releases occur) in Massachusetts. These sites are currently regulated under Massachusetts General Laws, Chapter 21E and the Massachusetts Contingency Plan (MCP) 310 CMR 40.0000 (MDEP 1997). When discussing potential health outcomes related to environmental exposures, it is very important to consider latency. Latency refers to the time between exposure to a potentially harmful substance and the development of disease (i.e., cancer). Because the latency period for most cancer types is believed to be somewhere between 15 and 20 years, sites that were reported before October 1993 were the primary focus of this analysis.

Data regarding environmental spills or releases that occurred prior to October 1993 in the towns of Weymouth, Abington, and Hingham were obtained from downloadable databases via the MDEP, Bureau of Waste Site Cleanup's (BWSC) website (BWSC 2001). A discussion of potentially hazardous waste sites in Rockland can be found on page 38 of Appendix A. The databases evaluated included the Sites Transition List and the Spills Database. The relative severity of spills could not be determined from the information provided by these databases. The locations of the majority of these sites were mapped using geographical information systems (GIS) software (Environmental Systems Research Institute 1998). Some sites could not be mapped because sufficient address information was unavailable. The locations of the residences of individuals diagnosed with each cancer type in the three towns during 1982-1998 were evaluated relative to the location of these potentially hazardous waste sites to determine whether any atypical patterns of cases exist in these areas.

In the town of Weymouth, the MDEP identified a total of 295 environmental spills prior to October 1993. Refer to Figure 13 for the location of these sites. Table 19 outlines information pertaining to each site (i.e., spill identification number, associated release number, address aid, address, town, and material released). In the town of Abington, MDEP identified a total of 78 environmental spills prior to October 1993. Refer to Figure 14 for the location these sites. Table 20 outlines information pertaining to each site. In Hingham, 197 spills that occurred prior to October 1993 were identified by the MDEP. Refer to Figure 15 for the location of these sites. Table 21 outlines information pertaining to each site. The geographic distribution of each of the eight cancer types evaluated between 1982-1998 was examined relative to the locations of these sites mapped for Weymouth, Abington, Hingham, and Rockland. Based on this review there were no unusual concentrations of cancer cases that would suggest a possible relationship to any of the sites evaluated.

C. Weymouth Neck Landfill

Several concerns about cancer have been raised by the Weymouth community in relation to the Weymouth Neck Landfill, located in CT 4228 at the opposite end of town from the SWNAS. The site consists of three different areas, Lots 24/25, Lot 1, and a developed portion of the property occupied by two condominium buildings. The site is bordered by the William

Webb Memorial State Park, the Fore River, the Weymouthport Condominium complex, a small apartment building, and the Weymouth Back River (GZA 1998). Residents who live in the area are concerned that soil contamination identified on the property may have caused adverse health effects such as cancer through exposure to airborne dust for extended periods of time (MDEP 2001).

The primary contaminants of concern at the site include metals, lead and arsenic in particular (GZA 1998). Areas where elevated lead and arsenic were detected in accessible and potentially accessible soil are scattered throughout the site. Both compounds were detected consistently throughout Lots 24/25 and sporadically throughout Lot 1. Lead was detected in soil at depths up to 15 feet and concentrations ranged from 3.35 to 16,000 parts per million (ppm). Concentrations of arsenic in soil ranged from 0.6 to 3,320 ppm, with elevated concentrations detected at depths exceeding 12 feet. Both lead and arsenic were detected in shallow soils above MDEP clean-up standards.

Studies that have investigated lead and its potential to cause cancer are mostly based on occupational exposures and are limited because the actual levels of lead, routes of exposure, and specific types of lead compounds have not been specified (ATSDR 1999c). In addition, the individuals studied were often smokers or exposed to other compounds that may have caused their cancer. One study found occupational exposure to lead to be associated with digestive and respiratory tract tumors. Another study among workers exposed to lead found increases of lung cancer and gliomas, a specific type of brain cancer (ATSDR 1999c).

Exposure to arsenic via inhalation has been shown to increase the risk of lung cancer among exposed workers and people who live near smelters or arsenical chemical plants (ATSDR 1993b). Studies that have investigated ingestion of arsenic have found that it increases the risk of developing certain types of skin cancer as well as some other internal cancers such as cancers of the liver, bladder, kidney, and lung. No human studies that investigated skin exposure to arsenic and cancer could be located, but dermal studies with mice did not result in skin tumors.

Of the cancer types evaluated between 1982 and 1994, none that have been associated with exposure to lead and arsenic were unusually elevated in CT 4228, where the Weymouth Neck Landfill is located. Within this census tract, there were no statistically significant

elevations during any of the time periods evaluated (see Tables 9A and 9B). Both brain cancer and lung cancer were observed less often than expected among males and females. Bladder cancer was slightly elevated among males and females combined (13 cases observed versus 11.2 cases expected) and no cases of liver cancer were observed in this census tract. The geographic distribution of cancer cases in this area was also reviewed. Within this census tract, there were no unusual concentrations of lung, liver, bladder, or brain cancer cases that were inconsistent with what would be expected based on population density in this area. During the period 1995 to 1998, lung cancer was statistically significantly elevated in CT 4228. Also during this time period, brain cancer was slightly elevated among males, and liver cancer was slightly elevated among females in this census tract. Neither elevation was statistically significant. Bladder cancer occurred at approximately the rate expected and no cases of kidney cancer were observed. None of the cancer types evaluated between 1995 and 1998 were unusually concentrated in this census tract. Refer to Appendix B for specific census tract information for 1995-1998.

D. Other Community Environmental Concerns

The MDPH was contacted regarding cancer health effects potentially related to two salvage yards located near a neighborhood close to the border of CTs 4224 and 4225 in the town of Weymouth. Of the cancer types evaluated, lung cancer was statistically significantly elevated in CT 4225 between the years 1982-1994, pancreatic cancer was statistically significantly elevated in CT 4224 during the earlier time period 1982-1996, and leukemia was statistically significantly elevated during the later time period 1987-1994 in CT 4224. None of the cancer types evaluated between 1982 and 1994 were unusually concentrated in CTs 4224 or 4225 or in the particular neighborhood of concern near the two salvage yards. Between 1995 and 1998, at statistically significant elevation of NHL among males was observed in CT 4224 (8 cases observed vs. 3.3 cases expected). No other statistically significant elevations were observed in these two census tracts. No unusual concentrations of cases were noted in this neighborhood for NHL or any of the other cancer types evaluated during this more recent time period.

Community concern was also raised regarding a suspected elevation of cancer in the Mt. Vernon Road area located in CT 4226 in the town of Weymouth. Of the cancer types evaluated between 1982-1994, male lung cancer was statistically significantly elevated in this census tract

during the earlier time period 1982-1986. Leukemia was also elevated between 1982-1994 in this census tract, but the elevation was not statistically significant. Between 1995 and 1998, the majority of cancer types evaluated occurred at or below the rates expected and none were statistically significantly elevated in CT 4226. Bladder cancer was slightly elevated between 1995-1998 (8 cases observed vs. 5 cases expected). Although elevations were observed for some cancers in this census tract, no unusual geographic concentration of cases was observed in the Mt. Vernon Road area for any of the cancer types evaluated between 1982-1998.

Regarding the town of Hingham, the MDPH was contacted about a suspected high incidence of cancer in the area near Hersey Street located in CT 5011.02. As noted previously, a statistically significant elevation in female lung cancer and a non-statistically significant elevation in brain cancer among males and females combined were observed in this census tract between 1982-1994, and the majority of cancer types occurred at the rates expected during the more recent time period 1995-1998. When the pattern of cancers evaluated between 1982-1998 was examined geographically and over time, the cases were distributed fairly evenly throughout the census tract and were not concentrated in the Hersey Street area. A small grouping of one cancer type was noted in this area, however review of specific case information did not suggest a single common risk factor for these individuals other than place of residence.

VIII. DISCUSSION

Between 1982-1994, the majority of cancer types evaluated in Weymouth, Abington, Hingham, and Rockland were at or below what would be expected based on statewide cancer rates. In the town of Weymouth, six of the eight cancer types evaluated were approximately equal to or below the rates expected. Lung cancer and leukemia were statistically significantly elevated among males and females combined during the 13 year time period 1982-1994. A significant elevation in pancreatic cancer was observed in the earlier time period 1982-1986, primarily due to an elevation of this cancer among females.

In Abington, six of the eight cancer types were approximately equal to or below expected rates. Elevations in brain and lung cancer were observed, primarily among males. Lung cancer was statistically significantly elevated among males during the overall 1982-1994 time-period

and among males and females combined during the earlier time period 1982-1986. The elevation observed in brain cancer did not represent a statistically significant increase and was based on an additional four cases among males and females combined during the thirteen-year time period evaluated.

In the town of Hingham, six of the eight cancer types evaluated were equal to or below expected rates. Both lung and pancreatic cancer were statistically significantly lower than expected as compared to statewide rates. Brain cancer was elevated, primarily among females between 1982-1994, but the increase was by approximately four cases and was not statistically significant.

In the town of Rockland as a whole, nine of the twelve cancer types evaluated between 1982-1994 occurred less often than expected. As presented in Appendix A, with the exception of lung cancer among females in CT 5021.01 during the time period 1987-1994, no cancer type was elevated at a level that was statistically significant in comparison to statewide rates of cancer in Rockland or any of its census tracts. Cancers of the brain and liver displayed slight increases in incidence above statewide rates. In Rockland overall, approximately one additional case of brain cancer occurred versus the expected number during the 13-year period 1982-1994. Among both males and females in Rockland combined, approximately two cases of liver cancer above the expected number occurred during 1982-1994. Again, none of the elevations observed were statistically significant.

When all four towns were evaluated by census tract, with the exception of lung cancer, the majority of cancer types occurred less than or equal to the rates expected during 1982-1994 when compared to state cancer rates. The incidence of lung cancer appears to be increasing over time in the majority of census tracts in Weymouth. During the period 1982-1986, census tracts in which lung cancer was elevated were predominantly located in North Weymouth. With regards to census tracts located near the SWNAS, although not statistically significant, CT 4222 displayed an elevated rate of lung cancer in both time periods.

With some exceptions, leukemia was generally observed less than or equal to the rates expected within all four towns. Statistically significant elevations were observed in the town of Weymouth as a whole and in CTs 4221, 4222, and 4224 during certain time periods. In addition,

leukemia was slightly elevated in some Weymouth and Abington census tracts, and occurred less often than expected throughout the towns of Hingham and Rockland.

With the exception of a statistically significant elevation observed among males and females in Weymouth CT 4227, brain cancer was generally observed less than or equal to the rates expected in the towns of Weymouth, Abington, and Hingham. In Rockland and CT 5021, approximately one additional case of brain cancer occurred over the expected number in 1982-1994. Slight elevations were observed among males and females in some census tracts located in Weymouth, Abington, and Hingham, but the elevations were generally based on increases of less than three cases.

Pancreatic cancer was observed less than or approximately equal to the rates expected in both Weymouth and Abington, and less than expected in the towns of Hingham and Rockland. Only CT 4224 located in Weymouth had a statistically significant elevation, primarily due to pancreatic cancer diagnosed in females of an advanced age. Slight elevations in pancreatic cancer were observed in a few census tracts in Weymouth and in CT 5202.01 in Abington.

With a few exceptions, bladder cancer was less than expected in Weymouth, Abington, Hingham, and Rockland. A statistically significant elevation in bladder cancer was observed among females in Abington CT 5202.01, and slight elevations were observed among males in a few census tracts located in Weymouth, Abington, Hingham, and Rockland during smaller time periods. None of the census tracts with slight elevations were adjacent to each other, and most elevations represented increases of less than three cases and were not statistically significant.

In general, NHL incidence was observed less than or equal to the rates expected within Weymouth, Abington, Hingham, and Rockland. No statistically significant elevations were observed in any census tract or time period evaluated. Slight elevations of this cancer were observed in some census tracts during certain time periods in all four towns, primarily among males. However, none of the census tracts with these elevations were adjacent to one another.

Between 1982-1994, kidney cancer generally occurred less than or equal to the rates expected in the four towns. Slight elevations of approximately two to three cases were observed in some census tracts and time periods located in Weymouth, Hingham and Rockland. None of

the census tracts with slight elevations were located near to each other and again, were not statistically significant.

Liver cancer was generally observed less than or equal to the rate expected in Abington and less than expected in Hingham. In Rockland, liver cancer was slightly elevated for males and females combined during 1982-1994. Slight elevations were observed in one census tract in Rockland and in two Weymouth census tracts, but the elevations represented increases of approximately two or three cases. There were no statistically significant elevations of this cancer type in any census tract within the four towns evaluated.

With the exception of lung cancer, none of the cancer types evaluated in Weymouth, Abington, Hingham, or Rockland appeared unusually geographically concentrated in any one particular area of the towns. Although lung cancer and leukemia were both statistically significantly elevated in more than one Weymouth census tract, these census tracts were generally not adjacent to each other and any concentrations of cases matched closely with the pattern of population density. In Weymouth CT 4224, where a statistically significant elevation of pancreatic cancer was observed, individual cases were generally distributed throughout the census tract with the exception of one particular area where a nursing home and several apartment complexes (most of which were elderly housing) were located. Bladder cancer cases in Abington CT 5202.01 and lung cancer cases in Abington CT 5202.02 seemed to follow a pattern that matched closely with population density. The geographic distribution of lung cancer cases within Hingham CT 5011.02 and throughout the rest of the town did not appear unusual. Similar to the patterns observed in Weymouth and Abington, the geographic distribution of cases for all cancer types evaluated in Hingham and Rockland seemed to be indicative of population density and not some other common factor. An evaluation of the geographic distribution of brain cancer, leukemia, and NHL cases as a group in the four towns revealed no common patterns of cases that would suggest a common etiology for these three cancer types.

In general, review of the patterns of cancer cases according to age and gender, as well as risk factor information related to smoking and occupation did not reveal any inconsistent patterns for those cancer types that experienced statistical elevations within the four communities of Weymouth, Abington, Hingham, and Rockland between 1982-1994. It should be noted that

occupational information from the MCR was fairly limited in that only some of the individuals with cancer reported an occupation. Smoking is one of the primary risk factors associated with three of the five cancer types that experienced statistically significant increases within one of the four towns. With just a few exceptions, in all four towns where statistically significant elevations were observed, the percentage of individuals with lung, bladder and pancreatic cancer who reported themselves as current or former smokers were equal to or higher than in the state. For example, among those diagnosed with lung cancer in Weymouth CT 4222, 90% of cases reported being current or former smokers, higher than the town as a whole as well as the state. Among females in CT 4224 where a statistically significant elevation of pancreatic cancer was observed in the earlier time period 1982-1986, 22% reported themselves as current or former smokers.

To address community concerns about cancer and the potential for off-site migration of contaminants in the past, cancer incidence data were evaluated in the vicinity of the SWNAS for the 17 years 1982-1998. Cancer in general has a lengthy latency period that can range from 10 to 30 years and in some cases may be more than 40 or 50 years (Berg 1996, Frumpkin 1995). The latency period is the period between exposure to a disease causing agent and the appearance of manifestations of the disease (Last 1995). For the majority of tumors, the period between first exposure and the appearance of the tumor is 12 to 25 years.

Based on the environmental information presented in the PHA for the SWNAS, it does not appear that there are any specific off-site locations where base related contamination appears to be migrating at concentration levels that currently present a major health concern. Also, once contaminated areas on the base are cleaned up, the potential for off-site migration of contaminants in the future is expected to be greatly reduced or eliminated. However, results of current investigations of potential off-site migration being conducted at the Mill River tributary in the northwest corner of the base were unavailable at the time of this evaluation. It is also important to note that very little or no historical data on contaminant concentrations both on and off the base were available to evaluate the potential for base-related exposures in the past. As more information is learned about possible off-site migration, an evaluation of possible health impacts will be provided by ATSDR (ATSDR 2001).

In general, there was no consistency in the types of cancers that were statistically significantly elevated in those census tracts immediately surrounding the SWNAS that would suggest a clear pattern with respect to exposures at the SWNAS. For example, lung cancer was statistically significantly elevated in Weymouth CTs 4222 and leukemia was statistically significantly elevated in Weymouth CTs 4221 and 4222 in some of the time periods reviewed. Bladder cancer was statistically significantly elevated among females in Abington CT 5202.01, and none of the cancers were significantly elevated in Hingham CT 5012 or Rockland CT 5022. An overall review of the geographic patterns of cancer in the neighborhoods and towns abutting the SWNAS, including Rockland, did not indicate a concentration of any of the cancer types evaluated. For most cancer types, the geographic distribution of cancer cases was away from the base boundary and was consistent with the population density in these areas.

Although there are several areas on the SWNAS property where contamination has been identified, based on the environmental information presented in the PHA, there is currently no evidence that off-site migration or movement of base contaminants through groundwater is occurring (ATSDR 1999a). No off-site groundwater sampling has been conducted in relation to the SWNAS (Barney 2001). A survey of private wells located near the base identified six confirmed drinking water wells in the town of Hingham and no wells used for drinking water near the base in the towns of Weymouth, Abington, and Rockland (ATSDR 1999b).

According to the PHA, current and/or past migration of base contaminants through the Old Swamp River and French's Stream to areas off-site are possible, but very little to no off-site sampling data were available making it difficult to evaluate whether these actual exposure pathways exist. Metals at concentrations above ATSDR comparison values were identified in surface water and sediment of both the Old Swamp River and French's Stream at the downstream base boundaries. However, actual health effects resulting from exposure to these metals in surface water or sediment are not expected. This is because comparison values used by ATSDR were established for drinking water and soil exposure, and actual contact with surface water and sediment close to the base would probably involve infrequent skin contact for short periods of time.

The PHA concluded that potential impacts to the Weymouth drinking water supply are expected to be minimal (ATSDR, 1999a). Although no fish tissue sampling was conducted, the PHA concluded that potential health effects associated with ingestion of fish from these surface waters would be minimal since fish from these rivers are not expected to represent a large portion of a person's diet. In addition, fish in the Old Swamp River are stocked annually and therefore are not in the river long enough to accumulate contaminants that may be present in surface water and sediments (ATSDR 1999a).

None of the cancer types evaluated were unusually concentrated in the area of Hingham where six confirmed drinking water wells were identified by the ATSDR private well survey. ATSDR concluded in the PHA that the potential health impacts to those who visit or play in the Old Swamp River or French's Stream, ingest fish caught in these rivers, or drink Weymouth municipal water would be expected to be minimal. No unusual geographic concentrations of cases were observed in neighborhoods along the Old Swamp River or French's Stream, downstream from the base. Although results of investigations at the Mill River tributary were not available at the time of this evaluation, none of the cancer types were unusually concentrated in this area of Weymouth near the northwest part of the base. Studies investigating a potential relationship between flight patterns at commercial airports and cancer were unable to be located, however, modeled flight paths for the SWNAS were evaluated together with patterns of cancer in those neighborhoods near the base. No apparent relationship between the distribution of cancer and flight paths was observed in any of the four towns.

Likewise, when cancer incidence was evaluated in relation to other specific community environmental concerns, no unusual patterns of cases were observed. Both incidence rates and the geographic distribution of cancer cases in Weymouth CT 4228 were reviewed to address community concerns regarding lead and arsenic contamination identified at the Weymouth Neck Landfill. Within this census tract, none of the cancer types evaluated were statistically significantly elevated and there were no unusual concentrations among those cancer-types suggested to be associated with exposure to these metals. No unusual patterns of cancer cases were observed for the other specific neighborhoods that were of concern to individuals located in Weymouth CTs 4224, 4225, and 4226, and Hingham CT 5011.02. In addition, a review of the

geographic distribution of each cancer type in relation to 21E sites in the towns of Weymouth, Abington, Hingham, and Rockland revealed no atypical patterns.

IX. LIMITATIONS

This assessment is an investigation that analyzes descriptive health outcome data for cancer to determine whether the pattern or occurrence of selected cancers is unusual. The purpose of this investigation was to evaluate the patterns of cancer in a geographical context in relation to available information about factors related to cancer (e.g., environmental factors) to see whether further investigation seems warranted. Information from descriptive analysis, which may suggest that a common etiology (or cause) is possible, can serve to identify areas where further public health actions may be warranted. Inherent limitations in this type of analysis and the available data make it impossible to determine the precise causal relationships or synergistic roles that may have played a part in the development of individual cancers in these communities. Also, this type of analysis cannot determine what may have caused any one individual's cancer. Cancers in general have a variety of risk factors that were not able to be fully evaluated in this report that are known or suggested to be related to the etiology (cause) of the disease. It is believed that many cancers are related largely to behavioral factors such as cigarette smoking, diet, and alcohol consumption. Other factors associated with various cancers are socioeconomic status, heredity/genetics, race, and geography. It is beyond the scope of this report to determine the causal relationship of these factors and the development of cancer or other health outcomes in Weymouth Abington, Hingham, or Rockland.

In addition, the reader may want to compare one census tract's SIR with another, or compare an SIR for a cancer type in these town's with an SIR for a cancer type in another town. This is not an appropriate or meaningful comparison as the SIRs calculated here were based on one standard or comparison population, the state of Massachusetts. Small differences in the age distribution of a specific population are sufficient to affect some change in SIR values.

X. CONCLUSIONS

- Of the eight cancer types evaluated in the communities of Weymouth, Abington, Hingham, and Rockland between 1982-1994, most were observed equal to or less often than expected at the town level. When evaluated by census tract, with the exception of lung cancer, the majority of cancer types evaluated in the four towns occurred less than or equal to the rates expected.

- In general, the town of Weymouth experienced more cancer elevations than the other three towns. In Abington, cancer rates were generally equal to or lower than expected. The majority of cancer types in the town of Hingham were observed to be lower than expected. In Rockland, the majority of cancer types evaluated occurred approximately as expected or in some cases slightly less often than expected.

- The most consistent trend was observed for lung cancer. Analysis of lung cancer rates by smaller time period suggests that the incidence of lung cancer in both Weymouth and Rockland may be increasing over time relative to the state rate.

- The pattern of some other cancer types showed elevations that were statistically higher than expected in certain areas or during certain time periods throughout the thirteen-year time period reviewed (i.e., 1982-1994). During the 1995-1998 time period, some cancer types were significantly elevated in some towns or census tracts. In general, no pattern among those census tracts with statistical elevations was observed in any of the four towns in any time period evaluated.

- Census tracts in the four communities adjacent to the SWNAS did not show a consistent pattern of increase for any one type of cancer. Little or no historical sampling data exist to evaluate whether migration of contaminants from the SWNAS occurred in the past. However, review of the geographic distribution of cancer cases in the census tracts surrounding the SWNAS did not present a clear pattern that would suggest the existence of a common environmental exposure pathway related to the base.

- Review of available risk factor information related to cancers that were elevated in the communities of Weymouth, Abington, Hingham, and Rockland suggests that cigarette smoking played a role in increased rates of cancers of the lung, pancreas, and bladder, particularly with lung cancer in the town of Weymouth.

- The occupational information reviewed suggests that occupational exposures may have been a potential factor in the development of some individuals' cancers. However, information on occupation reported to the MCR is generally too limited to evaluate the actual role it may have played in areas where increased cancer rates were observed.

- An evaluation of the geographic distribution of cancer cases in relation to other environmental concerns in specific neighborhoods in the towns of Weymouth and Hingham unrelated to the SWNAS did not reveal any unusual patterns of cases.

XI. RECOMMENDATIONS

- As a result of trends observed in the incidence of lung cancer, the MDPH plans to further investigate lung cancer in these communities in relation to individual length of residence, particularly among non-smokers, to determine whether a clearer pattern related to environmental or other risks for this cancer may emerge.

- Based on the important role that smoking appears to have played in the incidence of lung, pancreatic, and bladder cancers in Weymouth, Abington, Hingham, and Rockland, the MDPH recommends that tobacco control efforts be focussed accordingly.

- The MDPH/BEHA will monitor the incidence of leukemia in Weymouth as new data from the MCR becomes available.

- The MDPH/BEHA will review additional environmental data associated with the SWNAS at the request of locals Boards of Health, residents, and others.

- The MDPH/BEHA Community Assessment Unit will review the Weymouth Neck Health Consultation currently in-progress in relation to the data evaluated in this report.

- The Boards of Health in Weymouth, Abington, Hingham, and Rockland should consider the results of this analysis in the planning of prevention and intervention strategies to evaluate potential health impacts in these communities in the future. Information regarding other non-environmental cancer risk factors (e.g. diet, exercise, and heredity) might be helpful to further explain the incidence of cancer in these towns.

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FIGURES

TABLES

APPENDIX A:

Assessment of Cancer Incidence in Rockland, MA 1982-1994

Appendix B:

Assessment of Cancer Incidence in Weymouth, Abington, Hingham, and Rockland, MA 1995-1998

APPENDIX C:

Risk Factor Information for Bladder Cancer, Brain Cancer, Kidney Cancer, Leukemia, Liver Cancer, Lung Cancer, Non-Hodgkin's Lymphoma, and Pancreatic Cancer