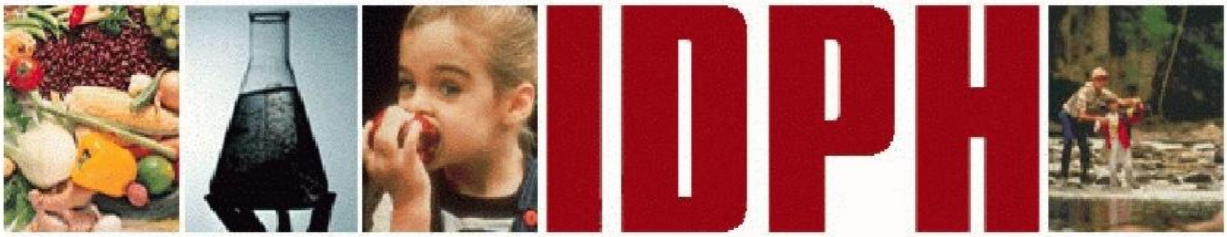

Illinois Department of Public Health ▪ Pat Quinn, Governor ▪ Damon T. Arnold, M.D., M.P.H., Director

INCIDENCE OF CANCER IN THE VILLAGE OF CRESTWOOD, (COOK COUNTY) ILLINOIS

1994-2006

Prepared by the

Division of Epidemiologic Studies
Illinois Department of Public Health

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Executive Summary

In response to concerns about cancer incidence in Crestwood related to the contamination of the area's drinking water system with probable or known cancer-causing chemicals, a cancer assessment was initiated by the Illinois State Cancer Registry (ISCR), Illinois Department of Public Health. Cancer cases collected from the area by the ISCR from 1994 to 2006 were geocoded and assigned by address to Crestwood. A total of 952 cancer cases were identified and compared, by cancer site, race and gender group, to expected cases from two reference groups, defined in this assessment as Cook County and Illinois. The assessment identified several cancers as significantly elevated in Crestwood: lung cancer in males and females (standardized incidence ratio, SIR=1.34 in males; SIR=1.35 in females), kidney cancer in males (SIR=1.92), and most gastrointestinal (GI) cancers in males: oral cavity and pharynx (SIR=1.73), esophagus (SIR=2.00) and colon-rectum (SIR=1.40). GI cancers, as a combined group that includes oral cavity and pharynx, esophagus, stomach and colorectal cancers, were also significantly elevated among males when assessed collectively (SIR=1.48). All the increases were limited to whites, which represented more than 90 percent of the potentially exposed population. Other cancer sites, in any gender or race combination, were not elevated. A number of risk factors, such as smoking, diet, hereditary background and workplace exposure to harmful chemicals, are known to be associated with these cancers, but their relative presence in the area could not be evaluated. It is possible that the historical presence of PCE and its degradation products in the Crestwood water contributed to the increase of these cancers. Due to methodological and data limitations, however, the assessment could not establish with certainty this relationship, nor rule out such a possibility. Future monitoring of the area's cancer incidence is needed to evaluate possible changes in cancer incidence following the discontinuation of the contaminated drinking water. Without regard to causation, increasing education and intervention programs in the area to promote cancer screening, particularly colorectal cancer screening, is recommended.

Introduction

Following a news media report in April 2009 about the potential contamination of city water with 1,1-dichloroethylene, 1,2-dichloroethylene, and vinyl chloride in the Village of Crestwood (http://www.chicagotribune.com/news/local/chi-crestwood-water-story,0,1734272.story), concerns were raised about the area's cancer incidence, as some of the contaminants are either a known human carcinogen (vinyl chloride) or a possible human carcinogen (1,1-dichloroethylene), and all are considered breakdown products of perchloroethylene (PCE), an organic solvent widely used in the dry cleaning industry, and also a probable human carcinogen. In response to this concern, the Division of Epidemiologic Studies, Office of Policy, Planning and Statistics of the Illinois Department of Public Health, initiated this assessment of cancer incidence for Crestwood.

Background

(Part of this section was abstracted from the Draft Health Consultation on Crestwood Groundwater Contamination, Illinois Department of Public Health under cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR) and from the Illinois EPA's Fact Sheet on Crestwood Public Drinking Water Contamination, May 2009)

In December of 2007, the Illinois Environmental Protection Agency (IEPA) determined that the Village of Crestwood had been using Crestwood Community Well #1, a known contaminated well, as a water source and mixing this well water with public water from 1985 to 2007 without informing the IEPA or its water customers. The Crestwood Community Water Supply provides water to approximately 11,000 persons (Map 1).

Site Description and History

Crestwood Community Well #1 was constructed in 1959 to a depth of 345 feet below the ground surface. The well is about 245 feet southeast of a dry cleaning facility in the Playfield Plaza Shopping Center in Playfield Park. Starting in 1972, IEPA inspections documented that Lake Michigan water was being used as a primary source of drinking water for Crestwood public water, and that Well #1 was an emergency stand-by well. In 1985, under an IEPA state-wide drinking water source sampling program for volatile organic compounds (VOCs), a water sample from Well #1 was collected and analyzed by IEPA and found to contain 1,1-dichloroethylene (DCE) at 2.8 micrograms per liter (µg/L).

In 2007, IEPA implemented a new requirement to sample emergency wells of community water systems. The samples collected by both Crestwood and IEPA showed vinyl chloride and cis-1,2 DCE in Crestwood Well #1. IEPA discovered that Crestwood had been supplementing the Lake Michigan water supply with water from Well #1, which based on available records from 1999 to 2007, averaged about 10 percent of Crestwood's water distribution per month, with peaks of 20 percent per month. Through independent investigation of records, IEPA determined that the well had not been used since November 2007.

Water Sampling For Contamination

No information regarding the sampling of VOCs in Crestwood Community Well #1 has been identified before 1985.

In 1985, Well #1 was found by IEPA to contain 1,1-DCE at 2.8 µg/L. DCE is a breakdown product of the dry cleaning solvent, perchloroethylene (PCE). Samples collected

from Well #1 in 1998 by a private consultant found another dry cleaning solvent breakdown product, cis-1,2 DCE, at 3 µg/L.

In 2007, in response to a new requirement to sample emergency wells of community water systems, IEPA and Crestwood both collected water samples from Well #1. The results showed cis-1,2-DCE in multiple samplings from 2007 to 2009 with a maximum level of 2.6 µg/L. In addition, another breakdown product of PCE, vinyl chloride was found.
In 2009, using groundwater modeling methods and bedrock monitoring which found vinyl chloride (55.7 µg/L), cis-1,2-DCE (14.0 µg/L), and trans-1,2-DCE (0.57 µg/L), IEPA and Illinois State Water Survey hydro-geologists concluded that the Playfield Plaza dry cleaners was the source of the well contamination.

Comparison Levels

IDPH compared the results of each shallow groundwater sample collected from Crestwood Well #1 with the appropriate comparison values, specifically United States Environmental Protection Agency (USEPA) maximum contaminant levels (MCL) and maximum contaminant level goals (MCLG) for drinking water, to select chemicals for further evaluation for exposure and possible carcinogenic and non-carcinogenic health effects.

Once USEPA has selected a contaminant for regulation, it examines the contaminant's health effects and sets a maximum contaminant level goal (MCLG). This is the maximum level of a contaminant in drinking water at which no known or anticipated adverse health effects would occur, and which allows an adequate margin of safety. For most carcinogens (contaminants that cause cancer) and microbiological contaminants, MCLGs are set at zero because a safe level often cannot be determined. MCLGs do not take cost and technologies into

consideration. The Maximum Contaminant Level (MCL) is the highest level of a contaminant that is allowed in drinking water. MCLs are set as close to MCLGs as feasible using the best available treatment technology and taking cost into consideration. MCLs are enforceable standards.

The following describes specific chemicals detected in Crestwood Well #1 relative to corresponding USEPA comparison levels:

1,1-dichloroethylene:

MCL and MCLG = 7 micrograms per Liter (µg/L) or 7 parts per billion (ppb).

Health Effects: Drinking water containing 1,1-dichloroethylene in excess of the MCL over years can produce liver disease and a possible human carcinogen.

Exposure: 1,1 dichloroethylene was detected in a sample in 1985 at 2.8 µg/L or 2.8 ppb, which is less than both the MCL and MCLG of the USEPA and therefore judged to be below a level associated with adverse health effects.

1,2-dichloroethylene:

MCL and MCLG = 70 micrograms per Liter (µg/L) or 70 parts per billion (ppb).

Health Effects: Drinking water containing cis-1,2-dichloroethylene at levels significantly in excess of the MCL over years may cause liver disease.

Exposure: 1,2 dichloroethylene was detected in multiple samples between the years 1985 and 2007 less than 3.0 µg/L or 3 ppb, which is less than both the MCL and MCLG of the USEPA and therefore judged to be below a level associated with human disease.

Vinyl chloride:

MCL = 2.0 micrograms per Liter (ug/L) or 2 parts per billion (ppb), MCLG = zero.

Health Effects: According to ATSDR Toxicological Profiles, the effects of ingesting vinyl chloride in drinking water at low concentrations are unknown. Some workers who have breathed vinyl chloride for a number of years have changes in the structure of their livers; others who have worked with vinyl chloride have nerve damage or immune reactions. These have been seen in workers with high level exposures yet the lowest levels that produce these changes are not known. Studies of long-term exposure in animals showed that cancer of the liver and mammary gland may increase at moderate levels of vinyl chloride in the air (50 ppm). Lab animals fed low levels of vinyl chloride each day (2 mg/kg/day) during their lifetime had an increased risk of getting liver cancer. The U.S. Department of Health and Human Services and the USEPA have determined that vinyl chloride is a known carcinogen. A rare cancer, angiosarcoma of the liver is known to be associated with exposure to vinyl chloride.

Exposure: The highest level of vinyl chloride detected in Crestwood Well #1 was 5.4 ug/L in October 2007 and was again detected at 4.9 µg/L in April 2008. Because the measured levels exceed the 2 ug/L MCL and the zero MCLG, IDPH conducted the current study of specific cancer rates for people who drank water from the municipal supply variably contaminated with Well #1 water in Crestwood.

Methods

Area of Concern, Case Geocoding, and Case Selection

According to information from the Illinois Environmental Protection Agency (IEPA), the area of potential exposure was confined to the Crestwood public water supply area, which approximately follows the city limits of Crestwood (see Map 1 of water district and Crestwood city limits). Using this exposure area to define the study area, however, posed some significant

challenges to the existing cancer assessment practice of the Illinois State Cancer Registry (ISCR), which collects statewide and population-based cancer incidence information and served as the data source for the present assessment.

When there is a known exposure to a substance that has potential for increased risk of cancer, the long standing practice of the ISCR has been to use the ZIP code to define the geographical area for a cancer assessment. The ZIP code is used because it is the smallest geographical unit where 100 percent of ISCR's data are reported and assigned with a geocode to the ZIP code level through geocoding, a process of assigning geographic coordinates to data. Due to missing or incorrect address information, or the presence of a post office box or a rural route, only about 90 percent of the registry's cases can be assigned a geocode at an address level, but 100 percent of the cases can be assigned to the center point or centroid of the ZIP code. However, selecting cancer cases simply by the ZIP code was not a viable option for this assessment because the ZIP code area for Crestwood, 60445, contains the village of Midlothian (see Map 2), which is not part of the Crestwood public drinking water supply (see Map 1). Selecting cases by the Crestwood city name could not capture all the cases either because of misspelled or misplaced city names, or incorporated city names different from postal delivery assigned city names that were reported to ISCR. To ensure that the assessment included all cancer cases of Crestwood and only cancer cases of Crestwood, all of the cases in and around Crestwood needed to be reviewed and geocoded to the address level. The following data quality and geocoding improvement on addresses were performed.

First, since ZIP codes are nearly 100 percent accurate, all cases residing in ZIP code 60445 and the surrounding four ZIP codes areas (60803, 60472, 60463, and 60452, as shown on Map 2) that were diagnosed between 1994 and 2006 were selected. This broad selection was

made to ensure all potential Crestwood cases were captured for further review. The 13-year period was chosen because it contained the most recent and complete cancer incidence data collected by ISCR. This data set provided an initial latency of at least 10 years from the first documented exposure. A total of 7,086 cases were identified from this five ZIP code catchment area.

These cases were then reviewed for correct city/county and correct ZIP code. Five cases with an incorrect city/county and 20 cases with an incorrect ZIP code that were not in the selected area were excluded (0.35 percent of the total). Of the remaining 7,061 cases, 96 percent (n=6,781) had an address level geocode. This left 280 cases (4.0 percent) without an address level geocode. Using several mapping and address verification tools such as Accurint™, a commercial service, and online assistance of Google® Earth, Google® Maps, Mapquest®, Yahoo® maps, Anywho, Melissa Data®, MapInfo and other sites, 256 of the 280 cases were able to be assigned an address. The remaining 24 cases (0.3 percent of the total), most with a geocode assigned at the center point of a ZIP code outside of Crestwood, were further excluded as the actual address could not be confidently assigned to Crestwood.

Finally, cases with an address level geocode (n=7,037 or 99.7 percent of the initial total) were plotted using MapMarker® Plus Version 14.2.2.0.23 Release Build, USPS Data Vintage February 2009 and Geographic Data Vintage February 2009. The initial set of geocoded addresses was projected onto a map of the five ZIP codes using ESRI ArcMaps 9.3 (build 1850), and those cases within the boundary of the Village of Crestwood (provided by NAVTEQ and created on 2/6/08) were ascertained using the "Select by Location" function.

A total of 958 cases from 1994 to 2006 were identified by this process for Crestwood, of which six were missing race information. Since the race variable was needed for analysis, these

six cases (<1 percent of the total) were further excluded. A total of 952 cases were available for the subsequent analysis.

Among the cases residing in the study area, some were reported by both Illinois health facilities and out-of-state facilities. No cases were reported only by out-of-state facilities. Duplicate reports for a case by multiple facilities, whether in or outside Illinois, were consolidated into a single case following standard procedures for cancer registry operation. The ISCR is the only population-based cancer registry in Illinois. It has received the highest level of national certification possible from the North American Association of Central Cancer Registries (NAACCR) annually from 1996 for its data completeness, quality and timeliness. As of November 2008, the statewide completeness of case reporting from all reporting sources, assessed using the NAACCR Standard (NAACCR, 2000), is considered to be 100 percent complete for the time period 1994 through 2006 as used for this assessment.

The 2000 Census city boundaries used to select "Crestwood" cases are shown in Map 3. The selection closely matched the Crestwood water distribution area (see Map 1).

Analyses and Comparisons

All cancer cases from Crestwood were grouped by tumor site, race, sex, and age. These are referred to as the *observed* cases. Age-, sex-, and race-specific rates from a comparable population in Illinois were applied to each age group of the study population (indirect age-adjustment) and to each tumor site to obtain an *expected* number of cases for the area (Mattson, 1986). The commonly used tumor site groups included oral cavity and pharynx, esophagus, stomach, colon and rectum, liver, pancreas, lung and bronchus, bone, melanoma, breast, cervix,

uterus, ovary, prostate, testis, bladder, kidney, Hodgkin lymphoma, non-Hodgkin lymphoma, multiple myeloma, leukemia, and all other cancers.

The comparable population was defined as the population in a reference area with a similar population density as the study area and with a large enough population to provide stable rates (Howe, et al., 1993). ISCR has defined and maintained four reference groups (urban Cook County, suburban 5 collar counties, small urban with 13 counties and rural with 83 counties) for Illinois based on population density, rate of growth, Beale codes (a classification of geography originally developed by Calvin Beale at the USDA, 1975) and a total population of at least 2 million. The comparable population for Crestwood was Cook County, because its population density and other demographic characteristics matched those of the study area better than any other reference groups and it is in Cook County where Crestwood is located. The state of Illinois was also used as an additional reference for verification purposes.

Age-, sex-, and race-specific population counts for the study area for each year were not available from the United States Census Bureau. Therefore, for the assessment period, 1994-2006, Census data (age-, sex-, race-specific) for Federal Information Processing Standard (FIPS) place code of 1717497 or the village of Crestwood in 2000 (see Map 4) was multiplied by 13 to obtain the estimated total population for the entire assessment period. The population for the village of Crestwood remained fairly stable between the 1990 and 2000 census, with a total population count of 10,823 and 11,251, respectively. The total population increased by only 428 (4 percent) during the 10 years between 1990 and 2000, and the racial distribution remained very similar (whites in 1990 were 94.3 percent; in 2000, 92.5 percent were white; blacks in 1990 were 4.0 percent, in 2000 blacks were 4.5 percent; and all other races combined in 1990 were 1.7 percent, and in 2000 all other races were 3.0 percent).

Age-, sex-, and race-specific population counts for the reference area for each year were obtained from the Surveillance, Epidemiology and End Results (SEER) website (at http://seer.cancer.gov/popdata). They represent a modification of the annual time series of July 1 county population estimates by age, sex, race and Hispanic origin produced by the Population Estimates Program of the United States Bureau of the Census with support from the National Cancer Institute through an interagency agreement. The population estimates now incorporate bridged single-race estimates for April 1, 2000 that are derived from the original multiple race categories in the 2000 census (as specified in the 1997 Office of Management and Budget standards for the collection of data on race and ethnicity). The bridged single-race estimates and a description of the methodology used to develop them can be found on the National Center of Health Statistics (NCHS) web site http://www.cdc.gov/nchs/about/major/dvs/popbridge/popbridge.htm. The citation for the population is: Surveillance, Epidemiology and End Results (SEER) Program Populations (1969-2006) (www.seer.cancer.gov/popdata). National Cancer Institute, DCCPS, Surveillance Research Program, Cancer Statistics Branch, released April 2009.

The observed number of cases was compared with the expected number of cases for all sex-, race-, and site-specific categories. Standardized incidence ratios (SIR) and their 95 percent confidence intervals (95 percent CI) were calculated (Kelsey, et al., 1996). An SIR is the ratio of the observed number of cases to the expected number of cases, and an SIR greater than 1.0 or less than 1.0 indicates either an increase or a decrease in observed cancer cases. A change in SIR is judged statistically by the SIR's confidence interval (CI) and if the CI does not include 1.0, the change is regarded as statistically significant. A statistically significant change means the change, as judged by statistical evidence, is unlikely to have occurred by chance. The

'unlikelihood' of the change or difference is quantified by a probability value (p-value) -- a p-value of 0.05 means that there is only one chance in twenty that the change could have happened by coincidence. A value not contained within the 95 percent CI has the same meaning. These values are affected by both the strength of the effect, prevalence of the disease, and the size of the population studied. With many age, sex, race and cancer site combinations to be compared, the number of pairwise statistical significance tests to be performed was estimated to be close to 250 in this assessment. This number of comparisons would produce some elevated risks by chance and therefore each association from this study cannot be judged to demonstrate a true association. Further, lack of demonstrated elevated risk, especially with respect to rare cancers, cannot eliminate that they may be associated with the exposure. It only means that this study provided no evidence for an association.

When the observed number of cases is greater than zero but less than six for a specific tumor site, the number was not listed in any table of this report (but aggregate findings, if relevant, were mentioned in the text). If possible, small numbers were grouped with other sites within body organ systems, or when not possible, they were included in the *All Other Sites* category.

As mentioned previously, since race-specific numbers were used in analysis, cases reported with unknown race were excluded. For the reference group (Cook County) 1.0 percent of the cases were excluded and for the study area 0.6 percent of the cases were excluded for unknown race. Cancer site distributions remained the same for the reference group after the exclusion and cancer of the excluded cases (n=6) for the study area included only lung, melanoma, prostate, and other sites. Due to small numbers of cases for minority races, race-specific numbers were aggregated to maintain data confidentiality. For both observed and

expected numbers, these aggregations resulted in a presentation of total races by gender and by cancer site.

Findings and Comments

Comparisons of cancer cases in Crestwood with those in Cook County or with those in Illinois generated similar findings. Therefore, only results from comparing with Cook County are presented.

Angiosarcoma of the Liver and Liver Cancers

As shown in Table 1, there were no cases of angiosarcoma of the liver observed in Crestwood, nor in any of the five ZIP code areas including or near Crestwood. The negative finding of hepatic angiosarcoma, although it appeared to be assuring, was not unexpected given the fact that this is an extremely rare cancer (Falk, et al., 1981), and even though it has been identified as the major cancer associated with vinyl chloride exposure, the assessment, due to its limited sample size and small geographic coverage, would not have been expected to find cases in a community the size of Crestwood even if there had been substantial exposures to vinyl chloride in the water or air over years. Existing data also suggest that extremely high levels of exposure to vinyl chloride are necessary for the tumor's induction in humans (London and McGlynn, 2006). High doses of exposure are not typically found outside workplaces, which probably explained why a relationship between angiosarcoma of the liver and vinyl chloride has not been demonstrated in the nonoccupational setting.

There has been growing evidence indicating that vinyl chloride is associated with other liver cancers (Boffetta, et al., 2003). For liver cancer, of which about 60 percent of cases were

hepatocellular carcinoma, the observed number in Crestwood was eight cases as compared to the six cases expected among males (SIR=1.33; 95 percent CI 0.57 to 2.63), and the observed number was six cases as compared to the three cases expected for females (SIR=2.0; 95 percent CI 0.73 to 4.35) (Table 2). Numerically, the observed number was higher than the expected number. However, the confidence intervals stretched well around 1.0 and therefore this finding might well be due to chance. As with angiosarcoma of the liver, human studies of exposures to vinyl chloride that showed the positive relationship with liver cancer were only observed in occupational settings where exposure doses were much greater than those expected in nonoccupational settings (London and McGlynn, 2006; Bosotti, et al., 2003).

For additional assurance that no cases of these two types of cancers were missed, a search was also conducted among the data earlier excluded from the assessment and among death certificates, which were collected and maintained by the Department's Vital Records Division. No additional cancer cases were found for Crestwood.

Other Cancers

Statistically significant increases were found for lung cancer in both males and females, and for kidney cancer and almost all gastrointestinal (GI) cancers in males. Specifically, the differences were as follows (Table 2): lung cancer – 79 cases observed with 59 cases expected in males (SIR=1.34; 95 percent CI 1.06 to 1.67) and 89 cases observed and 66 cases expected in females (SIR=1.35; 95 percent CI 1.08 to 1.66); kidney cancer – 23 observed with 12 expected in males (SIR=1.92; 95 percent CI 1.21 to 2.88); oral cavity and pharynx cancers – 19 observed with 11 expected in males (SIR=1.73; 95 percent CI 1.04 to 2.70); esophagus cancer – 12 observed with 6 expected in males (SIR=2.00; 95 percent CI 1.03 to 3.49); and colorectal cancer

– 63 cases observed with 45 cases expected in males (SIR=1.40; 95 percent CI 1.08 to 1.79). Unlike lung cancer, which increased in both males and females, kidney and GI cancers were found to be increased only in males (Table 2).

When all GI cancers were combined into a single group to include oral cavity and pharynx, esophagus, stomach, and colorectal cancers, a statistically significant increase was observed in males (105 observed vs. 71 expected; SIR=1.48; 95 percent CI 1.21 to 1.79). This overall GI cancer elevation was not seen in females (Table 2).

There were no significant differences in cancer incidence found for bone, melanoma, breast, cervix, uterus, ovary, prostate, bladder, Non-Hodgkin lymphoma, and leukemias, in any race and gender combinations. Race-specific analyses indicated that all of the increases were in the white population. No cancer increase was found among other races.

Although not shown in Table 2 due to the small numbers of cases, there were 7 cases observed with 11 cases expected for nervous system cancers for both sexes and all races combined. For childhood cancers (aged 0-14), the observed number was less than expected (both the observed and expected numbers were less than six).

The following are specific comments on the significantly elevated cancers:

Lung Cancer

Lung cancer is the number one cancer in the United States. It is one of the most fatal cancers, and is known to be strongly associated with cigarette smoking. It is estimated that in the United States, more than 90 percent of lung cancer cases and deaths are caused or attributable to tobacco smoke. Other risk factors include exposure to asbestos, mustard gas, polycyclic aromatic hydrocarbons, chloromethyl ethers, arsenic, chromium, nickel, silica, ionizing radiation, air pollution, and radon in the home environment (Prüss-Üstün and Corvalán, 2006; Spitz, et al.,

2006). Early research suggested a possible role of vinyl chloride in lung cancer, but subsequent larger and more complete studies have failed to demonstrate such an effect (Siemiatyckl, et al., 2006; Berwick, 2006).

A number of studies have found PCE and other related volatile organic compounds (VOCs) as possible risk factors for lung cancer, but studies have not been consistent (Cantor, et al., 2006). PCE has not been detected in samples from the contaminated drinking water source in Crestwood, but the detection of its degradation products in the source well and the long period of water mixing suggested its past presence in the village's drinking water system.

Kidney Cancer

In the United States, the incidence for cancer of the kidney is increasing in both sexes with the increase in males greater than in females. It occurs most commonly among white males. Common risk factors include smoking, obesity, and hypertension. Studies have also consistently suggested that occupational exposure to asbestos, cadmium, some herbicides, benzene, and organic solvents increases the risk for developing kidney cancer (McLaughlin, 1996; McLaughlin, et al., 2006; Chow, et al., 2000).

Of the organic chemicals that are associated with kidney cancer, PCE is noteworthy due to its possible presence in the contaminated Crestwood water. PCE is known to cause kidney toxicity, and in animal studies it has been shown to cause kidney cancer (particularly in male rodents) (McLaughlin, et al., 2006; ATSDR, 1997). Since kidney cancer could be related to occupational exposure and it occurred more among males, a reasonable question could be raised about whether the male-only higher incidence in the study area could be occupationally-related. The incomplete occupation information for the majority of the cases in the registry data

precluded such an evaluation in this assessment. Additional research may be needed to further explore this scenario.

GI Cancers

The assessment noted an overall elevation of GI cancers among males in Crestwood. GI cancers include oral cavity and pharynx, esophagus, stomach and colorectal cancers, each of which involve a set of common as well as distinctive risk factors and epidemiology profiles, and often have water ingestion as a common pathway of exposure. While causative conclusions clearly cannot be drawn here with respect to the contaminants and these cancers in Crestwood, the elevated rate of GI cancers should prompt a consideration of implementing secondary prevention interventions as many effective screenings exist for these types of cancers (e.g., colorectal cancer, as a major GI cancer, can be screened and even prevented by periodic occult blood stool testing and colonoscopy).

The synergistic involvement of alcohol and tobacco use in the promotion of cancers of the oral cavity and pharynx are well known, and the increased risk could be 30-fold for these cancers. Recently, human papilloma viruses have been associated with certain types of these cancers (ACS, 2009; Mayne, et al., 2006). The strong interaction from alcohol and tobacco would support the increased attention to smoking cessation and alcohol reduction campaigns in this area.

The incidence of cancer of the esophagus occurs more frequently in males than females and the risk increases with age. Tobacco and alcohol use are the major risk factors with the combined risk from tobacco and alcohol use being greater than from tobacco or alcohol use alone. Exposure to ionizing radiation also increases the risk for esophageal cancer. Occupational

studies have shown an increased risk with heavy exposure to PCE and trichloroethylene (TCE) (Blot, et al., 2006).

Worldwide, the incidence rate of stomach cancer is highest in Japan, China and Eastern Asia and lowest in the United States and Northern Africa. The rate of stomach cancer in the United States has steadily been decreasing since 1975. The risk is higher in males than females, higher in blacks than whites, higher among Hispanics and the highest among Asian and Pacific Islanders. Chronic infection with *Helicobacter pylori* is the strongest risk factor for stomach cancer. Other risk factors include family history of stomach cancer, previous stomach surgery, pernicious anemia, use of tobacco, and diets high in salt, salted foods, and smoked fish and meat. Eating fresh fruits and vegetables that contain antioxidant vitamins appears to lower the risk of stomach cancer (Shibata, et al., 2006).

Cancers of the colon and rectum are the third most common cancer in both males and females. About 91 percent of the cases occur after age 50. Common risk factors for colorectal cancer include obesity, physical inactivity, a diet high in red or processed meats, heavy alcohol consumption, and long-term smoking. Other risk factors include certain inherited genetic mutations, a personal or family history of colorectal cancer and/or polyps, a personal history of chronic inflammatory bowel disease, and non-insulin dependent diabetes (Schatzkin, 1996; Giovannucci and Wu, 2006).

Fewer colorectal cancers in this group were diagnosed at an early stage when compared to the county as a whole (30.0 percent for the area vs. 34.9 percent for the county). This suggests that the area could benefit from increased education and programs promoting colorectal screening perhaps sponsored by the county health department and health care institutions in the area. As a general guideline, the American Cancer Society (ACS) recommends that people start

colorectal cancer screening beginning at age 50. People with family history of colorectal cancer and other colorectal cancer risk factors (e.g., adenomatous polyps) should talk to their doctor about starting screening earlier and/or being screened more often.

Elevations in overall GI cancers are a relevant issue with drinking water contamination of potentially harmful chemicals such as PCE. A number of epidemiological studies found that PCE was associated with a wide range of cancer sites, including cervix, breast, prostate, ovary, kidney, lung, esophagus, colon-rectum, Non-Hodgkin lymphoma (NHL), liver, bladder, and leukemia (ATSDR, 1997; Paulu, et al., 1999; ATSDR, 2009). Although many of these findings are still debatable, existing evidence seems to indicate a consistent association between PCE and some GI cancers, especially esophagus cancer (Siemiatyckl, et al., 2006; Blot, et al., 2006).

As with kidney cancer, the male-only pattern of increase in GI cancers probably suggested higher sensitivity of males, or exposure to different risk factors/carcinogenic chemicals, or both. The present assessment, however, could not provide clear answers to these questions.

Analytical Considerations

The present assessment has several significant limitations that need to be considered. First, due to the lack of annual population data from the Census for the "Village of Crestwood," the 2000 Census population numbers (multiplied by 13 to match the 13 years of cancer cases) were used. Even though the assessment period included six years prior and six years after 2000 and there was little change in the population from 1990 to 2000 (see Methods section), these imprecise denominator numbers, when used to derive race- and sex-specific expected numbers,

might have introduced errors and biases to the comparison, of which neither the direction nor the magnitude was known.

Second, many potential risk factors to cancer, including occupation, diet, lifestyle, family history, and other medical conditions, are not collected by the current surveillance system and, as a result, their inclusion for analysis was not possible. Living in Crestwood at the time of diagnosis was used to represent potential exposure to possible carcinogens from the contaminated drinking water, but it was a very crude proxy. The lack of case-level information on the history of residence and individual water consumption for each case and the general population in the study area made more refined analysis and comparison impossible. The lack of control for other potential carcinogenic risk factors between Crestwood and Cook County as a whole was not absolutely necessary when there was no evidence of any unique characteristics of the Crestwood population, but it would have strengthened the conclusions. It has been recognized that some 'group-level' risk factors, such as the type of industry and employment in the area, can be different from one neighborhood to another, creating a 'geographic cluster' that is independent of the specific environmental factor under consideration (Selvin, 1996; NCI, 2009; Brautbar, 2005; Rom, 1992; Rothman and Poole, 1996; Lave, 1996; Robinson, 2002).

The lack of information on actual exposure is particularly noticeable. There is considerable uncertainty about the chemical hazards - length and the level of exposure that people in Crestwood may have experienced in the past - in the Crestwood drinking water supply. With the lack of sampling data, it is impossible to know the degree of chemical contamination that has existed in the Crestwood drinking water supply, and with the presence of many other etiological and confounding factors and a number of methodological limitations (discussed in this section), it also is impossible for this assessment to establish whether drinking contaminated

water was truly associated with the cancer elevations observed in Crestwood. It should be borne in mind that according to the IEPA's estimate, even at the 20 percent maximum contribution from the contaminated water, none of the tested contaminants would have exceeded federal maximum contaminant levels.

Third, the length of time or latency period between the time of exposure and the onset of clinically-recognizable disease for most adult cancers is between 10 and 20 years. Specific cancers may vary somewhat in the length of the latent period, but generally speaking, recent exposure, that is, exposures in the last 10 years, cannot be expected to be associated with current cancer incidence. Although some data suggest that exposure existed in 1985, which would have provided a 10 plus year latency for this study, it is not quite clear when this started or the amounts involved. The extension of exposure until 2007 could suggest that some cancers associated with the exposure might have not yet occurred. Continuous monitoring of the area's cancer incidence in the future therefore is recommended. The results from this assessment could serve as the baseline for such future cancer surveillance.

Finally, and potentially most important, random fluctuation in cancer distributions and its associated chance occurrences, cannot be ruled out in explaining differences between the observed and expected numbers, even when the difference is statistically significant. The problem of chance occurrences, often severe with small numbers, could be further amplified by the practice of conducting multiple statistical tests and comparisons in a single study. In this assessment, there were more than 200 statistical comparisons made. Given the p-value of 0.05, about a dozen 'statistically significant differences' were expected to occur even when the underlying data were randomly distributed. The chance possibility caused by multiple comparisons therefore was substantial in this assessment.

Conclusions

The present assessment found statistically significant elevations of cancer incidence in lung cancer, kidney cancer, oral cavity and pharynx, esophagus, colorectal cancer, and gastrointestinal cancers as a combined group, in the Village of Crestwood, Cook County. No case of the signature cancer related to vinyl chloride, angiosarcoma of the liver, was found. Yet due to its rare occurrence this was not unexpected.

Except for lung cancer whose elevation was observed in both males and females, all other cancer increases were limited to males. In addition to the association noted here with exposure to drinking water, the elevation may be related alone or in combination with a number of well-established risk factors, such as tobacco use and possible occupational exposures. A number of methodological and data limitations prevent the researchers from arriving at a causative conclusion or firm confidence in the identified association between exposure to the water supply in Crestwood and cancer.

Recommendations

- Continue to monitor cancer incidence in Crestwood to evaluate future changes, including changes possibly related to the discontinuation of the contaminated drinking water.
- Without regard to causation, increase education and programs promoting colorectal screening.
- In collaboration with federal agencies and university researchers, consider additional studies to determine whether there are other factors, such as occupational exposure, that may explain some of the cancer elevations or distribution patterns in Crestwood.

References

ACS, 2009. American Cancer Society: Cancer Facts and Figures - 2009. Atlanta, Ga.: American Cancer Society; 2009.

ATSDR, 1997. Agency for Toxic Substances and Disease Registry, CDC: Tetrachloroethylene. ToxFAQs CAS #127-18-4; 1997.

ATSDR, 2009. Agency for Toxic Substances and Disease Registry, CDC: Fourth National Report on Human Exposure to Environmental Chemicals. Atlanta, GA. 2009.

Berwick M. 2006. Soft Tissue Sarcoma. In Schottenfeld D, Fraumeni JF (eds). Cancer Epidemiology and Prevention, Third edition. Oxford University Press, 2006:959-974.

Blot WJ, McLaughlin JK, Fraumeni JF. Esophageal Cancer. In Schottenfeld D, Fraumeni JF (eds). Cancer Epidemiology and Prevention, Third edition. Oxford University Press, 2006:697-706.

Boffetta P, Matisane L, Mundt K, Dell L. 2003. Meta-analysis of Studies of Occupational Exposure to Vinyl Chloride in Relation to Cancer Mortality. Scand J Work Environ Health 2003; 29:220-229.

Bosotti C, La Vecchia C, McLaughlin JK. 2003. Occupational Exposure to Vinyl Chloride and Cancer Risk: A Review of the Epidemiological Literature. Eur J Cancer Prev 2003;12:427-430.

Brautbar N, 2005. Chemicals and Cancer: Establishing Causation through Medical Toxicology. Article retrieved October 2005 from web site URL: http://www.environmentaldiseases.com/article_chemicals_cancer.html

Cantor KP, Ward MH, Moore LL, Lubin JH. 2006. Water Contamination. In Schottenfeld D, Fraumeni JF (eds). Cancer Epidemiology and Prevention. Third edition. New York: Oxford University Press; 2006:382-404.

Chow WH, Gridley G, Fraumeni JF, Jarvholm B. 2000. Obesity, Hypertension, and Risk of Kidney Cancer in Men. N Engl J Med 2000; 343:1305-11.

Falk H, Herbert J, Crowley S, Ishak KG, Thompson LB, Popper H, Caldwell GG. 1981. Epidemiology of Hepatic Angiosarcoma in the United States: 1964-1974. Env Health Perspective 1981; 41:107-113.

Giovannucci E, Wu K. 2006. Cancers of the Colon and Rectum. In Schottenfeld D, Fraumeni JF (eds). Cancer Epidemiology and Prevention. Third edition. New York: Oxford University Press; 2006:809-829.

Howe HL, Keller JE, Lehnherr M. 1993. Relation between Population Density and Cancer Incidence, Illinois 1986-1990. Am J Epidemiol 1993;138:29-36.

Kelsey JL, Whittemore AS, Evans AS, Thompson WD. 1996. Methods in Observational Epidemiology. Second Edition. Oxford University Press. 1996:167-187.

Lave L. 1996. Environmental regulation and policy making. In Schottenfeld D, Fraumeni JF (eds). Cancer Epidemiology and Prevention, Second edition. Philadelphia: WB Saunders Co; 1996:1453-1470.

London WT, McGlynn KA. 2006. Liver Cancer. In Schottenfeld D, Fraumeni JF (eds). Cancer Epidemiology and Prevention. Third edition. New York: Oxford University Press; 2006:763-786.

Mattson DE. 1986. Statistics: Difficult Concepts, Understandable Explanations. Oak Park, Ill.: Bolchazy-Carducci Publishers Inc; 1986:386-389.

Mayne ST, Morse DE, Winn DM. Cancers of the Oral Cavity and Pharynx. In Schottenfeld D, Fraumeni JF (eds). Cancer Epidemiology and Prevention. Third edition. New York: Oxford University Press; 2006:674-696.

McLaughlin JK. 1996. Kidney. In Harras A, Edwards BK, Blot WJ, and Ries LA (eds). Cancer Rates and Risks. Bethesda Md.: National Cancer Institute; May 1996. United States Department of Health and Human Services publication NIH 96-691

McLaughlin JK, Lipworth L, Tarone RE, Blot WJ. 2006. Renal Cancer. In Schottenfeld D, Fraumeni JF (eds). Cancer Epidemiology and Prevention. Third edition. New York: Oxford University Press; 2006:1087-1096.

NAACCR, 2000. Data Evaluation and Publication Committee, Workgroup for High Quality Criteria for Data Use. Winter 2000 Newsletter. Springfield, Ill.: North American Association of Central Cancer Registries, February 2000.

NCI, 2009. National Cancer Institute: Cancernet web site: URL http://cancernet.nci.nih.gov/clinpdq/risk/Cancer_Clusters.html Cancer Clusters - Facts About Cancer Clusters.

Paulu C, Aschengrau A,Ozonoff D. 1999. Tetrachloroethylene-Contaminated Drinking Water in Massachusetts and the Risk of Colon-rectum, Lung, and Other cancers. Env Health Perspective 1999;107;265-271.

Prüss-Üstün A. Corvalán C. 2006. Preventing Diseases through Healthy Environment. Toward an Estimate of the Environmental Burden of Diseases. Geneva, WHO, 2006.

Robinson D. 2002. Cancer Clusters: Findings Vs Feelings. American Council on Science and Health, Council Report. Medscape General Medicine. 4(4), 2002. New York.

Rom WN. 1992. Causation, in Environmental and Occupational Medicine (2nd Ed), 1992. Little Brown and Co., Boston, Toronto and London.

Rothman KJ, Poole C. 1996. Causation and casual inference. In Schottenfeld D, Fraumeni JF (eds). Cancer Epidemiology and Prevention. Philadelphia: WB Saunders Co; 1996:1-10.

Russi M, Borak JB, Cullen MR. 2008. An Examination of Cancer Epidemiology Studies among Populations Living Close to Toxic Waste Sites. Environmental Health. 2008;26;27-32.

Schatzkin AG. 1996. Colon and Rectum. In Harris A (ed) Cancer Rates and Risks. Washington, DC: National Cancer Institute;1996. United States Department of Health and Human Services publication NIH 96-691.

Selvin S. 1996. Statistical Analysis of Epidemiological Data, Second edition, New York: Oxford University Press; 1996:83-102.

Shibata A, Parsonnet J. Stomach Cancer. In Schottenfeld D, Fraumeni JF (eds). Cancer Epidemiology and Prevention, Third edition. New York: Oxford University Press; 2006:707-720.

Siemiatyckl J. Richardson L, Boffetta P. 2006. Occupation. In Schottenfeld D, Fraumeni JF (eds). Cancer Epidemiology and Prevention, Third edition. Oxford University Press, 2006:322-354.

Spitz MR, Wu X, Wilkinson A, Wei Q. 2006. Cancer of the Lung. In Schottenfeld D, Fraumeni JF (eds). Cancer Epidemiology and Prevention, Third edition. New York: Oxford University Press; 2006:638-658.

Table 1. Observed and Expected Numbers of Angiosarcoma of the Liver and Liver Cancer Cases by Site and Sex Residents of Crestwood, Illinois, 1994-2006

	Males			Females		
Cancer Site Group	Obs.	Exp.[a]	SIR (CI)[b]	Obs.	Exp.[a]	SIR (CI)[b]
Angiosarcoma of the liver	0	0		0	0	
Liver	8	6	1.33 (0.57-2.63)	6	3	2.00 (0.73-4.35)

SOURCE: Illinois State Cancer Registry, November 2008.

[a] Expected numbers are based on the age-, sex-, race-specific incidence rates in an area of Illinois with a similar population density as the study area.
[b] Standardized incidence ratio (SIR) with 95 percent confidence interval (CI)

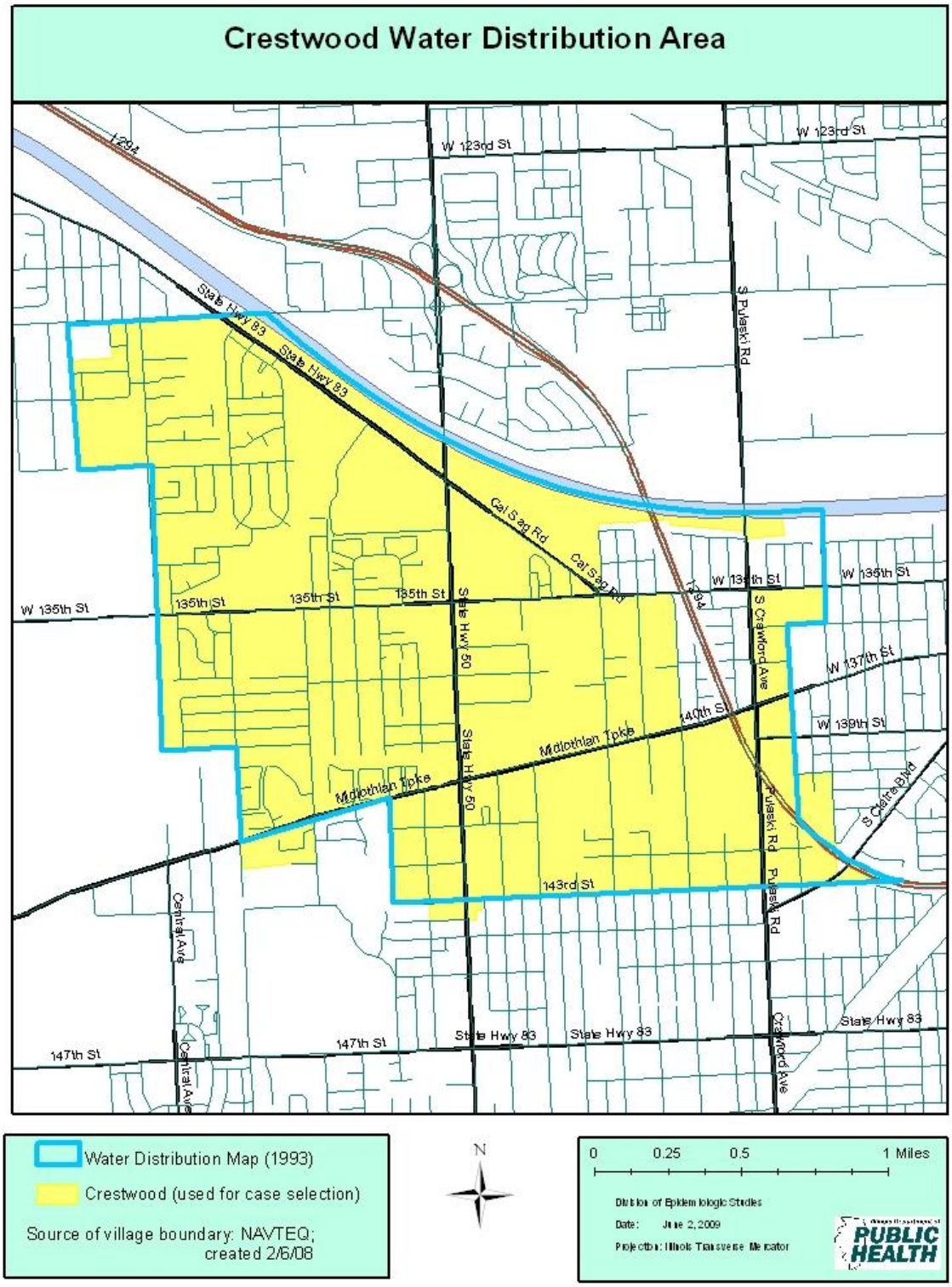
Table 2. Observed and Expected Numbers of Cancer Cases by Site and Sex
Residents of Crestwood, Illinois, 1994-2006

	Males			Females		
Cancer Site Group	Obs.	Exp.[a]	SIR (CI)[b]	Obs.	Exp.[a]	SIR (CI)[b]
Oral Cavity and Pharynx	19	11	1.73 (1.04-2.70)	6	7	0.86 (0.31-1.87)
Esophagus	12	6	2.00 (1.03-3.49)	7	3	2.33 (0.93-4.81)
Stomach	11	9	1.22 (0.61-2.19)	6	8	0.75 (0.27-1.63)
Colorectal	63	45	1.40 (1.08-1.79)	58	62	0.94 (0.71-1.21)
All GI Cancers	105	71	1.48 (1.21-1.79)	77	80	0.96 (0.76-1.20)
Lung and Bronchus	79	59	1.34 (1.06-1.67)	89	66	1.35 (1.08-1.66)
Bone	0	1	0.00 (-3.67)	0	1	0.00 (-3.67)
Melanomas	9	9	1.00 (0.46-1.90)	8	8	1.00 (0.43-1.97)
Breast invasive	-	-	-	134	136	0.99 (0.83-1.17)
Breast *in situ*	-	-	-	18	27	0.67 (0.39-1.05)
Cervix	-	-	-	8	9	0.89 (0.38-1.75)
Uterus	-	-	-	30	29	1.03 (0.70-1.48)
Ovary	-	-	-	12	16	0.75 (0.39-1.31)
Prostate	101	103	0.98 (0.80-1.19)	-	-	-
Bladder	32	27	1.19 (0.81-1.67)	15	14	1.07 (0.60-1.77)
Kidney	23	12	1.92 (1.21-2.88)	8	11	0.73 (0.31-1.43)
Non-Hodgkin Lymphomas	13	16	0.81 (0.43-1.39)	18	20	0.90 (0.53-1.42)
Leukemias	9	11	0.82 (0.37-1.55)	9	12	0.75 (0.34-1.42)
All Other Sites	61	62	0.98 (0.75-1.24)	80	80	1.00 (0.79-1.24)

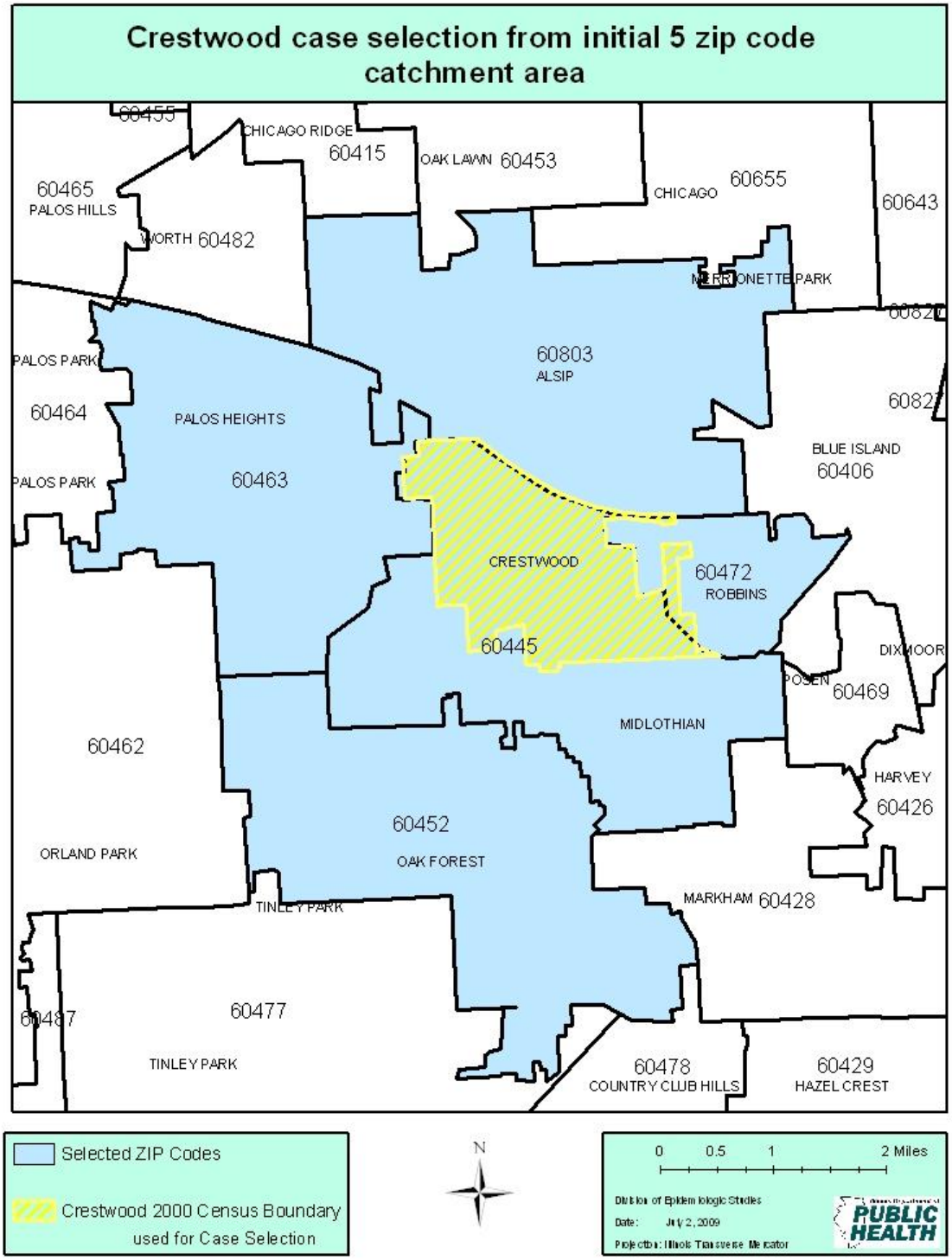
SOURCE: Illinois State Cancer Registry, November 2008.

[a] Expected numbers are based on the age-, sex-, race-specific incidence rates in an area of Illinois with a similar population density as the study area.
[b] Standardized incidence ratio (SIR) with 95 percent confidence interval (CI)
[c] Gastrointestinal (GI) cancers include oral cavity and pharynx, esophagus, stomach, and colorectal cancers

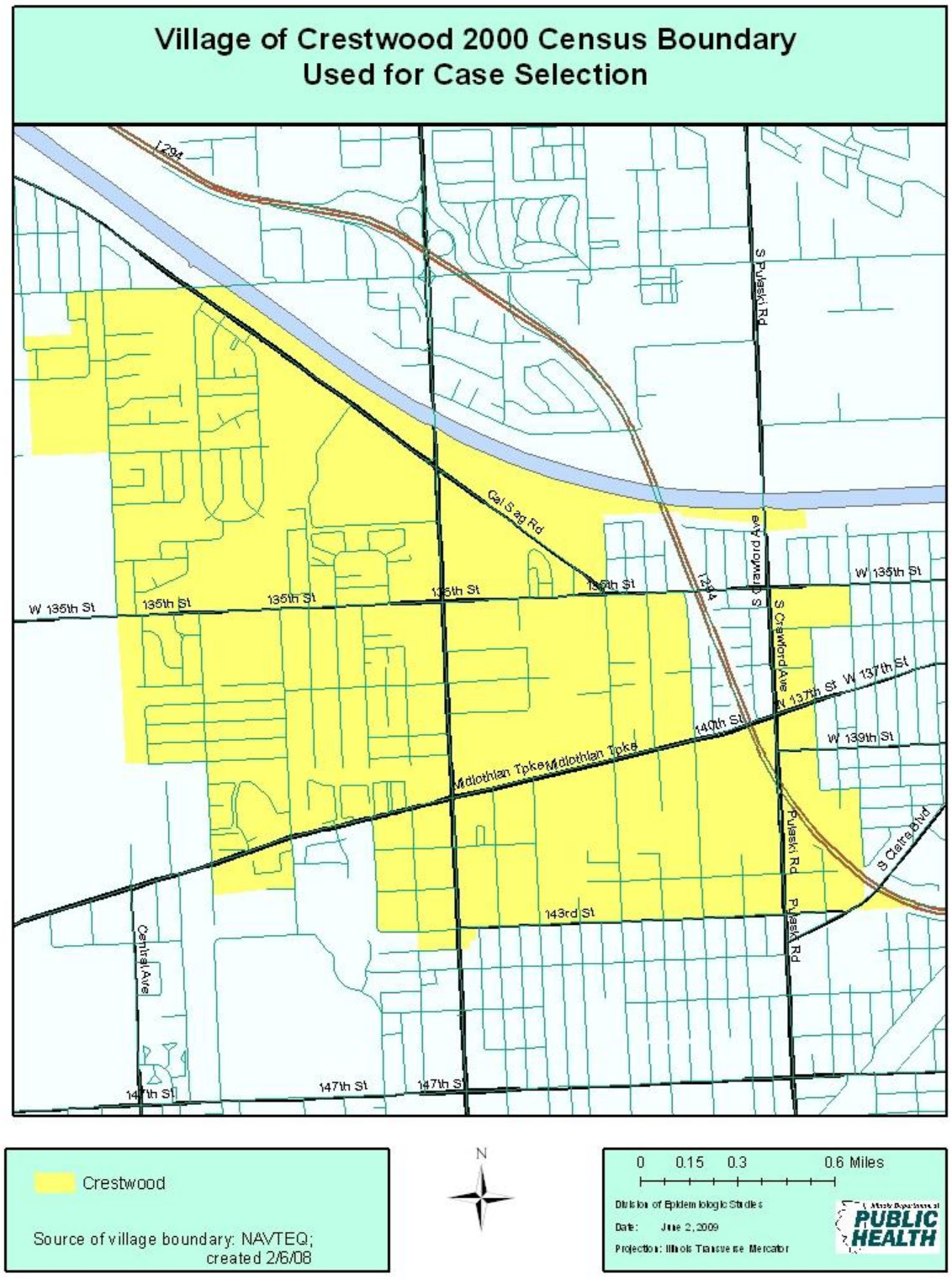
Map 1


Crestwood Water Distribution Area
I-294
W 123rd St
S Pulaski Rd
State Hwy 83
Cal Sag Rd
W 135th St
135th St
S State Hwy 50
S Crawford Ave
W 137th St
140th St
W 139th St
Midlothian Tpke
S Cicero Blvd
143rd St
Central Ave
147th St
Crawford Ave
Water Distribution Map (1993)
Crestwood (used for case selection)
Source of village boundary: NAVTEQ; created 2/6/08
N
0
0.25
0.5
1 Miles
Division of Epidemiologic Studies
Date: June 2, 2009
Projection: Illinois Transverse Mercator
PUBLIC HEALTH

Map 2


Crestwood case selection from initial 5 zip code catchment area
60455
CHICAGO RIDGE
60415
OAK LAWN
60453
60465
PALOS HILLS
WORTH
60482
CHICAGO
60655
60643
MERRIONETTE PARK
60803
ALSIP
PALOS PARK
60464
PALOS HEIGHTS
60463
PALOS PARK
BLUE ISLAND
60406
CRESTWOOD
60472
ROBBINS
60445
DIXMOOR
POSEN
60469
MIDLOTHIAN
60462
HARVEY
60426
60452
OAK FOREST
ORLAND PARK
TINLEY PARK
MARKHAM
60428
60477
TINLEY PARK
60478
COUNTRY CLUB HILLS
60429
HAZEL CREST
Selected ZIP Codes
Crestwood 2000 Census Boundary used for Case Selection
N
0
0.5
1
2 Miles
Division of Epidemiologic Studies
Date: July 2, 2009
Projection: Illinois Transverse Mercator
PUBLIC HEALTH

Map 3


Village of Crestwood 2000 Census Boundary
Used for Case Selection
I-294
S Pulaski Rd
Cal Sag Rd
S Crawford Ave
W 135th St
135th St
S Crawford Ave
W 137th St
140th St
W 139th St
Midlothian Tpke
S Cicero Blvd
143rd St
Central Ave
147th St
Crestwood
Source of village boundary: NAVTEQ;
created 2/6/08
N
0 0.15 0.3 0.6 Miles
Division of Epidemiologic Studies
Date: June 2, 2009
Projection: Illinois Transverse Mercator
PUBLIC HEALTH

Map 4

2000 Census Boundaries used for selection of population numbers for Village of Crestwood, Illinois