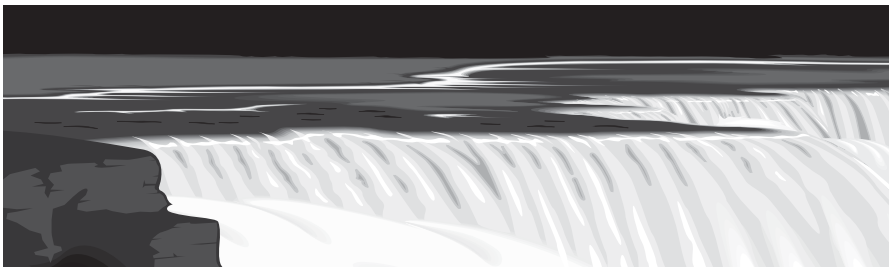

Love Canal Follow-up Health Study

Prepared by the

Division of Environmental Health Assessment
Center for Environmental Health
New York State Department of Health
for the
U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry

In memory of Charlene M. Spampinato and her longstanding dedication to the Love Canal project.

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LIST OF ABBREVIATIONS

AKA	Also known as
ATSDR	Agency for Toxic Substances and Disease Registry
BPA	British Pediatric Association
CDC	Centers for Disease Control
CDC-WONDER	Centers for Disease Control-Wide-ranging Online Data for Epidemiologic Research
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CI	Confidence Interval
CI_{95}	95% Confidence Interval
CL12	Tiers 1 and 2 during Closed Period
CL34	Tiers 3 and 4 during Closed Period
CMR	Congenital Malformations Registry
DHHS	Department of Health and Human Services
DMV	Department of Motor Vehicles
EDA	Emergency Declaration Area
GEE	Generalized Estimating Equations
HCH	Hexachlorocyclohexane
HR	Hazard Ratio
IARC	International Agency for Research on Cancer
ICD-9	International Classification of Diseases-9th Revision
LBW	Low Birth Weight
LCIC	Love Canal Indicator Chemicals
N	Number (of observations in the category)
NC	Niagara County
NDI	National Death Index
NPL	National Priorities List
NTP	National Toxicology Program
NYC	New York City (the five boroughs)
NYS	New York State (excluding NYC)
NYSCR	New York State Cancer Registry
NYSDCR	New York State Death Certificate Registry
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
NYSVR	New York State Vital Records
OP12	Tiers 1 and 2 during Open Period
OP34	Tiers 3 and 4 during Open Period
OR	Odds Ratio
PH	Proportional Hazards
PPB	Parts per Billion
PT	Pre-Term
SGA	Small for Gestational Age
SIR	Standardized Incidence Ratio
SMR	Standardized Mortality Ratio
SSA	Social Security Administration
SSDI	Social Security Death Index
TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin
TRC	Technical Review Committee
USEPA	United States Environmental Protection Agency
VLBW	Very Low Birth Weight

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EXECUTIVE SUMMARY

Love Canal, a tract of land in Niagara Falls, NY, was the site of a landfill used for the disposal of some 21,800 tons of chemical wastes. The landfill was covered with soil in 1953, and houses and an elementary school were built on the area immediately adjacent to the landfill. The increasing appearance of visible seepage, noxious smells and other signs of chemical contamination originating in the landfill led to its designation as an Emergency Declaration Area (EDA) and, in 1978-80, the evacuation of the residents from the surrounding area. Several studies of residents' health were performed around the time of the evacuations, with inconclusive or contradictory results.

In 1996, with input from a number of former Love Canal residents and an Expert Advisory Committee, the New York State Department of Health (NYSDOH) commenced an exploratory study of various health outcomes among the residents who consented to be interviewed in 1978 - 1982 and their children. The study was approved by the New York State Department of Health Institutional Review Board (IRB) at a full board meeting in August 1996 and annually thereafter. The study examined overall and cause-specific mortality; cancer incidence; low birth weight; preterm birth; births small-for-gestational age; congenital malformations; and the ratio of female to male births. Data were obtained from birth and death records and the New York State Cancer and Congenital Malformations Registries. The study used two complementary research designs. For external comparisons, using standardized mortality ratios (SMRs) and standardized incidence ratios (SIRs), the cohort was compared with two "standard" populations: New York State exclusive of New York City (NYS), which provides stable disease incidence and mortality rates; and Niagara County (NC), which has demographic and environmental characteristics similar to those of Love Canal. Internal comparisons examined differences in health status among members of the cohort without reference to other populations. Each member of the cohort was assigned an exposure level according to their potential exposure to Love Canal chemicals; modeling was performed to control for potential confounders. The study included 6,026 of the 6,181 residents interviewed by the NYSDOH from 1978 to 1982.

As there were no data on the actual concentrations of chemicals in the air, soil or water during the period of exposure (1942-1978), several qualitative variables were used as indirect indicators of exposure. The EDA was divided into four "tiers," according to proximity to the landfill, and into two time periods, before and after the landfill was covered in 1953. "Time/tier" variables indicated years of residence in each possible combination of tier and time period. Other exposure variables included residence on "swales" (natural depressions of land that might facilitate the migration of chemicals) or “hot spots” (residential areas where the results of the soil sampling showed elevated chemical concentrations); exposure during childhood; and attendance at the 99th Street School, located directly adjacent to the landfill.

Overall mortality rates were similar to those of NYS and NC, but rates were elevated for certain specific causes of death, compared to NYS: chronic rheumatic heart disease (in men), acute myocardial infarction, and external causes of injury (primarily motor vehicle accidents and suicide). In the internal comparisons, exposure as a child, defined by combination of sex, age and residence, was associated with mortality from cancer and acute myocardial infarction, but these findings were based on small numbers and therefore the estimates were imprecise. For cancer incidence, the results of the external comparisons indicated that the total number of cancers observed among Love Canal residents was within the range expected for NYS and NC. The respiratory and digestive systems were the only major organ systems to show any elevation, and some individual sites such as gall bladder, kidney, bladder, testis, liver and rectum also showed elevations. Due to small numbers, these elevations remained within the range of rates that would be expected by chance. Some of these findings, however, are consistent with other investigations. For instance, excess lung cancer was observed in a previous study of the Love Canal census tract, and kidney, bladder, and other cancers have also been reported among persons occupationally exposed to chlorinated benzenes and aniline compounds such as those found at Love Canal.

Reproductive outcomes were examined among the women who lived in the EDA prior to or during their reproductive years. The rates of preterm and small-for-gestational

age (SGA) births among these women were similar to those in NYS and NC, and the rates of low (LBW) and very low (VLBW) birth weight tended to be lower. In the internal comparisons, LBW and SGA were consistently associated with potential exposure as a child, defined as a combination of sex, age and residence. The ratio of female to male births among these women was higher than in either comparison population; in the internal comparisons, the proportion of female births was positively associated with childhood exposure and with conception in the EDA. Such an effect has been reported among men heavily exposed to dioxins at Seveso, Italy. Rates of congenital malformations were twice that expected compared to the external standard populations, a difference that exceeded the range of rates expected by chance alone. In addition, the internal comparisons revealed that malformations were positively associated with potential exposure as a child. There also was a tendency for children born to mothers who lived on the Canal at some time during their pregnancy to be at higher risk for low birth weight, preterm births and small-for-gestational age than those conceived after the mother left the Canal area. Similarly, children conceived on the Canal were more likely to be female than those children conceived after the mother left the canal area.

For convenience, the numerical findings are reported with 95% confidence intervals, a commonly used indicator of statistical precision. However, in this case the confidence intervals must be cautiously interpreted due to the large number of statistical comparisons. This was unavoidable given the exploratory nature of the study and the need to examine multiple indicators of exposure. As a result, the potential for spurious associations to emerge by chance alone is higher than the confidence intervals would suggest. Conclusions should not be drawn from any single association in the study, but rather, from coherent patterns of associations. In that light, the reproductive findings suggest the most coherent pattern. Higher proportions of female births and rates of congenital malformations were observed for Love Canal children compared to NYS (exclusive of NYC) and NC. Women with the potential for exposure as a child and maternal residences on the Canal during pregnancy also were positively associated with a number of adverse reproductive outcomes. In general, these findings are also consistent

with previous Love Canal investigations which also showed increased risks of low birth weight, congenital malformations and other adverse reproductive events among Love Canal births. Such consistency lends additional weight to the results of this investigation.

The study is an observational study, with all the strengths and limitations of such studies. It included only the subset of former residents that participated in the NYSDOH interviews of 1978-1980. Data could not be obtained from before 1960 for reproductive outcomes, 1979 for mortality and cancer incidence, and 1983 for congenital malformations. For cohort members who left New York State, outcomes other than mortality could not be ascertained after they migrated. Because the numbers were small for many analyses, statistical power was low. Finally, the use of qualitative, indirect indicators of exposure may have caused some misclassification. This would have been non-differential (not associated with health outcomes); on average this would bias the results toward the null and make associations more difficult to detect.

However, the study also has several strengths. The cohort is well-defined, with known residential locations and dates. More than ninety-seven percent of the potential participants were successfully traced, minimizing a potential source of selection bias. Two different, complementary research designs were used. One compares the cohort as a whole to two different standard populations, while the other examined potential internal differences in outcome in the cohort associated with different exposures to the landfill and controlled for potential confounders. The data on health outcomes were obtained from records of the NYSDOH and National Death Index (NDI), effectively eliminating the problem of recall bias. Input was sought from outside scientists and community consultants, and the study serves as the most comprehensive description to date of the health status of former residents of the Love Canal, one of the first and most seriously contaminated hazardous waste sites in the history of the USA.

INTRODUCTION

The Love Canal has been documented as one of the most seriously contaminated landfills/dumpsites in the United States. Contamination of nearby homes became apparent in the late 1970s. By 1980, several state and federal emergency declarations paved the way for an emergency appropriation that helped the State purchase the private residences in the larger neighborhood surrounding the waste site, known as the Emergency Declaration Area (EDA) (Figure 1).

The site and unprecedented needs of residents in the area attracted national attention. This man-made disaster prompted not only relocation and compensation of residents of the EDA, but also encouraged the passage of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) by the US Congress in 1980, the enabling legislation that authorized federal funding for Superfund remedial activities at hazardous waste sites nationwide.

For more than a decade after the initial emergency declaration and relocation of nearby residents, many local, state and federal agencies worked with resident groups to contain contamination at the site (remediation) and determine whether the EDA could be resettled (habitability). In 1988, the state health commissioner reviewed available information and decided that much of the EDA could be restored to residential use.

As discussed later in this report, numerous health studies were performed to assess the effects of living near the Love Canal. The results of these studies were often inconclusive and conflicting. In the habitability decision, the state health commissioner committed to continued health studies to assess the effects of exposure to the Love Canal before remediation. To honor this commitment, the New York State Department of Health (NYSDOH) has conducted this evaluation of the health status of former Love Canal residents. Financial support was provided, in part, by the federal Agency for Toxic Substances and Disease Registry (ATSDR), using funds from the final settlement between the federal government and Occidental Chemical Corporation (formerly Hooker

Chemicals and Plastics Corporation), and by the NYSDOH. Over the eight-year course of the evaluation, many changes in design and focus have occurred, largely resulting from the active interchange among the NYSDOH investigators, an Expert Advisory Committee formed in 1998, and members of the Love Canal cohort. This study was approved by the New York State Department of Health Institutional Review Board (IRB) at a full board meeting in August 1996 and annually thereafter. Participants in the study were sent one to two newsletters per year informing them of the status of the study and of the time and place of the public meetings held annually.

Love Canal History

The Love Canal is a rectangular, 16-acre tract of land located in the southeast corner of the City of Niagara Falls in northwestern New York State. In 1894, William T. Love started to dig a Canal between the upper and lower Niagara Rivers to provide cheap hydroelectric power (1,2,3,4). Left unfinished, the actual canal was about 3,000 feet long, about 7 to 16 feet deep and 80 to 100 feet wide, ending approximately 1,500 feet from the Niagara River (4). Except for serving as a swimming hole for nearby children, the Love Canal appears to have remained unused until the early 1940's when Hooker Chemicals and Plastics Corporation and others began filling the Canal with various chemical and municipal wastes (1,2,3,4). From 1942 to 1953, Hooker Chemicals dumped approximately 21,800 tons of at least 200 different known chemicals in the Canal (3,4). According to company records, about 80% of the total chemicals dumped were hexachlorocyclohexanes (e.g. lindane); benzylchlorides; organic sulfur compounds (e.g., lauryl mercaptans); chlorobenzenes; sodium sulfide/sulfhydrates; various chlorinated waxes, oils, naphthalenes and anilines; benzoyl chlorides; benzotrichlorides; liquid disulfides; or chlorotoluenes (3,4). Although there were rumors that the federal government buried radioactive material at the Love Canal, sampling by the United Stated Environmental Protection Agency (EPA) found 'no evidence of radioactive contamination' (5).

Although a few homes existed near the Canal before the waste disposal, residential development nearby accelerated in the early 1950's. By 1953, the Love Canal was completely filled and covered with soil. In 1953, Hooker Chemical sold the Love Canal to the Niagara Falls Board of Education, and the next year, an elementary school (the 99th Street School) was built on the edge of the Canal with playing fields on the filled area. By 1972, virtually all the houses with backyards bordering the Canal (Tier 1 homes, Figure 1) were completed (3,4).

Prior to 1976, there were sporadic accounts of surfaced chemicals, chemical odors, minor explosions and fires (3,4). Unusually heavy precipitation in 1976 and 1977 led to very high groundwater levels (6). In late 1976, engineers from New York State Department of Environmental Conservation (NYSDEC) visited the Love Canal to investigate suspected dumping of Mirex by Hooker Chemical (2,4). At the strong urging of the NYSDEC, the City of Niagara Falls retained a consultant to conduct a hydrogeology investigation and develop a conceptual remedial plan. Sampling in Tier 1 homes detected numerous volatile organic chemicals that suggested a serious health threat in the basement air (3,4). In August 1978, the NYSDOH Commissioner declared a health emergency at the Love Canal. Governor Hugh Carey announced that New York State would purchase the first two rings (tiers) of houses around the Canal and relocate the 239 families and that the elementary school would be closed (3). Shortly thereafter, President Jimmy Carter also declared a federal state of emergency, thereby enabling the use of federal funds to aid in site remediation.

In October of 1981, the Love Canal was listed on the EPA's National Priorities List (NPL). By 1982, the EPA had constructed a barrier drain and leachate collection system, covered the clay cap over the canal with a synthetic material to prevent rain from entering the canal and demolished the houses adjacent to the landfill and the 99th Street School. Remediation of the site continued and the surrounding area continued until 1999. In September 2003, the EPA issued a report declaring that the site was adequately controlled and in September of 2004 the site was delisted. It does, however, remain on the New York State's Inactive Hazardous Waste Disposal Site Program.

Environmental Sampling

Environmental sampling focused on indoor air, particularly in the basements and living spaces of homes closest to the buried wastes (Tiers 1 and 2). These data documented exposures of some residents to Love Canal chemicals, particularly in some Tier 1 homes (1,3). Subsequently, sampling efforts were expanded to include soil, sediments, water, leachate (including non-aqueous-phase liquids) and some biota. Much of this expanded sampling was focused on identifying mechanisms and routes of migration of chemical contamination from the Love Canal. Migration routes of particular concern were buried utilities, storm sewers and "swales." The backfill of utility trenches was generally not found to be very porous nor was it a major route of migration. However, the storm sewers were found to be an obvious source of chemicals into nearby streams. From aerial photography, "swales" that intersected the Love Canal and extended several blocks away from the Canal could be seen in 1938 but were filled during development of the area. An excavation of the major swale found no evidence of migration along the bottom of the swale, but scattered, low-level contamination of the fill material suggested that chemically contaminated soils were used to fill the swales (4).

Controversy over the extent of contamination and health effects and who should qualify for permanent relocation led President Carter in May 1980 to declare a second federal emergency at Love Canal. In July, 1980, Congress authorized funding for emergency relocation and purchase of another 550 homes over a more extensive area (3, 7). The evacuated area became known as the EDA and contained about 800 single-family homes and about 500 public housing units (8). The exact number of public housing units is unknown as the tax records for the complex (Griffin Manor Project) were destroyed when the new complex (LaSalle Project) was built. The EDA included all the residential units in a series of parallel streets from 93rd Street through 103rd Street and bounded on the north and south respectively by Bergholtz Creek and Buffalo Avenue (Figure 1).

Soon after the federal emergency order, USEPA began to consider what would be done with the properties remaining after remediation was completed. During remediation of the Love Canal, the first two rings of homes were to be leveled and covered by soil and a membrane to prevent further infiltration of precipitation into the Canal and its buried waste. However, properties in the much larger EDA were to be purchased and maintained by the Love Canal Area Revitalization Agency for possible future resettlement. Some mechanism was needed to decide how those properties could be used. A study was designed to guide decisions on resettlement of the remaining properties in the EDA (9). About 6,000 environmental samples (water, soil, sediment air and biota) were collected in late 1980 and analyzed for a wide variety of organic and inorganic chemicals. The data confirmed contamination in the sump water and sediments in some Tier 1 houses and in shallow groundwater and soils near them. Contamination of storm sewers and stream sediment and water was also described. Some "limited" dioxin (2,3,7,8-tetrachlorodibenzo-*p*-dioxin) contamination was found in the EDA, but no pattern of contamination with Love Canal chemicals was found in the EDA. The data also provided little or no support for the hypothesis that swales were a preferential route of movement of Love Canal chemicals into the EDA.

The USEPA study and a US Department of Health and Human Services (DHHS) review (10) were seriously criticized by the Congressional Office of Technology Assessment (11). In response to this criticism, a Technical Review Committee (TRC) was formed to coordinate the remedial actions and guide the habitability process. The TRC was headed by the USEPA and included senior scientists from USEPA, DHHS-Centers for Disease Control and Prevention (CDC), NYSDEC and NYSDOH. The NYSDOH and CDC staff consulted with a panel of 10 distinguished scientists from a variety of disciplines and the public to develop criteria to define habitability of the EDA neighborhoods (8). These criteria established 22 action steps to make a habitability decision, including the preparation of a final Habitability Study Report that would be submitted to the state health commissioner for a habitability decision and the completion of all remedial actions. The criteria established environmental sampling, chemical

analysis and data interpretation steps as well as procedures for independent scientific peer review and public participation.

The criteria selected a group of chemicals – called Love Canal Indicator Chemicals (LCICs) – that were expected to represent the potential of exposure from all chemicals in the Canal. The LCICs were chemicals known to have been dumped in the Love Canal that were not ubiquitous in the environment, not commonly used in households, were relatively stable in the environment, had the ability to migrate and were quantitatively analyzable (8). Three air LCICs (chlorobenzene and two chlorotoluenes) were sampled in 562 properties. Eight soil LCICs (three chlorobenzenes, 2-chloronaphthalene and four isomers of hexachlorocyclohexanes) were analyzed in 781 soil samples. In addition, soil from 2260 locations were analyzed for dioxin. The sampling plans were rigorously developed to permit statistical comparisons among 13 areas of the EDA (9).

Results of the peer reviewed environmental assessments were published in five volumes in 1988 (9). In September 1988, David Axelrod, New York State Health Commissioner, released his decision on the habitability of the Love Canal EDA (12). His decision noted that most of the EDA met the habitability criteria and could be used for residential or other purposes. However, portions of the EDA south of Colvin Boulevard and east of 100th Street (EDA Areas 2 and 3) and Buffalo Avenue (EDA Area 1) did not meet the criteria for habitability. The State also required the Love Canal Area Revitalization Agency to develop a land use plan with advice and input from a Land Use Advisory Committee appointed by Commissioner Axelrod. That plan was released in June 1990 (13). To assess the feasibility of remediation of EDA Areas 2 and 3, NYSDOH evaluated surface soil contamination levels and concluded that removal of the top six inches of soil would be sufficient to permit residential use in that area (14).

Study Area

To help identify patterns of contamination that may be useful for defining exposure categories among the EDA residents, the data from these different sampling efforts were mapped (see examples in Figures 2-4). Review of the environmental sampling data and reports of residents led to the designation of four areas or 'tiers' that might reflect different degrees of exposure to Love Canal chemicals (Figure 1) as follows:

Tier 1 - the west side of 99th and the east side of 97th Streets, south of Colvin Boulevard and north of the Robert Moses Parkway;

Tier 2 - across the street from the Canal (east side of 99th and west side of 97th Streets, the northern side of Colvin between 97th and 99th Streets and north of Buffalo Avenue, also between 97th and 99th Streets);

Tier 3 - the balance of the EDA between Colvin Boulevard and Buffalo Avenue and the houses along the northern side of Colvin;

Tier 4 - the area between Bergholtz Creek and the remaining houses north of Colvin Boulevard.

Review of Earlier Love Canal Health Studies

Several research groups investigated various aspects of the health status of the EDA residents. These studies were performed during or shortly after the two evacuations (1978 to 1982) by: the NYSDOH (1,15-18), the USEPA (19-21), and several independent researchers (22-28). Most were designed as cohort studies except one cytogenetic study, the critique of that study and the assessment of exposure to organochlorine chemical contaminants in blood (19-21). Three of the above cited studies were not, technically, studies; one was a health survey (25), another was a critique of a prior study (20), and the third was a confirmation of a laboratory technique used to assess chemical levels in human blood (21).

The results of these studies are equivocal, and at times conflicting. One common problem was the lack of actual environmental sampling results to construct exposure estimates for individuals living near Love Canal. Instead, exposure was classified

variously into categories in three ways: (1) street location of the home (as a proxy for distance from the Canal) (17,18,22,25,26), and/or (2) "historically wet" versus "historically dry" homes (17-19,25,26) (described below) and/or (3) residence in the EDA (16-19,23,24,27,28).

Before development of housing in the area there were a number of natural shallow depressions, called swales, traversed the neighborhood, some of which intersected the Canal itself. These depressions served as intermittent creeks and produced ponds in certain areas during times of high water. Although the swales were filled during construction, some authors hypothesized that these "historically wet" areas could have served as preferential pathways for underground chemical migration from the Canal to the neighborhood.

Several studies categorized homes as "wet" or "dry" and often used the individuals who lived in the "dry" homes as internal controls (17-19,25,26). Extensive testing by the NYSDOH in 1978 and by the USEPA in 1980 demonstrated that there was a low likelihood of any important differences in the concentrations of Love Canal chemicals in the swale versus non-swale areas, outside of Tier I (3,5). Because of these sampling results, it is difficult to ascribe any observed differences in the health status of these two groups of residents to differences in direct chemical exposure.

In the survey, the prevalence of asthma was found to be elevated, in the "wet" versus "dry" homes (25). However, this prevalence was not elevated in one other, better-controlled study of children (26). The prevalence of seizure disorders in children was elevated in "wet" versus "dry" homes in one study, but participation rates likely varied by exposure and disease status, raising the possibility of selection bias (26). The prevalence of seizure disorders was not elevated in another study, which included the most highly exposed individuals (3). Several other symptoms or diseases were reported more often in the "wet" versus "dry" homes in two studies (25,26), but these findings are difficult to evaluate due to recall bias and other problems associated with self-reported health data, as well as possible selection bias and confounding due to psychological stress.

Complete blood counts and liver function tests were performed on many of the Love Canal single-family home residents and some apartment residents. Preliminary evaluation of liver function tests suggested that people residing closer to the canal had an increased risk of having abnormal results. However, "none of the individuals with abnormal test results, who were examined by their family physicians had clinical evidence of liver disease. Repeat liver function tests for residents relocated from the canal showed a return to normal in most cases." (3,15).

The results of a controversial investigation suggested that 36 Love Canal residents had an increased frequency of cells with chromosomal aberrations (19,20). A better controlled study later demonstrated no excess of chromosomal aberrations or sister chromatid exchanges in 46 Love Canal residents (22), many of whom were the same subjects as in the previous study. Body burdens of 25 chlorinated organic chemicals deposited in the Love Canal were generally very low (1.0 ppb or less in blood); and the levels found in 36 Love Canal residents were no different from the levels found in 12 North Carolina residents (21). In two small pilot projects, adult or child residents of the EDA demonstrated no differences in nerve conduction velocities when compared to residents of other parts of Niagara Falls (23). Rates of theophylline biotransformation, a marker for liver enzyme integrity, were no different in 11 residents of the EDA than in 25 matched residents of Erie County (24).

Respiratory cancer incidence was significantly elevated during the period 1966 to 1977 within the census tract that contained Love Canal. This elevation was evident only in the 65 to 74 year old group and only 4 of the 34 cases were located close to the canal. The authors speculate that it may be related to a high rate for the whole City of Niagara Falls. The incidence of nine other cancer types was not elevated (16). These results were limited by the too short length of follow-up time to assess many cancers and by the inability to trace people who moved from the neighborhood and who may have developed cancer later. Perhaps the greatest limitation was the lack of control for a history of smoking, the strongest single predictor of respiratory cancers.

Two studies found no excess of low birth weight infants in their entire Love Canal groups when compared to an external control group, but both studies demonstrated an excess of low birth weight infants who were born to owners of "wet" homes versus owners of "dry" homes (17,27). These studies were limited, again, by the imprecise nature of the "wet" versus "dry" exposure measure, and by the lack of control for confounding due to previous adverse pregnancy outcomes. Rates of congenital malformations were increased in "wet" versus "dry" homes in a study that was limited by maternal recall (18). When possible, the cases were confirmed; however, the findings are based on only 26 confirmed cases. This study was also limited by the same problems discussed above (17,27). Two other studies that reported elevated rates of congenital malformations in Love Canal residents suffered from possible selection bias and recall bias (25,27).

A growth study, examining the height and weight of children, found a Love Canal-related decrease in height-for-age, but only in males less than 12 years old (28). The authors did not convincingly explain why this detrimental effect would occur in only one age and sex group; also, there is no exposure-response relationship, and selection bias is possible.

To reiterate, some of the common limitations in the study designs included: (1) imprecise estimates of exposure status (i.e., wet versus dry homes or the whole census tract); (2) small sample size; (3) selection bias (that is, the subgroup of residents who chose to participate were not representative in regard to their exposure and disease status; (4) recall bias (for example, difference in recall of exposure by sick people compared to non-sick people); (5) vaguely described control groups, or no control group at all (as in the first chromosomal study); and (6) lack of control for important confounders (for example, lung cancer and smoking, or low birth weight and previous adverse pregnancy outcomes). In addition, many residents did not settle at Love Canal until the 1960s or later, providing insufficient latency for cancer and many other chronic diseases to develop by 1978 - 82, the time period for these investigations.

In retrospect, the challenges posed by Love Canal were unprecedented because this crisis was the first recognition of its kind, that is, a large residential population in close proximity to a major hazardous waste site. Many of the investigators attempted to conduct scientifically defensible studies despite serious time constraints, budgetary limitations, and political pressures. It was difficult to conclude from the results of these efforts, however, whether exposure to chemical wastes dumped at Love Canal was associated with any adverse health effects.

Community Involvement

Given the magnitude and precedent-setting nature of Love Canal and the equivocal results of previous studies, there was a clear need for a comprehensive assessment of the long-term health status of former Love Canal residents. It was also apparent that such an endeavor had to involve the Love Canal community to be successful. There were, however, at least two major obstacles to this goal. First, although the cohort might be considered a historic community, it was no longer a geographic one. Most of the residents had moved away from the Canal more than 25 years ago, and their current addresses were unknown at the beginning of this study. Secondly, there was a high level of tension among the diverse Love Canal community groups' relationship with the NYSDOH and other agencies. The dynamics of their past participation in previous inconclusive health studies and their frustration with government processes manifested itself in a declaration that they would not participate in any additional health studies.

To develop an active, productive relationship with the former residents, a dialogue was initiated well before funding for the study became available. In 1988 and 1989, public meetings were held in the Niagara Falls area to elicit from the community their concerns and ideas for a follow-up health study. Comments were compiled, reviewed and, whenever feasible, incorporated into the study design.

In addition, NYSDOH formed an Expert Advisory Committee of eight scientists with expertise in epidemiology, biostatistics, toxicology, engineering, and other disciplines relevant to the investigation. Many had served as consultants for previous Love Canal projects, and consequently were already familiar with the history and background. Community leaders were invited to nominate three of these scientists, all of whom were appointed by NYSDOH.

A fact sheet was developed and used to inform interested officials and community organizations about the study before it was announced in the press. A copy of the same fact sheet was also sent to former residents with a letter explaining the study. The letter also included a toll-free telephone number, maintained by the NYSDOH, to encourage people with comments or concerns about the study to contact the Health Department. To date, study staff has responded to hundreds of callers.

Meetings of the Expert Advisory Committee were held in Niagara Falls and, through direct mailings and media coverage, interested members of the public were invited to attend. Although the first meeting was held in the daytime only, all subsequent meetings included both day and evening sessions for community convenience and meeting information was mailed in advance to everyone who requested to be kept informed. These meetings were held every six months and were open to the general public and press; time was set aside for public comment. Day and evening availability sessions, where people can talk one-on-one with committee members and study investigators, were also held.

Newsletters about the status of the health study were mailed to all former residents included in the study. Each newsletter contained an information sheet explaining a basic epidemiological concept, the possible designs to collect and explore relevant data and the strengths and limits of such studies. Also included were sheets requesting any suggestions, comments and concerns the readers might have about the study, the newsletter, or any other concerns. Over 500 individuals have responded thus far, nearly all of them expressing interest and acceptance of the study, a desire to

continue receiving the newsletter and an interest in the Expert Advisory Committee meetings. The NYSDOH has committed to continuing the newsletter updates.

The Expert Advisory Committee was asked to continue guiding community involvement efforts, and implementation of their suggestions has occurred where feasible. For instance, they recommended that the original proposal to conduct a chronic disease morbidity interview study be put aside given limited statistical power. Instead, they suggested that the NYSDOH describe the health status of former Love Canal residents using registry data. As an additional effort to involve the community, three members of the community were recruited to review documents related to the study and to attend committee meetings in a consultant capacity. The community consultants' advice and information sharing has been extremely valuable in refining the exposure assessment, which will be described in the Methods section.

Study Objectives

With input from the community and suggestions from the Expert Advisory Committee, the NYSDOH has conducted a comprehensive observational study to describe the mortality, cancer incidence, and reproductive experiences of former Love Canal residents from 1978 through 1996 and how they compare with that for NYS and NC residents. The study also compares the health status of residents according to where when, and for how long they lived at Love Canal. The study focuses on more than 6,000 individuals who lived in the EDA some time between 1942 and 1978 and were interviewed by the NYSDOH as part of its original investigations from 1978 to 1982, or who were the minor children of interviewees.

The specific objectives were:

1. Trace the Love Canal cohort from 1996 back to the time of the original NYDOH interviews of the Love Canal residents (1978 to 1982) to determine their vital status and current address;

2. Qualitatively assess the potential for exposure of each individual based on time period and/or location of residence and potential additional exposure associated with childhood behaviors, and other factors;

3. Calculate the overall and cause-specific mortality rates of the Love Canal population from the date of original interview to December 31, 1996, compare the resulting rates to those for NYS and NC while adjusting for age and gender, and evaluate the total risk of mortality according to exposure status after adjusting for age, gender, race, and other potential confounders;

4. Calculate the total and site-specific cancer incidence rates of the Love Canal population from the date of original interview to December 31, 1996, compare the resulting rates to those for NYS and NC while adjusting for age and gender, and evaluate the total risk of cancer according to exposure status after adjusting for age, gender, race and other potential confounders;

5. Calculate rates of low birth weight (beginning 1960), preterm births and small-for-gestational age (beginning 1967) and congenital malformations (beginning 1983) as well as sex ratios (beginning 1960) among children born to women in the Love Canal population to the end of follow-up period of December 31, 1996. Compare the resulting rates to those of NYS and NC while adjusting for age, and the total risk of selected adverse reproductive outcomes according to exposure status will be evaluated after adjusting for age and other potential confounders.

6. The project also includes the measurement of concentrations of eight LCICs in archived blood sera drawn from EDA residents in 1978. The concentrations will be used to indicate the residents' body burdens more quantitatively than the assessment based on time period and location of residence. However, the evaluation of those data is still ongoing, so they are not included in this report.

METHODS

Study Population

The follow-up health study is an observational study of the former residents of the Love Canal EDA based on the cohort that was identified, traced and interviewed by the NYSDOH from 1978 to 1982. Only residents who were 18 years of age or older were interviewed. The present cohort is composed of 6,181 former residents who met the following criteria:

1. lived in the Love Canal EDA some time between 1940 and June 1978;
2. was 18 years or older during the interview period and completed a detailed questionnaire; or
3. if younger than 18 years during the interview period, was a child of at least one parent who completed the questionnaire.

Of the 6,181 cohort members, 3,191 (51.6%) lived in the EDA in 1978; 2,990 (48.4%) lived in the EDA sometime between 1940 and 1977.

Variables abstracted from the interviews and used in this analysis were: interview date; date of birth; sex; residential history including addresses, dates moved in, dates moved out; occupational history including job titles, company names, dates of employment; and a history of smoking and alcohol consumption at the time of the interview. The date of entry into the study for each member was the date of interview. Children were assigned the interview date of the parent as their date of entry into the study.

All addresses of the Love Canal cohort members were abstracted from the interviews, data entered and checked for consistency (i.e. children living in a house the same years as their parents, only one family per time period, etc). A time line was created from these address files tracing the occupancy of a specific residence from 1940

to 1978. Of the 814 single family homes in the EDA, 776 (95%) had at least one cohort member occupying that residence for some period between 1940 and 1978. All 100 single family homes in Tier 1, 142 (99%) of the 143 house in Tier 2, 336 (98%) of the 342 houses in Tier 3 and 198 (86%) of the 229 houses in Tier 4 were represented for some time between 1940 and 1978. Of the 776 homes represented, 575 had one or more members of the cohort at that address 75% or more of the total period from 1940 to 1978. A large portion of Tier 3 to the west of the Canal contained two sequential public housing projects: Griffin Manor, which was torn down, and a new housing project, LaSalle, which together with senior citizen housing was built on the same land area in the 1960s. When the physical projects were torn down, the housing authorities destroyed the leasing records. Only the historical real property information remains, and this was not available by apartment. Thus, neither the total number of apartments nor residents in these projects is known. The NYSDOH attempted to include residents of the LaSalle projects in 1978 by setting up tables in the lobbies of the building and going door-to-door, but the success of this endeavor was unknown. However, 1,315 (21.3%) members of the cohort resided in at least one of these rental units.

Comparison Populations

New York State (NYS) exclusive of New York City (NYC) and Niagara County (NC) were selected as comparison populations. The five boroughs of NYC were excluded because their greater level of ethnic diversity would introduce potential confounding which could not be adjusted for in the analyses. Even excluding NYC, the population of NYS was large enough to provide stable death rates and disease rates by year, age group and sex. Although the population of NC is, obviously, not as large as NYS and therefore the rates were not as stable, NC provided a population very similar to the Love Canal cohort demographically, while mitigating any potential regional differences in reporting of the outcome of interest and controlling for exposures to other major environmental sources of chemicals in addition to the Love Canal itself.

Tracing Former Love Canal Residents

Tracing of the Love Canal cohort began in 1996, the year funding began, and extended back in time to the date of each subject's original NYSDOH interview (1978 to 1982) to determine whether each person in the cohort was still alive, and if alive, their current address. The tracing methods used are typical for studies of this type. (29)

To obtain information on possible name changes due to marriage, the names and birth dates of women were submitted to New York State Vital Records (NYSVR) for matching to the marriage registry. A total of 183 names were successfully matched and the new names noted.

All known names (birth names, married names, etc) and dates of birth were matched against the internet web site 'ssdi.rootsweb.com.' This site uses the Social Security Death Index (SSDI) database that originates from the Social Security Administration (SSA). It contains the records of deceased persons who were assigned Social Security numbers and whose deaths were reported to the SSA. The database currently contains more than 73 million names. Those names which matched with the SSDI were noted on the registry as 'hits.' See Figure 5 for a schematic presentation on the tracing process.

Names of both men and women who were not known to be deceased were then matched against the New York State Department of Motor Vehicles' (DMV) drivers' licenses and motor vehicle registration files. If a person moved out of state and surrendered their New York State driver's license, DMV records the date and state to which the license was surrendered. DMV also issues non-driver photo identification to individuals and that information is maintained in the DMV files for a period of ten years. In addition, if a driver from another state is issued a moving violation ticket in New York, their name and out of state addresses are added to the New York State DMV file. A member of the cohort was considered a 'hit' if their name and date of birth matched and the license or registration were still valid.

For those names not found using the SSDI or DMV records, a variety of other tracing sources were applied: the Albany Credit Bureau's Locate Services, United States Post Office address corrections service, local Board of Elections and the NYSVR death registry. For many former residents, family members or former neighbors were asked if they had address information about the cohort member. If the information obtained from the Credit Bureau's Locate Services was found to be incorrect, it was confirmed using one of the other tracing sources.

A letter explaining the study and a fact sheet were then sent to the confirmed addresses of those persons successfully matched. If the letter was returned as undeliverable by the Post Office, any of the additional sources of tracing not yet employed were needed to corroborate the vital status and/or address information. If DMV files were the only source of tracing information found, the date of last renewal was noted and these subjects were considered alive up to that date and then denoted as 'lost to follow up.' If the letter and subsequent communications were not returned, the subject was considered alive in 1996.

Exposure Assessment

There were two distinct time periods of potential chemical exposure: 1942 to 1953 (the open period) and 1954 to 1978 (the closed period). During the open period, when the Canal was used for active disposal of chemicals, the families who lived in the few existing homes may have been exposed through air transport and deposition (10). Children played at the Canal or swam in the water-filled dump during those years and were likely to have been exposed through dermal contact, inhalation and ingestion. There were very few homes in Tiers 1 or 2 during this period, but they would have been the most highly affected; other less-impacted residences were in the Griffin Manor project or beyond. Contaminants may have entered yards and homes through air transport and deposition, surface water run off, and shallow groundwater transport (7). The closed period began in 1954 when the landfill was covered and construction in the area immediately adjacent to the Canal began. Odor complaints were made to local

officials as early as the late 1950s and had continued through 1978. Study participants reported picking up phosphorus rocks as school children on the playground and throwing them against the ground to create sparks. Thus, for the closed period, the historic, qualitative environmental evidence suggests that there was the potential for continuous exposure that began with the covering of the Canal in 1954 and extended through 1978.

An exposure matrix was created to characterize the above potential for residential exposure for each member of the cohort. Initially, the exposure matrix consisted of twelve time/tier correlated variables. The time periods were divided into three distinct categories: 1942 when the dumping began to 1953 when the canal was covered; 1954 to 1976; and 1977 to 6/1978 when the chemicals, loose or in drums, seeped up through the soil covering. Each of these three time periods were further divided into the four tiers. When the analyses began, it became clear that the second and third time periods were highly correlated; people who were living in their homes up to 1976 continued to live in those homes until the evacuation. Thus the time period 1954 to 1976 was highly correlated with 1977 to 6/1978, and therefore, statistically unusable in modeling exposure.

A factor analysis was performed on the 12 variables to try to reduce the number of variables and create exposure variables that would be independent of each other. The results of the factor analyses combined the two latter time periods into one factor for tiers 1 and 2, and a second factor for the combined time periods and tiers 3 and 4. The third and fourth factors were the earlier time period, tiers 1 and 2, and 3 and 4, respectively. These time and tier variables were consistent with the anecdotal environmental information of a continuum of leakage from the covered landfill.

To summarize, the four resulting independent factors were:

Open period (1942-1953) – tiers 1 and 2 (OP12);
Open period (1942-1953) – tiers 3 and 4 (OP34);
Closed period (1954-1978) – tiers 1 and 2 (CL12); and
Closed period (1954-1978) – tiers 3 and 4 (CL34).

Persons in OP12 had high potential for exposure, given that they lived on or adjacent to Love Canal during the period of active dumping. Since they lived further away from the Canal, persons in OP34 had a medium potential for exposure. The potential for exposure was medium to high for residents in CL12, since they lived closest to the Canal and there was the resurfacing of chemicals during that period. Those in CL34 had the lowest potential for exposure, given that they lived further away and had less access to the Canal than persons in Tiers 1 and 2. Exposure dose was then quantified by assigning the number of years the study participants lived in each of the four factors; these exposure variables were not mutually exclusive for many people.

Three additional exposure values were used: 1) childhood exposure, 2) living on a hot spot or historical swale area, and 3) attendance at the 99th Street School. Childhood exposure was defined as the additional potential for exposure among children growing up on Love Canal. This was assessed for two time periods: 1) 1942 to 1953, and 2) 1954 to 1978. Anecdotal evidence suggested that teenaged boys swam in the Canal during the years of active dumping; therefore, 13 to 18 year old males were considered exposed in childhood from 1942 to 1953. From 1954, playing on the soil covering of the Canal was considered the main route of additional exposure for children; therefore, all children less than 13 who lived close to the covered Canal (Tiers1 and 2) were also considered potentially exposed during childhood.

Additionally, in response to community concerns, a dichotomous variable was created to indicate whether the cohort member lived in a residence built on one of the historical swales. This swale/hot spot variable also described residences where the 1978 sampling evidence indicated higher than expected values in the soil. It was felt that these 'hot spots' may have been created when the residences were built using fill from the Canal area. Finally, the names of all students who attended the 99th Street School, which had been built on the original site of the Canal, were obtained from the Niagara Falls School Board. These were then matched to the registry to ascertain which members of the cohort attended the school and the number of years of attendance for each. Thus, the

third additional exposure variable used was the number of years the cohort member attended the 99th Street School.

Outcome Assessment

Mortality

All names of study participants not known to be alive in 1996 after the above described tracing methods were matched with the New York State Death Certificate Registry (NYSDCR). The New York State Department of Vital Records (NYSDVR) uses SAS software to match cohort names with the information in the NYSDCR. Matching variables include all names, including any known aliases, year of birth and, when available, social security number, year of death and/or death certificate number. A scoring system was used that assessed the closeness of the potential match. Data files containing the matching variables plus other death certificate variables (county of residence at time of death, race, cause of death, etc.) were returned to study staff. Staff then hand matched using many of the additional variables as corroboration.

The names of those who were known to be dead but did not match with the NYSDCR and those 'lost to follow up' were sent to the National Center for Health Statistics' National Death Index (NDI) for matching. The NDI is a national file of identifying death record information, beginning in 1979, which is compiled from information submitted by all 50 state vital statistics offices plus those of the U.S. Virgin Islands, Puerto Rico and the District of Columbia. First and last names, additional names people may have used (AKA), sex, race, dates of birth and social security numbers, when noted on the original Love Canal interviews, were submitted to the NYSDCR or the NDI and the underlying cause of death was abstracted. In addition, there were twenty-four subjects who were deceased according to informants but did not match with either NYSDCR or the NDI.

Centers for Disease Control's Wide-ranging OnLine Data for Epidemiologic Research (CDC-WONDER) (30) was the source of the comparison mortality data. The site maintains a county-level national mortality and population database. The mortality database is derived from records of deaths reported by each state's Department of Vital Records. CDC's web data begin with the year 1979 and report mortality for ages 1 and older.

Data were collected by sex and age group for each year from 1979 to 1996. The pre-assigned age groups used by CDC Wonder are 1-4, 5-9, 10-14, 15-19, 20-24, 25-34, 35-44, 45-54, 55-64, 65-74, 75-84, and 85+ years. Data from each year were then grouped for analysis purposes as follows: June, 1978 – 1981, 1982 - 1986, 1987 - 1991 and 1992 - 1996. Deaths that occurred in the last six months of 1978 were considered to have the same rates as 1979. Data were included for any three digit category of the International Classification of Diseases-9th Revision (ICD-9, in use from 1979 to 1998) for which there was at least one event in the cohort. These three digit categories were then combined into major disease classification systems. If the disease classification system category had fewer than five expected events, the three digit categories data were not presented. Small numbers also prohibited examination by most individual ICD-9 codes and rendered unstable year-by-year comparisons.

Cancer Incidence

All names of persons in the Love Canal cohort were matched with the New York State Cancer Registry (NYSCR) using last name, first name, month and year of birth, sex, social security number (where available), and the soundex of first and last names. The matching was done with five passes of the NYSCR's Automatch program, varying the matching criteria for each successive pass. The matching point cutoffs were set low so that the process was as 'sensitive' as possible. The 'successful' matches were visually reviewed after each pass, and matches that were incorrect were unlinked and thus available for the next pass. The years of diagnosis can be considered complete for 1979-1996.

In addition, the names of persons who lived in the eight states to which the largest number of cohort members moved and which had cancer registries were submitted to the appropriate registries for matching. These states included: Arizona (registry began 1995), California (registry began 1985), Florida (registry began 1981), Ohio (registry began 1992), North Carolina (registry began 1990), Pennsylvania (registry began 1985), Virginia (registry began 1990) and Texas (registry began 1995).

The NYSCR also provided the comparison data. For consistency, the same year groupings were used as in the mortality analysis. The three digit ICD-9 categories were combined by organ system level. Data were also collected by sex and age group. The age groups used for the cancer were chosen to be the same as used in the mortality analyses.

To increase power when analyzing cancers of organ systems, it was decided to group systems based on how strongly the literature supported a link between each endpoint and the chemical/chemical classes believed to have been disposed of at Love Canal. Using the list of LCICs and associated chemical classes, several resources were reviewed to help determine evidence for carcinogenicity. These included the International Agency for Research on Cancer (IARC) Monographs (Vol. 1 – 80 and Supplement 7), ATSDR Toxicological Profiles, National Toxicology Program (NTP) 9th Report on Carcinogens and the Carcinogenic Potency Database (31).

Each chemical or chemical class was reviewed initially to determine if there was general evidence that it may be a carcinogen. In the IARC Monographs, only those chemicals classified as having “sufficient” animal evidence or at least “limited” human evidence were reviewed further. The search was further refined to reflect the presence of animal and/or human evidence for individual organ cancer endpoints.

The review was used to determine which cancer endpoints were associated with the greatest number of LCICs, based on the results of previous studies. These endpoints were grouped for the purposes of statistical analyses. Additional endpoints that

demonstrated a more moderate degree of evidence were added sequentially. The resulting groups were:

- Liver, lung and non-Hodgkin's lymphoma
- Liver, lung, non-Hodgkin's lymphoma and leukemia
- Liver, lung, non-Hodgkin's lymphoma, leukemia and soft tissue sarcoma
- Liver, lung, non-Hodgkin's lymphoma, leukemia, soft tissue sarcoma, stomach and kidney

In addition, a NYSDOH toxicologist was consulted and other plausible methods of grouping endpoints were considered: 1) organs of first contact (lung and skin); 2) organs of the endocrine system; 3) estrogen sensitive organs in males and females; 4) known probable occupational hazards (32); 5) environmentally sensitive organs (32, 33); and 6) cancers in childhood (18 years of age or less) vs. adult cancers.

Reproductive Outcomes

The incidence of six birth outcomes was analyzed: low birth weight (<2500 grams), very low birth weight (<1500 grams), preterm births (<37 weeks gestation), small-for-gestational age, sex ratios (female to male) and congenital malformations. Adjusted SIRs were calculated controlling for mother's age, the birth year and child's sex, except for congenital malformations which controlled for birth year and sex of child. Two alternative populations were used as the standard: NYS and NC.

To assemble the reproductive cohort, the names of all female members of the Love Canal Follow-Up Health Study cohort who lived at any time in the EDA from 1942 to 1978 and were between 12 to 55 years of age after 1960 were matched with maternal information on NYSVR birth certificates. The age range was defined broadly to ensure the capture of all births to cohort members. Statistical birth files already existed for the years 1970 to 1996; the NYSVR Bureau created statistical files for the years 1960 to 1969 specifically for this study. The primary matching criteria included maternal first

and last names, maternal age (± one year), and, if known, maternal birth name, and, for births after 1967 and where noted on the interview, social security number. For births that took place prior to the mother's interview, reproductive data from the mother's interview was used to confirm or refute any questionable matches.

To be eligible for inclusion in the reproductive outcome portion of the study, a child must have been born during or after maternal residence in the EDA to a mother who was not herself exposed in utero. This definition was used in an attempt to eliminate any trans-generational effect; that is, eliminate the possibility that any risk observed could be attributed to the fact that the birth mother was also exposed in utero. Thus, all acceptable matches were linked with the maternal address information to confirm that the birth occurred during or after the mother had moved to the EDA and that the mother, herself, had not been born on the EDA.

Data from the birth certificates were used to analyze birth weight, gestational length, small-for-gestational age (SGA) and sex ratios (female/male). Low birth weight was defined as less than 2,500 grams, very low birth weight as less than 1,500 grams and preterm births as less than 37 weeks gestational length. Small-for-gestational age was defined as a singleton birth whose weight falls in the lower 10% of NYS births distributed by week of gestation, sex of infant and calendar year groups defined below.

Data on birth defects were obtained from two sources. From 1983 to 1996, all births included in the reproductive outcome portion of the study were matched to the New York State Congenital Malformation Registry (CMR). The CMR is a legislatively-mandated, population based registry that collects data on birth defects diagnosed within the first two years of life among all children born to NYS residents. The first year of complete data collection for the CMR is 1983. Periodic audits of hospital records encourage complete reporting. Incomplete or inconsistent reports are returned to the sender for clarification. For the purposes of this study, only selected, well-reported malformations (see Appendix A) were included in the SIR and modeling analyses. These defects were chosen to minimize differences in regional reporting to the CMR, which

could bias differences between former Love Canal residents and comparison groups. However, both reported and selected malformations were included in the descriptive statistics.

To obtain information on birth defects prior to 1983, the number of births to study mothers for the years 1970 to 1982 was calculated for every hospital in the area. There were three hospitals representing 610 (87%) of all births in those years. The names and dates of birth of children born in these hospitals were sent to the respective medical records offices. The appropriate medical birth records were found and a trained medical abstractor recorded the relevant information.

Singleton births only were included in the analyses of birth weight, gestational length and SGA, since multiple births may affect these outcomes. All births were included in the analyses of sex ratios and birth defects.

The NYSVR statistical birth files also provided the external comparison data for the reproductive outcomes of birth weight, gestational length and sex ratios. The CMR provided the comparison data for the 1983-1996 birth defects portion of the study. There is no appropriate comparison population for birth defects prior to 1983.

Data were grouped for analyses of SIRs by birth years 1960-1967, 1968-1978, 1979-1987 and 1988-1996. The first year group, 1960-1967, was chosen because in those years the NYS birth certificates reported birth weight and gestational length in categories, not in actual grams or days. The end points for the second year interval, 1968-1978, completed the time the whole cohort could have lived in the EDA. Small numbers of low birth weight or preterm babies required broader year groups than for the mortality or cancer components of the study. For the same reasons, maternal age was also categorized into only 4 age groups: less than 20, 20-27, 28-34 and greater than 34 years old. The youngest and oldest age groups were chosen to coincide with increased risk of adverse reproductive outcomes in mothers of these ages.

Results are reported for 1960 (1968 for preterm birth and SGA) to 1978 and 1979-1996. The results for 1960 (1968) -1978 are further divided into those pregnancies during which the mother lived at some time in the EDA (on Canal) and those that occurred after the mother had left the EDA (off Canal). The exception to this division was for analyses of sex ratios: 'on Canal' implies the infant was conceived while the mother was living in the EDA and 'off Canal' means the infant was conceived after the mother left the canal. Any births that were conceived prior to residence in the EDA were excluded from analyses of sex ratios. These three groups: 'on Canal,' 1960-1978; 'off Canal,' 1960 - 1978; and 1979 - 1996, when essentially all births were off-Canal represents an increasing temporal distance from the potential exposures associated with residence in the EDA. On average, 1979-1996 implies a longer time period away from the EDA than the births prior to 1978. The time period prior to 1978 is of special interest to the community as it represents the period of active exposure.

Potential Confounders

Variables were abstracted from the original interviews to control for potential confounding of the association between exposure and health outcomes. Occupational history, including job titles, company names and dates of employment, were data entered. All occupational information was given to the Industrial Hygiene Section of the NYSDOH's Bureau of Occupational Health. Three industrial hygienists reviewed the job histories and evaluated each job's potential for exposure to LCICs, carcinogens, and repro-toxins as high, medium or low/no. Other covariates included sex, birth date (to calculate age), race, a history of smoking or alcohol consumption, and a family history of cancer at the time of the interview. The latter three variables were coded to ever/never.

Statistical Analysis

For the mortality, cancer and reproductive sections of the study, univariate analyses were first performed to check for outliers and coding errors as well as to assess the distributional properties of the data. General descriptive statistics were then

generated for all variables used in the analyses. Two major types of multivariable analyses were performed: 1) external comparisons, focusing on differences between the Love Canal population and NYS and NC and using Standardized Mortality Ratio (SMR) or Standardized Incidence Ratios (SIR), and 2) internal comparisons, focusing differences among the Love Canal population according to their potential for exposure and using survival analysis methods (mortality and cancer) or logistic regression (reproductive outcomes). All point estimates are presented to two decimals for consistency, even where small numbers may preclude such precision.

Mortality and Cancer

External comparisons

To compare the mortality and cancer incidence experiences of the study group to NYS and NC, SMRs and SIRs were calculated controlling for age group, sex and calendar year using the indirect method described below (34). Person-years for the Love Canal cohort were computed as the difference from the date of interview to the date of death or cancer diagnosis, loss to follow-up, or end of the study period (December 31, 1996). A mid-year assignment was used for persons where only the year of death, diagnosis, or loss to follow-up was known.

As discussed previously, ICD-9 codes were grouped by major disease categories, and rates for each year group, age group, and sex were calculated for both NYS and NC. Annual interpolations of the US Census were used to provide population estimates. These rates were then multiplied by the respective person-years of observation for the Love Canal cohort to calculate expected numbers of cases. Point estimates for the SMRs/SIRs were computed as the ratio of observed to expected cases, and confidence intervals (CI_{95}) were calculated using the exact probabilities of the Poisson distribution. Age-adjusted SMRs/SIRs were also calculated by sex for both NYS and NC. There was no comparison information for Neoplasm of Unspecified Nature (ICD-9 = 239) for NYS and NC. Since only one person in the Love Canal cohort was diagnosed with this

category of cancer, this person was included in the analysis of all cancer sites, but no further analysis was conducted for this subgroup of cancer.

Internal comparisons

Survival analysis, specifically the Cox proportional hazards model (PH model), was used to statistically model the association between the potential environmental exposure risk factors and mortality and cancer incidence among members of the Love Canal cohort (35). Due to the descriptive nature of the study, a Type I error of .10 was used as a criterion for constructing the final survival analyses models.

The survival analyses of mortality focused on six categories of the underlying cause of death: all causes; neoplasms (ICD-9 140-239); diseases of the circulatory system ICD-9 390-459); acute myocardial infarction (ICD-9 410); diseases of the respiratory system (ICD-9 460-519); and external causes of injury and poisoning (ICD-9 E800-E999). These categories were chosen because of the large numbers of deaths experienced by the cohort in these groups.

The survival analyses of cancer focused on all sites of cancers and three major categories of cancers: cancers of the digestive organs and peritoneum (ICD-9: 150-159), cancers of the respiratory and intrathoracic organs (ICD-9: 160-165), and cancers of the genitourinary tract (ICD-9: 179-189). In addition, two subgroups of the latter two categories were included: cancers of the liver, rectum and intrahepatic bile ducts (a sub-group of cancers of the digestive organs, ICD-9: 154-155) and bladder, kidney and other urinary organs (a subgroup of genitourinary cancers, ICD-9: 188-189). These categories were chosen either because there were sufficient numbers of cancers in the categories to allow for analyses or because they were cancers which might be expected to be especially affected by exposures to chemicals (liver, rectal, bladder and kidney cancers). The analyses include only cancers diagnosed in June 1978 or later, because the NYSCR was not fully computerized until then.

As discussed earlier, seven exposure variables and five potential confounding variables obtained from the original 1978 to 1981 interviews were included in these

analyses (see Table 1). For continuous variables, the hazard ratios (HR) are per one-unit increments: age, years of attendance at the 99th Street School and the years of residence in the time/tier specified. For the dichotomous variables sex, ever smoked, ever consumed alcohol, childhood exposure , and lived in a residence on a swale/hot spot, the hazard ratios compare the two categories.

To test the proportionality assumption of the models, the interactive terms for each of the exposure covariates of interest with survival time were included in the model. If the parameter for the interactive term is not statistically significant, then one concludes that the proportionality assumption is valid and the model is limited to time invariant explanatory variables. If the interactive term is statistically significant, that is, there is evidence for non-proportionality, then the inclusion of the interactive term corrects for the non-proportionality (36). All covariates in each of the final models were tested for time-dependency, and if indicated, the interactive term with survival time remained in the model.

Schonfeld residuals were also plotted as an additional check to detect possible departures from the proportionality assumption (35). Residuals were calculated for each covariate in the model: the observed covariate value for the person who died minus the expected value of that covariate. The results did not show a relationship with time, suggesting that the proportionality assumption was not violated.

Reproductive Outcomes

For the years 1960 to 1967, birth weight and gestational length were not reported as an exact value in the computerized birth certificate files; instead, they were grouped and reported as categories. The categories were defined such that, for birth weight, the upper class limits for two of the categories were 1500 grams and 2500 grams (< 1500 grams is considered very low birth weight and < 2500 grams is low birth weight), and for gestation, one category had an upper class limit of 37 weeks (<37 weeks defines preterm births). To determine whether the percent of live births with low and very low birth weight could be validly estimated from these grouped data, the distributions of the

grouped data were compared to the data for those years after 1967. For birth weight, the results before and after 1967 were similar, so the percent of births that were low and very low birth weight could be ascertained before 1967. Mean birth weights were calculated by using the mid-value of the class interval of each grouping from 1960 to 1967 to estimate the exact birth weight. Gestational age, however, proved more problematic. For the years 1960-1967, 4.8% of all NYS births were preterm (< 37 weeks), 72.8% were reported as 40 weeks of gestation and the remaining 22.4% were 38-39 weeks of gestation. In contrast, for the years 1968-1996, when gestation was reported in days of gestation, 8.3% births were preterm, 23.4% were reported as 40 weeks gestation and the remaining 68.3% were 38-39 weeks of gestation. To avoid this apparent reporting bias, preterm births and SGA, which includes gestational age, were limited to 1968 and later.

External comparisons

Mean birth weight, sex ratios, and the proportions of low and very low birth weight, preterm births, SGA, and birth defects were calculated for the Love Canal cohort and for NYS and NC. Proportions were computed for the total years of follow-up, before 1978 ‘on Canal’ and ‘off Canal,’ and after 1978, when the evacuation of the EDA began. The proportions of both all reportable and selected birth defects from 1983-1996 were calculated for the Love Canal reproductive cohort and for NYS and NC. Since there is no comparison population for birth defects prior to 1983, only the proportions for the Love Canal cohort were presented for those years.

After adjustment for birth year, sex of infant and maternal age, SIRs were calculated for low birth weight, very low birth weight, preterm, SGA, and total birth defects, using both NYS and NC as comparison populations. The ratios of female to male births in the cohort were also compared to the ratios observed in both external populations.

Internal comparisons

Logistic regression was used to statistically model the association between potential environmental risk factors and the reproductive outcomes, controlling for potential confounders. There is a dependence of a given pregnancy outcome on other pregnancy outcomes for a given same woman, i.e., the resulting repeated observations are correlated over time. If this correlation is not taken into account then the standard errors of the parameter estimates will not be valid and hypothesis testing results will be non-replicable. Generalized Estimation Equations (GEE) are methods of parameter estimation for such correlated data (37). Thus, logistic regression using GEE methodology was used in this analysis.

RESULTS

Study Population and Tracing

The Love Canal cohort is composed of 6,181 men, women and children. The demographic characteristics of the cohort are presented in Table 2 by tracing status. Most of the 6,181 members of the cohort were white (94.6%) and female (52.0%). The two persons with missing sex information were infants for whom no names were available and who could not be traced. Approximately 77.3% lived exclusively in single family homes, 13.1% lived only in the rental units and 9.6% lived in both the rental units and single family homes. More than half of the interviews of the adults in the cohort wre conducted in 1978 (51.2%); the date of interview is important because that marks the start of the follow-up period for each cohort member. The median number of years from first residential exposure to Love Canal until the end of follow-up for each cohort member was 32.0 years with a range of two to 54 years. The total length of time of residence in the EDA ranged from 0.5 to 36.5 years with a median of 7.0 years. Three thousand one hundred ninety one (51.6%) of the cohort resided in the EDA in 1978, the remaining 2,990 (48.4%) had left the EDA prior to 1978.

Figure 5 shows the tracing process and Table 3 gives the results of the tracing of the cohort members. There were 5,241 persons (84.8%) successfully traced from date of

original interview, alive through 1996 and with a current, known address. For thirteen individuals (0.2%) who were known to be alive through 1996, current address information was not available. Seven hundred twenty-five (11.7%) were found to be deceased. Forty-seven (0.8%) were successfully traced from date of interview but then lost to follow-up at some point prior to December 31, 1996. One hundred and fifty-five persons (2.5%) were lost to follow-up immediately after date of original interview. Of the 155 lost to follow-up, 75 (48%) lived, at some time, in one of the rental units.

Of the 6,013 for whom we have address information, 4,461 (74.2%) never moved out of New York State and 1,035 (17.2%) left New York State but responded to our request for address information from the date of interview to 1996. The remaining 517 cohort members (8.6%) had an out of state addresses in 1996 with no address information between their date of interview and 1996.

External Comparisons

Mortality

After excluding the 155 cohort members lost to follow-up immediately after the original interview, the remaining 6,026 people contributed a total of 97,926 person-years to the analysis. The distribution of person-years by age, sex, and time period is displayed in Appendix B.

Of the 725 deaths observed among cohort members during the study period, 701 had cause-specific information; the remaining 24 deaths were reported by relatives and the cause of death was unknown. The latter deaths were included in all-cause mortality but deleted from the analyses of specific causes.

Table 4 presents the SMRs for men and women combined compared to NYS; Table 5 gives the data for men and women separately. Tables 6 and 7 respectively include men and women combined and separately, using NC as the comparison

population. For the sake of brevity and to avoid problems with small numbers, the results displayed in these tables are limited to those causes with 10 or more expected deaths or with SMRs greater than 1.0 and more than one observed case for at least one comparison. (Tables with a more complete set of SMRs are included in Appendices C through F). Confidence intervals are given in the tables for each SMR, but are only cited in the text if they excluded the null value of 1.00. The results using NYS as the standard are the focus of most of the discussion below, since the results relative to NC were generally similar.

The SMR for all-cause mortality hovered around 1.00 in every analysis. For example, for both sexes combined the SMR relative to NYS was 1.04 (Table 4); for men only, the SMR was 1.06 and for women only the SMR was 1.00 (Table 5).

The most common cause of death was diseases of the circulatory system (N = 308). For this disease classification, the number of deaths observed was similar to that expected, using the rates for NYS as the standard (SMRs of 1.01 for both sexes combined (Table 4), 0.93 for women and 1.06 for men (Table 5)). Among individual causes, the SMR for acute myocardial infarction was consistently high for both sexes (SMR=1.43, CI_{95} = 1.06-1.89 for women and SMR=1.37, CI_{95} = 1.08-1.71 for men, Table 5). Chronic rheumatic heart disease was also elevated among men (SMR = 4.18), although the observed number of cases was small. Among both sexes combined, the lowest SMR was for other forms of chronic ischemic heart disease (0.81).

The second most common cause of death category was neoplasms (N = 189). The SMRs for this category as a whole were equal to or less than 1.00 combined (Table 4) and for each sex separately (Table 5), using NYS as the standard. In sex-specific analyses, the only SMR greater than 1.00 among women was 1.11 for digestive system neoplasms. The lowest was 0.54 (CI_{95} = 0.28-0.95) for bone, connective tissue, skin and breast. Among men, the only SMRs greater than 1.00 were 1.52 for other and unspecified sites and 1.06, for lymphatic and hematological neoplasms. The lowest SMR among men was 0.89 for digestive system neoplasms.

The third most common cause of death category was external causes of injury and poisoning (N=62). For both sexes combined (Table 4), the SMR was 1.41 (CI_{95} = 1.08-1.81) relative to NYS. This excess risk was greater among women (SMR = 1.95 (CI_{95} = 1.25-2.90) compared to men (SMR = 1.20) (Table 5). Among women, excess SMRs were apparent for suicide (2.35), motor vehicle accidents (2.12, CI_{95} = 1.02-3.89), and other types of accidents (1.52). Suicide (SMR = 1.52) and "other types of accidents" (SMR = 1.33) were also elevated among men. Both sexes had elevated SMRs for "other external causes," but these estimates were based on only one or two cases.

Cancer Incidence

The study cohort for external comparisons of cancer incidence rates included 5,052 persons. This number consisted of 4,461 persons who never left New York State, and 591 persons who left after the date of the original interview. For the latter group, 324 resided in one of the eight states contacted, and seven of those states replied yielding a total of only eight cancers. Given the poor yield of the out of state cancer search and also the fact that there were gaps in person-time from when these people left New York State and when the registries in these eight states began, the attempt to account for out-of state cancers was abandoned. Instead, we focused only the portion of the follow-up period in which they were New York State residents, and cancers diagnosed during that time, were included in the analysis. The 5,052 people contributed a total of 76,496 person-years to the analysis. The distribution of person-years by age, sex, and time period is displayed in Appendix G.

A total of 304 incident cancers were observed among the study cohort during the follow-up period. Of these 304 cancers, all but one could be included in the subgroup SIR analyses; the remaining cancer, Kaposi's sarcoma, is a diagnosis based on morphology, not site. Thus, the cancer bureau could not provide comparison information for either NYS or NC. This person was included in the analysis of all cancer sites, but

excluded from any further subgroup analyses. The results discussed below use NYS as the standard; the results relative to NC were generally similar.

Table 8 presents the SIRs for cancer incidence among men and women combined compared to NYS; Table 9 displays similar data for men and women separately. Tables 10 and 11 respectively include men and women combined and separately, using NC as the comparison population. Criteria for inclusion in the tables and for discussion were the same as those for mortality. See Appendices H through K for a complete list of SIRs calculated.

For all cancers combined, the SIR relative to NYS was 0.94 (CI_{95} = 0.83-1.05) (Table 8). The SIRs for both sexes were similarly close to 1.00 (females: SIR = 0.86; male: SIR = 1.02). The most common individual cancer site was genitourinary (N = 82). The SIR for this category was 0.81 for women and 1.09 for men (Table 9). Four of the six subcategories in this group had SIRs greater than 1.00 for one or both sexes – ovaries, testis, bladder, and kidney (Table 9), although the number of observed cases generally was small.

The second most common cancer site was digestive organs and peritoneum (N = 69). The combined SIR for this site was 1.03 (Table 8). The SIRs were greater than 1.00 for four of the five specific digestive sites for one or both sexes – stomach, liver, rectum, and gall bladder. The resulting SIRs ranged from 1.08 for cancer of the stomach to 2.46 for cancer of the gall bladder. However, the confidence intervals were wide due to the relatively small number of observed and expected cases. Cancers of the trachea, bronchus and lung were the third most frequent site (N = 62). Fifty-seven of the 62 cancers in this category were of the trachea, bronchus and lung, with a combined SIR of 1.10 (0.94 for women and 1.20 for men) (Table 9).

The results of the analyses grouped according to either literature reports or toxicological endpoints are presented in Tables 12 and 13, respectively, using NYS as the standard, and in Tables 14 and 15, respectively, using NC as the standard. Most SIRs

were essentially 1.00 with the exception of cancers suspected of resulting from environmental insults (SIR = 1.08) and probable occupational cancers (SIR = 1.11) using NYS as the standard. Small numbers was again a limitation.

Reproductive Outcomes

There were 1,799 births to 980 eligible women during the period 1960-1996. Only singleton births (N=1,767) were included in the analyses of birth weight, preterm births and SGA. Table 16 presents the demographic and exposure characteristics of the mothers. Approximately 92.6% of the mothers were white, and 6.5% were African-American. The majority (80.7%) were 20 - 34 years of age. Nearly half of the mothers responded on the interview conducted in 1978-1981 that they smoked and 56.6% reported drinking alcohol.

Low Birth Weight, Very Low Birth Weight, Preterm Births and SGA

Table 17 presents the SIRs and CI_{95} for low birth weight, very low birth weight, preterm births and SGA, by time period and, for the pre-evacuation period, according to whether the birth occurred while the mother lived on or off the Canal.

In general, the SIRs approximated the null value of 1.00 for each birth outcome over the entire study period as well for the periods before and after evacuation. There was a tendency, however, for children born on the Canal to have a higher risk of an adverse outcome than children born off the Canal, compared to the external populations. The greatest difference was for preterm birth, where the SIR for children born on the Canal from 1968 to 1978 was 1.37, compared with an SIR of 0.74 for children born off the Canal during the same time period.

Sex Ratios

Table 18 presents the number and proportion of female and male births according to time period and whether the child was conceived on or off the Canal. For both NYS and NC, the ratio of female to male births was 0.95 from 1960 through 1996. Among Love Canal births, however, the ratio was 1.01, indicating proportionately more female births than expected. The greatest difference was for on Canal births from 1960 through 1978, where the ratio was 1.06. The 95% CI for this point estimate, however, ranged from 0.93 to 1.21, which includes the comparison ratio of 0.95 for both NC and NYS.

Congenital Malformations

A total of 23 Love Canal children born between 1983 and 1996 were found by the CMR to have a birth defect. Sixteen of these children had a defect that was included among those that the CMR considers to be consistently and reliably reported by hospitals and physicians. Eleven of these defects occurred among boys, and five among girls. There were two cases with pyloric stenosis and the rest of the anomalies were unique. Examples of these latter malformations include oral cleft, ventricle septal defect, gonadal dysgenesis, esophageal atresia and talipes equinovarus.

Table 19 presents the results of the SIR analyses for these 16 congenital malformations. The results indicated an elevated risk of malformations among Love Canal children, especially when NC was used as the standard (SIR = 2.05, CI_{95} = 1.17-3.33). Both girls (SIR = 1.79) and boys (SIR = 2.20, CI_{95} = 1.09-3.93) had a greater than expected risk compared to NC.

An examination of the medical records from the three local hospitals that were reviewed revealed another 14 Love Canal children with a malformation who were born between 1970 and 1982. Nine of the fourteen were musculoskeletal: five cases of metatarsus adductus of varus, and one of each bilateral club foot, talipes calcanevalgus, mild deformity of the thoracic cage and anguli oris muscle hypoplasia. The remaining five cases were defects of the genitals: micropenis (3), undescended testicle and first degree hypospadias. Only one child, however, had a defect (hypospadias) that is

considered by the CMR to be consistently and reliably reported. Thus, it was not possible to calculate an SIR for this time period, given only one consistently and reliably reported defect and the lack of comparison data.

Internal Comparisons

Mortality

The study cohort for these analyses included 5,974 persons whose vital status and dates of residence in the EDA were known. Of these, 706 were deceased, 5,221 were alive through 1996, and 47 were lost to follow-up sometime after their original interview but before December 31, 1996. Analyses were also performed on the subset of adults with interview data regarding cigarette smoking, alcohol consumption and occupation. Table 20 presents the demographic information for these two groups. Although 4,457 cohort members were interviewed, the data were complete for only 3,796 persons. The study cohort and subset of interviewees were similar with respect to sex, race and residence in the open period. By definition, the interviewees, who had to be at least 18 years old to participate, were older and had longer residencies in the closed period than the entire cohort.

Table 21 presents the full survival models for all-cause and selected cause-specific mortality among the subset of adults who had complete interview data. As full models, they include all relevant environmental exposure and background variables, regardless of their p-values. In contrast, the final models presented in Appendix L were developed by a backward stepwise selection of variables, using $p < 0.10$ as the criterion for retention of each variable. The final models were more parsimonious, but, in general, the results for the full and final models were virtually identical with respect to the exposure variables of interest. Appendix M includes the results for the full cohort including persons without interview data, full and final models, but those results were generally similar to those for the subset with interview data.

As noted in Table 21, all cause mortality increased with age (HR = 1.10; CI_{95} = 1.09-1.10), male sex (HR = 1.65; CI_{95} = 1.36-2.01), and having ever smoked (HR = 1.66 CI_{95} = 1.35-2.05). The HRs for alcohol consumption and occupational exposures to LCICs were close to the null value of 1.00, as were the four residential exposure variables representing tier and time period, attendance at the 99th Street School, and residence on a swale or hot spot. The only elevated HR among the exposure variables was for childhood exposure (HR = 1.14).

Age and male sex also showed positive associations with cause-specific mortality. For age, the lowest HR was 1.01 for external causes of injury and poisoning, with a confidence interval that included 1.00; with all other causes of death, HRs ranged from 1.09 to 1.12, with confidence intervals that did not include 1.00. For male sex, the HRs ranged from 1.24 (respiratory system diseases) to 1.87 (acute myocardial infarction), and only two of the confidence intervals did not include the null value of 1.00.

Smoking also was positively associated with cause-specific mortality. HRs ranged from 1.36 (CI_{95} = 1.00-1.84) for circulatory diseases to 6.23 (CI_{95} = 2.15-18.02) for respiratory system. In contrast, there was little evidence that alcohol consumption or occupation were associated with cause-specific mortality. The four residential exposure variables representing tier and time period also showed no association with cause-specific mortality. One other residentially based exposure variable, living in a home built on a hot spot or one of the historic swales, had very small numbers, with no deaths from respiratory disorders or external causes of injury. For attendance at the 99th Street School, the only elevated HR was for external causes of injury (HR = 1.12). Childhood exposure had HRs of approximately 2.50 for both deaths from neoplasms and from acute myocardial infarction, but the CI for each was very wide as a result of small numbers – in fact, no deaths from respiratory disease were observed for this exposure variable.

Cancer Incidence

The study cohort for survival analysis of cancer incidence included 5,007 persons who either resided in New York State for the full follow-up period (N = 4417) or for whom dates when they left the state were available (N = 590). Analyses were restricted to persons whose dates of residence in the EDA were known. As with mortality, full models are presented including all relevant environmental and exposure and background variables, regardless of their p-values among the subset of adults who had complete interview data regarding cigarette smoking, alcohol consumption, occupational exposure to known carcinogens and a family history of cancer (Table 22). Appendix N contains the results for the final model for those with interview data. Appendices O and P contain the full and final models for the entire cohort. Final models include only those variables that were significant at $p < 0.10$, but those results were generally similar to those for full models and for the subset with interview data.

There were a total of 296 incident cancers observed among the members of the cohort, of these, 268 had complete interview information. As shown in Table 22, the HRs for age, male sex and smoking were all elevated (1.07, 1.53, and 2.08 respectively) for total cancers, and the confidence intervals did not include one. The HR for family history was also elevated (HR = 1.28). No associations were apparent for alcohol consumption or occupational exposure to carcinogens.

Regarding the four time/tier variables, the HRs for total cancers ranged from 0.95 (open period, tier 1 and 2) to 1.00 (open period, tiers 3 and 4). One other residential exposure variable, having a residence on a hot spot or swale, had an HR of 1.02 (CI_{95} = 0.45-2.31). Thirteen children who attended the 99th Street School had cancer (HR = 0.95), eight children who met the criteria for childhood exposure had cancer (HR = 0.99) and five children with cancer had both potential exposures.

Age and male sex also consistently demonstrated a positive association with the grouped site-specific cancers. For age, the HRs ranged from 1.08 to 1.11, with all five confidence intervals not including one. For male sex, HRs ranged from 2.01 to 3.42, and confidence intervals for the following cancer categories did not include 1.00:

respiratory/intrathoracic; digestive organs and peritoneum; genitourinary; and bladder/kidney (a subcategory of genitourinary). As with all-site cancers, the hazard ratios for smoking for the five grouped site-specific categories were above one and ranged from 1.39 (bladder and kidney cancer) to 6.56 (respiratory and intrathoracic cancers). Prior alcohol use was most positively associated with liver and rectal cancers (HR = 2.24). For family history, the greatest HR was 1.34 for genitourinary cancers. Potential occupational exposure to known carcinogens was positively associated with three sub-categories: respiratory and intrathoracic cancers (HR=1.05), genitourinary cancers (HR = 1.05) and bladder and kidney cancers (HR = 1.26).

The results for the environmental exposure variables and the incidence of site-specific cancers were severely limited by the small numbers of observed cases. For example, the greatest HR for the four time/tier residential exposure variables was 1.07 for liver and rectal cancers among persons who lived on Tiers 3 or 4 during the open period, but this estimate was based on only nine such cancers. There were no cancers of the digestive organs or its sub-group, liver/rectum, for residents of the open period, tiers 1 and 2. Among the interviewed members of the cohort who had a residence on a hot spot or swale, there were no cancers of the bladder and kidney and very small numbers in the remaining categories. The only cancer site with more than one observed case among those who attended the 99th Street School was genitourinary (HR = 1.05). Only in two site-specific subcategories of cancers were there any cases among the interviewees who met the criteria for childhood exposure: genitourinary (N = 2, HR = 2.27) and bladder and kidney cancers (N = 2, HR = 17.36). The CI_{95} for genitourinary included the null value of 1.00, while the CI_{95} for bladder and kidney cancers excluded 1.00 but were very imprecise.

Reproductive Outcomes

The study cohorts for GEE modeling of reproductive outcomes included the births (N=1799) from 1960 to 1996 for a total of 980 women. Of the 980 women, 818 women representing 1520 births had interview data regarding cigarette smoking, alcohol

consumption, and occupational exposure to reproductive toxicants. Fifteen of the 980 women had pregnancies with multiple gestation (twins or triplets = 32 births) while 976 had one or more singleton births (N=1767) during the period of follow-up. Only singleton births were used in the analyses of low birth weight, preterm births and SGA and a subset of 814 of these women (1490 births) had interview data. As with mortality and cancer incidence, analyses were restricted to persons whose dates of residence in the EDA were known. Since we are interested in maternal exposure prior to a given birth, childhood exposure refers to exposure when the mother was less than 13 and living on Tiers 1 or 2. Full models are presented including all relevant environmental exposure and background variables, regardless of their p-values among the subset of adults who had complete interview data. These models focused on the years prior to 1978 since this period reflects the potential effect of exposure while living in the EDA and being pregnant. Appendices Q, R, and S also include the results for the entire cohort, including persons without interview data, for final models including only those variables that were significant at $p < 0.10$, and for the entire study period from 1960 to 1996.

Table 23 gives the results for low birth weight, preterm birth, and SGA. Black race was associated with a greater risk of preterm birth (OR = 2.36) and SGA (OR = 1.75), but the numbers were small and the CI for both outcomes included 1.00. Female babies were more likely to be of low birth weight (OR = 1.69) and preterm (OR = 1.33). Smoking was positively associated with all three outcomes, with the greatest OR being 2.38 (CI_{95} = 1.02-5.56) for low birth weight.

Regarding the environmental exposure variables, the results for the four residential time/tier variables all hovered around the null value of 1.00. Childhood exposure had elevated risks for both low birth weight (OR = 6.37) and SGA (OR = 2.46), but the numbers of observed events was small and the CI for each estimate included 1.00. Children who were born on the Canal were more likely to experience each of the three adverse outcomes, with the greatest OR being 1.56 for preterm birth, but each CI again included 1.00. The only elevated OR for residence on a swale or hotspot was 1.55 for

SGA. Attendance at the 99th Street School was not associated with any of the three outcomes.

The results of the GEE modeling for female births are given in Table 24. There was little evidence of a relationship with any socio-demographic or lifestyle variable. Regarding the environmental exposure variables, the results for childhood exposure and being conceived on the Canal again suggested associations. In both cases, an excess of female births was evident (OR = 2.63, CI_{95} = 1.16-5.96 for childhood exposure and OR = 1.29, CI_{95} = 0.99-1.67) for conceived on the Canal).

The GEE modeling for congenital malformations was limited by the fact that only 16 women had a child born with a birth defect from 1983 to 1996. Consequently, zero cells and small numbers were major problems, even when the results of the modeling for congenital malformations included any woman who gave birth during that time period, regardless of whether she was interviewed (Table 25). The greatest elevated risk was for childhood exposure (OR = 14.81), but the OR is based on an observation of one. Hence, the confidence limits were wide, indicating a lack of precision, and included the null value of 1.00.

DISCUSSION

As stated in the Introduction, the follow-up health study is observational with all the strengths and limitations of such studies. The analyses were descriptive and exploratory with the intent that the results be used to describe the status of the Love Canal Cohort with respect to mortality, cancer, and reproductive outcomes and to suggest directions for future research. Thus, the data were analyzed in several ways using more than one definition of exposure and more than one time period. With this type of approach, the potential of chance findings is increased. It is important not to over emphasize any single finding but instead to search for interpretable, coherent patterns of findings, since these are more likely to indicate valid and meaningful associations. For example, if several analyses show positive associations of a certain type of outcome with

an exposure, or there is a pattern of associations that are biologically plausible, more weight should be given to these rather than a single finding. One also needs to exercise caution in that, given the large number of statistical comparisons made, the likelihood of committing a type 1 error is much greater than the nominal five percent. Finally, qualitatively, the width of the confidence interval is very informative: if extremely wide, it shows that the finding is imprecise. Wide confidence intervals are usually caused by small numbers of observations in categories.

Mortality

The overall mortality experience of the Love Canal cohort was similar to that of the general population of NYS and of NC, as was mortality from many individual causes. Comparison with the results of other Love Canal studies is not possible, since no other investigation focused on mortality as an endpoint. However, in a study of another Niagara Falls waste site, no excess in cancer mortality was detected in three surrounding census tracts from 1973 to 1982 (38), a finding consistent with that observed in this investigation. Similarly, in a study of a community in South Wales surrounding a landfill site, Fielder et al. (39) found no excess in all-cause mortality, cancer mortality or respiratory disease. The study population lived within three kilometers of the site which was used for household, commercial and industrial wastes, and, like Love Canal, the residents complained about noxious odors emanating from the site. In contrast, excess mortality was observed in the Love Canal cohort for chronic rheumatic heart disease (men), acute myocardial infarction (both sexes combined), and external causes of injury and poisoning (both sexes combined), relative to NYS. Excessive deaths due to external causes were more common among women than men, with the greatest relative elevations observed for motor vehicle accidents and suicide.

Elevated mortality from rheumatic heart disease has been reported among residents of an area contaminated by 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) (40, 41). However, this was seen only in one, extremely heavily contaminated locale. Rheumatic heart disease is essentially an autoimmune reaction to infection by Group A

streptococcus (42, 43), and little is known about whether it may be affected by chemical exposures.

With regard to the observed associations with mortality from acute myocardial infarction, motor vehicle accidents and suicides, one may postulate two types of causal pathways: 1) cardio- or neurotoxic effects leading, through biological mechanisms, to heart disease or to psychological or behavioral symptoms; 2) stress-induced physiologic or psychological reactions, including elevated blood pressure and/or injurious behavioral reactions.

Neurotoxic effects have been reported from occupational exposure to organic solvents, largely among industrial painters (44, 45). At a community level, there is evidence for neuropsychological effects (including anxiety and depression) from exposure to trichloroethylene (associations that were strongest in the context of alcohol consumption) (46); and, among farmers, similar effects were associated with organophosphate pesticides (47, 48). In the studies of farmers, one correlate of the neuropsychological symptoms was a tendency not to follow safety practices (48), a pattern with implications for injury risks.

As for heart disease, oxidative chemical injury is thought to be important in atherogenesis, potentially implicating a wide range of chemicals (49). Exposure to carbon disulphide (50, 51), methylmercury (52), arsenic (53) and bis (2-chloroethoxy) methane (54) has been shown to cause atherogenesis or myocardial damage in human, *in vitro* and/or animal studies. Additional evidence has come from research on the toxicology of fine airborne particulate matter, found to be associated with cardiovascular disease in epidemiologic studies (55).

Effects of stress in communities near hazardous waste sites have included physiologic reactions that constitute risk factors for cardiovascular disease: elevated blood pressure, elevated levels of stress hormones and catecholamines (56), demoralization (57), depression and anxiety (58). Three Mile Island, where leakage from

a nuclear reactor was reported (59), provides a similar example to Love Canal. Research supports the notion that at least a segment of the population reacts to stress with increased drinking (60, 61) or smoking (62, 63, 64). Alcohol consumption is a risk factor for injury outcomes, including suicide and motor vehicle crash injuries, while smoking is a risk factor for myocardial infarction and several cancers (65).

One of the difficulties of citations re: stress is that the term is variously defined, and the definition is not always made clear. Stressors may be defined strictly as external phenomena, such as a hurricane or a war, or as a set of effects (psychological and/or physiologic) of exposure to a stressor. These have been defined and measured in diverse ways, according to the investigator's interests and theoretical orientation. Chronic stress can affect the immune system and can potentiate the development of certain types of cancer (66,67). However, stress takes different forms, depending on the context, background and personal/ population characteristics; and these may have different effects. Helplessness/ hopelessness is associated with lower disease-free survival in breast cancer patients; yet stress defined differently (e.g., tension, anxiety or sleeplessness, or job stress), has been found to have no effect or a protective effect on breast cancer risk (68,69). Racial/ethnic disparities in rates of low birth weight and preterm delivery may be largely attributable to psychosocial stress (70), but much is unknown about the mechanisms responsible.

As to the effects of the stressors experienced at Love Canal, the literature does not offer examples in which the stressors and population are similar and the investigation appropriately focused. It might be objected that involuntary relocation and environmental contamination are not rare. In fact, the effects of relocation have been conceptualized in terms of attachment, familiarity and place identity (71). Communities near hazardous waste sites have been studied, as has the case of Three Mile Island (59). Effects have included known risk factors for cardiovascular disease (elevations of blood pressure, stress hormones and catecholamines) (56), and psychological effects such as demoralization (57), depression and anxiety (58). However, in some ways the case of Love Canal is unique: the stressor consisted of a series of events over months and years,

starting with the first reports of chemical contamination, and continuing through the responses of governmental agencies, different investigations, relocation and its aftermath.

It is also possible that the excess mortality from myocardial infarction among Love Canal residents relative to NYS is an artifact of regional differences in heart attack death rates or how physicians completing death certificates describe death due to cardiovascular disease. Supporting this contention is the observation that the expected numbers of death from myocardial infarction in the Love Canal cohort is not elevated when compared to NC.

When comparing the environmental exposure variables and mortality within the cohort, no consistent associations were observed for the residential time/tier combinations. Too few deaths occurred among persons who lived on swales or hotspots to provide for a meaningful analysis. In addition, there was no evidence of excess risk among persons who attended the 99th Street School. Elevated risks were apparent for overall mortality and for mortality from cancer and acute myocardial infarction among persons with childhood exposure, but these findings were based on small numbers and consequently imprecise. Several established risk factors for mortality, such as age, smoking, and male sex were significantly associated with increased overall and cause-specific mortality.

Cancer Incidence

Compared to NYS, the Love Canal cohort had about 20 or 6% fewer total cancers than expected. Less than the expected numbers of total cancers were evident for women; men had three more cases than expected. Except for digestive organs and peritoneum, and respiratory and intrathoracic organs, the SIR for each major organ site was depressed, contributing to the overall deficit. The explanation for this deficit is not clear. Since this analysis was limited to NYS residents, it is possible that the exclusion of cancers diagnosed among cohort members after they had moved from NYS is at least partially responsible. Despite the slightly low overall number of cancers, the rank order was

similar to that for the general population, with lung, female breast, and prostate the leading individual cancer sites.

Some individual cancer sites did have elevated SIRs relative to NYS, including gall bladder, kidney, bladder, testis, rectum and liver, but in every case the numbers were small and the 95% CI included 1.00. Grouping according to literature reports and toxicological endpoints did result in increased statistical power, but the findings were again essentially negative.

In general, the numbers were too small to draw any meaningful conclusions regarding the findings of the survival analysis and the environmental exposure variables. For example, elevated risks were found for childhood exposure and genitourinary and bladder plus kidney cancers, but each of these were based on only two observations. However, as was noted with mortality, established risk factors (age, smoking and male sex) were evident in the survival analyses for total cancers and for the organ system-specific cancer incidence (65,72). Also, consistent with the results of other studies, there was some indication of positive association between alcohol consumption and liver and rectal cancer (73,74), potential occupational exposure to carcinogens and bladder and kidney cancer (75,76,77), and a family history of cancer and genitourinary cancer (78, 79).

Other studies of cancer incidence or mortality associated with waste sites have yielded mixed results, and many studies were ecologic. The only other study of cancer incidence among the LC residents was conducted by Janerich et al. (16) who examined SIRs for each city of Niagara Falls census tract relative to NYS, by age group and sex, from 1955 to 1977. Stronger results for respiratory cancers were found for the census tract containing the landfill than in the current analysis (SIRs=1.7 in men and 2.0 in women), but this was also found in several other census tracts and in Niagara Falls as a whole, and the residences of cases were not clustered near the waste site. SIRs for urinary tract cancers for men and women were 1.2 and 0.4, respectively. Important limitations of this study included the short time from first exposure to diagnosis given the

long latency periods required for most cancers, crude exposure estimates, and the lack of information on smoking and other cancer risk factors. A case control study in NC by Polednak and Janerich (80) found no association of lung cancer mortality with residence in census tracts containing toxic waste disposal sites.

Outside of NC, two ecologic studies conducted in populations living near landfills in Italy found significant excesses of mortality from bladder cancer (81,82), a large ecologic study in Great Britain found a slight excess risk of bladder cancer (SIR=1.01; 95% CI, 1.00-1.02) in residents near landfill sites (83), and a study by Griffith et al. (84) found that among whites, the presence of National Priorities List sites in the United States was associated with mortality from cancers of the bladder, lung, stomach and large intestine and rectum. In a county-level, ecologic study in New Jersey, Najem and colleagues found associations between proximity to toxic waste sites and mortality from lung cancer (85), and gastrointestinal organ cancers (86), but not bladder cancer (87). However, these findings emerged from a large number of analyses, making the reported p-values questionable. No elevation in total cancer incidence near hazardous waste sites were found in other such studies (88,89). In summary, most other research was solely ecologic in nature, and addressed cancer mortality rather than cancer incidence, but several studies of populations residing near sources of hazardous waste report results for bladder cancer that are consistent with those of the current study, and consistent with toxicologic data from the IARC, ATSDR and NTP.

Reproductive Outcomes

Though rates of preterm, SGA, LBW and VLBW were generally similar to or lower than those in NYS and NC, there was a tendency for children born on the Canal to be at higher risk for these outcomes compared to the external populations, than those born off the Canal. The ratio of female to male births was also higher for children born on the Canal compared to those who were born elsewhere. Because the numbers were small, the 95% CI included the null value of 1.00 for these comparisons, but the general pattern of results was more consistent than that for mortality or cancer incidence. In addition, congenital malformations were also more frequent than expected among Love

Canal children born from 1983 to 1996. In fact, the risk of a malformation among Love Canal children was twice that for NC, and the 95% CI excluded 1.00.

The GEE modeling revealed the effect of established risk factors for low birth weight, SGA, and preterm birth, including black race (90), female sex (91), and cigarette smoking (72). No such associations were observed for proportion of female births. As noted in other studies, males were at higher risk for congenital malformations (92). Regarding the environmental exposure variables, there was little evidence of a relationship with the residential time/tier variables, attendance at the 99th Street School, and residence on a swale or hotspot. Positive associations, however, were consistently observed for childhood exposure. Although the numbers were small and the 95% CI included 1.00, elevated risks for childhood exposure were observed for three of the five birth outcomes studies: low birth weight, SGA and congenital malformations. Childhood exposure was also associated with a greater proportion of female births. Consistent with the results of the SIR analyses, the GEE modeling also indicated that the children born on Love Canal were more likely to be low birth weight, SGA, preterm, or female.

Our finding of increased risks for low birth weight among children born on the Canal is consistent with those of previous Love Canal investigations. Vianna and Polan (17) reported an excess of low birth weight associated with residence in swale areas compared to NYS, especially during the period of active dumping. Goldman et al. (27) also observed a three-fold risk of low birth weight among children born to mothers who lived near Love Canal at some time during gestation.

As noted above, the ratio of female to male births was greater for all years than either NYS or NC. Additionally, this ratio was even greater for those children whose mothers conceived while living in the EDA compared to those who were conceived elsewhere. Sex ratios may change over time, and the explanations for such changes, particularly at the population level, have been a matter of controversy (93,94,95). There is some evidence that the sex ratio can change in response to certain toxic exposures. In Seveso, Italy, after a large accidental release of TCDD in 1976, the ratio of female to

male births showed a clear increase among the offspring of young exposed males (defined by serum dioxin levels > 15 parts per trillion), and this effect persisted through the follow up period of approximately twenty years (96). This effect, however, was not observed in the offspring of females exposed at the same level. Additionally, two occupational studies (97,98) have observed the same skewing of the sex ratio in workers exposed to pesticides: increased female births associated with paternal, but not maternal exposure.

The findings that Love Canal children born from 1983 to 1996 were more likely to have a congenital malformation are consistent with earlier Love Canal studies. Vianna and Polan (18) observed an excess of congenital malformations associated with swale areas from 1955 to 1964. Higher rates of fetal deaths and birth defects were also found in a survey conducted by Paigen (25) in 1978 among residents of "wet" versus "dry" single-family homes. A positive association between residential proximity to 590 hazardous waste sites and birth defects was also found in one early study in New York State (99). However, another study done on the same population but using GIS in place of zip codes found no such associations in a statewide study of central nervous system and musculoskeletal system anomalies and exposure to pesticides, metals and solvents from hazardous waste sites (100).

The results of birth defect studies around hazardous waste sites outside of New York State have been inconsistent. For example, Sosniak et al. (101) found no associations with proximity to National Priorities List (NPL) sites across the United States. However, Croen et al. (102) report associations of several birth defects with proximity to NPL sites in California; and the EUROHAZCON study has reported similar findings from 21 hazardous waste sites in five European countries (103,104) In one large British study, Elliott et al. (105) found relative risks ranging from 1.03 (abdominal wall defects) to 1.11 (cardiovascular defects and hypo- and epispadias), and 1.07 for all congenital malformations, associated with residence near "special" (hazardous) waste sites. For low and very low birth weight, relative risks were 1.05 and 1.03, respectively. Paradoxically, however, for several outcomes the relative risks were higher before the

opening of the waste sites than after. Similarly, Fielder et al. (39) found increased rates of congenital anomalies associated with residence near a Welsh landfill site, but both before and after the site became operational. In a subsequent letter to the journal's editors, Roberts et al. (106) suggested other local exposures that may have contributed to the elevated rates prior to that date. This may be a common problem - multiple major sources of exposure that vary over time, making it difficult to attribute effects to a specific source.

Methodological problems such as selection and recall bias limit the interpretation of many of the earlier Love Canal investigations. The small sample sizes are also a problem. Nevertheless, the general pattern of results in previous studies, together with that found in the current investigation, suggest children born to Love Canal mothers may have been at greater risk for a number of adverse reproductive outcomes compared to the general population.

Strengths

The current study has a number of important strengths as enumerated below.

- The cohort was well-defined with interview information delineating residential locations and dates. A time line for all addresses in the EDA was created and, with the aid of city directories, conflicting address information was able to be resolved. Children were given the address of the parents. In addition, for a large subset of the cohort, there were data on potential confounders from the interviews performed by the NYSDOH in 1978 to 1980.

- As is only possible with observational cohort studies, follow-up time was lengthy. The median number of years of follow-up for the whole cohort until death or lost to follow-up was 17.9 years, ranging from a little more than one month to 18.5 years. The length of the period between date of first exposure and end of follow-up ranged from two to 54 years (median of 32 years), which provided for a

sufficiently long latency period to allow time for most environmentally-induced cancers or causes of death to develop.

- All areas of the EDA as well as the years of potential exposure (1942-1978) are represented in the cohort. The duration of exposure ranged from six months to 36 years (median of seven years). Residents at the time of the evacuations were included, as well as persons who lived at Love Canal but moved before 1978.

- Ninety-six percent of the identified cohort was successfully traced. Vital status as of 1996 was ascertained and present addresses obtained. The highly successful tracing results diminished an important potential source of selection bias.

- Two different, complementary research designs were employed. The external comparisons examined the Love Canal cohort against two different standard populations. The NYS comparison provided stable rates, while NC data reflected background social, economic and environmental conditions similar to those of Love Canal. For the internal comparisons, multivariable statistical modeling was used to compare Love Canal cohort members with each other based on differences in potential exposure.

- The data on health outcomes included birth and death records and data from the NYS Cancer and Congenital Malformations Registries. These data originated from medical diagnoses, hospital records, and vital records, preventing the potential errors and biases associated with self-report data.

Limitations

The study's strengths are accompanied by significant limitations. In constructing the study cohort, the investigations were limited to persons who were interviewed in 1978 to 1982 by the NYSDOH and to their children. It was not possible to retrospectively create a complete list of everyone who had ever lived at Love Canal from 1942 to 1978.

Housing real estate records had been destroyed when the buildings were razed. It was even more problematic to identify, much less to count, former residents of the rental housing projects on the site who failed to respond to the original recruitment efforts. This sub-population of the EDA was much more mobile which makes finding them 20 years later particularly problematic, especially since they chose not to participate in the initial identification of residents. Selection bias may have been introduced to the extent that such exclusions were related to both exposure and outcome. However, the rate of deaths and cancers among the renters and single home owners are approximately the same: 11% deaths for both groups and 4% cancers among single home owners and 5% cancers among the renters.

No data could be obtained on mortality prior to 1979, since, by definition, all members of the cohort had to be alive in 1978 to be interviewed. Cancer incidence could not be assessed before 1979 because that was the first year for which the NYS Cancer Registry has complete computerized data. Computerized birth certificate data were available beginning in 1960, but gestational age was not coded in usable form until 1968. The Congenital Malformations Registry did not have complete data on birth defects among live births until 1983. Consequently, any adverse health effects that occurred among Love Canal residents before these dates were, of necessity, not included in the current investigation. In addition, other than mortality, there were no practical means to identify health events among residents after they left NYS, which also limited the ability to capture all relevant outcomes. Although statistical power was adequate for all-cause mortality and total cancer incidence for the cohort as a whole relative to the standard populations, power was low for many individual causes of death and cancer sites. Small numbers of observations also limited statistical power for many of the reproductive outcomes and for the internal analyses that compared the cohort according to exposure status. As a result, the study may have failed to detect many differences in health status and estimates of many measures of association were imprecise.

Unfortunately, there were no data on the concentration of chemical contaminants in air, soil and water prior to 1978. Thus, the variables indicating residents' exposures

were of necessity qualitative in nature. Some previous studies have used residence on swales, or in "wet" versus "dry" areas, as indicators of relatively heavy exposure (17-19,25-28); however, extensive testing by the DOH in 1978 and the USEPA in 1980 suggests that “soil contamination directly attributable to the migration of contaminants from Love Canal was confined to ring 1 [associated with filled swales, etc.;] … no patterns of soil contamination were found outside of ring 1, …” chemicals in the swale vs. non-swale areas (1, 2, 3, 7). Swales and hot spots were not consistently associated with health outcomes in the current investigation. The four "time/tier" variables were constructed for this study on the basis of two assumptions, specifically, that the potential for exposure was greater during the "open" period and among persons who lived closest to the Canal. Neither these variables nor attendance at the 99th Street School showed a pattern of association with any health outcome studied. The only exceptions were childhood exposure and, for the reproductive outcomes, being born or conceived on the Canal, but small numbers limited our confidence in the positive findings for those exposure variables. The lack of positive findings with many of the environmental exposure variables may be due, at least in part, to misclassification, given the qualitative nature of measures used.

The scope of the project was also limited to those health outcomes that could be identified through matching with NYSDOH data systems. There may be other relevant endpoints that could not be studied because they do not result in death and are not routinely tracked on a state-wide basis. In addition, some data systems were not available. Fetal death certificates can be a source of information for spontaneous abortions; however, in NYS, the data files are closed to researchers for confidentiality reasons. Consequently, anomalies of fetal development so severe as to reduce the fetus' viability were not identified. However, early fetal deaths are significantly underreported on fetal death certificates (98), so the ability to capture all spontaneous abortions regardless of gestation would have been seriously limited, even if access to fetal death certificates was granted.

Another limitation was the fact that birth records were only identified among children of female members of the cohort. An attempt was made to match Love Canal men with the birth records of their offspring, but this effort proved problematic since NYS birth certificates did not include the father's first name until 1980. The men were contacted by mail and asked to report their reproductive histories. However, of the 2,364 men contacted, 455 (19%) responded and of these only 365 (15%) had children.

We also considered evaluating fertility among the 41% of Love Canal women who were of reproductive age. The reproductive histories of these women obtained in the original NYSDOH interview revealed that many of these women moved in and out of New York State during their reproductive years. Consequently, any analysis of fertility would be grossly underestimated, and the effort was abandoned.

Finally, despite the long period between date of first exposure and end of follow-up, the cohort is still relatively young (median age of 46 years in 1996, the end of the follow-up period). It remains possible that as the cohort ages, more cases of chronic diseases such as cancer will develop, increasing statistical power and perhaps revealing more consistent patterns between potential exposure and health effects, especially among those residents who lived at Love Canal as children.

Next Steps

To summarize, the results suggest that the overall mortality experience of the Love Canal cohort was similar to that for the general population of NYS and for NC. Regarding individual causes of death, there was some evidence indicating the Love Canal residents were at higher risk of death from myocardial infarction and from external causes such as suicide and motor vehicle accidents. In general, the incidence of total cancers was less than that for the general population, as was the incidence of cancer for most organ systems. The most notable findings for site-specific cancers were bladder and kidney, which were elevated but imprecise due to small numbers. More suggestive findings were observed for reproductive outcomes. Although low birth weight, preterm

births and SGA results were on average similar to the comparison populations, children whose mothers lived in the EDA at some time during the pregnancy were at higher risk for these outcomes than those whose mothers lived elsewhere. The ratio of female to male births was also greater among children conceived on the Canal. In addition, relative to NC, Love Canal children born from 1983 to 1996 were twice as likely to have a congenital malformation.

The most consistent findings in the internal comparisons were for childhood exposure. This variable was defined, by necessity, without benefit of specific data on an individual child's activity patterns, or the concentrations of chemicals in soil, air and water during the exposure period. It was guided by qualitative, retrospective information, using assumptions that cannot be verified. Former residents stated that, when the Canal was open and contained water, adolescent boys would play or swim in it. Therefore, the "exposed" category was defined to include males age 13-18 (regardless of the residence tier), and other children living in Tiers 1 and 2. The assumption was that adolescent boys from throughout the EDA were exposed through playing in the Canal; that other children's exposure was in or around their homes; and that the heaviest contamination was in Tiers 1 and 2. Yet, among the environmental exposure variables, only childhood exposure showed a consistent pattern of positive associations, especially in regard to the reproductive outcomes.

Community members, the Expert Advisory Committee and the NYSDOH therefore propose to examine, in more depth, associations between reproductive outcomes and a mothers' exposure during her childhood. The analyses will focus on two reproductive outcomes: birth weight and female sex of the child. This allows us to use data from a longer period of time than the other health outcomes (1960 to 1996), and birth weight and sex have very few missing observations. We will also treat birth weight as a continuous variable, looking for differences in means instead of rates of LBW, thereby increasing statistical power. Childhood exposure will be examined in many different ways. For example, modeling the total number of years the woman was exposed between the ages of 0 to 18, the Tier she lived in during those years and the time

periods she lived there may reveal more information about the exposure-outcome association.

Members of the community and the Expert Advisory Committee have also suggested that the predominantly negative findings of the study may be, in part, due to the inadequacy of the residential exposure variables. For that reason, residential exposure will also be decomposed and reassembled using the same approach as described above for childhood exposure.

An important limitation of the Love Canal Follow-Up Study has been the lack of definitive data on personal exposure. The proposed analyses will allow us to address this limitation to the maximum extent that available data will allow, and, in the process, follow up on the suggestive findings on associations of childhood exposure with birth outcomes. For the former residents of Love Canal, as well as the scientific community, this final step will help ensure that everything possible has been done to characterize the health risks associated with living near the site.

It is expected that, after the completion of the above analyses, three articles will be published in peer-reviewed journals; one each for mortality, cancer incidence and the reproductive outcomes. These articles will include the results of all analyses. In addition, three newsletters will be sent to study participants discussing the results of each article.

Future Steps

Follow-up of this cohort is warranted since it remains possible that as the cohort ages, more cases of chronic diseases such as cancer will develop, increasing statistical power and perhaps revealing more consistent patterns between potential exposure and health effects, especially among those residents who lived at Love Canal as children.

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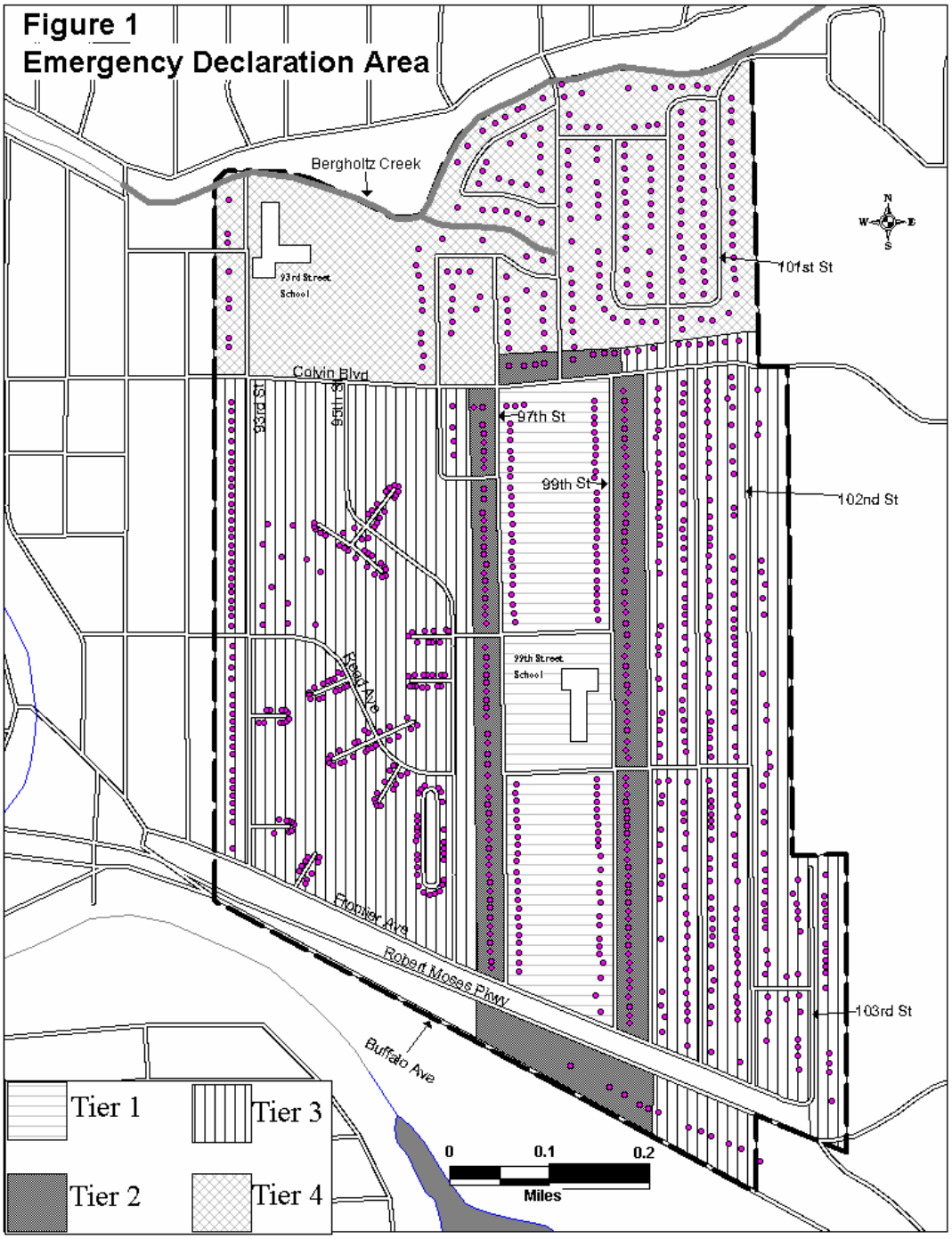
Figure 1
Emergency Declaration Area
Bergholtz Creek
93rd Street School
Colvin Blvd
93rd St
95th St
97th St
99th St
101st St
102nd St
103rd St
99th Street School
Read Ave
Cropsey Ave
Robert Moses Pkwy
Buffalo Ave
Tier 1
Tier 2
Tier 3
Tier 4
0
0.1
0.2
Miles
N
W
E
S

Figure 2. β-HCH Concentrations in Surface Soil

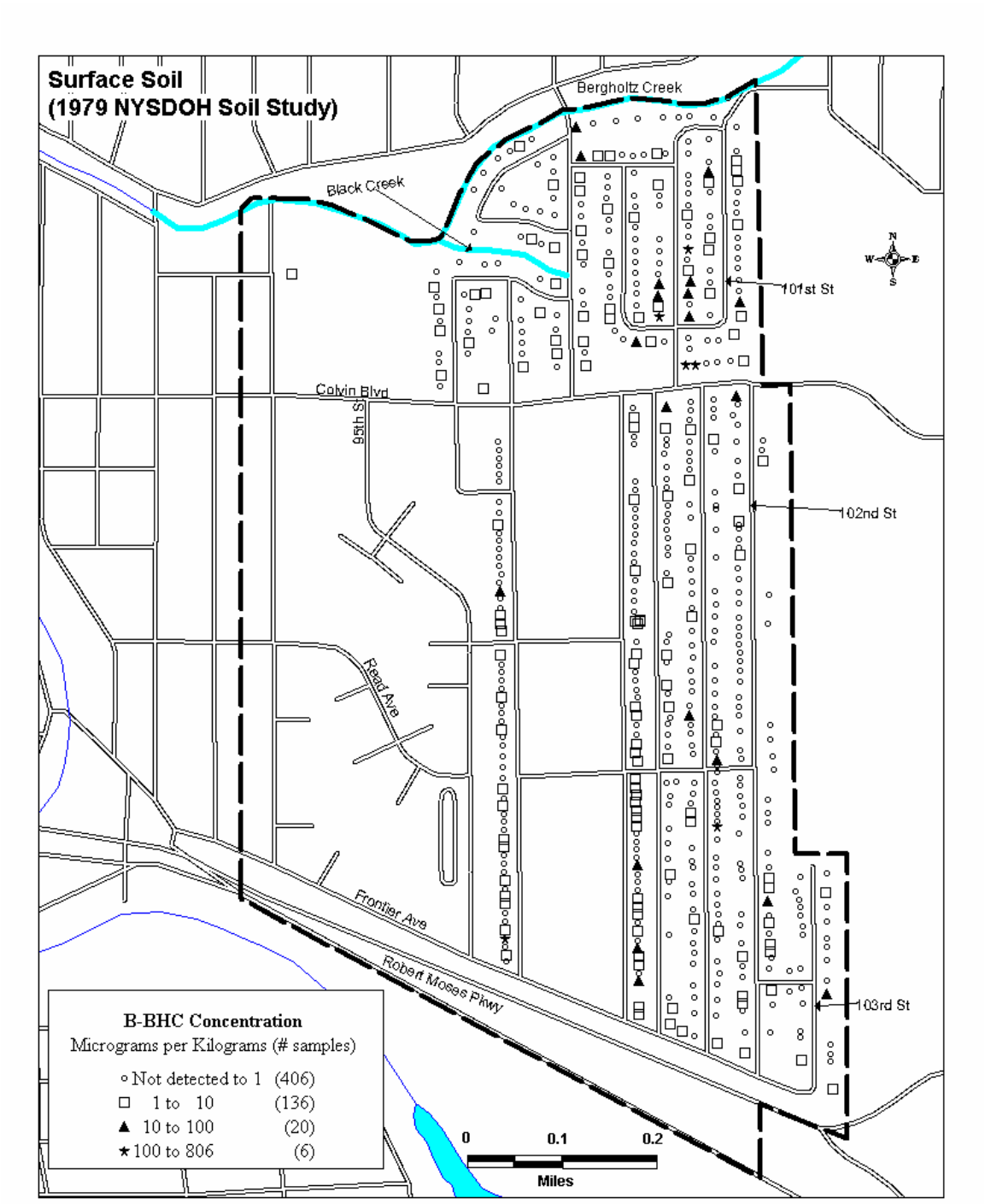

Figure 3. 1,2,4-Tricholorbenzene in Indoor Air

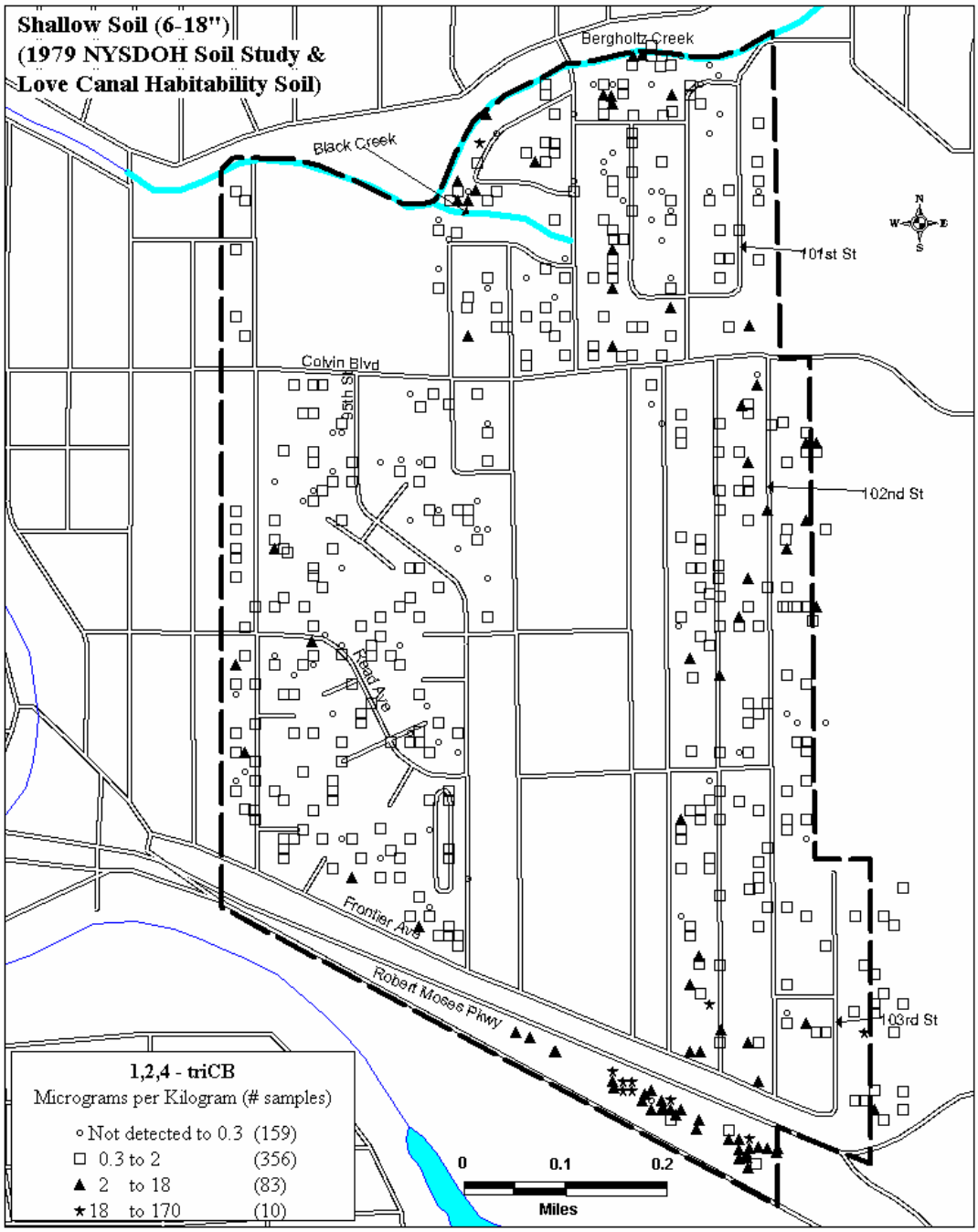

Figure 4. Chlorotoluene in Shallow Soil

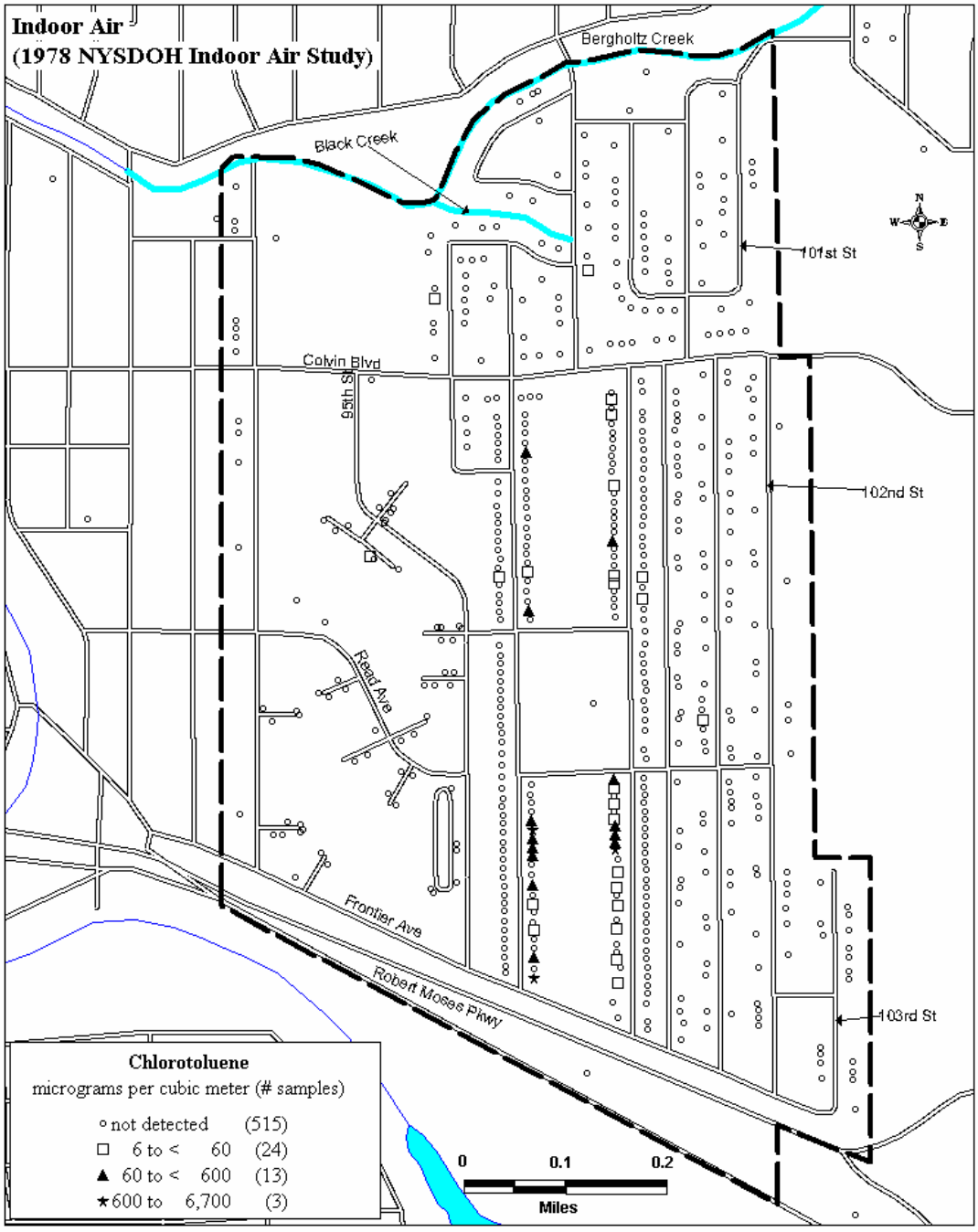

Figure 5. Schematic of the Tracing of the Love Canal Cohort

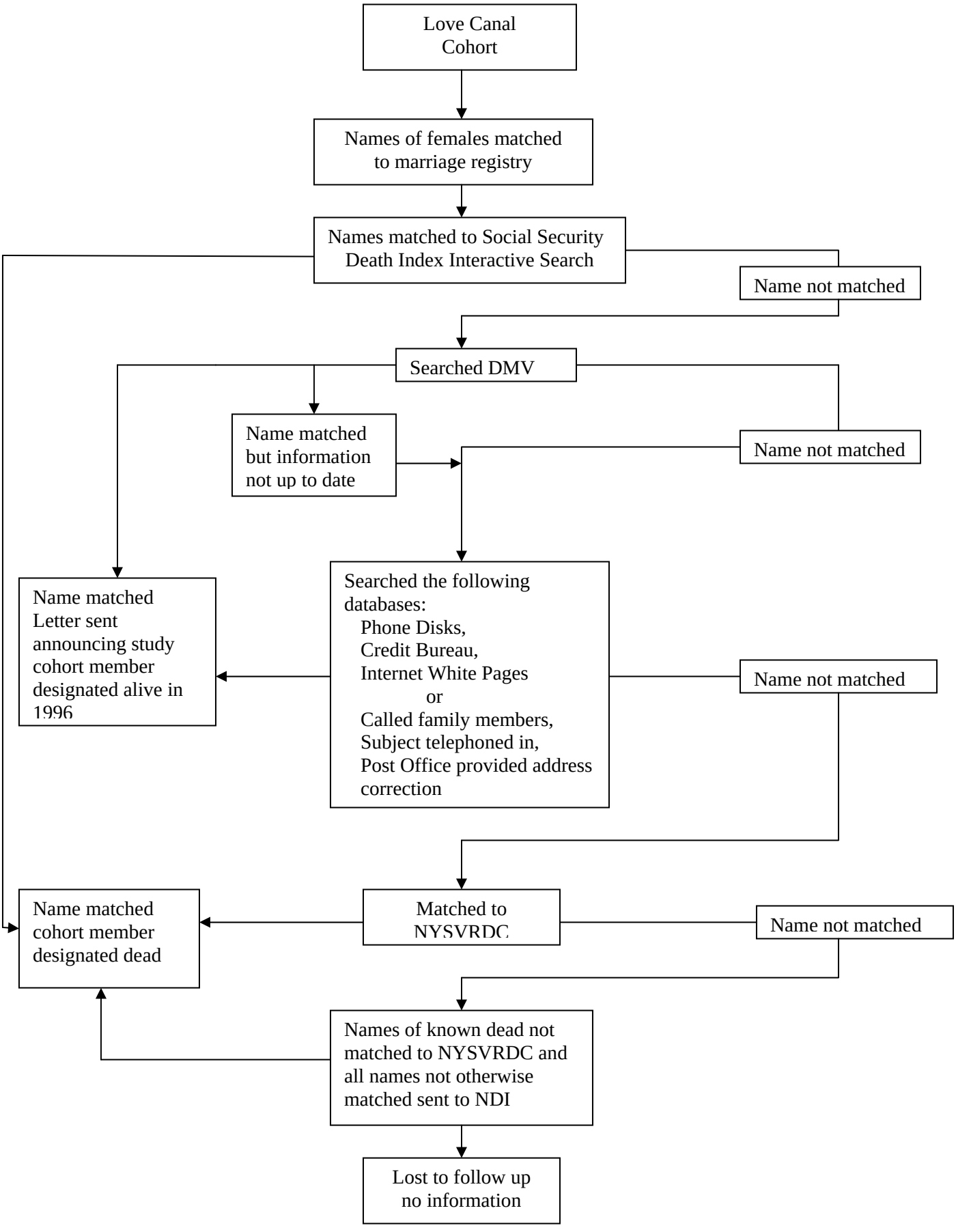

Table 1. The Seven Exposure Variables and Five Potential Confounding Variables Obtained from the Original 1978 to 1981 Interviews Included in Analyses

Exposure variables	Potential confounding variables
1942-1953 tiers 1 and 2 (OP12) (years)	Age (years)
1942-1953 tiers 3 and 4 (OP34) (years)	Sex (female/male)
1954-1978 tiers 1 and 2 (CL12) (years)	Ever smoked (yes/no)
1954-1978 tiers 3 and 4 (CL34) (years)	Alcohol use (yes/no)
Hot spot / swale (yes/no)	Occupation (yes*/no)
Childhood exposure (yes/no)	
99^{th} Street School (years)	

* For mortality, yes implies possibly exposed to LCIC; for cancer, possibly exposed to carcinogens; and for reproductive outcomes, possibly exposed to repro-toxins

Table 2. Demographic Characteristics of the Love Canal Cohort (N = 6,181)

	Traced		Not Traced	
	N	%	N	%
Total	6,026		155	
Race				
White	5,717	94.9	130	83.9
Black	239	4.0	19	12.3
Other	48	0.8	4	2.6
Missing	22	0.4	2	1.3
Sex				
Male	2,914	48.4	50	32.3
Female	3,112	51.6	103	66.4
Missing			2	1.3
Residence				
Single family homes only	4,699	78.0	79	51.0
Public housing only	747	12.4	65	41.9
Public and single family	580	96.6	11	7.1
Year of entry into study				
1978	3,069	50.9	97	62.6
1979	652	10.8	10	6.4
1980	676	11.2	17	11.0
1981	1,353	22.5	25	16.1
1982	276	4.6	6	3.9
Lived in the EDA in 1978				
Yes	3,099	51.4	92	59.4
No	2,927	48.6	63	40.6

	Median	Range	Median	Range
Age (years) in 1978 [a]	29	(newborn – 94)	22	(1 – 73)
Length (years) of residence in EDA [b]	7.0	(0.5 – 36.5)	4.0	(0.5 – 35.0)
Latency in years (first exposure to death, lost-to-follow-up or 1996)	32.0	(2.0-54.0)	NA	

* Less than 0.1%

[a] Two people had missing dates of birth and, therefore, age could not be calculated.

[b] Not including 200 people with missing residential information

Table 3. Tracing of the Love Canal Cohort (N = 6,181)

Tracing Status	Method	Number	%
Alive in 1996 - current address known	DMV	2,595	
	Family members	1,290	
	Post Office	490	
	Credit bureau	304	
	Internet white pages	216	
	Subject telephoned us	159	
	Purchased phone list	145	
	Other	42	
Total		5,241	84.8
Alive in 1996 – current address unknown	DMV	9	
	Family members	4	
Total		13	0.2
Deceased	NYSVR – Death	564	
	NDI	137	
	Family members	24	
Total		725	11.7
Lost to follow-up: date of interview to 1996	DMV	44	
	Other	3	
Total		47	0.8
Lost to follow-up: never located		155	2.5

Table 4. Standardized Mortality Ratio (SMR), Year, Age and Sex Adjusted, for Females and Males Combined Compared to NYS (Exclusive of NYC)

Cause of death	ICD-9	O*	E*	SMR	95% CI*
All causes		725	699.52	1.04	0.96-1.12
Infectious disease	030-044, 130-139	13	13.39	0.97	0.52-1.66
Human immunodeficiency virus	042-044	7	6.24	1.04	0.45-2.31
Other infectious diseases	130-139	1	0.79	1.26	0.03-7.04
Neoplasm	140-208, 239	189	201.88	0.94	0.81-1.08
Digestive system	150-159	49	49.84	0.98	0.73-1.30
Respiratory system	160-165	57	58.19	0.98	0.74-1.27
Bone, connective tissue, skin	170-175	18	25.34	0.71	0.42-1.12
Genitourinary tract	179-189	26	28.61	0.91	0.59-1.33
Other and unspecified site	190-199	18	16.05	1.12	0.66-1.77
Lymphatic and hematologic	200-208	19	18.43	1.03	0.62-1.61
Endocrine and metabolic disease	250-259, 270-279	14	17.14	0.82	0.45-1.37
Other endocrine glands	250-259	13	13.70	0.95	0.50-1.62
Diseases of the nervous system	330-337, 340-349	6	8.64	0.69	0.25-1.51
Hereditary and degenerative diseases	330-337	4	5.65	0.71	0.19-1.81
other disorders of the CNS	340-349	2	2.99	0.67	0.08-2.42
Diseases of the circulatory system	393-411, 414-459	308	306.07	1.01	0.90-1.13
Chronic rheumatic heart disease	393-398	4	2.89	1.38	0.38-3.54
Acute myocardial infarction	410	126	90.52	**1.39**	**1.16-1.66**
Other acute forms of IHD	411	2	1.81	1.10	0.13-3.99
Chronic ischemic heart disease	414	81	99.58	0.81	0.65-1.01
Other form of heart disease	415-429	42	48.08	0.87	0.63-1.18
Cerebrovascular diseases	430-438	36	39.49	0.91	0.64-1.26
Diseases of the veins and lymphatics	451-459	3	1.79	1.67	0.34-4.89
Diseases of the respiratory system	480-519	57	54.29	1.05	0.79-1.36
Pneumonia and influenza	480-487	15	19.18	0.78	0.44-1.29
Chronic obstructive pulmonary disease	490-496	34	28.37	1.20	0.83-1.67
Other respiratory system	510-519	7	5.03	1.39	0.56-2.87
Diseases of the digestive system	520-579	33	26.29	1.26	0.86-1.76
Esophagus, stomach, duodenum	530-537	6	3.07	.95	0.72-4.25
Hernia of abdominal cavity	550-553, 560-569	4	3.62	1.11	0.30-2.83
Non-infective enteritis and colitis	555-558	3	2.66	1.13	0.23-3.30
Other digestive system	570-579	20	16.94	1.18	0.72-1.82
Diseases of the musculoskeletal system	710-739	3	2.14	1.40	0.29-4.10
Congenital Anomalies	740-759	2	1.65	1.21	0.15-4.38
External causes of injury and poisoning	E800-E978, E980-E999	62	44.01	**1.41**	**1.08-1.81**
Other accidents/adverse effects	E800-E807, E825-E949	18	12.99	1.39	0.82-2.19
Motor vehicle accidents	E810-E825	20	15.84	1.26	0.77-1.95
Suicide	E950-E959	17	10.01	1.70	0.99-2.72
All other external causes	E980-E999	3	1.10	2.72	0.56-7.95

* O = observed number of cases, E = expected number of cases, CI = confidence interval

N.B. Only the subgroups with expected deaths >10 or SMRs > 1.00 were reported. Not all categories of mortality are presented in the table. (See the Appendices for the full list.)

1.00^{+} implies a number slightly greater than 1.00 and 1.00^{-} implies slightly less than 1.00.

Bold indicates CI does not include 1.00

Table 5. Standardized Mortality Ratio (SMR), Year and Age Adjusted, for Females and Males Separately Compared to NYS (Exclusive of NYC)

	Females				Males			
Cause of death	O*	E*	SMR	95% CI*	O*	E*	SMR	95% CI*
All causes	309	308.61	1.00	0.89-1.12	416	390.87	1.06	0.96-1.17
Infectious disease	2	4.70	0.43	0.05-1.54	11	8.70	1.27	0.63-2.26
Other bacterial diseases	1	3.27	0.31	0.01-1.71	4	3.10	1.29	0.35-3.30
Human immunodeficiency virus	0				7	5.14	1.36	0.55-2.81
Other infectious diseases	1	0.33	2.99	0.07-16.67	0			
Neoplasm	83	95.69	0.87	0.69-1.08	106	106.19	1.00	0.82-1.21
Digestive system	24	21.67	1.11	0.71-1.65	25	28.17	0.89	0.57-1.31
Respiratory system	21	21.14	0.99	0.61-1.52	36	37.06	0.97	0.68-1.34
Bone, connective tissue, skin	12	22.07	0.54	0.28-0.95	6	3.27	1.83	0.67-3.99
Genitourinary tract	12	13.14	0.91	0.47-1.59	14	15.46	0.91	0.50-1.52
Other and unspecified site	5	7.52	0.67	0.22-1.55	13	8.54	1.52	0.81-2.60
Lymphatic and hematologic	8	8.08	0.99	0.43-1.95	11	10.35	1.06	0.53-1.90
Endocrine and metabolic disease	7	8.61	0.81	0.33-1.67	7	8.53	0.82	0.33-1.69
Other endocrine glands	7	7.06	0.99	0.40-2.04	6	6.64	0.90	0.33-1.97
Diseases of the nervous system	5	4.19	1.19	0.39-2.78	1	4.45	0.22	0.01-1.25
Hereditary and degenerative diseases	3	2.65	1.13	0.23-3.31	1	3.00	0.33	0.01-1.86
Other disorders	2	1.54	1.30	0.16-4.69	0			
Diseases of the circulatory system	125	134.17	0.93	0.78-1.11	183	171.90	1.06	0.92-1.23
Hypertensive disease	4	4.70	0.85	0.23-2.18	1	4.72	0.21	0.01-1.18
Chronic rheumatic heart disease	0				4	0.96	**4.18**	**1.14-10.70**
Acute myocardial infarction	49	34.19	**1.43**	**1.06-1.89**	77	56.33	**1.37**	**1.08-1.71**
Other acute forms of IHD	2	0.64	3.12	0.38-11.28	0			
Chronic ischemic heart disease	30	42.72	0.70	0.47-1.00^{+}	51	56.86	0.90	0.67-1.18
Other form of heart disease	20	22.09	0.91	0.55-1.40	22	25.98	0.85	0.53-1.28
Cerebrovascular diseases	16	21.84	0.73	0.42-1.19	20	17.65	1.13	0.69-1.75
Diseases of the veins and lymphatics	0				3	0.96	3.12	0.64-9.12
Diseases of the respiratory system	29	24.09	1.20	0.81-1.73	28	30.19	0.93	0.62-1.34
Pneumonia and influenza	8	9.03	0.89	0.38-1.75	7	10.15	0.69	0.28-1.42
Chronic obstructive pulmonary disease	18	12.16	1.48	0.88-2.34	16	16.22	0.99	0.56-1.60
Other respiratory system	2	2.22	0.90	0.11-3.25	5	2.8	1.78	0.58-4.16
Diseases of the digestive system	10	11.62	0.86	0.41-1.58	23	14.67	1.57	0.99-2.35
Esophagus, stomach, duodenum	1	1.34	0.75	0.02-4.17	5	1.74	2.88	0.93-6.71
Hernia of abdominal cavity	1	2.11	0.47	0.01-2.64	3	1.51	1.99	0.41-5.82
Non-infective enteritis and colitis	3	1.59	1.88	0.39-5.51	0			
Other digestive system	5	6.59	0.76	0.25-1.77	15	10.36	1.45	0.81-2.39
Diseases of the musculoskeletal system	2	1.48	1.35	0.16-4.87	1	0.66	1.53	0.04-8.50
Congenital Anomalies	1	0.76	1.31	0.03-7.31	1	0.89	1.13	0.03-6.28
External causes of injury and poisoning	24	12.31	**1.95**	**1.25-2.90**	38	31.70	1.20	0.85-1.65
Other accidents/adverse effects	6	3.95	1.52	0.56-3.31	12	9.05	1.33	0.69-2.32
Motor vehicle accidents	10	4.72	**2.12**	**1.02-3.89**	10	11.11	0.90	0.43-1.65
Suicide	5	2.13	2.35	0.76-5.48	12	7.88	1.52	0.79-2.66
Homicide and legal intervention	1	1.17	0.85	0.02-4.75	3	2.90	1.03	0.21-3.02
All other external causes	2	0.34	5.96	0.72-21.54	1	0.77	1.30	0.03-7.26

* O = observed number of cases, E = expected number of cases, CI = confidence interval

N.B. Only the subgroups with expected deaths >10 or SMRs > 1.00 were reported. Not all categories of mortality are presented in the table. (See the Appendices for the full list.)

1.00^{+} implies a number slightly greater than 1.00 and 1.00^{-} implies slightly less than 1.00.

Bold indicates CI does not include 1.00

Table 6. Standardized Mortality Ratio (SMR) Year, Age and Sex Adjusted, for Females and Males Combined Compared to Niagara County

Cause of death	ICD-9	O*	E*	SMR	95% CI*
All causes		725	742.2	0.98	0.91-1.05
Infectious disease	030-044, 130-139	13	8.92	1.46	0.78-2.49
Other bacterial diseases	030-041	5	5.30	0.94	0.31-2.20
Human immunodeficiency virus	042-044	7	3.12	2.25	0.90-4.63
Other infectious diseases	130-139	1	0.50	1.99	0.05-11.08
Neoplasm	140-208, 239	189	204.32	0.93	0.80-1.07
Digestive system	150-159	49	49.49	0.99	0.73-1.31
Respiratory system	160-165	57	64.32	0.89	0.67-1.15
Bone, connective tissue, skin	170-175	18	21.98	0.82	0.49-1.29
Genitourinary tract	179-189	26	26.69	0.97	0.64-1.43
Other and unspecified site	190-199	18	16.74	1.08	0.64-1.70
Lymphatic and hematologic	200-208	19	19.83	0.96	0.58-1.50
Endocrine and metabolic disease	250-259, 270-279	14	18.73	0.75	0.41-1.25
Other endocrine glands	250-259	13	15.72	0.83	0.44-1.41
Diseases of the nervous system	330-337, 340-349	6	8.78	0.68	0.25-1.49
Diseases of the circulatory system	393-411, 414-459	308	343.68	0.90	$0.80\text{-}1.00^{+}$
Chronic rheumatic heart disease	393-398	4	1.87	2.14	0.58-5.48
Acute myocardial infarction	410	126	124.41	1.01	0.84-1.21
Other acute forms of IHD	411	2	1.37	1.46	0.18-5.26
Chronic ischemic heart disease	414	81	101.41	**0.80**	**0.63-0.99**
Other forms of heart disease	415-429	42	42.1	1.00	0.72-1.35
Cerebrovascular diseases	430-438	36	50.33	**0.72**	**0.50-0.99**
Diseases of the veins and lymphatics	451-459	3	1.96	1.53	0.31-4.46
Diseases of the respiratory system	480-519	57	53.65	1.06	0.80-1.38
Pneumonia and influenza	480-487	15	16.13	0.93	0.52-1.53
Chronic obstructive pulmonary disease	490-496	34	30.51	1.11	0.77-1.56
Other respiratory system	510-519	7	5.72	1.22	0.49-2.52
Diseases of the digestive system	520-579	33	29.58	1.12	0.77-1.57
Esophagus, stomach, duodenum	530-537	6	4.18	1.44	0.53-3.13
Hernia of abdominal cavity	550-553, 560-569	4	4.05	0.99	0.27-2.53
Non-infective enteritis and colitis	555-558	3	2.48	1.21	0.25-3.53
Other digestive system	570-579	20	18.87	1.06	0.65-1.64
Diseases of the musculoskeletal system	710-739	3	2.08	1.44	0.30-4.22
Congenital anomalies	740-759	2	1.36	1.47	0.18-5.31
External causes of injury and poisoning	E800-E978, E980-E999	62	49.22	1.26	0.97-1.61
Other accidents/adverse effects	E800-E807, E825-E949	18	14.29	1.26	0.75-1.99
Motor vehicle accidents	E810-E825	20	18.12	1.10	0.67-1.70
Suicide	E950-E959	17	10.99	1.55	0.90-2.48
Homicide and legal intervention	E960-E978	4	3.64	1.10	0.30-2.81
All other external causes	E980-E999	3	2.17	1.38	0.28-4.04

* O = observed number of cases, E = expected number of cases, CI = confidence interval

N.B. Only the subgroups with expected deaths >10 or SMRs > 1.00 were reported. Not all categories of mortality are presented in the table. (See the Appendices for the full list.)

1.00^{+} implies a number slightly greater than 1.00 and 1.00^{-} implies slightly less than 1.00.

Bold indicates CI does not include 1.00

Table 7. Standardized Mortality Ratio (SMR), Year and Age Adjusted, for Females and Males Separately Compared to Niagara County

	Females				Males			
Cause of death	O*	E*	SMR	95% CI*	O*	E*	SMR	95% CI*
All causes	309	324.61	0.95	0.85-1.06	416	417.63	1.00	0.90-1.10
Infectious disease	2	3.39	0.59	0.07-2.13	11	5.53	1.99	0.99-3.56
Other bacterial diseases	1	2.48	0.40	0.01-2.24	4	2.82	1.42	0.39-3.64
Human immunodeficiency virus	0				7	2.48	**2.82**	**1.13-5.81**
Other infectious diseases	1	0.27	3.71	0.09-20.68	0			
Neoplasm	83	92.58	0.90	0.71-1.11	106	111.7	0.95	0.78-1.15
Digestive system	24	21.01	1.14	0.73-1.70	25	28.48	0.88	0.57-1.30
Respiratory system	21	22.27	0.94	0.58-1.44	36	42.05	0.86	0.60-1.18
Bone, connective tissue, skin	12	19.43	0.62	0.32-1.08	6	2.54	2.36	0.87-5.14
Genitourinary tract	12	11.95	1.00	0.52-1.75	14	14.74	0.95	0.52-1.59
Other and unspecified site	5	7.53	0.66	0.22-1.55	13	9.22	1.41	0.75-2.41
Lymphatic and hematologic	8	8.55	0.94	0.40-1.84	11	11.28	0.98	0.49-1.74
Endocrine and metabolic disease	7	9.27	0.76	0.30-1.56	7	9.46	0.74	0.30-1.52
Other endocrine glands	0				6	7.90	0.76	0.28-1.65
Diseases of the nervous system	5	4.23	1.18	0.38-2.76	1	4.55	0.22	0.01-1.22
Diseases of the circulatory system	125	152.6	**0.82**	**0.68-0.98**	183	191.05	0.96	0.82-1.11
Hypertensive disease	4	3.55	1.13	0.31-2.88	1	3.44	0.29	0.01-1.62
Chronic rheumatic heart disease	0				4	0.72	**5.59**	**1.52-14.32**
Acute myocardial infarction	49	47.05	1.04	0.77-1.38	77	77.36	1.00	0.79-1.24
Other acute forms of IHD	2	0.62	3.24	0.39-11.70	0			
Chronic ischemic heart disease	30	46.01	**0.65**	**0.44-0.93**	51	55.40	0.92	0.69-1.21
Other form of heart disease	20	20.32	0.98	0.60-1.52	22	21.80	1.01	0.63-1.53
Cerebrovascular diseases	16	27.67	0.58	0.33-0.94	20	22.65	0.88	0.54-1.36
Diseases of the veins and lymphatics	0				3	1.06	2.83	0.58-8.28
Diseases of the respiratory system	29	23.62	1.23	0.82-1.76	28	30.03	0.93	0.62-1.35
Pneumonia and influenza	8	7.01	1.14	0.49-2.25	7	9.13	0.77	0.31-1.58
Chronic obstructive pulmonary disease	18	13.49	1.33	0.79-2.11	16	17.02	0.94	0.54-1.53
Other respiratory system	2	2.69	0.74	0.09-2.68	5	3.03	1.65	0.54-3.85
Diseases of the digestive system	10	12.72	0.79	0.38-1.45	23	16.87	1.36	0.86-2.05
Esophagus, stomach, duodenum	1	1.69	0.59	0.01-3.30	5	2.49	2.01	0.65-4.69
Hernia of abdominal cavity	1	2.26	0.44	0.01-2.47	3	1.79	1.67	0.34-4.89
Non-infective enteritis and colitis	3	1.47	2.04	0.42-5.95	0			
Other digestive system	5	7.29	0.69	0.22-1.60	15	11.58	1.30	0.73-2.14
Diseases of the musculoskeletal system	2	1.54	1.30	0.16-4.68	1	0.54	1.86	0.05-10.39
Congenital Anomalies	1	0.60	1.67	0.04-9.28	1	0.76	1.32	0.03-7.34
External causes of injury and poisoning	24	13.89	**1.73**	**1.11-2.57**	38	35.34	1.08	0.76-1.48
Other accidents/adverse effects	6	4.46	1.34	0.49-2.93	12	9.83	1.22	0.63-2.13
Motor vehicle accidents	10	5.46	1.83	0.88-3.37	10	12.67	0.79	0.38-1.45
Suicide	5	2.03	2.46	0.80-5.74	12	8.96	1.34	0.69-2.34
Homicide and legal intervention	1	1.23	0.82	0.02-4.54	3	2.42	1.24	0.26-3.63
All other external causes	2	0.71	2.83	0.34-10.22				

* O = observed number of cases, E = expected number of cases, CI = confidence interval

N.B. Only the subgroups with expected deaths >10 or SMRs > 1.00 were reported. Not all categories of mortality are presented in the table. (See the Appendices for the full list.)

1.00^{+} implies a number slightly greater than 1.00 and 1.00^{-} implies slightly less than 1.00.

Bold indicates CI does not include 1.00

Table 8. Standardized Incidence Ratio (SIR), Year, Age and Sex Adjusted, for Cancer for Females and Males Combined, Full and Part Time Residents, Compared to NYS (Exclusive of NYC)

Cancer	ICD-9	O*	E*	SIR	95% CI*
All cancers		304	324.92	0.94	0.83-1.05
Digestive organs and peritoneum	150-159	69	66.95	1.03	0.80-1.30
Stomach	151	7	6.46	1.08	0.44-2.23
Colon	153	26	29.38	0.88	0.58-1.30
Rectum	154	17	13.31	1.28	0.74-2.04
Liver	155	3	2.36	1.27	0.26-3.71
Gall bladder	156	5	2.03	2.46	0.80-5.75
Respiratory and intrathoracic organs	160-165	62	58.08	1.07	0.82-1.37
Larynx	161	4	4.52	0.88	0.24-2.27
Trachea, bronchus, and lung	162	57	51.93	1.10	0.83-1.42
Bone, connective tissue, skin, breast	170-175	50	62.41	0.80	0.59-1.06
Malignant melanoma of the skin	172	5	7.23	0.69	0.22-1.61
Breast – female only	174	42	51.40	0.82	0.59-1.10
Genitourinary organs	179-189	82	83.58	0.98	0.78-1.22
Body of the uterus	182	5	10.05	0.50	0.16-1.16
Ovary – female only	183	9	7.91	1.14	0.52-2.16
Prostate – male only	185	29	31.92	0.91	0.61-1.30
Testis – male only	186	3	2.34	1.28	0.26-3.75
Bladder	188	23	15.97	1.44	0.91-2.16
Kidney	189	12	8.12	1.48	0.76-2.58
Other and unspecified sites	190-199	18	19.11	0.94	0.56-1.49
Brain	191	4	5.09	0.79	0.21-2.01
Thyroid gland	193	6	3.82	1.57	0.58-3.42
Other endocrine glands	194	2	0.44	4.55	0.55-16.42
Without specification of sites	199	4	7.79	0.51	0.14-1.31
Lymphatic and hematopoietic tissue	200-208	19	26.61	0.71	0.43-1.12
Lymphoid and histiocytic tissue	202	5	6.04	0.83	0.27-1.93
Myeloma and immunoproliferative	203	5	3.52	1.42	0.46-3.32

* O = observed number of cases, E = expected number of cases, CI = confidence interval.

NB. Only the subgroups with expected cancers >10 or SIRs > 1.00 were reported. Not all categories of cancer are presented in the table. (See Appendices for the full list.)

1.00^{+} implies a number slightly greater than 1.00 and 1.00^{-} implies slightly less than 1.00.

Table 9. Standardized Incidence Ratio (SIR), Year and Age Adjusted, for Cancer for Females and Males Separately, Full and Part Time Residents, Compared to NYS (Exclusive of NYC)

	Females				Males			
Cancer	O*	E*	SIR	95% CI*	O*	E*	SIR	95% CI*
All cancers	142	165.48	0.86	0.72-1.01	162	159.44	1.02	0.87-1.18
Digestive organs and peritoneum	33	30.39	1.09	0.75-1.52	36	36.56	0.98	0.69-1.36
Stomach	2	2.26	0.88	0.11-3.20	5	4.20	1.19	0.39-2.78
Colon	14	14.63	0.96	0.52-1.61	12	14.75	0.81	0.42-1.42
Rectum	9	5.73	1.57	0.72-2.98	8	7.57	1.06	0.46-2.08
Liver	0	0.82			3	1.53	1.96	0.40-5.73
Gall bladder	3	1.17	2.56	0.53-7.49	2	0.86	2.33	0.28-8.40
Respiratory and intrathoracic organs	19	21.72	0.87	0.53-1.37	43	36.35	1.18	0.86-1.59
Larynx	0	1.02			4	3.50	1.14	0.31-2.93
Trachea, bronchus, and lung	19	20.15	0.94	0.57-1.47	38	31.78	1.20	0.85-1.64
Bone, connective tissue, skin, breast	47	56.27	0.84	0.61-1.11	3	6.14	0.49	0.10-1.43
Connective and other soft tissue	2	0.92	2.17	0.26-7.85	0	1.09		
Malignant melanoma of the skin	3	3.35	0.90	0.18-2.62	2	3.88	0.52	0.06-1.86
Breast – female only	42	51.39	0.82	0.59-1.10				
Genitourinary organs	26	32.15	0.81	0.53-1.18	56	51.42	1.09	0.82-1.41
Body of the uterus	5	10.05	0.50	0.16-1.16				
Ovary – female only	9	7.91	1.14	0.52-2.16				
Prostate – male only					29	31.92	0.91	0.61-1.30
Testis – male only					3	2.34	1.28	0.26-3.75
Bladder	7	4.17	1.68	0.67-3.46	16	11.80	1.36	0.78-2.20
Kidney	4	3.08	1.30	0.35-3.32	8	5.03	1.59	0.69-3.13
Other and unspecified sites	10	10.18	0.98	0.47-1.81	8	8.93	0.90	0.39-1.76
Brain	1	2.29	0.44	0.01-2.43	3	2.80	1.07	0.22-3.13
Thyroid gland	5	2.79	1.79	0.58-4.18	1	1.02	0.98	0.02-5.46
Other endocrine glands	2	0.23	**8.70**	**1.05-31.41**	0	0.21		
Lymphatic and hematopoietic tissue	7	11.99	0.58	0.23-1.20	12	14.62	0.82	0.42-1.43
Lymphoid and histiocytic tissue	1	2.79	0.36	0.01-2.00	4	3.25	1.23	0.33-3.15
Myeloma and immunoproliferative	2	1.65	1.21	0.15-4.38	3	1.87	1.60	0.33-4.69

* O = observed number of cases, E = expected number of cases, CI = confidence interval.

NB. Only the subgroups with expected cancers >10 or SIRs > 1.00 were reported. Not all categories of cancer are presented in the table. (See Appendices for the full list.)

1.00^{+} implies a number slightly greater than 1.00 and 1.00^{-} implies slightly less than 1.00.

Bold indicates CI does not include 1.00

Table 10. Standardized Incidence Ratio (SIR), Year and Age Adjusted, for Females and Males Combined, Full and Part Time Residents, Compared to Niagara County

Cancer	ICD-9	O*	E*	SIR	95% CI*
All cancers		304	332.76	0.91	0.81-1.02
Digestive organs and peritoneum	150-159	69	65.26	1.06	0.82-1.34
Stomach	151	7	5.92	1.18	0.48-2.44
Colon	153	26	28.22	0.92	0.60-1.35
Rectum	154	17	13.12	1.30	0.76-2.07
Liver	155	3	2.03	1.48	0.30-4.32
Gall bladder	156	5	2.26	2.21	0.72-5.16
Respiratory and intrathoracic organs	160-165	62	62.34	0.99	0.76-1.28
Larynx	161	4	4.23	0.95	0.26-2.42
Trachea, bronchus, and lung	162	57	56.26	1.01	0.77-1.31
Bone, connective tissue, skin, breast	170-175	50	60.90	0.82	0.61-1.08
Malignant melanoma of the skin	172	5	6.79	0.74	0.24-1.72
Breast – female only	174	42	50.94	0.82	0.59-1.11
Genitourinary organs	179-189	82	87.68	0.94	0.74-1.16
Body of the uterus	182	5	9.45	0.53	0.17-1.23
Ovary – female only	183	9	7.90	1.14	0.52-2.16
Prostate – male only	185	29	35.24	0.82	0.55-1.18
Testis – male only	186	3	2.70	1.11	0.23-3.25
Bladder	188	23	17.89	1.29	0.82-1.93
Kidney	189	12	7.79	1.54	0.80-2.69
Other and unspecified sites	190-199	18	20.29	0.89	0.53-1.40
Brain	191	4	4.92	0.81	0.22-2.08
Thyroid gland	193	6	4.57	1.31	0.48-2.86
Lymphatic and Hematopoietic tissue	200-208	19	28.03	0.68	0.41-1.06
Lymphoid and histiocytic tissue	202	5	6.39	0.78	0.25-1.83
Myeloma and immunoproliferative	203	5	3.69	1.36	0.44-3.16

* O = observed number of cases, E = expected number of cases, CI = confidence interval.

NB. Only the subgroups with expected cancers >10 or SIRs > 1.00 were reported. Not all categories of cancer are presented in the table. (See Appendices for the full list.)

1.00^{+} implies a number slightly greater than 1.00 and 1.00^{-} implies slightly less than 1.00.

Table 11. Standardized Incidence Ratio (SIR), Year and Age Adjusted, for Females and Males Separately, Full and Part Time Residents, Compared to Niagara County

	Females				Males			
Cancer	O*	E*	SIR	95% CI*	O*	E*	SIR	95% CI*
All cancers	142	164.84	0.86	0.73-1.02	162	167.92	0.96	0.82-1.12
Digestive organs and peritoneum	33	29.66	1.11	0.77-1.56	36	35.59	1.01	0.71-1.40
Stomach	2	1.89	1.06	0.13-3.82	5	4.03	1.24	0.40-2.90
Colon	14	14.31	0.98	0.54-1.64	12	13.92	0.86	0.45-1.51
Rectum	9	5.71	1.58	0.72-2.99	8	7.41	1.08	0.47-2.13
Liver	0	0.78			3	1.25	2.40	0.49-7.01
Gall bladder	3	1.29	2.33	0.48-6.80	2	0.97	2.06	0.25-7.45
Respiratory and intrathoracic organs	19	22.46	0.85	0.51-1.32	43	39.88	1.08	0.78-1.45
Larynx	0	1.01	0.00		4	3.23	1.24	0.34-3.17
Trachea, bronchus, and lung	19	21.09	0.90	0.54-1.41	38	35.17	1.08	0.76-1.48
Bone, connective tissue, skin, breast	47	55.26	0.85	0.63-1.13	3	5.64	0.53	0.11-1.55
Malignant melanoma of the skin	3	2.90	1.03	0.21-3.02	2	3.89	0.51	0.06-1.86
Breast – female only	42	50.94	0.82	0.59-1.11				
Genitourinary organs	26	31.30	0.83	0.54-1.22	56	56.38	0.99	0.75-1.29
Body of the uterus	5	9.45	0.53	0.17-1.23				
Ovary – female only	9	7.90	1.14	0.52-2.16				
Prostate – male only					29	35.24	0.82	0.55-1.18
Testis – male only					3	2.70	1.11	0.23-3.25
Bladder	7	4.50	1.56	0.63-3.20	16	13.39	1.19	0.68-1.94
Kidney	4	3.09	1.29	0.35-3.31	8	4.69	1.71	0.74-3.36
Other and unspecified sites	10	10.49	0.95	0.46-1.75	8	9.79	0.82	0.35-1.61
Brain	1	2.20	0.45	0.01-2.53	3	2.72	1.10	0.23-3.22
Thyroid gland	5	3.44	1.45	0.47-3.39	1	1.13	0.88	0.03-4.93
Lymphatic and Hematopoietic tissue	7	13.10	0.53	0.21-1.10	12	14.92	0.80	0.42-1.41
Lymphoid and histiocytic tissue	1	3.23	0.31	0.01-1.73	4	3.16	1.27	0.34-3.24
Myeloma and immunoproliferative	2	1.92	1.04	0.13-3.76	3	1.76	1.70	0.35-4.98

* O = observed number of cases, E = expected number of cases, CI = confidence interval.

NB. Only the subgroups with expected cancers >10 or SIRs > 1.00 were reported. Not all categories of cancer are presented in the table. (See Appendices for the full list.)

1.00^{+} implies a number slightly greater than 1.00 and 1.00^{-} implies slightly less than 1.00.

Table 12. Standardized Incidence Ratio (SIR), Age and/or Sex Adjusted, for Cancer Groups Based on Literature Reports Compared to NYS Exclusive of NYC

	Liver, Lung and Non-Hodgkins Lymphoma (NHL)		Liver, Lung, NHL and Leukemia		Liver, Lung, NHL, Leukemia and Soft Tissue Sarcoma (STS)		Liver, Lung, Stomach, Leukemia, NHL, STS, and Kidney		Age group 1-18		Age group 18+	
SIR	1.00		0.93		0.90		0.97		0.65		0.92	
CI	0.77-1.27		0.72-1.18		0.78-1.13		0.78-1.19		0.24-1.42		0.82-1.03	
SIR for 80% Power	1.34		1.32		1.30		1.28		1.98		1.14	
	O	E	O	E	O	E	O	E	O	E	O	E
All									6	9.21	298	323.56
Stomach							7	6.24				
Colon												
Rectum												
Liver	3	2.03	3	2.03	3	2.03	3	2.03				
Bladder												
Kidney							11	7.81				
Brain												
NHL	5	6.39	5	6.39	5	6.39	5	6.39				
Leukemia			4	9.14	4	9.14	4	9.14				
Lung	57	56.76	57	56.76	57	56.76	57	56.76				
Skin												
STS					3	5.91	3	5.91				
Thyroid												
Pancreas												
Breast												
Ovary												
Uterus												
Testes												
Prostate												
Total	65	65.18	69	74.32	72	80.23	91	93.94	6	9.21	298	323.56

Table 13. Standardized Incidence Ratio (SIR), Age and/or Sex-Adjusted, for Cancer Groups Based on Toxicological Endpoints Compared to NYS Exclusive of NYC

	Environment Sensitive**		Known Probable Occupational Hazards***		Organs of First Contact		Organs of Endocrine System		Estrogen Affected Tissues			
									Females		Males	
SIR	1.08		1.11		1.05		0.87		0.81		0.95	
CI	0.92-1.26		0.91-1.34		0.80-1.34		0.71-1.05		0.61-1.05		0.65-1.34	
SIR for 80% Power	1.22		1.27		1.35		1.24		1.32		1.49	
	O	E	O	E	O	E	O	E	O	E	O	E
All												
Stomach	7	6.46										
Colon	26	29.38										
Rectum	17	13.31										
Liver	3	2.36	3	2.36								
Bladder	23	15.97	23	15.97								
Kidney	12	8.12	12	8.12								
Brain	4	5.09	4	5.09								
NHL	5	6.04	5	6.04								
Leukemia	4	8.03	4	8.03								
Lung	57	51.93	57	51.93	57	51.93						
Skin					5	7.23						
STS												
Thyroid							6	3.82				
Endocrine Glands							2	0.44				
Pancreas							6	8.19				
Breast							43	61.81	42	51.40	1	0.41
Ovary							9	7.91	9	7.91		
Uterus							5	10.05	5	10.05		
Testes							3	2.34			3	2.34
Prostate							29	31.92			29	31.92
Total	158	146.69	108	97.54	62	59.16	103	118.82	56	69.36	33	34.67

** Doll and Peto: ‘Causes of Cancer.’ Oxford University Press, 1981, Higginson, Muir and Munoz: ‘Human Cancer: Epidemiology and Environmental Causes.’ Cambridge University Press, 1992

*** Doll and Peto: ‘Causes of Cancer.’ Oxford University Press, 1981

Table 14. Standardized Incidence Ratio (SIR), Age or Sex Adjusted, for Cancer Groups Based on Literature Reports Compared to Niagara County

	Liver, Lung and NHL		Liver, Lung, NHL and Leukemia		Liver, Lung, NHL, Leukemia and Soft Tissue Sarcoma (STS)		Liver, Lung, Stomach, Leukemia, NHL, STS, and Kidney		Age group 1-18		Age group 18+	
SIR	1.00		0.93		0.90		0.97		0.65		0.92	
CI	0.77-1.27		0.72-1.18		0.70-1.13		0.78-1.19		0.24-1.42		0.82-1.03	
SIR for 80% Power	1.34		1.32		1.30		1.28		1.98		1.14	
	O	E	O	E	O	E	O	E	O	E	O	E
All									6	9.21	298	323.56
Stomach							7	5.92				
Colon												
Rectum												
Liver	3	2.03	3	2.03	3	2.03	3	2.03				
Bladder												
Kidney							12	7.79				
Brain												
NHL	5	6.39	5	6.39	5	6.39	5	6.39				
Leukemia			4	9.14	4	9.14	4	9.14				
Lung	57	56.76	57	56.76	57	56.76	57	56.76				
Skin												
STS					3	5.91	3	5.91				
Thyroid												
Pancreas												
Breast												
Ovary												
Uterus												
Testes												
Prostate												
Total	65	65.18	69	74.32	72	80.23	91	93.94	6	9.21	298	323.56

Table 15. Standardized Incidence Ratio (SIR), Age and/or Sex Adjusted, for Cancer Groups Based on Toxicological Endpoints Compared to Niagara County

	Environment Sensitive**		Known Probable Occupational Hazards***		Organs of First Contact		Organs of Endocrine System		Estrogen Affected Tissues			
									Females		Males	
SIR	1.03		1.03		1.01		0.82		0.78		0.87	
CI	0.88-1.21		0.85-1.25		0.77-1.29		0.66-1.00		0.58-1.02		0.59-1.22	
SIR for 80% Power	1.22		1.26		1.36		1.25		1.33		1.46	
	O	E	O	E	O	E	O	E	O	E	O	E
All												
Stomach	7	5.70										
Colon	24	27.33										
Rectum	16	12.62										
Liver	3	1.98	3	1.98								
Bladder	22	17.28	22	17.28								
Kidney	11	7.51	11	7.51								
Brain	4	4.70	4	4.70								
NHL	5	6.16	5	6.16								
Leukemia	3	8.74	3	8.74								
Lung	56	54.13	56	54.13	56	54.13						
Skin					5	6.51						
STS												
Thyroid							5	4.36				
Pancreas							6	7.90				
Breast							38	48.91	38	48.91		
Ovary							8	7.58	8	7.58		
Uterus							5	9.08	5	9.08		
Testes							3	2.54			3	2.54
Prostate							29	34.35			29	34.35
Total	151	146.15	104	100.5	61	60.64	94	114.72	51	65.57	32	36.89

** Doll and Peto: 'Causes of Cancer.' Oxford University Press, 1981, Higginson, Muir and Munoz: 'Human Cancer: Epidemiology and Environmental Causes.' Cambridge University Press, 1992

*** Doll and Peto: 'Causes of Cancer.' Oxford University Press, 1981

N.B. 1.00^{+} implies a number slightly greater than 1.00 and 1.00^{-} implies slightly less than 1.00

Table 16. Exposure Patterns and Characteristics of Mothers and Singleton Births, 1960-1996

Variable	Mothers (N=980) n	(%)	Singleton Births (N=1767) n	(%)	Variable	Mothers (N=980) n	(%)	Singleton Births (N=1767) n	(%)
Open Period Tier 1 or 2					Smoke				
Length of residence									
<1 year	1	(0.10)	1	(0.06)	Yes	494	(50.41)	880	(49.80)
1-9 years	8	(0.82)	13	(0.73)	No	250	(25.51)	476	(26.94)
>=10 years	2	(0.20)	4	(0.23)	Missing	236	(24.08)	411	(23.26)
Open Period Tier 3 or 4					Alcohol Consumption				
Length of residence									
<1 year	16	(1.63)	29	(1.64)	Yes	543	(55.41)	998	(56.48)
1-9 years	82	(8.37)	148	(8.37)	No	199	(20.31)	356	(20.15)
>=10 years	36	(3.67)	71	(4.02)	Missing	238	(24.29)	413	(23.37)
Closed Period Tier 1 or 2					Occupational Exposure				
Length of residence									
<1 year	22	(2.24)	53	(3.00)	Yes	81	(8.27)	146	(8.26)
1-9 years	228	(23.27)	380	(21.50)	No	483	(49.29)	884	(50.03)
>=10 years	55	(5.61)	107	(6.06)	Maybe	182	(18.57)	324	(18.34)
					Missing	234	(23.88)	413	(23.37)
Closed Period Tier 3 or 4									
Length of residence									
<1 year	58	(5.92)	129	(7.30)	Mother's Age				
1-9 years	483	(49.29)	867	(49.07)	<20	-	-	164	(9.28)
>=10 years	123	(11.53)	212	(12.00)	20-27	-	-	914	(51.72)
					28-34	-	-	512	(28.98)
Childhood Exposure[a]					>34	-	-	177	(10.02)
Yes	130	(13.27)	250	(14.15)					
No	850	(86.73)	1517	(85.85)	Mother's Race				
					White	907	(92.56)	1641	(92.87)
Attended 99th St. School					Black	64	(6.53)	107	(6.06)
Yes	248	(25.31)	495	(28.01)	Other/Unknown	8	(0.82)	17	(0.96)
No	732	(74.69)	1272	(71.99)	Missing	1	(0.10)	2	(0.11)
Hot Spot / Swale					Infant Sex				
Yes	24	(2.45)	41	(2.32)	Female	-	-	893	(50.54)
No	956	(97.55)	1726	(97.68)	Male	-	-	874	(49.46)
Year of Birth					Gestational Age				
1960-67	-	-	492	(27.84)	<37 weeks	-	-	123	6.96)
1968-78	-	-	606	(34.29)	>=37 weeks	-	-	1583	(89.59)
1979-87	-	-	385	(21.79)	Missing	-	-	61	(3.45)
1988-96	-	-	284	(16.07)					
					Birth Weight				
Singleton Birth[b]					<2500 g	-	-	92	(5.21)
Yes	976		1767	(98.22)	>=2500 g	-	-	1671	(94.45)
No	15		32	(1.78)	Missing	-	-	4	(0.34)

[a] Defined as: maternal exposure on tiers 1 and 2, 0-13 years old prior to the given birth
[b] Not mutually exclusive
N.B. The total number of births in this study was 1799 of which 32 were multiple births and therefore omitted from the analysis of birth weight, gestational age and small for gestational age analysis.

Table 17. Standardized Incidence Ratios (SIR) For Low Birth Weight (LBW), Very Low Birth Weight (VLBW), Pre-Term (PT), and Small for Gestational Age (SGA), Compared to Niagara County and NYS Exclusive of NYC, Singleton Births Only

Years	Outcome	Observed	Niagara County			NYS excluding of NYC		
			Expected	SIR	95% CI	Expected	SIR	95% CI
ALL YEARS								
1960 - 96	LBW (<2500g)	92	111.49	0.83	0.67 - 1.01	106.19	0.87	0.70 - 1.06
1960 - 96	VLBW (<1500g)	10	17.48	0.57	0.27 - 1.05	16.79	0.60	0.29 - 1.10
1968 - 96	PT (<37w)	106	107.22	0.99	0.81 - 1.20	100.60	1.05	0.86 - 1.27
1968 - 96	SGA**	118	118.17	1.00	0.83 - 1.20	117.43	1.00	0.83 - 1.20
PRE-EVACUATION								
All births								
1960 – 78	LBW (<2500g)	62	74.95	0.83	0.63 - 1.06	69.11	0.90	0.69 -1.15
1960 – 78	VLBW (<1500g)	10	11.39	0.88	0.42 - 1.61	10.22	0.98	0.47 -1.80
1968 – 78	PT (<37w)	53	51.49	1.03	0.77 - 1.35	48.02	1.10	0.83 -1.44
1968 – 78	SGA**	54	55.69	0.97	0.73 - 1.27	55.30	0.98	0.74 -1.27
On canal[a]								
1960 - 78	LBW (<2500g)	42	46.83	0.90	0.65 - 1.21	43.19	0.97	0.70 - 1.31
1960 - 78	VLBW (<1500g)	7	7.14	0.98	0.39 - 2.02	6.39	1.10	0.44 - 2.26
1968 - 78	PT (<37w)	38	29.74	1.28	0.90 - 1.75	27.66	1.37	0.97 - 1.89
1968 - 78	SGA**	34	31.95	1.06	0.74 - 1.49	31.75	1.07	0.74 - 1.50
Off canal[a]								
1960 - 78	LBW (<2500g)	20	28.11	0.71	0.43 - 1.10	25.92	0.77	0.47 - 1.19
1960 - 78	VLBW (<1500g)	3	4.25	0.71	0.15 - 2.06	4.17	0.72	0.15 - 2.10
1968 - 78	PT (<37w)	15	21.79	0.69	0.39 - 1.14	20.36	0.74	0.41 - 1.22
1968 - 78	SGA**	20	23.73	0.84	0.51 - 1.30	23.55	0.85	0.52 - 1.31
POST-EVACUATION								
1979 - 96	LBW (<2500g)	30	36.54	0.82	0.55 - 1.17	37.08	0.81	0.55 - 1.16
1979 - 96	VLBW (<1500g)	0	-	-	-	-	-	-
1979 - 96	PT (<37w)	53	55.73	0.95	0.71 - 1.24	52.58	1.01	0.75 - 1.32
1979 - 96	SGA**	64	62.48	1.02	0.79 - 1.31	62.13	1.03	0.79 - 1.32

* LBW, VLBW and SGA adjusted for birth year, sex and mother's age; PT adjusted for birth year and mother's age

** Singleton births below the 10th percentile of Upstate NY birth weights distributed by week of gestation, sex, and calendar year groups. The years 1960-67 are not included for calculation since gestational age was estimated by weeks and not calculated during these years

[a] On canal: at some time in the pregnancy, the mother lived in the EDA; Off canal: at no time during the pregnancy did the mother live in the EDA

Table 18. Proportion of Births by Sex and Ratio of Female to Male Births Compared to Niagara County and NYS Exclusive of NYC

	Love Canal			Niagara County			Upstate NY		
	N	% (95% CI)	Ratio (95% CI)	N	%	Ratio	N	%	Ratio
ALL YEARS (1960 – 1996)									
Total births	1728		1.01	132686			5670495		
Females	868	50.23 (47.85-52.55)	(0.93-1.09)	64687	48.75	0.95	2761824	48.7	0.95
Males	860	49.70 (45.45-52.15)		67999	51.25		2908671	51.3	
PRE-EVACUATION (1960 – 1978)									
Total births	1045		1.00	77222			3030313		
Females	523	50.05 (47.70-52.40)	(0.91-1.11)	37701	48.82	0.95	1476155	48.7	0.95
Males	522	49.95 (47.85-52.08)		39521	51.18		1554158	51.3	
On canal									
Total births	609		1.06	-	-		-	-	
Females	313	51.40 (47.43-55.37)	(0.93-1.21)	-	-		-	-	
Males	296	48.60 (44.63-52.57)		-	-		-	-	
Off canal				-	-		-	-	
Total births	436		0.93	-	-		-	-	
Females	210	48.17 (43.48-52.86)	(0.79-1.09)	-	-		-	-	
Males	226	51.83 (47.14-56.52)		-	-		-	-	
POST EVACUATION (1979 – 1996)									
Total births	683		1.02	55464			2640182		
Females	345	50.51 (46.76-54.26)	(0.90-1.16)	26986	48.65	0.94	1285669	48.7	0.95
Males	338	49.49 (45.74-53.24)		28478	51.35		1354513	51.3	

Table 19. Standardized Incidence Ratio (SIR), Adjusted for Maternal Age, for Congenital Malformations Compared to Niagara County and NYS Exclusive of NYC

Years	Gender	Observed	Niagara County			NYS excluding NYC		
			Expected	SIR	95% CI	Expected	SIR	95% CI
1983-1996	Total	16	7.81	**2.05**	**1.17 - 3.33**	11.61	1.38	0.79 - 2.24
	Females	5	2.80	1.79	0.58 - 4.17	4.26	1.17	0.38 - 2.74
	Males	11	5.01	**2.20**	**1.09 - 3.93**	7.35	1.50	0.75 - 2.68

Bold indicates the CI does not include 1.00

Table 20. Summary of Demographic Information of Persons with Known Vital Status and Dates of Residence in the EDA and Subset of Interviewees Only

	Persons with Known Vital Status (N = 5,974) [a]		Subset of Interviewees Only (N = 4,457) [b]	
	n	%	n	%
Sex				
Male	2,893	48.4	2,105	47.2
Female	3,081	51.6	2,352	52.8
Race				
White	5,674	95.0	4,229	94.9
Non-white	281	4.7	222	5.0
Missing info.	19	0.3	6	0.1
Occupation				
Possibly exposed [c]			2,070	46.4
Non-exposed			1,972	44.2
Missing info.			415	9.3
Smoking				
Ever smoked			2,806	63.0
Never smoked			1,176	26.4
Missing info.			475	10.7
Drinking				
Ever drank			2,959	66.4
Never drank			1,010	22.7
Missing info.			488	10.9
	Median (Min. – Max.)		Median (Min. – Max.)	
Age (years) in 1978	29.0 (0.0 – 94.0)		37.0 (17.0 – 94.0) [d]	
Median years that people lived in each exposure category				
Open period, Tier 1 or 2	1.5 (0.5 – 12.0)		1.5 (0.5 – 12.0)	
Open period, Tier 3 or 4	5.5 (0.5 – 12.0)		5.5 (0.5 – 12.0)	
Closed period, Tier 1 or 2	6.0 (0.5 – 24.5)		8.0 (0.5 – 24.5)	
Closed period, Tier 3 or 4	6.5 (0.5 – 24.5)		8.0 (0.5 – 24.5)	

[a] All members of the cohort with exposure information.
[b] Members of the cohort with exposure information and interviews.
[c] Occupations possibly exposed to LCICs.
[d] There were 2 persons who were 17 years in 1978, but they were 18 years or older at the time of interview.
N.B. Percentages may not add up to 1 due to rounding.

Table 21. Cox Proportional Hazards Modeling for Mortality, Hazard Ratios (HR) and 95% Confidence Intervals (CI), Interviewees Only (N = 3,796)

	All-Causes of Death (n=620)	Neoplasms (n=172)	Circulatory System (n=272)	Acute Myocardial Infarction (n=116)	Respiratory System (n=49)	External Causes of Injury and Poisoning (n=42)
Variable	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI
Open period, Tier 1 or 2 (years)	0.98 (0.89-1.08)	0.86 (0.64-1.16)	1.02 (0.92-1.14)	1.02 (0.87-1.20)	1.13 (0.92-1.38)	0.90 (0.40-2.02)
Open period, Tier 3 or 4 (years)	0.99 (0.97-1.01)	0.98 (0.94-1.02)	1.00 (0.97-1.03)	0.98 (0.94-1.03)	1.00 (0.93-1.07)	1.03 (0.94-1.12)
Closed period, Tier 1 or 2 (years)	1.00 (0.98-1.01)	1.01 (0.98-1.03)	1.00 (0.98-1.02)	1.00 (0.96-1.03)	0.99 (0.94-1.03)	0.97 (0.91-1.04)
Closed period, Tier 3 or 4 (years)	1.00 (0.99-1.01)	1.00 (0.99-1.02)	1.00 (0.98-1.01)	1.02 (1.00^{-}-1.04)	0.99 (0.96-1.02)	0.98 (0.93^{-}-1.02)
Hot spot / swale (yes/no)	0.91 (0.50-1.66)	1.11 (0.41-3.02)	1.36 (0.64-2.89)	0.89 (0.22-3.64)	[a]	[a]
Childhood Exposure (yes/no)	1.14 (0.53-2.42)	2.5 (0.72-8.72)	0.98 (0.13-7.51)	2.53 (0.31-20.63)	[a]	0.72 (0.16-3.13)
Years attending 99th Street School (years)	0.96 (0.85-1.08)	0.58 (0.32-1.04)	0.56 (0.24-1.29)	0.52 (0.15-1.74)	[a]	1.12 (0.94-1.33)
Age (years)	**1.10 (1.09-1.10)**	**1.09 (1.08-1.10)**	**1.12 (1.10-1.13)**	**1.11 (1.09-1.13)**	**1.12 (1.09-1.15)**	1.01 (0.98-1.04)
Male (yes/no)	**1.65 (1.36-2.01)**	**1.50 (1.04-2.18)**	**1.84 (1.35-2.49)**	**1.87 (1.17-2.99)**	1.24 (0.62-2.46)	1.72 (0.81-3.62)
Ever smoked (yes/no)	**1.66 (1.35-2.05)**	**1.64 (1.10-2.44)**	**1.36 (1.00^{+}-1.84)**	1.38 (0.87-2.19)	**6.23 (2.15-18.02)**	2.25 (0.93-5.44)
Alcohol consumption (yes/no)	0.91 (0.76-1.08)	1.15 (0.81-1.62)	0.87 (0.67-1.14)	0.79 (0.53-1.18)	1.65 (0.83-3.28)	1.16 (0.52-2.57)
Potential occupational exposure to LCICs (yes/no)	1.00 (0.83-1.21)	1.01 (0.70-1.45)	1.24 (0.92-1.67)	1.35 (0.86-2.14)	**0.50 (0.25-0.97)**	0.94 (0.45-1.96)

[a] HR not calculable due to zero cells

N.B. 1.00^{+} implies a number slightly greater than 1.00 and 1.00^{-} implies slightly less than 1.00

Bold indicates the CI does not include 1.00

Table 22. Cox Proportional Hazards Modeling for Cancer (Full and part-time Residents), Hazard Ratios (HR) and 95% Confidence Intervals (CI), Interviewees Only (N = 3,081)

Variable	All-Sites of Cancer (n=268) HR (95% CI)	Respiratory and Intrathoracic Cancer (n=57) HR (95% CI)	Cancer of Digestive Organs and Peritoneum (n=64) HR (95% CI)	Liver and Rectal Cancer (n=19) HR (95% CI)	Genitourinary Cancer (n=70) HR (95% CI)	Bladder and Kidney Cancer (n=32) HR (95% CI
Open period, Tier 1 or 2 (years)	0.95 (0.80-1.12)	1.04 (0.83-1.29)	[a]	[a]	1.01 (0.79-1.29)	0.93 (0.63-1.36)
Open period, Tier 3 or 4 (years)	1.00 (0.97-1.04)	0.95 (0.87-1.03)	1.03 (0.97-1.09)	1.07 (0.96-1.18)	1.04 (0.98-1.10)	1.04 (0.96-1.13)
Closed period, Tier 1 or 2 (years)	0.99 (0.97-1.02)	1.02 (0.98-1.06)	0.98 (0.94-1.03)	0.99 (0.92-1.07)	**0.95 (0.90-1.00$^-$)**	0.96 (0.89-1.03)
Closed period, Tier 3 or 4 (years)	0.99 (0.98-1.01)	1.00 (0.97-1.04)	1.01 (0.98-1.04)	0.98 (0.93-1.04)	0.98 (0.96-1.01)	1.00 (0.96-1.04)
Hot spot / swale (yes/no)	1.02 (0.45-2.31)	0.74 (0.10-5.39)	0.75 (0.10-5.44)	3.05 (0.40-23.42)	1.59 (0.39-6.55)	[a]
Childhood Exposure (yes/no)	0.99 (0.36-2.69)	[a]	[a]	[a]	2.27 (0.42-12.31)	**17.36 (3.02-99.73)**
Years attending 99th Street School (years)	0.95 (0.82-1.10)	0.85 (0.54-1.35)	0.85 (0.55-1.30)	[a]	1.05 (0.81-1.35)	0.49 (0.14-1.70)
Age (years)	**1.07 (1.06-1.08)**	**1.09 (1.07-1.12)**	**1.08 (1.06-1.10)**	**1.11 (1.06-1.15)**	**1.09 (1.06-1.11)**	**1.09 (1.05-1.12)**
Male (yes/no)	**1.53 (1.12-2.08)**	**2.21 (1.08-4.53)**	**2.12 (1.09-4.15)**	2.01 (0.57-7.09)	**2.55 (1.35-4.84)**	**3.42 (1.29-9.09)**
Ever smoked (yes/no)	**2.08 (1.50-2.90)**	**6.56 (2.00-21.48)**	1.67 (0.89-3.13)	2.20 (0.60-8.15)	1.69 (0.90-3.19)	1.39 (0.57-3.35)
Alcohol consumption (yes/no)	0.90 (0.68-1.18)	1.08 (0.58-2.01)	0.77 (0.45-1.32)	2.24 (0.69-7.33)	0.94 (0.54-1.64)	0.63 (0.29-1.34)
Potential occupational exposure to carcinogens (yes/no)	0.84 (0.61-1.16)	1.05 (0.48-2.31)	0.60 (0.31-1.16)	0.53 (0.15-1.82)	1.05 (0.53-2.09)	1.26 (0.42-3.72)
Family History of Cancer (yes/no)	1.28 (1.00$^-$-1.64)	1.08 (0.62-1.88)	1.16 (0.69-1.93)	0.84 (0.32-2.25)	1.34 (0.82-2.17)	0.84 (0.39-1.84)

[a] HR not calculable due to zero cells

N.B. 1.00$^+$ implies a number slightly greater than 1.00 and 1.00$^-$ implies slightly less than 1.00

Bold indicates the CI does not include 1.00

Table 23. Generalized Estimating Equations Modeling for Low Birth Weight (1960-1978), Pre-term Births (1968-1978) and SGA (1968-1978) Among Women with Interviews, Odds Ratios (OR) and 95% Confidence Intervals (CI)

Variable	Low Birth Weight (n=1055)		Pre-term Births (n=572)		SGA (n=538)	
	OR	95% CI	OR	95% CI	OR	95% CI
Open Period, Tier 1 or 2 (years)	[a]	[a]	0.87	0.66-1.15	[a]	[a]
Open Period, Tier 3 or 4 (years)	1.04	0.92-1.16	0.91	0.77-1.08	0.95	0.80-1.13
Closed Period, Tier 1 or 2 (years)	0.96	0.79-1.16	0.97	0.86-1.11	0.99	0.87-1.12
Closed Period, Tier 3 or 4 (years)	1.06	0.97-1.16	0.95	0.87-1.03	1.04	0.96-1.14
Childhood Exposure (yes/no)	6.37	0.69-59.26	0.96	0.14-6.31	2.46	0.42-14.47
Attended 99th St. School (years)	0.89	0.69-1.13	0.99	0.80-1.23	0.91	0.76-1.09
Hot spot / swale (yes/no)	[a]	[a]	0.60	0.05-6.70	1.55	0.31-7.61
Year of Infant's Birth	0.97	0.90-1.05	0.97	0.86-1.09	1.00	0.90-1.10
Smoke (yes/no)	**2.38**	**1.02-5.56**	1.62	0.77-3.44	1.67	0.84-3.35
Alcohol Consumption (yes/no)	1.27	0.56-2.87	0.84	0.40-1.77	1.06	0.52-2.16
Occupational Exposure (possible/no)	0.76	0.37-1.59	0.54	0.26-1.12	0.78	0.39-1.56
Mother's Age (years)	1.01	0.95-1.07	1.03	0.96-1.10	0.96	0.90-1.03
Mother's Race (black/white)	0.88	0.30-2.51	2.36	0.68-8.25	1.75	0.59-5.16
Infant's Sex (female/male)	1.69	0.85-3.38	1.33	0.71-2.48	0.72	0.41-1.26
Gestational Age (days)	**0.91**	**0.88-0.95**	-	-	-	-
Born/Conceived On (on/off)[b]	1.44	0.63-3.29	1.56	0.74-3.30	1.27	0.60-2.71

[a] OR not calculable due to zero cells

[b]On/off refers to infant having been conceived or born when infant's mother lived in the EDA.

Bold indicates the CI does not include 1.00

Table 24. Generalized Estimating Equations Modeling for Female Births (1960-1978) Among Women with Interviews, Odds Ratio (OR) and 95% Confidence Intervals (CI)

Variable	Female Births (n=1043)	
	OR	95% CI
Open Period, Tier 1 or 2 (years)	0.99	0.93-1.05
Open Period, Tier 3 or 4 (years)	1.00	0.96-1.04
Closed Period, Tier 1 or 2 (years)	0.96	0.90-1.01
Closed Period, Tier 3 or 4 (years)	1.01	0.98-1.04
Childhood Exposure (yes/no)	**2.63**	**1.16-5.96**
Attended 99th St School (years)	1.00	0.68-1.47
Hot spot / swale (yes/no)	0.58	0.29-1.17
Smoke (yes/no)	1.10	0.84-1.43
Alcohol Consumption (yes/no)	0.96	0.72-1.27
Occupational Exposure (possible/no)	1.12	0.95-1.34
Mother's Age (years)	0.99	0.97-1.02
Conceived on (on/off) [a]	1.29	0.99-1.67

[a]On/off refers to infant having been conceived when infant's mother lived in the EDA.
Bold indicates the CI does not include 1.00

Table 25. Generalized Estimating Equations Modeling for Congenital Malformations (1983-1996) Among Women with Interviews, Odds Ratios (OR) and 95% Confidence Intervals (CI)

Variable	Congenital Malformations (n=125)	
	OR	95% CI
Open Period, Tier 1 or 2 (years)	[a]	[a]
Open Period, Tier 3 or 4 (years)	[a]	[a]
Closed Period, Tier 1 or 2 (years)	0.62	0.35-1.11
Closed Period, Tier 3 or 4 (years)	0.97	0.79-1.19
Childhood Exposure[b] (yes/no)	14.81	0.17-1255.48
Attended 99th St School (years)	1.12	0.71-1.76
Hot spot / swale (yes/no)	[a]	[a]
Year of Infant's Birth	1.11	0.89-1.40
Smoke (yes/no)	1.39	0.19-10.36
Alcohol Consumption (yes/no)	[a]	[a]
Occupational Exposure (possible/no)	1.51	0.34-6.66
Mother's Age (years)	1.08	0.86-1.35
Mother's Race (black/white)	1.62	0.13-19.74
Infant's Sex (female/male)	0.31	0.06-1.66

[a] OR not calculable due to zero cells
[b] n = 1

APPENDIX A

Selected Malformations for Analysis - ICD-9/BPA
Revised according to Holmes article (Teratology 1999; 59:1-2)

Malformation	ICD-9/BPA	ICD-9 only
Amniotic Bands	658.8	658.8
Anencephalus	740.X[1]	740.X[*]
Spina bifida with/without hydrocephalus	741.0X/741.9X	741.0X/741.9X
Encephalocele	742.0	742.0
Reduction Deformities of Brain	742.2	742.2
Congenital hydrocephalus =>2500g	742.3	742.3
Other Spec Anomalies Spinal Cord	742.5X	742.5X
An/microphthalmus	743.0X/.1X	743.0X/.1X
Congenital cataract	743.3X	743.3X
Coloboma of lens/iris	743.3X/.4X	743.3X/.4X
Spec anomalies of anterior chamber	743.44	743.44
Aniridia	743.45	743.45
Anomalies of ear causing impairment of hearing	744.0X	744.0X
Common truncus	745.0	745.0
Transposition of great vessels	745.1X	745.1X
Tetralogy of Fallot	745.2 746.09	745.2 746.09
Common ventricle	745.3	745.3
VSD[2]	745.4	745.4
ASD - secundum type[†]	745.5	745.5
Endocardial cushion defects	745.6X	745.6X
Cor Bilocurare	745.7	745.7
Atresia/Stenosis of pulmonary valve	746.01/.02	746.01/.02
Insufficiency of pulmonary valve	746.09	746.09
Tricuspid Atresia/Stenosis/Hypoplasia	746.1	746.1
Ebstein's Anomaly	746.2	746.2
Congenital stenosis of aortic valve	746.3	746.3
Hypoplastic left heart syndrome	746.7	746.7
Other spec obstructive anomalies	746.81-87	746.81-87
Patent ductus arteriosus =>2500g	747.0	747.0
Coarctation/interuption of aorta	747.10/.11	747.10/.11
Atresia/stenosis of aorta	747.22	747.22
Total/partial anomalous pulmonary venus connection	747.41/.42	747.41/.42
Choanal artesia	748.0	748.0[*]

[1] Where X = 0 through 9
[2] May want to exclude in some analyses as diagnosis may be variable

Malformation	ICD-9/BPA	ICD-9 only
Other anomalies of nose[3]	*748.100, 748.185, 748.110*	**Do not include**
Oral Clefts	749.0X/.1X/.2X	749.0X/.1X/.2X
Tracheoesophageal fistula, etc.	750.3	750.3
Congenital hypertrophic pyloric stenosis	750.5	750.5
Atresia/stenosis of small intestine	751.1	751.1
Atresia and stenosis of rectum or anus	751.2	751.2
Hirschsprung's disease	751.3	751.3
Biliary atresia	751.61	751.61
Hypospadias/Epispadias[4]	*752.6X (exclude 752.605, 752.621, 752.625)*	752.6 or 752.61 & 752.62 (will vary by year)
Indeterminate sex	752.7	752.7
Renal agenesis and dysgenesis	753.0	753.0
Cystic kidney disease	753.11-19	753.11-19
Obstructive defects renal pelvis and ureter[5]	753.2	753.2
	753.4	753.4
Exstrophy of urinary bladder	753.5	753.5
Atresia/stenosis urethra and bladder neck	753.6	753.6
Talipes equinovarus		754.51
Reduction deformities of upper limb	755.2X	755.2X
Reduction deformities of lower limb	755.3X	755.3X
Other upper limb	755.53, .54, .55, .58	755.53, .54, .55, .58
Other Lower limb		755.63, .67
Arthrogryposis multiplex congenita	*755.800*	**Do not include**
Anomalies of Skull and Face Bones	*756.000, 005, 006, 020, 030, 040, 045, 046, 050, 055, 056, 057, 060, 065, 087*	756.0
Chondrodystrophy	756.4	756.4
Osteodystrophies	756.5X	756.5X
Diaphragmatic hernia	756.6	756.6
Omphalocele	*756.700, 7001, 7002, 7003*	756.7 or 756.79 (will vary by year)
Gastroschisis	*756.710*	
Ehler-danlos syndrome	756.83	756.83
Ichthyosis Congenita	757.1	757.1
Down syndrome	758.0	758.0
Patau syndrome	758.1	758.1
Edwards syndrome	758.2	758.2

[3] Need BPA code when italicized
[4] Holmes article recommends excluding coronal hypospadias
[5] Holmes article suggests excluding abnormalities detected by ultrasound that would not have been detected on initial exam. We do not have that information but will leave in for now but consider excluding/ refining if further analysis needed.

Malformation	ICD-9/BPA	ICD-9 only
Gonadal dysgenesis	758.6	758.6
Klinefelter's syndrome	758.7	758.7
Situs inversus	759.3	759.3
Conjoined twins	759.4	759.4
Tuberous sclerosis	759.5	759.5
Other Hamartoses	759.6	759.6
Other syndromes	759.81, .82, .83, .89	759.81, .82, .83, .89
Fetal Alcohol Syndrome	760.71	760.71
Congenital rubella	771.0	771.0
Congenital cytomegalovirus infection	771.1	771.1
Other congenital infections	771.2	771.2

APPENDIX B

Love Canal Cohort Mortality Data: Person Years of Follow-Up

Years	Age	Female	Male
78-81	1 – 4	192.40	2164.67
	5 – 9	463.42	453.42
	10 - 14	615.08	735.58
	15 - 19	820.58	876.33
	20 – 24	695.17	626.00
	25 - 34	1224.25	960.33
	35 - 44	1018.58	766.33
	45 - 54	881.67	741.92
	55 - 64	755.17	697.92
	65 - 74	275.33	259.08
	75 - 84	98.75	70.75
	over 85	19.42	10.33
82-86	1 - 4	8.00	6.00
	5 - 9	447.92	390.00
	10 - 14	857.50	928.17
	15 - 19	1302.83	1484.42
	20 - 24	1699.67	1719.92
	25 - 34	3106.08	2742.00
	35 - 44	2697.42	2366.33
	45 - 54	2029.75	1761.00
	55 - 64	1877.83	1598.25
	65 - 74	842.17	815.75
	75 - 84	304.58	214.50
	over 85	60.92	26.17
87-91	5 - 9	8.00	6.00
	10 - 14	448.00	387.00
	15 - 19	854.50	926.00
	20 - 24	1287.67	1478.83
	25 - 34	3235.00	3128.67
	35 - 44	3004.25	2641.17
	45 - 54	2293.00	1923.83
	55 - 64	1804.83	1545.33
	65 - 74	1270.50	1110.42
	75 - 84	462.00	294.83
	over 85	93.67	41.08
92-96	10 - 14	8.00	6.00
	15 - 19	448.00	387.00
	20 - 24	844.00	923.50
	25 - 34	2957.25	3152.25
	35 - 44	3061.75	2700.50
	45 - 54	2645.08	2284.33
	55 - 64	1877.25	1589.33
	65 – 74	1586.33	1227.67
	75 - 84	606.83	468.17
	over 85	152.25	45.83
Total Person Years		51242.67	46682.92

APPENDIX C

Age and Sex Adjusted Standardized Mortality Ratios (SMR) and Confidence Intervals (CI)
Compared To NYS (Exclusive of NYC): Date of Interview - 1996

DISEASE	DEATHS		SMR	95% CI		POWER	POWER FOR SMR		
	O*	E*		L*	U*		1.5	2.0	2.5
All Causes of Death (includes 24 additional deaths of unknown cause)	725	699.52	1.04	0.96	1.12	0.24	0.99	0.99	0.99
Infectious and Parasitic Diseases (030 – 044, 130 – 139)	13	13.39	0.97	0.52	1.66	0.05	0.45	0.89	0.99
Other Bacterial Diseases (030 – 041)	5	6.37	0.79	0.26	1.83	0.12	0.25	0.62	0.87
Human Immunodeficiency Virus (042 – 044)	7	6.24	1.12	0.45	2.31	0.05	0.23	0.59	0.85
Other Infectious and Parasitic Diseases (130 – 139)	1	0.79	1.26	0.03	7.04	0.08	0.12	0.21	0.32
Neoplasm (140 – 165, 170 – 175, 179 – 208, 239)	189	201.88	0.94	0.81	1.08	0.22	0.99	0.99	0.99
Lip, Oral Cavity and Pharynx (140 – 149)	1	3.63	0.28	0.01	1.54	0.37	0.18	0.44	0.68
Digestive Organs and Peritoneum (150 – 159)	49	49.84	0.98	0.73	1.30	0.06	0.92	0.99	0.99
Respiratory and Intrathoracic Organs (160 – 165)	57	58.19	0.98	0.74	1.27	0.06	0.96	0.99	0.99
Bone, Connective Tissue, Skin and Breast (170 – 175)	18	25.34	0.71	0.42	1.12	0.38	0.71	0.99	0.99
Genitourinary Organs (179 – 189)	26	28.61	0.91	0.59	1.33	0.10	0.75	0.99	0.99
Other and Unspecified Sites (190 – 199)	18	16.05	1.12	0.66	1.77	0.10	0.53	0.94	0.99
Lymphatic and Hematopoietic Tissue (200 – 208)	19	18.43	1.03	0.62	1.61	0.05	0.57	0.96	0.99

DISEASE	DEATHS		SMR	95% CI		POWER	POWER FOR SMR		
	O*	E*		L*	U*		1.5	2.0	2.5
Unspecified Nature (239)	1	1.79	0.56	0.01	3.11	0.37	0.14	0.29	0.46
Endocrine, Nutritional and Metabolic diseases (250 – 259, 270 – 279)	14	17.14	0.82	0.45	1.37	0.18	0.58	0.96	0.99
Other Endocrine Glands (250 – 259)	13	13.70	0.95	0.50	1.62	0.05	0.49	0.91	0.99
Other metabolic Disorders and Immunity Disorders (270 – 279)	1	3.44	0.29	0.01	1.62	0.37	0.15	0.38	0.63
Diseases of the Blood and Blood-forming Organs (280-289)	2	2.44	0.82	0.10	2.96	0.14	0.17	0.36	0.57
Mental Disorders (290-319)	3	5.35	0.56	0.12	1.64	0.20	0.29	0.63	0.86
Diseases of the Nervous System and Sense Organs (330 – 337, 340 – 349)	6	8.64	0.69	0.25	1.51	0.15	0.32	0.74	0.94
Hereditary and Degenerative Diseases of the CNS (330 – 337)	4	5.65	0.71	0.19	1.81	0.09	0.23	0.58	0.83
Other Disorders of the CNS (340 – 349)	2	2.99	0.67	0.08	2.42	0.14	0.17	0.39	0.62
Diseases of the Circulatory System (393 – 398, 401 – 405, 410, 411, 414, 415 – 429, 430 – 438, 440 – 448, 451 – 459)	308	306.07	1.01	0.90	1.13	0.06	0.99	0.99	0.99
Chronic Rheumatic Heart Disease (393 – 398)	4	2.89	1.38	0.38	3.54	0.11	0.15	0.36	0.58
Hypertensive Disease (401 – 405)	5	9.42	0.53	0.17	1.24	0.44	0.34	0.77	0.96
Acute Myocardial Infarction (410)	126	90.52	1.39	1.16	1.66	0.96	0.99	0.99	0.99
Other Acute and Subacute Forms of Ischemic Heart Disease (411)	2	1.81	1.10	0.13	3.99	0.05	0.14	0.30	0.47
Other Forms of Chronic Ischemic Heart Disease (414)	81	99.58	0.81	0.65	1.01	0.57	.99	0.99	0.99
Other Forms of Heart Disease (415 – 429)	42	48.08	0.87	0.63	1.18	0.20	0.92	0.99	0.99
Cerebrovascular Diseases (430 – 438)	36	39.49	0.91	0.64	1.26	0.10	0.87	0.99	0.99

DISEASE	DEATHS		SMR	95% CI		POWER	POWER FOR SMR		
	O*	E*		L*	U*		1.5	2.0	2.5
Diseases of the Arteries, Arterioles and Capillaries (440 – 448)	9	12.48	0.72	0.33	1.37	0.21	0.41	0.86	0.99
Diseases of the Veins and Lymphatics, and Other Diseases (451-459)	3	1.79	1.67	0.34	4.89	0.18	0.14	0.29	0.46
Diseases of the Respiratory System (480 – 487, 490 – 496, 500 – 508, 510 – 519)	57	54.29	1.05	0.79	1.36	0.08	0.94	0.99	0.99
Pneumonia and Influenza (480 – 487)	15	19.18	0.78	0.44	1.29	0.18	0.58	0.97	0.99
Chronic Obstructive Pulmonary Disease and Allied Conditions (490 – 496)	34	28.37	1.20	0.83	1.67	0.27	0.78	0.99	0.99
Pneumoconioses and Other Lung Diseases Due to External Agents (500 – 508)	1	1.70	0.59	0.01	3.27	0.37	0.12	0.26	0.42
Other Diseases of the Respiratory System (510 – 519)	7	5.03	1.39	0.56	2.87	0.17	0.23	0.55	0.80
Diseases of the Digestive System (520 – 579)	33	26.29	1.26	0.86	1.76	0.32	0.73	0.99	0.99
Diseases of Esophagus, Stomach and Duodendum (530 – 537)	6	3.07	1.95	0.72	4.25	0.39	0.18	0.42	0.65
Hernia of Abdominal Cavity and Other Disease of Intestines and Peritoneum (550 – 553, 560 – 569)	4	3.62	1.11	0.30	2.83	0.05	0.18	0.44	0.68
Non-infective Enteritis and Colitis (555 – 558)	3	2.66	1.13	0.23	3.30	0.03	0.11	0.29	0.50
Other Diseases of Digestive System (570 – 579)	20	16.94	1.18	0.72	1.82	0.16	0.56	0.95	0.99
Diseases of the Genitourinary System (580 – 589, 590 – 599)	6	9.88	0.61	0.22	1.32	0.29	0.41	0.83	0.97
Nephritis, Nephrotic Syndrome and Hephrosis (580 – 589)	5	6.17	0.81	0.26	1.89	0.04	0.32	0.69	0.90
Other Diseases of Urinary System (590 – 599)	1	3.72	0.27	0.01	1.50	0.37	0.20	0.47	0.71
Diseases of the Musculoskeletal System and Connective Tissue (710-739)	3	2.14	1.40	0.29	4.10	0.08	0.11	0.26	0.44
Congenital Anomalies (740-759)	2	1.65	1.21	0.15	4.38	0.05	0.11	0.24	0.40

DISEASE	DEATHS		SMR	95% CI		POWER	POWER FOR SMR		
	O*	E*		L*	U*		1.5	2.0	2.5
Symptoms, Signs and Ill-defined Conditions (780-799)	3	6.34	0.47	0.10	1.38	0.42	0.25	0.61	0.87
External Causes of Injury and Poisoning (E800 – E807, E810 – E978, E980 – E999)	62	44.01	1.41	1.08	1.81	0.79	0.90	0.99	0.99
All Other Accidents and Adverse Effects (E800 – E807, E826 – E949)	18	12.99	1.39	0.82	2.19	0.35	0.48	0.90	0.99
Motor Vehicle Accidents (E810 – E825)	20	15.84	1.26	0.77	1.95	0.21	0.51	0.93	0.99
Suicide and Self Inflicted Injury (E950 – E959)	17	10.01	1.70	0.99	2.72	0.63	0.43	0.84	0.98
Homicide and Legal Intervention (E960 – E978)	4	4.07	0.98	0.27	2.51	0.02	0.16	0.43	0.69
All Other External Causes (E980 – E999)	3	1.10	2.72	0.56	7.95	0.35	0.09	0.18	0.30

* O => Observed, E => Expected, L => Lower Limit, U => Upper Limit

APPENDIX D

Age and Sex Adjusted Standardized Mortality Ratios (SMR) and Confidence Intervals (CI) Compared To Niagara County: Date of Interview - 1996

DISEASE	DEATHS		SMR	95 % CI		POWER	POWER FOR SMR		
	O*	E*		L*	U*		1.5	2.0	2.5
All Causes of Death (includes 24 additional deaths of unknown cause)	725	742.24	0.98	0.91	1.05	0.15	0.99	0.99	0.99
Infectious and Parasitic Diseases (030 – 044, 130 – 139)	13	8.92	1.46	0.78	2.49	0.32	0.36	0.78	0.96
Other Bacterial Diseases (030 – 041)	5	5.30	0.94	0.31	2.20	0.04	0.28	0.61	0.85
Human Immunodeficiency Virus (042 – 044)	7	3.12	2.25	0.90	4.63	0.55	0.19	0.43	0.66
Other Infectious and Parasitic Diseases (130 – 139)	1	0.50	1.99	0.05	11.08	0.08	0.04	0.08	0.13
Neoplasm (140 – 165, 170 – 175, 179 – 208, 239)	189	204.32	0.93	0.80	1.07	0.27	0.99	0.99	0.99
Lip, Oral Cavity and Pharynx (140 – 149)	1	3.31	0.30	0.01	1.69	0.37	0.13	0.34	0.58
Digestive Organs and Peritoneum (150 – 159)	49	49.49	0.99	0.73	1.31	0.05	0.93	0.99	0.99
Respiratory and Intrathoracic Organs (160 – 165)	57	64.32	0.89	0.67	1.15	0.20	0.97	0.99	0.99
Bone, Connective Tissue, Skin and Breast (170 – 175)	18	21.98	0.82	0.49	1.29	0.21	0.66	0.98	0.99
Genitourinary Organs (179 – 189)	26	26.69	0.97	0.64	1.43	0.06	0.76	0.99	0.99
Other and Unspecified Sites (190 – 199)	18	16.74	1.08	0.64	1.70	0.07	0.54	0.95	0.99
Lymphatic and Hematopoietic Tissue (200 – 208)	19	19.83	0.96	0.58	1.50	0.06	0.65	0.98	0.99

DISEASE	DEATHS		SMR	95 % CI		POWER	POWER FOR SMR		
	O*	E*		L*	U*		1.5	2.0	2.5
Unspecified Nature (239)	1	1.96	0.51	0.01	2.84	0.37	0.17	0.36	0.54
Endocrine, Nutritional and Metabolic diseases (250 – 259, 270 – 279)	14	18.73	0.75	0.41	1.25	0.26	0.61	0.97	0.99
Other Endocrine Glands (250 – 259)	13	15.72	0.83	0.44	1.41	0.17	0.57	0.95	0.99
Other Metabolic Disorders and Immunity Disorders (270 – 279)	1	3.01	0.33	0.01	1.85	0.37	0.17	0.40	0.63
Diseases of the Blood and Blood-forming Organs (280-289)	2	2.07	0.97	0.12	3.49	0.14	0.10	0.24	0.42
Mental Disorders (290-319)	3	4.19	0.72	0.15	2.09	0.05	0.18	0.46	0.72
Diseases of the Nervous System and Sense Organs (330 – 337, 340 – 349)	6	8.78	0.68	0.25	1.49	0.15	0.34	0.76	0.95
Hereditary and Degenerative Diseases of the CNS (330 – 337)	4	5.21	0.77	0.21	1.96	0.09	0.26	0.59	0.84
Other Disorders of the CNS (340 – 349)	2	3.57	0.56	0.07	2.03	0.14	0.17	0.42	0.67
Diseases of the Circulatory System (393 – 398, 401 – 405, 410, 411, 414, 415 – 429, 430 – 438, 440 – 448, 451 – 459)	308	343.68	0.90	0.80	1.00^{+}	0.60	0.99	0.99	0.99
Chronic Rheumatic Heart Disease (393 – 398)	4	1.87	2.14	0.58	5.48	0.37	0.15	0.32	0.50
Hypertensive Disease (401 – 405)	5	6.99	0.72	0.23	1.67	0.12	0.26	0.64	0.89
Acute Myocardial Infarction (410)	126	124.41	1.01	0.84	1.21	0.06	0.99	0.99	0.99
Other Acute and Subacute Forms of Ischemic Heart Disease (411)	2	1.37	1.46	0.18	5.26	0.05	0.06	0.14	0.26
Other Forms of Chronic Ischemic Heart Disease (414)	81	101.41	0.80	0.63	0.99	0.66	0.99	0.99	0.99
Other Forms of Heart Disease (415 – 429)	42	42.12	1.00	0.72	1.35	0.05	0.89	0.99	0.99
Cerebrovascular Diseases (430 – 438)	36	50.33	0.72	0.50	0.99	0.67	0.94	0.99	0.99

DISEASE	DEATHS		SMR	95 % CI		POWER	POWER FOR SMR		
	O*	E*		L*	U*		1.5	2.0	2.5
Diseases of the Arteries, Arterioles and Capillaries (440 – 448)	9	13.21	0.68	0.31	1.29	0.32	0.51	0.92	0.99
Diseases of the Veins and Lymphatics, and Other Diseases (451 – 459)	3	1.96	1.53	0.31	4.46	0.18	0.18	0.36	0.54
Diseases of the Respiratory System (480 – 487, 490 – 496, 500 – 508, 510 – 519)	57	53.65	1.06	0.80	1.38	0.11	0.94	0.99	0.99
Pneumonia and Influenza (480 – 487)	15	16.13	0.93	0.52	1.53	0.07	0.54	0.94	0.99
Chronic Obstructive Pulmonary Disease and Allied Conditions (490 – 496)	34	30.51	1.11	0.77	1.56	0.13	0.78	0.99	0.99
Pneumoconioses and Other Lung Diseases Due to External Agents (500 – 508)	1	1.28	0.78	0.02	4.37	0.37	0.13	0.25	0.40
Other Diseases of the Respiratory System (510 – 519)	7	5.72	1.22	0.49	2.52	0.10	0.25	0.59	0.84
Diseases of the Digestive System (520 – 579)	33	29.58	1.12	0.77	1.57	0.13	0.76	0.99	0.99
Diseases of Esophagus, Stomach and Duodendum (530 – 537)	6	4.18	1.44	0.53	3.13	0.15	0.18	0.46	0.72
Hernia of Abdominal Cavity and Other Disease of Intestines and Peritoneum (550 – 553, 560 – 569)	4	4.05	0.99	0.27	2.53	0.02	0.16	0.42	0.68
Non-infective Enteritis and Colitis (555 – 558)	3	2.48	1.21	0.25	3.53	0.08	0.17	0.38	0.59
Other Diseases of Digestive System (570 – 579)	20	18.87	1.06	0.65	1.64	0.08	0.62	0.97	0.99
Diseases of the Genitourinary System (580 – 589, 590 – 599)	6	9.10	0.66	0.24	1.44	0.15	0.39	0.81	0.97
Nephritis, Nephrotic Syndrome and Hephrosis (580 – 589)	5	5.95	0.84	0.27	1.96	0.04	0.28	0.64	0.87
Other Diseases of Urinary System (590 – 599)	1	3.16	0.32	0.01	1.77	0.37	0.20	0.44	0.67
Diseases of the Musculoskeletal System and Connective Tissue (710-739)	3	2.08	1.44	0.30	4.22	0.08	0.10	0.24	0.42
Congenital Anomalies (740-759)	2	1.36	1.47	0.18	5.31	0.14	0.15	0.29	0.44

DISEASE	DEATHS		SMR	95 % CI		POWER	POWER FOR SMR		
	O*	E*		L*	U*		1.5	2.0	2.5
Symptoms, Signs and Ill-defined Conditions (780-799)	3	6.56	0.46	0.09	1.34	0.42	0.29	0.66	0.89
External Causes of Injury and Poisoning (E800 – E807, E810 – E978, E980 – E999)	62	49.22	1.26	0.97	1.61	0.52	0.93	0.99	0.99
All Other Accidents and Adverse Effects (E800 – E807, E826 – E949)	18	14.29	1.26	0.75	1.99	0.20	0.48	0.91	0.99
Motor Vehicle Accidents (E810 – E825)	20	18.12	1.10	0.67	1.70	0.11	0.62	0.97	0.99
Suicide and Self Inflicted Injury (E950 – E959)	17	10.99	1.55	0.90	2.48	0.44	0.39	0.83	0.98
Homicide and Legal Intervention (E960 – E978)	4	3.64	1.10	0.30	2.81	0.05	0.19	0.44	0.69
All Other External Causes (E980 – E999)	3	2.17	1.38	0.28	4.04	0.08	0.11	0.27	0.46

* O => Observed, E => Expected, L => Lower, U => Upper
NB. 1.00^{+} implies a number slightly greater than 1.00 and 1.00^{-} implies slightly less than 1.00

APPENDIX E

Age Adjusted Standardized Mortality Ratios (SMR) and Confidence Intervals (CI) Compared to Niagara County And NYS (Exclusive of NYC): Date of Interview - 1996, Females Only

DISEASE	NIAGARA COUNTY					NEW YORK STATE (EXCLUDING NEW YORK CITY)			
	O*	E*	SMR	95% CI		E*	SMR	95% CI	
				L*	U*			L*	U*
All Causes of Death (includes 15 additional deaths of unknown cause)	309	324.61	0.95	0.85	1.06	308.65	1.00	0.89	1.12
Infectious and Parasitic Diseases (030 – 044, 130 – 139)	2	3.39	0.59	0.07	2.13	4.70	0.43	0.05	1.54
For other bacterial diseases	1	2.48	0.40	0.01	2.24	3.27	0.31	0.01	1.71
Other infectious and parasitic diseases and late effects	1	0.27	3.71	0.09	20.68	0.33	2.99	0.07	16.67
Neoplasm (140 – 165, 170 – 175, 179 – 208, 239)	83	92.58	0.90	0.71	1.11	95.69	0.87	0.69	1.08
Digestive Organs and Peritoneum (150 – 159)	24	21.01	1.14	0.73	1.70	21.67	1.11	0.71	1.65
Respiratory and Intrathoracic Organs (160 – 165)	21	22.27	0.94	0.58	1.44	21.14	0.99	0.61	1.52
Bone, Connective Tissue, Skin and Breast (170 – 175)	12	19.43	0.62	0.32	1.08	22.07	0.54	0.28	0.95
Genitourinary Organs (179 – 189)	12	11.95	1.00	0.52	1.75	13.14	0.91	0.47	1.59
Other and Unspecified Sites (190 – 199)	5	7.53	0.66	0.22	1.55	7.52	0.67	0.22	1.55
Lymphatic and Hematopoietic Tissue (200 – 208)	8	8.85	0.94	0.40	1.84	8.08	0.99	0.43	1.95
Unspecified Nature (239)	1	0.88	1.14	0.03	6.36	0.88	1.13	0.03	6.31
Endocrine, Nutritional and Metabolic Diseases (250 – 259, 270 – 279)	7	9.27	0.76	0.30	1.56	8.61	0.81	0.33	1.67
Other Endocrine Glands (250 – 259)	7	7.82	0.90	0.36	1.84	7.06	0.99	0.40	2.04

DISEASE	NIAGARA COUNTY					NEW YORK STATE (EXCLUDING NEW YORK CITY)			
	O*	E*	SMR	95% CI		E*	SMR	95% CI	
				L*	U*			L*	U*
Diseases of the Blood and Blood-forming Organs (280 – 289)	1	1.02	0.98	0.02	5.46	1.18	0.84	0.02	4.70
Mental Disorders (290 – 319)	1	2.11	0.47	0.01	2.64	2.48	0.40	0.01	2.24
Diseases of the Nervous System and Sense Organs (330 – 337, 340 – 349)	5	4.23	1.18	0.38	2.76	4.19	1.19	0.39	2.78
Hereditary and degenerative diseases of the central nervous system	3	2.59	1.16	0.24	3.39	2.65	1.13	0.23	3.31
Other disorders of the central nervous system	2	1.64	1.22	0.15	4.40	1.54	1.30	0.16	4.69
Diseases of the Circulatory System (393 – 398, 401 – 405, 410, 411, 414, 415 – 429, 430 – 438, 440 – 448, 451 – 459)	125	152.62	0.82	0.68	0.98	134.17	0.93	0.78	1.11
Hypertensive Disease (401 – 405)	4	3.55	1.13	0.31	2.88	4.70	0.85	0.23	2.18
Acute Myocardial Infarction (410)	49	47.05	1.04	0.77	1.38	34.19	1.43	1.06	1.89
Other Acute and Subacute Forms of Ischemic Heart Disease (411)	2	0.62	3.24	0.39	11.70	0.64	3.12	0.38	11.28
Other Forms of Chronic Ischemic Heart Disease (414)	30	46.01	0.65	0.44	0.93	42.72	0.70	0.47	1.00+
Other Forms of Heart Disease (415 – 429)	20	20.32	0.98	0.60	1.52	22.09	0.91	0.55	1.40
Cerebrovascular Diseases (430 – 438)	16	27.67	0.58	0.33	0.94	21.84	0.73	0.42	1.19
Diseases of the Arteries, Arterioles and Capillaries (440 – 448)	4	5.34	0.75	0.20	1.92	5.22	0.77	0.21	1.96
Diseases of the Respiratory System (480 – 487, 490 – 496, 500 – 508, 510 – 519)	29	23.62	1.23	0.82	1.76	24.09	1.20	0.81	1.73
Pneumonia and Influenza (480 – 487)	8	7.01	1.14	0.49	2.25	9.03	0.89	0.38	1.75
Chronic Obstructive Pulmonary Disease and Allied Conditions (490 – 496)	18	13.49	1.33	0.79	2.11	12.16	1.48	0.88	2.34
Pneumonconioses and Other Lung Diseases Due to External Agents (500 – 508)	1	0.42	2.37	0.06	13.19	0.68	1.47	0.04	8.17
Other Diseases of Respiratory System (510 – 519)	2	2.69	0.74	0.09	2.68	2.22	0.90	0.11	3.25

DISEASE	NIAGARA COUNTY					NEW YORK STATE (EXCLUDING NEW YORK CITY)			
	O*	E*	SMR	95% CI		E*	SMR	95% CI	
				L*	U*			L*	U*
Diseases of the Digestive System (520 – 579)	10	12.72	0.79	0.38	1.45	11.62	0.86	0.41	1.58
Diseases of Esophagus, Stomach and Duodendum (530 – 537)	1	1.69	0.59	0.01	3.30	1.34	0.75	0.02	4.17
Hernia of Abdominal Cavity and Other Diseases of Intestines and Peritoneum (550 – 553)	1	2.26	0.44	0.01	2.47	2.11	0.47	0.01	2.64
Non-Infective Enteritis and Colitis (555 – 558)	3	1.47	2.04	0.42	5.95	1.59	1.88	0.39	5.51
Other Diseases of Digestive System (570 – 579)	5	7.29	0.69	0.22	1.60	6.59	0.76	0.25	1.77
Diseases of the Genitourinary System (580 – 589, 590 – 599)	2	4.65	0.43	0.05	1.55	4.95	0.40	0.05	1.46
Nephritis, nephritic syndrome, and hephrosis	2	3.05	0.65	0.08	2.37	2.88	0.69	0.08	2.51
Diseases of the Musculoskeletal System and Connective Tissue (710 – 739)	2	1.54	1.30	0.16	4.68	1.48	1.35	0.16	4.87
Congenital Anomalies (740 – 759)	1	0.60	1.67	0.04	9.28	0.76	1.31	0.03	7.31
Symptoms, Signs and Ill-defined Conditions (780 – 799)	2	2.38	0.84	0.10	3.03	2.40	0.83	0.10	3.00
External Causes of Injury and Poisoning (E800 – E807, E810 – E978, E980 – E999)	24	13.89	1.73	1.11	2.57	12.31	1.95	1.25	2.90
All Other Accidents and Adverse Effects (E800 – E807, E826 – E949)	6	4.46	1.34	0.49	2.93	3.95	1.52	0.56	3.31
Motor Vehicle Accidents (E810 – E825)	10	5.46	1.83	0.88	3.37	4.72	2.12	1.02	3.89
Suicide and Self Inflicted Injury (E950 – E959)	5	2.03	2.46	0.80	5.74	2.13	2.35	0.76	5.48
Homicide and Legal Intervention (E960 – E978)	1	1.23	0.82	0.02	4.54	1.17	0.85	0.02	4.75
All Other External Causes (E980 – E999)	2	0.71	2.83	0.34	10.22	0.34	5.96	0.72	21.54

* O => Observed, E => Expected, L => Lower Limit, U => Upper Limit
NB. 1.00^{+} implies a number slightly greater than 1.00 and 1.00^{-} implies slightly less than 1.00

APPENDIX F

Age Adjusted Standardized Mortality Ratios (SMR) and Confidence Intervals (CI) Compared to Niagara County and NYS (Exclusive of NYC): Date of Interview - 1996, Males Only

DISEASE	NIAGARA COUNTY					NEW YORK STATE (EXCLUDING NEW YORK CITY)			
	O*	E*	SMR	95% CI		E*	SMR	95% CI	
				L*	U*			L*	U*
All Causes of Death	416	417.63	1.00	0.90	1.10	390.87	1.06	0.96	1.17
Infectious and Parasitic Diseases (030 – 044, 130 – 139)	11	5.53	1.99	0.99	3.56	8.70	1.27	0.63	2.26
Other Bacterial Diseases (030 – 041)	4	2.82	1.42	0.39	3.64	3.10	1.29	0.35	3.30
Human Immunodeficiency Virus (042 – 044)	7	2.48	2.82	1.13	5.81	5.14	1.36	0.55	2.81
Neoplasm (140 – 165, 170 – 175, 179 – 208, 239)	106	111.7	0.95	0.78	1.15	106.2	1.00	0.82	1.21
Lip, Oral Cavity and Pharynx (140 – 149)	1	2.34	0.43	0.01	2.38	2.44	0.41	0.01	2.29
Digestive Organs and Peritoneum (150 – 159)	25	28.48	0.88	0.57	1.30	28.17	0.89	0.57	1.31
Respiratory and Intrathoracic Organs (160 – 165)	36	42.05	0.86	0.60	1.18	37.06	0.97	0.68	1.34
Bone, Connective Tissue, Skin and Breast	6	2.54	2.36	0.87	5.14	3.27	1.83	0.67	3.99
Genitourinary Organs (179 – 189)	14	14.74	0.95	0.52	1.59	15.46	0.91	0.50	1.52
Other and Unspecified Sites (190 – 199)	13	9.22	1.41	0.75	2.41	8.54	1.52	0.81	2.60
Lymphatic and Hematopoietic Tissue (200 – 208)	11	11.28	0.98	0.49	1.74	10.35	1.06	0.53	1.90
Endocrine, Nutritional and Metabolic Diseases (250 – 259, 270 – 279)	7	9.46	0.74	0.30	1.52	8.53	0.82	0.33	1.69
Endocrine Glands (250 – 279)	6	7.90	0.76	0.28	1.65	6.64	0.90	0.33	1.97
Metabolic Disorders and Immunity Disorders (270 – 279)	1	1.56	0.64	0.02	3.57	1.89	0.53	0.01	2.95

DISEASE	NIAGARA COUNTY					NEW YORK STATE (EXCLUDING NEW YORK CITY)			
	O*	E*	SMR	95% CI		E*	SMR	95% CI	
				L*	U*			L*	U*
Diseases of the Blood and Blood-forming Organs (280 – 289)	1	1.05	0.95	0.02	5.31	1.26	0.79	0.02	4.43
Mental Disorders (290 – 319)	2	2.08	0.96	0.12	3.47	2.86	0.70	0.08	2.52
Diseases of the Nervous System and Sense Organs (330 – 337, 340 – 349)	1	4.55	0.22	0.01	1.22	4.45	0.22	0.01	1.25
Diseases of the Circulatory System (393 – 398, 401 – 405, 410, 411, 414, 415 – 429, 430 – 438, 440 – 448, 451 – 459)	183	191.1	0.96	0.82	1.11	171.9	1.06	0.92	1.23
Chronic Rheumatic Heart Disease (393 – 398)	4	0.72	5.59	1.52	14.32	0.96	4.18	1.14	10.70
Hypertensive Disease (401 – 405)	1	3.44	0.29	0.01	1.62	4.72	0.21	0.01	1.18
Acute Myocardial Infarction (410)	77	77.36	1.00	0.79	1.24	56.33	1.37	1.08	1.71
Chronic Ischemic Heart Disease (414)	51	55.40	0.92	0.69	1.21	56.86	0.90	0.67	1.18
Other Forms of Heart Disease (415 – 429)	22	21.80	1.01	0.63	1.53	25.98	0.85	0.53	1.28
Cerebrovascular Disease (430 – 438)	20	22.65	0.88	0.54	1.36	17.65	1.13	0.69	1.75
Diseases of the Arteries, Arterioles and Capillaries (440 – 448)	5	7.87	0.64	0.21	1.48	7.26	0.69	0.22	1.61
Diseases of the Veins and Lymphatics, and Other Diseases (451 – 459)	3	1.06	2.83	0.58	8.28	0.96	3.12	0.64	9.12
Diseases of the Respiratory System (480 – 487, 490 – 496, 500 – 508, 510 – 519)	28	30.03	0.93	0.62	1.35	30.19	0.93	0.62	1.34
Pneumonia and Influenza (480 – 487)	7	9.13	0.77	0.31	1.58	10.15	0.69	0.28	1.42
Chronic Obstructive Pulmonary Disease and Allied Conditions (490 – 496)	16	17.02	0.94	0.54	1.53	16.22	0.99	0.56	1.60
Other Diseases of Respiratory System (510 – 519)	5	3.03	1.65	0.54	3.85	2.80	1.78	0.58	4.16
Diseases of the Digestive System (520 – 579)	23	16.87	1.36	0.86	2.05	14.67	1.57	0.99	2.35
Diseases of Esophagus, Stomach and Duodendum	5	2.49	2.01	0.65	4.69	1.74	2.88	0.93	6.71

DISEASE	O*	NIAGARA COUNTY E*	SMR	95% CI L*	U*	NEW YORK STATE (EXCLUDING NEW YORK CITY) E*	SMR	95% CI L*	U*
Hernia of Abdominal Cavity and Other Diseases of Intestines and Peritoneum (550 – 553)	3	1.79	1.67	0.34	4.89	1.51	1.99	0.41	5.82
Other Diseases of Digestive System (570 – 579)	15	11.58	1.30	0.73	2.14	10.36	1.45	0.81	2.39
Diseases of the Genitourinary System (580 – 589, 590 – 599)	4	4.45	0.90	0.24	2.30	4.94	0.81	0.22	2.07
Diseases of the Musculoskeletal System and Connective Tissue (710 – 739)	1	0.54	1.86	0.05	10.39	0.66	1.53	0.04	8.50
Congenital Anomalies (740 – 759)	1	0.76	1.32	0.03	7.34	0.89	1.13	0.03	6.28
Symptoms, Signs and Ill-defined Conditions (780 – 799)	1	4.18	0.24	0.01	1.33	3.94	0.25	0.01	1.41
External Causes of Injury and Poisoning (E800– E807, E810 – E978, E980 – E999)	38	35.34	1.08	0.76	1.48	31.70	1.20	0.85	1.65
All Other Accidents and Adverse Effects (E800 – E807)	12	9.83	1.22	0.63	2.13	9.05	1.33	0.69	2.32
Motor Vehicle Accidents (E810 – E825)	10	12.67	0.79	0.38	1.45	11.11	0.90	0.43	1.65
Suicide and Self Inflicted Injury (E950 – E959)	12	8.96	1.34	0.69	2.34	7.88	1.52	0.79	2.66
Homicide and Legal Intervention (E960 – E978)	3	2.42	1.24	0.26	3.63	2.90	1.03	0.21	3.02
All Other External Causes (E980 – E999)	1	1.47	0.68	0.02	3.80	0.77	1.30	0.03	7.26

* O => Observed, E => Expected, L => Lower Limit, U => Upper Limit

APPENDIX G

Love Canal Cohort Cancer Data: Person Years Of Follow Up (Full & Part Time) Residents

Years	Age	Female	Male
78-81	01 - 19	1895.92	2014.67
	20 - 34	1704.08	1402.58
	35 - 44	924.25	683.50
	45 - 54	795.75	638.00
	55 - 64	646.50	620.50
	65 - 74	233.42	219.25
	75 - 84	90.17	62.42
	over 85	15.92	10.25
82-86	01 - 19	2283.83	2411.67
	20 - 34	3727.50	3474.17
	35 - 44	2154.83	1861.08
	45 - 54	1583.75	1328.92
	55 - 64	1451.42	1248.42
	65 - 74	669.58	623.50
	75 - 84	235.42	162.08
	over 85	52.58	19.00
87-91	01 - 19	1167.00	1124.75
	20 – 34	3451.67	3534.33
	35 – 44	2253.67	1949.08
	45 – 54	1754.33	1434.67
	55 – 64	1317.92	1122.92
	65 – 74	959.50	809.50
	75 – 84	340.58	212.08
	over 85	72.42	22.08
92-96	01 – 19	411.00	341.00
	20 – 34	2906.25	3075.50
	35 – 44	2171.67	1929.50
	45 – 54	1982.83	1704.17
	55 – 64	1307.50	1090.25
	65 – 74	1085.67	830.42
	75 – 84	448.67	299.00
	over 85	115.42	25.67
Total Person Years		40211.00	36284.92

APPENDIX H

Age and Sex Adjusted Standardized Incidence Ratios (SIR) and Confidence Intervals (CI) for Cancer Compared To NYS (Exclusive of NYC): Date of Interview - 1996

CANCER	CASES		SIR	95% CI		POWER	POWER FOR SIR		
	O*	E*		L*	U*		1.5	2.0	2.5
All Cancers (includes one case with unspecified type)	304	324.92	0.94	0.83	1.05	0.32	1.00	1.00	1.00
Lip, Oral Cavity and Pharynx (140-149)	3	8.18	0.37	0.08	1.07	0.65	0.35	0.75	0.95
Digestive Organs and Peritoneum (150-159)	69	66.95	1.03	0.80	1.30	0.07	0.97	1.00	1.00
Esophagus (150)	3	3.42	0.88	0.18	2.56	0.05	0.15	0.38	0.62
Stomach (151)	7	6.46	1.08	0.44	2.23	0.05	0.27	0.64	0.88
Small Intestine (152)	1	0.94	1.06	0.03	5.93	0.02	0.05	0.12	0.21
Colon (153)	26	29.38	0.88	0.58	1.30	0.14	0.75	1.00	1.00
Rectum (154)	17	13.31	1.28	0.74	2.04	0.19	0.44	0.89	0.99
Liver (155)	3	2.36	1.27	0.26	3.71	0.08	0.15	0.34	0.54
GallBladder (156)	5	2.03	2.46	0.80	5.75	0.38	0.09	0.22	0.40
Pancreas (157)	6	8.19	0.73	0.27	1.59	0.15	0.35	0.76	0.95
Peritoneum (158)	1	0.65	1.54	0.04	8.57	0.08	0.08	0.14	0.22
Respiratory and Intrathoracic Organs (160-165)	62	58.08	1.07	0.82	1.37	0.12	.096	1.00	1.00
Larynx (161)	4	4.52	0.88	0.24	2.27	0.02	0.24	0.55	0.79
Trachea, Bronchus, and Lung (162)	57	51.93	1.10	0.83	1.42	0.16	0.94	1.00	1.00
Pleura (163)	1	0.64	1.56	0.04	8.71	0.08	0.07	0.14	0.22
Bone, Connective Tissue, Skin, Breast (170-175)	50	62.41	0.80	0.59	1.06	0.48	0.96	1.00	1.00

CANCER	CASES		SIR	95% CI		POWER	POWER FOR SIR		
	O*	E*		L*	U*		1.5	2.0	2.5
Malignant Melanoma of the Skin (172)	5	7.23	0.69	0.22	1.61	0.12	0.29	0.69	0.91
Breast – Female only (174)	42	51.40	0.82	0.59	1.10	0.36	0.94	1.00	1.00
Breast – Male only (175)	1	0.41	2.44	0.06	13.59	0.08	0.02	0.05	0.08
Genitourinary Organs (179-189)	82	83.58	0.98	0.78	1.22	0.06	0.99	1.00	1.00
Cervix Uteri–Female Only (180)	1	4.70	0.21	0.01	1.19	0.37	0.17	0.47	0.74
Body of Uterus–Female Only (182)	5	10.05	0.50	0.16	1.16	0.44	0.34	0.79	0.96
Ovary – Female Only (183)	9	7.91	1.14	0.52	2.16	0.07	0.30	0.71	0.93
Prostate – Male only (185)	29	31.92	0.91	0.61	1.30	0.11	0.82	1.00	1.00
Testis – Male Only (186)	3	2.34	1.28	0.26	3.75	0.08	0.14	0.33	0.53
Bladder (188)	23	15.97	1.44	0.91	2.16	0.44	0.52	0.94	1.00
Kidney (189)	12	8.12	1.48	0.76	2.58	0.32	0.34	0.74	0.94
Other and Unspecified Sites (190-199)	18	19.11	0.94	0.56	1.49	0.05	0.57	0.96	1.00
Eye (190)	1	0.61	1.64	0.04	9.13	0.08	0.07	0.12	0.20
Brain (191)	4	5.09	0.79	0.21	2.01	0.09	0.24	0.56	0.82
Thyroid Gland (193)	6	3.82	1.57	0.58	3.42	0.26	0.22	0.50	0.74
Other Endocrine Glands and Related Structures (194)	2	0.44	4.55	0.55	16.42	0.32	0.03	0.06	0.10
Without Specification of Sites (199)	4	7.79	0.51	0.14	1.31	0.43	0.29	0.69	0.92
Lymphatic and Hematopoietic Tissue (200-208)	19	26.61	0.71	0.43	1.12	0.38	0.75	0.99	1.00
Lymphosarcoma, Reticulosarcoma (200)	3	5.98	0.50	0.10	1.47	0.20	0.29	0.65	0.88
Hodgkin’s Disease (201)	2	3.04	0.66	0.08	2.38	0.14	0.18	0.41	0.64
Lymphoid and Histiocytic tissue (202)	5	6.04	0.83	0.27	1.93	0.04	0.30	0.66	0.89

CANCER	CASES		SIR	95% CI		POWER	POWER FOR SIR		
	O*	E*		L*	U*		1.5	2.0	2.5
Myeloma & Immunoproliferative Neoplasm (203)	5	3.52	1.42	0.46	3.32	0.13	0.16	0.41	0.65
Leukemia (204-208)	4	8.03	0.50	0.14	1.28	0.43	0.32	0.73	0.94

* O = Observed, E= Expected, L=Lower, U=Upper

APPENDIX I

Age and Sex Adjusted Standardized Incidence Ratios (SIR) and Confidence Intervals (CI) for Cancer Compared To Niagara County: Date of Interview - 1996

CANCER	CASES		SIR	95% CI		POWER	POWER FOR SIR		
	O*	E*		L*	U*		1.5	2.0	2.5
All Cancers (includes one case with unspecified type)	304	332.76	0.91	0.81	1.02	0.47	1.00	1.00	1.00
Lip, Oral Cavity and Pharynx (140-149)	3	8.27	0.36	0.07	1.06	0.65	0.36	0.77	0.95
Digestive Organs and Peritoneum (150-159)	69	65.26	1.06	0.82	1.34	0.11	0.97	1.00	1.00
Esophagus (150)	3	3.50	0.86	0.18	2.50	0.05	0.16	0.40	0.65
Stomach (151)	7	5.92	1.18	0.48	2.44	0.10	0.28	0.64	0.87
Small Intestine (152)	1	0.86	1.16	0.03	6.48	0.02	0.04	0.10	0.17
Colon (153)	26	28.22	0.92	0.60	1.35	0.10	0.77	1.00	1.00
Rectum (154)	17	13.12	1.30	0.76	2.07	0.26	0.50	0.91	0.99
Liver (155)	3	2.03	1.48	0.30	4.32	0.08	0.09	0.22	0.40
GallBladder (156)	5	2.26	2.21	0.72	5.16	0.38	0.13	0.30	0.50
Pancreas (157)	6	8.16	0.74	0.27	1.60	0.15	0.34	0.75	0.94
Peritoneum (158)	1	0.89	1.12	0.03	6.26	0.02	0.05	0.11	0.19
Respiratory and Intrathoracic Organs (160-165)	62	62.34	0.99	0.76	1.28	0.05	0.96	1.00	1.00
Larynx (161)	4	4.23	0.95	0.26	2.42	0.02	0.19	0.47	0.73
Trachea, Bronchus, and Lung (162)	57	56.26	1.01	0.77	1.31	0.05	0.95	1.00	1.00
Pleura (163)	1	0.90	1.11	0.03	6.19	0.02	0.05	0.11	0.19
Bone, Connective Tissue, Skin, Breast (170-175)	50	60.90	0.82	0.61	1.08	0.37	0.96	1.00	1.00

CANCER	CASES		SIR	95% CI		POWER	POWER FOR SIR		
	O*	E*		L*	U*		1.5	2.0	2.5
Connective and Other Soft Tissue (171)	2	1.94	1.03	0.12	3.72	0.05	0.17	0.35	0.53
Malignant Melanoma of the Skin (172)	5	6.79	0.74	0.24	1.72	0.12	0.32	0.70	0.91
Breast – Female only (174)	42	50.94	0.82	0.59	1.11	0.36	0.93	1.00	1.00
Breast – Male only (175)	1	0.35	2.86	0.07	15.92	0.26	0.10	0.16	0.22
Genitourinary Organs (179-189)	82	87.68	0.94	0.74	1.16	0.15	0.99	1.00	1.00
Cervix Uteri–Female Only (180)	1	3.93	0.25	0.01	1.42	0.37	0.24	0.53	0.76
Body of Uterus–Female Only (182)	5	9.45	0.53	0.17	1.23	0.44	0.35	0.78	0.96
Ovary – Female Only (183)	9	7.90	1.14	0.52	2.16	0.07	0.30	0.71	0.93
Prostate – Male only (185)	29	35.24	0.82	0.55	1.18	0.26	0.84	1.00	1.00
Testis – Male Only (186)	3	2.70	1.11	0.23	3.25	0.03	0.12	0.30	0.51
Bladder (188)	23	17.89	1.29	0.82	1.93	0.29	0.59	0.96	1.00
Kidney (189)	12	7.79	1.54	0.80	2.69	0.32	0.29	0.69	0.92
Other and Unspecified Sites (190-199)	18	20.29	0.89	0.53	1.40	0.09	0.63	0.98	1.00
Eye (190)	1	0.51	1.96	0.05	10.93	0.08	0.04	0.08	0.14
Brain (191)	4	4.92	0.81	0.22	2.08	0.09	0.21	0.52	0.78
Thyroid Gland (193)	6	4.57	1.31	0.48	2.86	0.15	0.25	0.56	0.80
Other Endocrine Glands and Related Structures (194)	2	0.39	5.13	0.62	18.52	0.32	0.02	0.04	0.08
Without Specification of Sites (199)	4	9.02	0.44	0.12	1.14	0.43	0.38	0.79	0.96
Lymphatic and Hematopoietic Tissue (200-208)	19	28.03	0.68	0.41	1.06	0.56	0.75	1.00	1.00
Lymphosarcoma, Reticulosarcoma (200)	3	5.91	0.51	0.10	1.48	0.20	0.28	0.63	0.87
Hodgkin’s Disease (201)	2	2.90	0.69	0.08	2.49	0.14	0.15	0.36	0.59

CANCER	CASES		SIR	95% CI		POWER	POWER FOR SIR		
	O*	E*		L*	U*		1.5	2.0	2.5
Lymphoid and Histiocytic tissue (202)	5	6.39	0.78	0.25	1.83	0.12	0.26	0.62	0.87
Myeloma & Immunoproliferative Neoplasm (203)	5	3.69	1.36	0.44	3.16	0.13	0.19	0.46	0.70
Leukemia (204-208)	4	9.14	0.44	0.12	1.12	0.43	0.40	0.81	0.97

* O = Observed, E= Expected, L=Lower, U=Upper

APPENDIX J

Age Adjusted Standardized Incidence Ratios (SIR) and Confidence Intervals (CI) for Cancer
Compared to Niagara County and NYS (Exclusive of NYC): Date of Interview - 1996, Females Only

CANCER	CASES		NIAGARA COUNTY			NEW YORK STATE (EXCLUDING NEW YORK CITY)			
			SIR	95% CI			SIR	95% CI	
	O*	E*		L*	U*	E*		L*	U*
All Cancers (includes one case with unspecified type)	142	164.84	0.86	0.73	1.02	165.48	0.86	0.72	1.01
Lip, Oral Cavity and Pharynx (140-149)	0	2.55	0.00			2.77	0.00		
Digestive Organs and Peritoneum (150-159)	33	29.66	1.11	0.77	1.56	30.39	1.09	0.75	1.52
Esophagus (150)	1	0.93	1.08	0.03	5.99	0.92	1.09	0.03	6.06
Stomach (151)	2	1.89	1.06	0.13	3.82	2.26	0.88	0.11	3.20
Colon (153)	14	14.31	0.98	0.54	1.64	14.63	0.96	0.52	1.61
Rectum (154)	9	5.71	1.58	0.72	2.99	5.73	1.57	0.72	2.98
Liver (155)	0	0.78	0.00			0.82	0.00		
GallBladder (156)	3	1.29	2.33	0.48	6.80	1.17	2.56	0.53	7.49
Pancreas (157)	3	3.69	0.81	0.17	2.38	3.93	0.76	0.16	2.23
Peritoneum (158)	1	0.48	2.08	0.05	11.61	0.37	2.70	0.07	15.06
Respiratory and Intrathoracic Organs (160-165)	19	22.46	0.85	0.51	1.32	21.72	0.87	0.53	1.37
Larynx (161)	0	1.01	0.00			1.02	0.00		
Trachea, Bronchus, and Lung (162)	19	21.09	0.90	0.54	1.41	20.15	0.94	0.57	1.47
Pleura (163)	0	0.06	0.00			0.14	0.00		
Bone, Connective Tissue, Skin, Breast (170-175)	47	55.26	0.85	0.63	1.13	56.27	0.84	0.61	1.11

CANCER	CASES		NIAGARA COUNTY			NEW YORK STATE (EXCLUDING NEW YORK CITY)			
			SIR	95% CI			SIR	95% CI	
	O*	E*		L*	U*	E*		L*	U*
Connective and Other Soft Tissue (171)	2	1.14	1.75	0.21	6.34	0.92	2.17	0.26	7.85
Malignant Melanoma of the Skin (172)	3	2.90	1.03	0.21	3.02	3.35	0.90	0.18	2.62
Breast – Female only (174)	42	50.94	0.82	0.59	1.11	51.39	0.82	0.59	1.10
Genitourinary Organs (179-189)	26	31.30	0.83	0.54	1.22	32.15	0.81	0.53	1.18
Cervix Uteri–Female Only (180)	1	3.93	0.25	0.01	1.42	4.70	0.21	0.01	1.19
Body of Uterus–Female Only (182)	5	9.45	0.53	0.17	1.23	10.05	0.50	0.16	1.16
Ovary – Female Only (183)	9	7.90	1.14	0.52	2.16	7.91	1.14	0.52	2.16
Bladder (188)	7	4.50	1.56	0.63	3.20	4.17	1.68	0.67	3.46
Kidney (189)	4	3.09	1.29	0.35	3.31	3.08	1.30	0.35	3.32
Other and Unspecified Sites (190-199)	10	10.49	0.95	0.46	1.75	10.18	0.98	0.47	1.81
Eye (190)	0	0.16	0.00			0.29	0.00		
Brain (191)	1	2.20	0.45	0.01	2.53	2.29	0.44	0.01	2.43
Thyroid Gland (193)	5	3.44	1.45	0.47	3.39	2.79	1.79	0.58	4.18
Other Endocrine Glands and Related Structures (194)	2	0.18	11.11	1.34	40.13	0.23	8.70	1.05	31.41
Without Specification of Sites (199)	2	4.13	0.48	0.06	1.75	3.87	0.52	0.06	1.87
Lymphatic and Hematopoietic Tissue (200-208)	7	13.10	0.53	0.21	1.10	11.99	0.58	0.23	1.20
Lymphosarcoma, Reticulosarcoma (200)	2	2.63	0.76	0.09	2.75	2.67	0.75	0.09	2.71
Hodgkin’s Disease (201)	1	1.22	0.82	0.02	4.57	1.45	0.69	0.02	3.84
Lymphoid and Histiocytic tissue (202)	1	3.23	0.31	0.01	1.73	2.79	0.36	0.01	2.00
Myeloma & Immunoproliferative Neoplasm (203)	2	1.92	1.04	0.13	3.76	1.65	1.21	0.15	4.38

CANCER	CASES	NIAGARA COUNTY				NEW YORK STATE (EXCLUDING NEW YORK CITY)			
			SIR	95% CI			SIR	95% CI	
	O*	E*		L*	U*	E*		L*	U*
Leukemia (204-208)	1	4.10	0.24	0.01	1.36	3.44	0.29	0.01	1.62

* O = Observed, E= Expected, L=Lower, U=Upper

APPENDIX K

Age Adjusted Standardized Incidence Ratios (SIR) and Confidence Intervals (CI) for Cancer
Compared to Niagara County and NYS (Exclusive of NYC): Date of Interview - 1996, Males Only

CANCER	CASES		NIAGARA COUNTY			NEW YORK STATE (EXCLUDING NEW YORK CITY)			
			SIR	95% CI			SIR	95% CI	
	O*	E*		L*	U*	E*		L*	U*
All Cancers (includes one case with unspecified type)	162	167.92	0.96	0.82	1.12	159.44	1.02	0.87	1.18
Lip, Oral Cavity and Pharynx (140-149)	3	5.72	0.52	0.11	1.53	5.41	0.55	0.11	1.62
Digestive Organs and Peritoneum (150-159)	36	35.59	1.01	0.71	1.40	36.56	0.98	0.69	1.36
Esophagus (150)	2	2.57	0.78	0.09	2.81	2.49	0.80	0.10	2.90
Stomach (151)	5	4.03	1.24	0.40	2.90	4.20	1.19	0.39	2.78
Colon (153)	12	13.92	0.86	0.45	1.51	14.75	0.81	0.42	1.42
Rectum (154)	8	7.41	1.08	0.47	2.13	7.57	1.06	0.46	2.08
Liver (155)	3	1.25	2.40	0.49	7.01	1.53	1.96	0.40	5.73
GallBladder (156)	2	0.97	2.06	0.25	7.45	0.86	2.33	0.28	8.40
Pancreas (157)	3	4.47	0.67	0.14	1.96	4.26	0.70	0.15	2.06
Peritoneum (158)	0	0.41	0.00			0.29	0.00		
Respiratory and Intrathoracic Organs (160-165)	43	39.88	1.08	0.78	1.45	36.35	1.18	0.86	1.59
Larynx (161)	4	3.23	1.24	0.34	3.17	3.50	1.14	0.31	2.93
Trachea, Bronchus, and Lung (162)	38	35.17	1.08	0.76	1.48	31.78	1.20	0.85	1.64
Pleura (163)	1	0.84	1.19	0.03	6.63	0.50	2.00	0.05	11.14
Bone, Connective Tissue, Skin, Breast (170-175)	3	5.64	0.53	0.11	1.55	6.14	0.49	0.10	1.43

CANCER	CASES		NIAGARA COUNTY			NEW YORK STATE (EXCLUDING NEW YORK CITY)			
			SIR	95% CI			SIR	95% CI	
	O*	E*		L*	U*	E*		L*	U*
Connective and Other Soft Tissue (171)	0	0.81	0.00			1.09	0.00		
Malignant Melanoma of the Skin (172)	2	3.89	0.51	0.06	1.86	3.88	0.52	0.06	1.86
Genitourinary Organs (179-189)	56	56.38	0.99	0.75	1.29	51.42	1.09	0.82	1.41
Prostate (185)	29	35.24	0.82	0.55	1.18	31.92	0.91	0.61	1.30
Testis (186)	3	2.70	1.11	0.23	3.25	2.34	1.28	0.26	3.75
Bladder (188)	16	13.39	1.19	0.68	1.94	11.80	1.36	0.78	2.20
Kidney (189)	8	4.69	1.71	0.74	3.36	5.03	1.59	0.69	3.13
Other and Unspecified Sites (190-199)	8	9.79	0.82	0.35	1.61	8.93	0.90	0.39	1.76
Eye (190)	1	0.35	2.86	0.07	15.92	0.32	3.13	0.08	17.41
Brain (191)	3	2.72	1.10	0.23	3.22	2.80	1.07	0.22	3.13
Thyroid Gland (193)	1	1.13	0.88	0.02	4.93	1.02	0.98	0.02	5.46
Other Endocrine Glands and Related Structures (194)	0	0.21	0.00			0.21	0.00		
Without Specification of Sites (199)	2	4.89	0.41	0.05	1.48	3.92	0.51	0.06	1.84
Lymphatic and Hematopoietic Tissue (200-208)	12	14.95	0.74	0.37	1.32	14.62	0.82	0.42	1.43
Lymphosarcoma, Reticulosarcoma (200)	1	3.29	0.30	0.01	1.69	3.31	0.30	0.01	1.68
Hodgkin's Disease (201)	1	1.68	0.60	0.01	3.32	1.59	0.63	0.02	3.50
Lymphoid and Histiocytic tissue (202)	4	3.16	1.27	0.34	3.24	3.25	1.23	0.33	3.15
Myeloma & Immunoproliferative Neoplasm (203)	3	1.76	1.70	0.35	4.98	1.87	1.60	0.33	4.69
Leukemia (204-208)	3	5.04	0.60	0.12	1.74	4.59	0.65	0.13	1.91

* O = Observed, E= Expected, L=Lower, U=Upper

APPENDIX L

Cox Proportional Hazards Modeling for All-Cause Mortality and Five Selected Groups of Mortality Diagnoses, Hazard Ratios (HR) and Confidence Intervals, Interviewees

Final Models

	All Causes of Death (n=637/3982)	Malignant Neoplasm (n=178/3982)	Circulatory System Diseases (n=276/3982)	Acute Myocardial Infarction (n=125/4457)	Respiratory System Diseases (n=49/3807)	External Causes (n=43/3982)
	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)
Age (1 year increment)	1.09 (1.09-1.10)	1.09 (1.07-1.10)	1.12 (1.10-1.13)	1.10 (1.09-1.13)	1.12 (1.09-1.14)	[b]
Sex (male)	1.62 (1.37-1.91)	1.52 (1.11-2.07)	3.21* (1.82-5.66)	4.82* (2.23-10.43)	[b]	1.79 (0.96-3.34)
Open Period, Tier 1 or 2	0.99 (0.90-1.08)	0.87 (0.65-1.16)	1.03 (0.92-1.15)	1.02 (0.86-1.20)	1.13 (0.92-1.38)	0.91 (0.41-2.01)
Open Period, Tier 3 or 4	1.00 (0.98-1.02)	0.99 (0.95-1.03)	1.00 (0.97-1.03)	0.98 (0.94-1.03)	1.00 (0.93-1.07)	1.03 (0.94-1.12)
Closed Period, Tier 1 or 2	1.00 (0.98-1.01)	1.01 (0.98-1.03)	1.00 (0.98-1.02)	1.06* (1.01-1.11)	0.98 (0.94-1.03)	0.88* (0.76-1.02)
Closed Period, Tier 3 or 4	1.00 ($0.99\text{-}1.00^{+}$)	1.00 (0.99-1.02)	1.00 (0.98-1.01)	1.01 (0.99-1.03)	0.99 (0.96-1.02)	0.87* (0.78-0.97)
Years at 99th St. School	0.97 (0.87-1.09)	0.57 (0.32-1.02)	0.55 (0.24-1.28)	0.51 (0.15-1.74)	[a]	1.08 (0.93-1.26)
Childhood Exposure	1.01 (0.48-2.14)	2.22 (0.64-7.65)	0.93 (0.12-7.09)	2.30 (0.29-18.49)	[a]	0.63 (0.15-2.64)
Hot spot / swale	0.91 (0.50-1.66)	1.10 (0.41-2.99)	1.40 (0.66-2.99)	0.90 (0.22-3.65)	[a]	[a]
Smoking	1.58 (1.29-1.93)	1.61 (1.10-2.37)	1.29 (0.96-1.74)	[b]	7.02 (2.47-19.98)	2.41 (1.01-5.75)
Occupational Exposure to LCIC's	[b]	[b]	[b]	[b]	0.58 (0.33-1.03)	[b]

* Adjusted for an interactive term with survival time

[a] HR not calculable due to zero cells

[b] Not retained in the final model because p>.10

NB. 1.00^{+} implies a number slightly greater than 1.00 and 1.00^{-} implies slightly less than 1.00

APPENDIX M

Cox Proportional Hazards Modeling for All-Cause Mortality and Five Selected Groups of Mortality Diagnoses, Hazard Ratios (HR) and Confidence Intervals, Entire cohort (N=5974)

Full (and Final) Models

	All Causes of Death (n=706)	Malignant Neoplasm (n=183)	Circulatory System Diseases (n=300)	Acute Myocardial Infarction (n=125)	Respiratory System Diseases (n=54)	External Causes (n=62)
	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)
Age (1 year increment)	1.09 (1.09-1.10)	1.09 (1.07-1.10)	1.10* (1.08-1.12)	1.10* (1.07-1.12)	1.11 (1.09-1.14)	1.02 (1.00+-1.03)
Sex (male)	1.82 (1.56-2.11)	1.74 (1.30-2.34)	2.13 (1.68-2.69)	4.84* (2.23-10.50)	1.44[b] (0.84-2.47)	1.78 (1.07-2.97)
Open Period, Tier 1 or 2	0.97 (0.88-1.07)	0.86 (0.64-1.16)	1.02 (0.91-1.14)	1.02 (0.87-1.21)	1.07 (0.86-1.32)	0.84 (0.35-2.01)
Open Period, Tier 3 or 4	0.99 (0.97-1.01)	0.99 (0.95-1.03)	1.00 (0.97-1.03)	1.05* (0.96-1.14)	0.99 (0.92-1.06)	1.01 (0.93-1.10)
Closed Period, Tier 1 or 2	0.99 (0.98-1.01)	1.01 (0.98-1.03)	1.00 (0.98-1.01)	1.06* (1.01-1.11)	0.98 (0.94-1.03)	0.98 (0.93-1.03)
Closed Period, Tier 3 or 4	1.00 (0.99-1.00+)	1.00 (0.99-1.02)	1.00 (0.98-1.01)	1.01 (0.99-1.03)	0.99 (0.95-1.02)	0.92* (0.84-1.00-)
Years at 99th St. School	0.96 (0.88-1.06)	0.56 (0.31-1.00+)	0.79 (0.56-1.11)	0.50 (0.14-1.72)	[a]	1.06 (0.93-1.22)
Childhood Exposure	1.28 (0.74-2.21)	1.39 (0.41-4.75)	0.94 (0.21-4.20)	1.68 (0.21-13.44)	[a]	0.83 (0.33-2.12)
Hot spot / swale	0.84 (0.46-1.52)	1.09 (0.40-2.95)	1.39 (0.65-2.96)	0.94 (0.23-3.84)	[a]	[a]

* Adjusted for an interactive term with survival time

[a] HR not calculable due to zero cells

[b] Not retained in the final model because p>.10

NB. 1.00+ implies a number slightly greater than 1.00 and 1.00- implies slightly less than 1.00

APPENDIX N

Cox Proportional Hazards Modeling for Total and Site-Specific Cancers (Full and Part-time Residents), Hazard Ratios (HR) and Confidence Intervals (CI), Date of Interview - 1996, Interviewees

Final Model

	All Cancers (n=275/3246)	Respiratory & intrathoracic cancer (n=58/3246)	Cancer of digestive organs & peritoneum (n =68/3659)	Liver& rectal cancer [c] (n=20/3659)	Genitourinary cancer (n=77/3659)	Bladder & kidney cancer [c] (n=33/3659)
	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)
Age[d] (years)	1.07 (1.06-1.08)	1.09 (1.06-1.11)	1.08 (1.06-1.10)	1.10 (1.06-1.13)	1.09 (1.07-1.11)	1.09 (1.06-1.12)
Sex (Male)	1.35 (1.05-1.72)	2.31 (1.30-4.11)	1.47 (0.91-2.38)	[b]	3.02 (1.87-4.90)	3.44 (1.62-7.29)
Open period, Tier 1 or 2 (years)	0.95 (0.81-1.13)	1.04 (0.83-1.30)	[a]	[a]	1.01 (0.79-1.29)	0.95 (0.65-1.38)
Open period, Tier 3 or 4 (years)	1.01 (0.98-1.04)	0.95 (0.88-1.03)	1.03 (0.97-1.09)	1.08 (0.98-1.19)	1.05 (0.99-1.11)	1.04 (0.96-1.13)
Closed period, Tier 1 or 2 (years)	1.00 (0.98-1.02)	1.02 (0.98-1.06)	0.98 (0.94-1.03)	1.00 (0.93-1.07)	0.95 (0.90-1.00$^-$)	0.96 (0.89-1.04)
Closed period, Tier 3 or 4 (years)	0.99 (0.98-1.01)	1.00 (0.97-1.03)	1.01 (0.98-1.03)	0.98 (0.93-1.03)	0.99 (0.96-1.01)	1.00 (0.97-1.05)
Years at 99 St Sch	0.94 (0.81-1.08)	0.84 (0.53-1.33)	0.84 (0.54-1.28)	[a]	1.02 (0.80-1.31)	0.50 (0.14-1.73)
Childhood exposure	0.92 (0.34-2.47)	[a]	[a]	[a]	1.98 (0.39-10.07)	14.36 (2.53-81.54)
Swale or hot spot	1.02 (0.45-2.30)	0.74 (0.10-5.40)	0.79 (0.11-5.72)	3.03 (0.40-22.96)	1.58 (0.39-6.48)	[a]
Family hx cancer	1.26 (0.98-1.60)	[b]	[b]	[b]	[b]	[b]
Smoking	2.00 (1.45-2.77)	6.66 (2.05-21.69)	[b]	[b]	[b]	[b]

[a] HR not calculable due to zero cells.
[b] Not retained in model because P > .10.
[c] The disease categories 'liver and rectal' and 'bladder and kidney' are subsets of 'digestive organs' and 'genitourinary,' respectively.
[d] Age at cancer diagnoses.
NB. 1.00$^+$ implies a number slightly greater than 1.00 and 1.00$^-$ implies slightly less than 1.00

APPENDIX O

Cox Proportional Hazards Modeling for Total and Site-Specific Cancers (Full and Part-time Residents), Hazard Ratios (HR) and Confidence Intervals (CI), Date of Interview - 1996, Entire Cohort (N=5007)

Full Model

	Total number of cohort members with cancer (N = 296)	Respiratory & intrathoracic cancer (N = 59)	Cancer of digestive organs & peritoneum (N = 68)	Liver& rectal cancer[b] (N = 20)	Genitourinary cancer (N = 80)	Bladder & kidney cancer[b] (N = 33)
	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)
Age [c] (years)	1.07 (1.06-1.08)	1.09 (1.07-1.11)	1.08 (1.07-1.10)	1.10 (1.07-1.14)	1.09 (1.07-1.10)	1.10 (1.07-1.13)
Sex (Male)	1.52 (1.21-1.91)	3.26 (1.85-5.75)	1.48 (0.91-2.39)	1.76 (0.72-4.31)	3.14 (1.94-5.06)	3.47 (1.63-7.37)
Open period, Tier 1 or 2 (years)	0.94 (0.79-1.12)	1.01 (0.80-1.28)	[a]	[a]	1.01 (0.79-1.29)	0.96 (0.65-1.40)
Open period, Tier 3 or 4 (years)	1.01 (0.98-1.04)	0.95 (0.88-1.03)	1.03 (0.97-1.09)	1.08 (0.98-1.20)	1.05 (0.99-1.11)	1.04 (0.96-1.13)
Closed period, Tier 1 or 2 (years)	0.99 (0.98-1.01)	1.03 (0.99-1.06)	0.98 (0.94-1.03)	1.00 (0.93-1.07)	0.94 (0.90-0.99)	0.96 (0.90-1.04)
Closed period, Tier 3 or 4 (years)	0.99 (0.97-1.00^{+})	1.00^{-} (0.96-1.03)	1.01 (0.98-1.03)	0.98 (0.93-1.03)	0.98 (0.96-1.01)	1.00 (0.96-1.05)
99 St School (years)	0.93 (0.82-1.06)	0.78 (0.48-1.26)	0.81 (0.53-1.26)	[a]	0.99 (0.79-1.24)	0.50 (0.14-1.73)
Child exposure	0.82 (0.37-1.81)	[a]	[a]	[a]	2.65 (0.77-9.11)	10.55 (1.77-62.84)
Hot spot / swale	1.00 (0.44-2.24)	0.75 (0.10-5.43)	0.79 (0.11-5.70)	3.00 (0.39-22.91)	1.46 (0.36-5.98)	[a]

[a] HR not calculable due to zero cells
[b]The disease categories 'liver and rectal' and 'bladder and kidney' are subsets of 'digestive organs' and 'genitourinary,' respectively.
[c]Age at cancer diagnoses.
NB. 1.00^{+} implies a number slightly greater than 1.00 and 1.00^{-} implies slightly less than 1.00

APPENDIX P

Cox Proportional Hazards Modeling for Total and Site-Specific Cancers (Full and Part-time Residents), Hazard Ratios (HR) and Confidence Intervals (CI), Date of Interview - 1996, Entire Cohort (N=5007)

Final Model

	Total number of cohort members with cancer (N = 296)	Respiratory & intrathoracic cancer (N = 59)	Cancer of digestive organs & peritoneum (N = 68)	Liver& rectal cancer[b] (N = 20)	Genitourinary cancer (N = 80)	Bladder & kidney cancer[b] (N = 33)
	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)
Age [c] (years)	1.07 (1.06-1.08)	1.09 (1.07-1.11)	1.08 (1.06-1.10)	1.10 (1.06-1.13)	1.09 (1.07-1.10)	1.10 (1.07-1.13)
Sex (Male)	1.52 (1.21-1.91)	3.26 (1.85-5.75)	[d]	[d]	3.14 (2.01-5.31)	3.47 (1.63-7.37)
Open period, Tier 1 or 2 (years)	0.94 (0.79-1.12)	1.01 (0.80-1.28)	[a]	[a]	1.01 (0.79-1.29)	0.96 (0.65-1.40)
Open period, Tier 3 or 4 (years)	1.01 (0.98-1.04)	0.95 (0.88-1.03)	1.02 (0.97-1.08)	1.08 (0.98-1.19)	1.05 (0.99-1.11)	1.04 (0.96-1.13)
Closed period, Tier 1 or 2 (years)	0.99 (0.98-1.01)	1.03 (0.99-1.06)	0.99 (0.94-1.03)	1.00 (0.93-1.07)	0.94 (0.90-0.99)	0.96 (0.90-1.04)
Closed period, Tier 3 or 4 (years)	0.99 (0.97-1.00^{+})	1.00 (0.96-1.03)	1.01 (0.98-1.03)	0.98 (0.93-1.03)	0.98 (0.96-1.01)	1.00 (0.96-1.05)
99 St School (years)	0.93 (0.82-1.06)	0.78 (0.48-1.26)	0.82 (0.53-1.26)	[a]	0.99 (0.79-1.24)	0.50 (0.14-1.73)
Child exposure	0.82 (0.37-1.81)	[a]	[a]	[a]	2.65 (0.77-9.11)	10.55 (1.77-62.84)
Hot spot / swale	1.00 (0.44-2.24)	0.75 (0.10-5.43)	0.80 (0.11-5.78)	3.03 (0.40-23.01)	1.46 (0.36-5.98)	[a]

[a] HR not calculable due to zero cells

[b] The disease categories 'liver and rectal' and 'bladder and kidney' are subsets of 'digestive organs' and 'genitourinary,' respectively.

[c] Age at cancer diagnoses.

[d] Not retained in model because P > .10.

NB. 1.00^{+} implies a number slightly greater than 1.00 and 1.00^{-} implies slightly less than 1.00

APPENDIX Q General Estimating Equations (GEE) Modeling for Low Birth Weight, Odds Ratio (OR) and Confidence Intervals (CI), Singleton Births

1960 – 1996	Interviewees only (N=1356)				Entire Cohort (N=1767)			
	Full Model		Final Model		Full Model		Final Model	
Variable	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Open Period, Tier 1 or 2 (Yrs)	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
Open Period, Tier 3 or 4 (Yrs)	1.04	0.94-1.15	1.05	0.94-1.17	1.02	0.93-1.12	1.02	0.92-1.12
Closed Period, Tier 1 or 2 (Yrs)	1.02	0.89-1.16	1.06	0.95-1.19	1.01	0.91-1.11	1.01	0.91-1.11
Closed Period, Tier 3 or 4 (Yrs)	1.03	0.96-1.11	1.03	0.96-1.10	1.00	0.94-1.08	1.01	0.94-1.08
Childhood Exposure[c] (Y/N)	1.35	0.23-7.83	0.77	0.15-3.98	1.90	0.58-6.20	1.82	0.56-5.95
Attended 99th St. School (Yrs)	0.98	0.83-1.15	1.02	0.88-1.18	1.08	0.95-1.22	1.08	0.96-1.22
Hotspot / swale (Y/N)	[a]	[a]	[a]	[a]	0.52	0.04-6.54	0.50	0.04-6.26
Year of Infant's Birth	0.99	0.94-1.04	[b]	[b]	0.97	0.94-1.00^{-}	0.97	0.94-1.00^{+}
Smoke (Y/N)	2.06	1.03-4.11	2.33	1.08-5.01	-	-	-	-
Alcohol Consumption (Y/N)	1.49	0.68-3.27	[b]	[b]	-	-	-	-
Occupational Exposure (Possible/N)	0.76	0.40-1.46	[b]	[b]	-	-	-	-
Mother's Age (Yrs)	1.02	0.97-1.08	[b]	[b]	1.04	1.00^{-}-1.09	1.04	0.99-1.09
Mother's Race (Black/White)	2.30	0.86-6.17	2.25	0.85-5.97	1.69	0.61-4.70	[b]	[b]
Infant's Sex (Female/Male)	1.36	0.77-2.41	[b]	[b]	1.05	0.65-1.71	[b]	[b]
Gestational Age (Days)	0.92	0.90-0.94	0.93	0.91-0.95	0.93	0.91-0.95	0.93	0.91-0.95
1960 – 1978	Interviewees only (N=1055)				Entire Cohort (N=1098)			
	Full Model		Final Model		Full Model		Final Model	
Variable	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Open Period, Tier 1 or 2 (Yrs)	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
Open Period, Tier 3 or 4 (Yrs)	1.04	0.92-1.16	1.05	0.93-1.18	1.02	0.91-1.15	1.04	0.93-1.17
Closed Period, Tier 1 or 2 (Yrs)	0.96	0.79-1.16	0.95	0.80-1.12	0.97	0.81-1.15	0.96	0.82-1.13
Closed Period, Tier 3 or 4 (Yrs)	1.06	0.97-1.16	1.06	0.97-1.15	1.07	0.99-1.15	1.06	0.99-1.13
Childhood Exposure[c] (Y/N)	6.37	0.69-59.26	6.68	1.04-43.17	6.14	0.80-46.92	5.92	1.02-34.26
Attended 99th St. School (Yrs)	0.89	0.69-1.13	0.88	0.70-1.12	0.89	0.71-1.12	0.90	0.72-1.12
Hot spot / swale (Y/N)	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
Year of Infant's Birth	0.97	0.90-1.05	[b]	[b]	0.96	0.90-1.04	[b]	[b]
Smoke (Y/N)	2.38	1.02-5.56	2.37	1.00^{-}-5.63	-	-	-	-
Alcohol Consumption (Y/N)	1.27	0.56-2.87	[b]	[b]	-	-	-	-
Occupational Exposure (Possible/N)	0.76	0.37-1.59	[b]	[b]	-	-	-	-
Mother's Age (Yrs)	1.01	0.95-1.07	[b]	[b]	1.00	0.95-1.06	[b]	[b]
Mother's Race (Black/White)	0.88	0.30-2.51	[b]	[b]	0.82	0.27-2.50	[b]	[b]
Infant's Sex (Female/Male)	1.69	0.85-3.38	[b]	[b]	1.60	0.81-3.17	[b]	[b]
Gestational Age (Days)	0.91	0.88-0.95	0.92	0.89-0.95	0.91	0.88-0.94	0.91	0.89-0.94
Born/Conceived On (On/Off)	1.44	0.63-3.29	1.62	0.72-3.68	1.46	0.63-3.34	1.57	0.70-3.53

NB. 1.00^{+} implies a number slightly greater than 1.00 and 1.00^{-} implies slightly less than 1.00

[a] OR not calculable due to zero cells

[b] Not entered into model because P > .10.

[c] Defined as: 1942-1953, tiers 1 and 2, males, 13-18 years old; 1954-1978, tiers 1 and 2, both sexes, 0-13 years old

APPENDIX R General Estimating Equations (GEE) for Pre-Term Birth

GEE Modeling for Pre-Term Births, Odds Ratio (OR) and 95% Confidence Intervals (CI), Singleton Births								
	Interviewees only (N=873)				Entire cohort (N=1275)			
1968 – 1996	Full Model		Final Model		Full Model		Final Model	
Variable	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Open Period, Tier 1 or 2 (Yrs)	0.94	0.73-1.19	0.95	0.75-1.20	0.98	0.75-1.28	0.98	0.76-1.27
Open Period, Tier 3 or 4 (Yrs)	0.86	0.72-1.03	0.87	0.73-1.03	0.89	0.77-1.03	0.91	0.79-1.05
Closed Period, Tier 1 or 2 (Yrs)	0.97	0.88-1.08	0.98	0.89-1.09	0.95	0.88-1.03	0.97	0.90-1.05
Closed Period, Tier 3 or 4 (Yrs)	0.96	0.90-1.03	0.96	0.90-1.02	0.98	0.93-1.03	0.98	0.93-1.03
Childhood Exposure[c] (Y/N)	0.33	0.07-1.63	0.33	0.07-1.58	1.01	0.44-2.32	0.79	0.35-1.78
Attended 99th St. School (Yrs)	1.08	0.94-1.24	1.06	0.92-1.22	1.07	0.96-1.19	1.05	0.95-1.17
Hotspot / swale (Y/N)	0.53	0.06-4.84	0.54	0.06-4.93	0.74	0.17-3.16	0.71	0.17-3.01
Year of Infant's Birth	0.99	0.93-1.04	[b]	[b]	0.98	0.95-1.01	[b]	[b]
Smoke (Y/N)	1.34	0.75-2.39	[b]	[b]	-	-	-	-
Alcohol Consumption (Y/N)	1.01	0.54-1.90	[b]	[b]	-	-	-	-
Occupational Exposure (Possible/N)	0.50	0.26-0.97	0.52	0.27-1.00[+]	-	-	-	-
Mother's Age (Yrs)	1.02	0.96-1.08	[b]	[b]	1.01	0.97-1.06	[b]	[b]
Mother's Race (Black/White)	2.33	0.87-6.29	2.53	1.02-6.27	2.05	0.98-4.30	1.96	0.95-4.07
Infant's Sex (Female/Male)	1.38	0.82-2.33	[b]	[b]	1.22	0.82-1.81	[b]	[b]
	Interviewees only (N=572)				Entire cohort (N=606)			
1968 – 1978	Full Model		Final Model		Full Model		Final Model	
Variable	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Open Period, Tier 1 or 2 (Yrs)	0.87	0.66-1.15	0.91	0.71-1.18	0.94	0.74-1.21	0.94	0.74-1.21
Open Period, Tier 3 or 4 (Yrs)	0.91	0.77-1.08	0.92	0.78-1.08	0.94	0.81-1.08	0.94	0.83-1.08
Closed Period, Tier 1 or 2 (Yrs)	0.97	0.86-1.11	0.98	0.87-1.10	0.98	0.87-1.10	0.98	0.87-1.09
Closed Period, Tier 3 or 4 (Yrs)	0.95	0.87-1.03	0.96	0.88-1.04	0.96	0.88-1.03	0.96	0.89-1.04
Childhood Exposure[c] (Y/N)	0.96	0.14-6.31	0.90	0.15-5.51	0.58	0.09-3.50	0.60	0.11-3.37
Attended 99th St. School (Yrs)	0.99	0.80-1.23	0.96	0.78-1.20	1.02	0.83-1.26	1.01	0.82-1.23
Hotspot / swale (Y/N)	0.60	0.05-6.70	0.62	0.06-6.18	0.64	0.07-5.86	0.65	0.08-5.65
Year of Infant's Birth	0.97	0.86-1.09	[b]	[b]	1.00	0.90-1.11	[b]	[b]
Smoke (Y/N)	1.62	0.77-3.44	[b]	[b]	-	-	-	-
Alcohol Consumption (Y/N)	0.84	0.40-1.77	[b]	[b]	-	-	-	-
Occupational Exposure (Possible/N)	0.54	0.26-1.12	0.57	0.28-1.19	-	-	-	-
Mother's Age (Yrs)	1.03	0.96-1.10	[b]	[b]	1.01	0.95-1.08	[b]	[b]
Mother's Race (Black/White)	2.36	0.68-8.25	[b]	[b]	2.26	0.73-6.95	[b]	[b]
Infant's Sex (Female/Male)	1.33	0.71-2.48	[b]	[b]	1.20	0.67-2.14	[b]	[b]
Born/ Conceived On (On/Off)	1.56	0.74-3.30	1.77	0.86-3.65	1.58	0.81-3.08	1.74	0.91-3.32

NB. 1.00[+] implies a number slightly greater than 1.00 and 1.00[-] implies slightly less than 1.00

[a,b] Not entered into model because P > .10.

[c] Defined as: 1942-1953, tiers 1 and 2, males, 13-18 years old; 1954-1978, tiers 1 and 2, both sexes, 0-13 years

APPENDIX S

GEE* Modeling for Small for Gestational Age, Odds Ratios (0R) and 95% Confidence Intervals (CI), Singleton Births

	Interviewees only (N=821)				Entire cohort (N=1202)			
1968 – 1996	Full Model		Final Model		Full Model		Final Model	
Variable	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Open Period, Tier 1 or 2 (Yrs)	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
Open Period, Tier 3 or 4 (Yrs)	0.96	0.82-1.13	0.94	0.80-1.11	0.96	0.82-1.13	0.94	0.81-1.10
Closed Period, Tier 1 or 2 (Yrs)	1.04	0.93-1.15	1.03	0.95-1.13	1.07	0.99-1.16	1.05	0.98-1.13
Closed Period, Tier 3 or 4 (Yrs)	1.02	0.95-1.08	1.02	0.96-1.09	1.01	0.95-1.06	1.00	0.95-1.06
Childhood Exposure[c] (Y/N)	1.01	0.22-4.63	1.26	0.38-4.23	0.69	0.26-1.79	0.85	0.38-1.92
Attended 99th St. School (Yrs)	0.93	0.79-1.10	1.00	0.87-1.15	0.99	0.89-1.10	1.01	0.91-1.12
Hotspot / swale (Y/N)	1.34	0.29-6.30	2.18	0.61-7.75	2.16	0.72-6.51	2.21	0.74-6.61
Year of Infant's Birth	1.01	0.95-1.07	[b]	[b]	1.01	0.98-1.04	[b]	[b]
Smoke (Y/N)	2.43	1.23-4.80	2.73	1.38-5.38	-	-	-	-
Alcohol Consumption (Y/N)	0.92	0.47-1.80	[b]	[b]	-	-	-	-
Occupational Exposure (Possible/N)	0.94	0.51-1.73	[b]	[b]	-	-	-	-
Mother's Age (Yrs)	0.97	0.91-1.03	[b]	[b]	0.97	0.93-1.02	[b]	[b]
Mother's Race (Black/White)	4.54	1.79-11.52	4.80	2.04-11.29	3.16	1.60-6.26	3.35	1.73-6.51
Infant's Sex (Female/Male)	0.60	0.36-0.98	0.55	0.34-0.90	0.62	0.43-0.89	0.62	0.43-0.90
	Interviewees only (N=538)				Entire cohort (N=569)			
1968 – 1978	Full Model		Final Model		Full Model		Final Model	
Variable	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Open Period, Tier 1 or 2 (Yrs)	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
Open Period, Tier 3 or 4 (Yrs)	0.95	0.80-1.13	0.93	0.79-1.10	0.95	0.80-1.12	0.94	0.80-1.10
Closed Period, Tier 1 or 2 (Yrs)	0.99	0.87-1.12	0.99	0.88-1.10	1.02	0.91-1.14	1.00	0.90-1.11
Closed Period, Tier 3 or 4 (Yrs)	1.04	0.96-1.14	1.04	0.97-1.11	1.05	0.99-1.12	1.05	0.98-1.12
Childhood Exposure[c] (Y/N)	2.46	0.42-14.47	2.43	0.53-11.17	2.18	0.47-10.18	2.68	0.65-11.12
Attended 99th St. School (Yrs)	0.91	0.76-1.09	0.92	0.78-1.10	0.89	0.74-1.07	0.90	0.76-1.07
Hotspot / swale (Y/N)	1.55	0.31-7.61	1.66	0.32-8.59	1.55	0.33-7.32	1.60	0.32-8.14
Year of Infant's Birth	1.00	0.90-1.10	[b]	[b]	0.98	0.90-1.08	[b]	[b]
Smoke (Y/N)	1.67	0.84-3.35	[b]	[b]	-	-	-	-
Alcohol Consumption (Y/N)	1.06	0.52-2.16	[b]	[b]	-	-	-	-
Occupational Exposure (Possible/N)	0.78	0.39-1.56	[b]	[b]	-	-	-	-
Mother's Age (Yrs)	0.96	0.90-1.03	[b]	[b]	0.96	0.91-1.02	[b]	[b]
Mother's Race (Black/White)	1.75	0.59-5.16	[b]	[b]	1.73	0.60-5.03	[b]	[b]
Infant's Sex (Female/Male)	0.72	0.41-1.26	[b]	[b]	0.72	0.41-1.24	[b]	[b]
Born/ Conceived On (On/Off)	1.27	0.60-2.71	1.33	0.63-2.82	1.26	0.61-2.60	1.30	0.64-2.66

* General Estimating Equations
[a] OR not calculable due to zero cells
[b] Not included in final model
[c] Defined as: 1942-1953, tiers 1 and 2, males, 13-18 years old; 1954-1978, tiers 1 and 2, both sexes, 0-13 years old

APPENDIX T
Public Comments and Responses, Love Canal Follow-up Health Study

RESPONSE TO COMMENTS BY DR. HEATH:

The report is well written, I think. Not a simple task! Two minor comments:

1) On page 53, 55, and 56, referring to small numbers, it might be better to say "numbers were small and 95% CIs included 1.00" rather than "due to small numbers…"

- *We have changed the occurrences of 'due to small numbers' to reflect Dr. Health's comment.*

2) The suggestion on page 62 about follow-up of chronic disease occurrence beyond 1996 could fit in the final "Next Steps" section. – Clark Heath

- *We have added a section called 'Future Steps' to address the second comment. The present 'Next Steps' are related only to steps to be taken to complete the present study.*

RESPONSE TO COMMENTS BY MARIAN OLSEN:

As we mentioned to NYSDOH, it is important to include information regarding the Institutional Review Board (IRB) evaluation of the project and updates to the original IRB evaluation. Information that should be included is the IRB name, date of review, and how the original members were contacted to continue participation in the project.

- *We have added two sentences including the above information requested. One was put into the Executive Summary and the other in the Introduction section.*

It may be helpful to discuss the next steps with NYSDOH i.e., publication of reports, issuance of the document, etc.

- *We have added a paragraph at the end of Next Steps describing the three articles and community reports.*

Page 4. It would be helpful to indicate in the discussion of the site history that this site is on the National Priority List of Sites for the Superfund program, the remedial actions at the site, and the current status of the site.

- *We have added a paragraph at the end of the 'Love Canal History' section discussing the NPL history, the current status and the NYS IHWSP.*

Page 7. It would be helpful to define the term "swales".

- *The first reference to 'swales' was followed by the parenthetic phrase (natural depressions of land that might facilitate the migration of chemicals) which defines a swale.*

Page 8. The discussion of the sampling and other actions at the site should be placed within the context of the Superfund program i.e., Remedial Investigation, Feasibility Study, Operable Unites, etc.

- *The environmental sampling that is described on pages 8 to 10 pre-dated the Superfund Program and hence can not be described in terms of RI, FS, etc.*

Page 9. It would be helpful to clarify whether the analyses for dioxin were for 2,3,7,8-TCDD, congeners or total TEQ.

- *As noted on page 19, the analyses were for 2,3,7,8-TCDD.*

Page 12. Consideration should be given to sharing this document with scientists from ORD based on their earlier involvement.

- *We would be pleased to share the document with staff scientists from ORD.*

Page 13. It would be helpful to clarify which organization conducted the growth study.

- *The growth study was conducted independently by Paigen et al., as cited in the References.*

Page 17. It would be helpful to list the additional confounders evaluated in this section of this analysis.

- *The list of confounders is described on page 31.*

Page 20 and 21. The section regarding the Tracking of Former Love Canal Residents should clarify the IRB review procedures for these activities.

- *As noted above, references to how we obtained IRB approval have been added to the report.*

Page 22. It would be helpful to clarify the 12 variables evaluated in the factor analysis by listing them.

- *The variables included in the factor analysis are described in the paragraph that precedes the factor analysis on page 23.*

Page 26. It would be helpful to indicate whether the selection of the 8 states resulted in a significant loss to follow-up. It may also be helpful to discuss the agreements with other state tumor registries i.e., how many states have tumor registries and the percentage represented by the 8 selected states.

- *We chose the eight states because they were the states with cancer registries to which the greatest numbers of former Love Canal residents migrated. Unfortunately, as noted on page 39, the yield for this effort was very low, revealing only eight additional cancers. As a result, we probably underestimated the total number of incident cancers in the cohort, a limitation noted on page 59.*

Page 27. It is unclear why data from EPA's Integrated Risk Information System was not also used in addition to the databases listed. The Integrated Risk Information System provides EPA's consensus database of toxicity information and is available at www.epa.gov/iris.

- *Since we were most interested in evaluating the carcinogenicity of Love Canal chemicals, we focused primarily on cancer databases such as those by IARC and NTP Carcinogenicity Report. It is unlikely that the addition of IRIS would have altered our conclusions.*

Page 31. Later sections of the report indicate small Ns. It would be helpful to clarify in the discussion of the statistical analysis how small Ns were addressed i.e., reported, if there was a limit below which data was not reported, etc.

- *The analyses were conducted and reported despite cell frequencies as small as N = 2, but the imprecision of such results is noted as a precaution throughout the report.*

Page 39. The N for the number of observed cases generally was small should be provided.

- *It would add considerable length to the tables to add the frequencies for every cell, especially for the internal analyses, but in general the number of cases for every outcome category, e.g, cause-specific deaths or site-specific cancers, are given.*

Page 45 and 46. It is suggested that the N be included when the N is described as too small.

- *As above.*

Page 46. It is suggested that further discussion should be provided here regarding the small N (N=2) and the stability of the result.

- *A phrase about the imprecision of this result has been added.*

Page 49. It would be helpful to indicate whether the other dioxin congeners were also evaluated and whether the analysis was based on just 2,3,7,8-TCDD or a TEQ. A reference for the conclusion that rheumatic heart disease is not known to be affected by chemical exposures should be provided.

- *As noted above, the chemical analyses were for 2,3,7,8-TCDD. The question about rheumatic heart disease has been reworded to state that it is not known whether it may be affected by chemical exposures (page 49).*

A discussion is provided regarding health effects of trichloroethylene, organophosphate, and pesticides. It may be helpful to clarify whether these chemicals were among the 12 LCIC chemicals or found at the site.

- *Although the Love Canal did contain chlorinated solvents and pesticides, we phrased the discussion in general terms to include a variety of chemical exposures to help assess the feasibility of adverse health effects among the study cohort as a consequence of their residence at Love Canal.*

RESPONSE TO COMMENTS BY GIBBS ET AL

1) The rate of congenital malformations (birth defects) found in this study was elevated in Love Canal residents compared to two comparison groups - New York State exclusive of New York City and Niagara County (DOH Report, p. 3). Children born at Love Canal were found to be twice as likely as other Niagara County (NC) children to be born with a birth defect (DOH Report, p. 43 and 97).

DOH's analysis of the birth defects data shows a *more than two fold increase in malformations* in Love Canal children compared to all children born in Niagara County. This finding is statistically significant (the 95% Confidence Interval does not include 1.0; DOH Report, p. 43). Yet, DOH says little about the significance of this finding in the report. There is no mention, for example, of this two-fold increase in the Executive Summary. Instead, DOH consistently plays down this finding by repeatedly discussing the "small number" of observations. They conclude that "the ability of the study to detect many differences in health status was limited and estimates of many measures of association were imprecise" (DOH Report, p. 60).

These statements are made despite the fact that the birth defect outcomes were consistent with previous Love Canal investigations including Vienna in 1975 and Paigen in 1982. This consistency should strengthen the confidence DOH has in its findings on birth defects. Instead, DOH dwells on the "inconsistencies" in results from other studies (DOH Report, p. 57).

- *We agree that the two fold elevation in birth defects among children born to women who lived at Love Canal is an important finding. For example, in the Discussion section we note that "congenital malformations were also more frequent than expected among Love Canal children born from 1983 to 1996. In fact, the risk of a malformation among Love Canal children was twice that for Niagara County, and the 95% CI excluded 1.00 (pg 55)". Although this finding is also cited in the Executive Summary, we have added "two fold" to indicate the magnitude of the association. The reference to "small numbers" and the "failure to detect many differences in health status and the imprecise estimates of many measures of association" on pg 60 is not at attempt to "play down" the two fold excess of birth defects, which was statistically significant despite the occurrence of only 16 birth defects. Rather, it was intended to explain why some of the other health endpoints with elevated rates may not have been statistically significant or have wide confidence intervals.*
- *We also refer to the consistency with the results with Vianna and Paigen on pg 56 – "The findings that Love Canal children born from 1983 to 1996 were more likely to have a congenital malformation are consistent with earlier Love Canal studies. Vianna and Polan (18) observed an excess of congenital malformations associated with swale areas from 1955 to 1964. Higher rates of fetal deaths and birth defects were also found in a survey conducted by Paigen (25) in 1978 among residents of "wet" versus "dry" single-family homes." The inconsistencies cited on pg 56 relate to studies of birth defects around hazardous waste sites outside of New York, some of which have found positive associations and some of which have not. It is important to discuss these other studies to help put the Love Canal findings in context with other findings elsewhere in the USA and Europe.*

2) DOH reports that "there was a tendency for children born to mothers who lived on the Canal at some time during their pregnancy to be at higher risk from low birth weight, pre-term births and small for gestational age (SGA) than those conceived after the mother left the Canal area" (DOH Report, p. 3).

Data presented in the report (see Tables 17 and 23) show increased rates of adverse pregnancy outcomes for children born on the Canal compared to children born off the Canal for all three adverse

pregnancy outcomes: low birth weight, pre-term births, and SGA (also see p. 42 and p. 48). However, these findings were consistently dismissed because of "small numbers" (DOH Report, p. 56) and because "the CI for each estimate included 1.00" (DOH Report, p. 48).

These findings may not be statistically significant, but there is a consistent trend showing that children born to mothers who lived on the Canal at some point during their pregnancy ARE to be more likely to have an adverse reproductive outcome than children whose mothers lived off the Canal. This trend is also consistent with results from earlier investigations at Love Canal including Vienna in 1985 and Goldman in 1985 (DOH Report, p. 56) and this should strengthen DOH's confidence that this effect is in fact real and would be more apparent if the number of participants were larger.

- *We agree that the results suggest a trend for Love Canal children to experience a greater likelihood of adverse reproductive outcomes, and that this trend is consistent with other Love Canal studies. For example, pg 57 in the Discussion states that " the general pattern of results in previous studies, together with that found in the current investigation, suggest children born to Love Canal mothers may have been at greater risk for a number of adverse reproductive outcomes compared to the general population. " As you noted, similar conclusions are also repeated in the Executive Summary.*
- *The "small numbers" referred to on pg 59 and the fact that "the CI included 1.00" (pg 48) refer to the results of the internal analyses which compared Love Canal residents according to childhood exposure using GEE modeling. The purpose is not to dismiss the findings, but rather to indicate that despite the small numbers, patterns were evident. For example, "Positive associations, however, were consistently observed for childhood exposure. Although the numbers were small and the 95% CI included 1.00, elevated risks for childhood exposure were observed for three of the five birth outcomes studies: low birth weight, SGA and congenital malformations. Childhood exposure was also associated with a greater proportion of female births. Consistent with the results of the SIR analyses, the GEE modeling also indicated that the children born on Love Canal were more likely to be low birth weight, SGA, pre-term, or female" (pg 55).*

3) DOH found that children conceived on the Canal were more likely to be female compared to children conceived after the mother left the Canal area. This finding was also statistically significant when compared to rates in NYS and NC (DOH Report, p. 42). This finding is also consistent with results found at Seveso, Italy where more females were born to parents exposed to a dioxin cloud released during an accident at a pesticide manufacturing plant in 1976.

- *We agree that the finding that children born on the Canal were more likely to be female is important and consistent with data from Seveso. For example, in the Discussion we state "As noted above, the ratio of female to male births was greater for all years than either New York State excluding New York City, or Niagara County. Additionally, this ratio was even greater for those children whose mother's conceived while living in the EDA compared to those who were conceived elsewhere. Sex ratios may change over time, and the explanations for such changes, particularly at the population level, have been a matter of controversy (94,95,96). There is some evidence that the sex ratio can change in response to certain toxic exposures. In Seveso, Italy, after a large accidental release of TCDD in 1976, the ratio of female to male births showed a clear increase among the offspring of young exposed males (defined by serum dioxin levels > 15 parts per trillion), and this effect persisted through the follow up period of approximately twenty years (97)"(pg 55).*

4) This study found that Love Canal residents had increased rates of cancer of the kidney, bladder, and lungs (DOH Report, p. 53). Several additional statistically strong findings were observed in several of the tables in the report, but all of these findings are dismissed due to "small numbers." According to DOH, "the numbers are too small to draw any meaningful conclusions" (DOH Report, p. 53). While this is true, increases in these three types of cancer are exactly what one would predict and expect in communities exposed to toxic chemicals and to not address this in any way is disappointing and does not do justice to the residents of Love Canal who want the truth about their exposures and the potential risks they face.

- *The small number of cancers of specific sites is a major limitation of the cancer incidence analysis, since as noted in Appendix N the only individual sites with 80% or greater power to detect at least a*

50% increase in incidence relative to upstate New York were lung, female breast, and prostate. There was a statistically significant elevation in bladder and kidney cancers combined for persons with childhood exposure, but we believe that it is difficult to draw meaningful conclusions to this finding since it was based on only two cases (pg 53). On pg 53 we note that the elevation in lung cancer incidence among Love Canal residents, although the not statistically significant, is consistent with the findings of Janerich et al. We have added to the Discussion and the Executive Summary additional language regarding the how other studies have linked bladder, kidney, and other cancers to chlorinated benzenes and anilines such as those found at Love Canal.

In summary, we are very disappointed in the way DOH has interpreted the results found in this study. DOH shows a clear bias in down playing virtually all of the positive findings in this report, especially the two-fold increase in congenital malformations found in children born to mothers who lived on the Love Canal at one time during their pregnancy. Conversely, DOH has no trouble discussing with confidence the negative findings in the report. We request that DOH re-examine the language it has used in this report and revise it. The agency should balance the presentation of their findings such that they speak equally to the positive findings as well the negative findings in this report.

It is also clear that the key findings in the this report, including cancer incidence, congenital malformations, and adverse pregnancy outcomes should be followed up over time and the results reported to the residents of Love Canal.

The lack of acknowledgment of the positive trends and findings in this study, even if they are not statistically strong, provide another example of the lack of sensitivity and understanding that DOH has for the residents of Love Canal. The people who lived through Love Canal want to know what their risks are and what they might expect for their children, more so than for themselves.

- *In summary, we agree that there are a number of positive findings, most notably for the adverse reproductive outcomes. We also agree that some of the cancer findings are consistent with those of other studies of persons exposed to chemicals similar to those found at Love Canal. We have revised portions of the Executive Summary and Discussion sections to better highlight these issues. We also agree that follow-up of these former Love Canal residents and their children should continue.*
- *The increase in birth defects for Love Canal women relative to upstate New York was statistically significant, as noted on pg 42 of the Results and on pg 63 of the Discussion. We have revised the Executive Summary to better highlight this finding and to draw greater attention to generally consistent pattern of findings for the reproductive outcomes. The limitations of the study are discussed in detail on pp 58-61 and summarized on pp 3 and 4 of the Executive Summary, including how the imprecise nature of the exposure assessment "would make associations more difficult to detect".*

<u>RESPONSE TO COMMENTS BY DR. RICHARD CLAPP</u>

On p. 3 of the executive summary, the authors caution against drawing conclusions from any single association, but then go on to say that results regarding higher proportions of female births, congenital malformations, and other adverse reproductive outcomes are consistent with other Love Canal investigations. In fact, this should strengthen the conclusion that these are real effects, as some previous investigators have claimed.

- *We have added language to the Executive Summary that strengthens the conclusions regarding the adverse reproductive effects.*

On p. 16, the authors say that this study "assesses differences in health status by exposure", but it doesn't "test the hypothesis that exposure to Love Canal chemicals caused adverse effects…". This confuses the process of reporting the results of a statistical analysis with a scientific judgment about cause and effect. The judgment is made based on the basis of more than just one study, but this study is a part of what a reasonable person should take into account. There is no need for this caveat in the text.

- *We agree, and the sentence has been modified accordingly.*

The authors note on p. 26 that they sought information on cancer incidence from eight states which most Love Canal residents migrated. Later, on p. 40, they note that 591 people left the state and only 324 resided in one of the eight states contacted; of these only seven state cancer registries responded, yielding eight cancers. If all the persons in the cancer incidence cohort were retained in the statistical analysis, this guarantees an under-ascertainment of cases and an underestimate of the SIRS for all cancers. Further evidence of the under-ascertainment of cancer cases is that there were 304 incident cases and 189 cancer deaths in the cohort. This ratio is lower than one would find in most communities and especially in a relatively young (median age in 1996=47) population. This should be clarified, and it would be of interest to know which state did not respond and how many former Love Canal residents resided there.

- *As noted on page 45, only the portion of the follow-up period in which they were New York State residents, and cancers diagnosed during that time, were included in the analysis. Hence, cancer incidence was not under ascertained due to how the SIRs were calculated. However, we do note on page 52 that the exclusion of cancers diagnosed among cohort members after they had moved from NYS may be at least partially responsible for the fact that the overall SIR is less than 1.0. Ohio refused to send us information regarding the one case of cancer diagnosed there among 50 former residents without approval from the patient. It is unlikely that omission significantly altered the result.*
-

On p. 47, and in various tables the authors note that bladder and kidney cancer were elevated in those who attended the 99th Street School. This is entirely consistent with exposure to chlorinated benzene compounds and aniline compounds noted on p. 6 as being dumped in the canal. Similarly, as the authors report on p. 48 and discuss on p. 56, the finding of an excess of female births for those with childhood exposure and being conceived on the Canal is consistent with findings in Seveso, Italy and several other studies.

- *As noted in our responses to the comments of Ms. Gibbs et al. above, we have added to the Discussion and the Executive Summary additional language regarding the how other studies have linked bladder, kidney, and other cancers to chlorinated benzenes and anilines such as those found at Love Canal. We also cite in the Executive Summary and Discussion how altered sex ratios have been reported for Seveso.*

On p. 49, the authors caution that "the likelihood of committing a type 1 error is much greater than the nominal five percent." Earlier, they note that several of the findings in this report are consistent with previous Love Canal investigations and with studies elsewhere. This reduces the concern about "multiple comparisons" since there is already evidence of some of the effects seen in the study. Again, this type of caution is unnecessary. In fact, the greater concern, given the likely misclassification of exposure and under-ascertainment of cancer incidence, is type 2 error (false negatives).

- *Type 1 errors due to multiple comparisons are an issue in this study, given the large number of statistical analyses that were conducted. Consequently, we argue on page 48 that "It is important not to over emphasize any single finding but instead to search for interpretable, coherent patterns of findings, since these are more likely to indicate valid and meaningful associations. For example, if several analyses show positive associations of a certain type of outcome with an exposure, or there is a pattern of associations that are biologically plausible, more weight should be given to these rather than a single finding." The pattern for the reproductive does indeed appear to be coherent, plausible, and consistent with earlier research. Consequently, we conclude on page 57 that "the general pattern of results in previous studies, together with that found in the current investigation, suggest children born to Love Canal mothers may have been at greater risk for a number of adverse reproductive outcomes compared to the general population". This point has also been added to the Executive Summary. We delineate in detail the limitations, including exposure misclassification and under-ascertainment of outcome, on pages 60 and 61.*

The authors note on p. 52 that there may be a regional difference in cause of death coding for acute myocardial infarction. The coding of death certificates is standardized and is based on what is written

on the death certificates. Presumably, all death certificates in New York Health Dept. files are coded by the same standard procedures. The more relevant question is whether physicians filling out death certificates use different language to describe heart disease deaths in Niagara County.

- *We have rephrased this sentence to more accurately state the issue of physician recording of cause of death than coding. We have also added the possibility that the regional differences in heart disease deaths may be involved.*

The discussion of cancer incidence on p. 53 is confused. Here, it says that the cancer incidence analysis "was limited to NYS residents" and that cancers in cohort members after they had moved from NYS were excluded. If this is so, then why did they seek to get information from eight other states where cohort members were likely to reside, and why did they mention getting eight cancers this way (on p. 40). Furthermore, the rates in comparison populations should be standard rates per year, calculated in the standard way using estimated annual populations; there is no reason to believe they are "inflated" as this paragraph suggests. This should be clarified and re-written.

- *We have rewritten the description on page 39 to more clearly indicate that given the poor yield of the out of state cancer search and also the fact that there were gaps in person-time from when these people left New York State and when the registries in these eight states began, the attempt to account for out-of state cancers was abandoned. Instead, we focused only the portion of the follow-up period in which they were New York State residents, and cancers diagnosed during that time, were included in the analysis.*
- *We have deleted the statement on page 53 regarding how the standard rates may be inflated.*

A further analysis that could be undertaken is to calculate proportional incidence ratios (PIR), which would not be influenced by under-ascertainment of cases that were missed by out-of-state registries. This could be a supplemental analysis that would provide more support for the rate-based analyses.

- *Although a PIR analysis of cancer could be conducted, it would not measure the risk of developing cancer since it does not take into account person-time. The PIR for a given cancer site is also affected by the frequency of other sites, rendering an interpretation of the results difficult.*

Tables 8-11 and Appendix H all show excess liver and gall bladder, bladder and kidney cancer, and myeloma and immunoproliferative system cancer incidence. These findings are consistent with solvent and aniline dye-exposed persons and with the findings of the Seveso, Italy studies of dioxin-exposed persons. Further analyses with respect to childhood exposure and living near "hot spots" reinforce the conclusion that this is related to Love Canal exposures. Similar conclusions follow from the analyses of altered sex ratio and adverse reproductive outcomes in Tables 24 and 25 and Appendix S.

There seems to be considerable evidence of adverse health and reproductive outcomes in the Love Canal cohort that reflect findings by previous investigators and other studies. The authors are encouraged to state his more clearly in their discussion and conclusions.

- *We have added to the Executive Summary and Discussion language emphasizing the consistency of the cancer and reproductive findings with those of other studies.*

RESPONSE TO LOVE CANAL CITIZEN'S COMMENT

Faxed in message:

Very good job – thank you everyone for your efforts. One comment on the limitations and strengths, p. 58 overstates the study provided for a sufficiently long latency period, and understates on page 62, despite the long period between date of first exposure and of follow-up….it remains possible as the cohort ages, more cases of chronic disease such as cancer will develop. This speaks to the latency issues and power to develop patterns of incidence of disease from exposure. Perhaps a comment that would suggest a follow-up of the cohort at some period in time would help the community understand the impact of Love Canal exposure.

- *The recommendation of further follow-up has been added to end of the report.*

Jean Connell's Letter:

I wanted to respond in writing to the Love Canal Study. A little heart trouble (stent) prevented me from doing it sooner, but I am feeling better. My doctor and I likely would have delayed in pursuing it had it not been for the study. You see how important your work is and how it can affect people everyday.

I think it is a very promising study. There is an unwritten axiom in the workplace, if you want something to get done quickly; you appoint it to one or two people. Because of all the political pressure and special interest groups, the study had to be done by consensus. You let anyone who was involved or interested take part, including me who only found out three years ago that I spent the first three years of my life in Griffin Manor. Thank you for letting me be involved, to the small extent I was. It was a mountain of work and all your staff are to be commended.

In reading the Fall 2006 Health Study Summary, I learned that the researchers had taken the extra step of contacting the hospitals to retrieve the birth records from 1970 to 1982. That is excellent, although it did not produce large numbers to add to the survey. A good thing when you are talking about birth defects.

Someone had mentioned on one of the phone conferences, that it is hard to find a pristine group of cohorts in New York State (or possibly worldwide) due to the above ground nuclear tests by the US and other nations. When reading into the subject, I learned that heavy doses were reported in Troy, NY from the US 1950s tests. Is there an increase in the number of thyroid cases being reported in this area, as I have heard?

Interestingly, the book on the nuclear tests said massive doses were also reported in Midland, Texas in the early 50s. I don't know if it is related, but when I read Barbara Bush's autobiography, she and George lost their precious daughter Robin to leukemia in 1953. They had to take her to New York City for treatment because the doctors in Midland were not that familiar with the disease.

Another consideration that hampers finding a pristine cohort group would be nuclear reactors in New York and other states. Also, a border county could be affected by toxic waste in another state or Canada.

Lastly, I would like to request that further study be one on the residents of the 8th ward of Niagara Falls from say 1942 to 1975? Some will be in your first study. Many moved away. I enclose a copy of Polk's City Directory, just for Angevine Street from 1946 to 1954. Other years are available in the Niagara Falls Public Library and the New York State Library. If you took a map of the Love Canal region, Rings 1-4 and placed it next to an earlier map, you could see it appears to be the 8th ward.

A spreadsheet could be easily prepared, by clerks, with street information, name, years of residence, place of employment. It could be cross referenced with school records, public and parochial schools to obtain children's information. You have the doctors, the statisticians, the epidemiologists, the toxicologists. There must be someway to prepare a study with this data base.

What I have learned from my studies is that Hooker Chemical was a contractor for the Federal Government. This was in the newspapers. Other companies (DuPont) dumped in Love Canal. The City of Niagara Falls had employees that worked by the Canal. The City had to buy new clothes and shoes for the employees when their apparel would disintegrate over a weekend after a Friday working on the Canal.

Finally, and inconceivably, see the attached Niagara Gazette page 26, 2/13/53, R.W. Hooker, who was VP of Sales for Hooker Chemicals was in charge of the citizens committee that decided where the schools would be placed. Mr. Hooker was listed in Who's Who in American Chemists. His uncle was

John D. Rockefeller III. He may not have had a full comprehension of what he was doing, but he was culpable.

Please ask for additional funding to do a study on the earlier residents. You do not need the records from Griffon Manor. The residents are listed by street.

The preset Love Canal study is very good. It gives warning so that people can watch their health. If Love Canal were a fluke, there would be no further need of studies. We know it is not. If you use the earlier database, you at least give a higher purpose to their suffering and death. Thank you.

- *As you note, there are few if any communities that are "pristine" in terms of not being impacted in some way by environmental pollution. The choice of Niagara County as a comparison group allowed us to assess the health status of Love Canal residents specifically relative to other persons in the surrounding area. We agree that further follow-up is warranted.*

Luella's e-mail:

I find this whole report is another slap in the face not only to Love Canal residents, but to everyone who is caught up in similar circumstances. I can see this being heralded by chemical companies as their vindication, instead of this report being a benchmark to protect future generations.

We have frequently discussed the limitations of this study because we did not get the cooperation of many of the former residents and the lack of available data. This report will further drop DOH's credibility with the residents and jeopardize any future studies that may be planned. I was present when this report was given to the Love Canal Medical fund. I saw the reaction of some of the former residents who had to leave the room as they were told that the increase in birth defects was not significant. The figures, the science, and the stats may be cold data, but we must remember that there are human beings behind the data that should be of prime concern.

The science was done with the available information, and a lot of hard work went into this whole project. We knew from the beginning that there were limitations, and yet we still saw some indication of the effects of exposure. This leads me to wonder what we would have seen if indeed we had truly comprehensive study covering all the years. The limitations need to be clearly and strongly addressed so that there is no misinterpretation or misconception. I know the dates of the cancer registry are there as well as the birth defects and cancer registries, but these facts are missed especially if taken out of context.

The former residents of Love Canal have been exposed because of greed and ignorance, and that cannot be changed. However, we should be concerned about the harm to future generations by this report.

- *The increase in birth defects from 1983 to 1996 is statistically "significant" and is highlighted in the Executive Summary and Discussion as being one of the most important findings in the study. The limitations of the study also are highlighted in those two sections.*