AN INVESTIGATION OF CANCER INCIDENCE IN SUNSET AND CLINTON, UTAH, 1973-1999

September 2, 2003

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EXECUTIVE SUMMARY

The Davis County Health Department received inquiries and concerns regarding a perceived elevated incidence of cancer in the communities of Sunset and Clinton within Davis County and the possible association of cancer to a contaminated groundwater plume originating from Hill Air Force Base. In response to the concerns, Jerry Thompson from the Davis County Health Department, Environmental Services, requested assistance from the Office of Epidemiology, Utah Department of Health, in conducting an epidemiological investigation of cancer incidence in Davis County. The communities of Sunset and Clinton are located in northern Utah, to the immediate West of Hill Air Force Base.

Cancer data was obtained from the Utah Cancer Registry for the communities of Sunset and Clinton *(census tracts 1253.01 and 1253.02, respectively),* and the state of Utah. The cancer data were requested for the following five-year periods: 1973-1977; 1978-1982; 1983-1987; 1988-1992; 1992-1997; and the additional two year period of 1998-1999. Only cancers that occurred three or more times in any time period in census tracts 1253.01 and 1253.02 were analyzed. The state of Utah was selected as the comparison population *minus* the population and the observed number of cases in census tracts 1253.01 and 1253.02.

The results of the investigation indicated that kidney and renal pelvis cancer were elevated during the first (1973 to 1978) and last (1998 to 1999) periods evaluated. Cancer of the gallbladder was significantly elevated in two periods, 1988-1992 and cumulatively from 1973-1999, respectively. The period of 1988 to 1992 is considered a statistical artifact. Testicular cancer was significantly elevated during the period of 1988 to 1992. The cause of the elevated cancer rates during these specific periods could not be determined.

This investigation did not find an association or link with the cancers (gallbladder, testicular, and kidney and renal pelvis) that were significantly elevated and the contaminants of interest (trichloroethylene, tetrachloroethylene, carbon tetrachloride and perchlorate). In addition, this investigation found no evidence suggesting that cancer (of any type) was significantly increasing in the communities of Sunset and Clinton during the periods evaluated.

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INTRODUCTION

The Office of Epidemiology began an investigation of cancer incidence as the result of a request from the Davis County Health Department, regarding a perceived elevated incidence of cancer in the communities of Sunset and Clinton within Davis County, Utah and the possible association to contaminated groundwater. Sunset and Clinton residents brought their concerns and questions to the attention of Hill Air Force Base. Hill Air Force Base communicated these citizen concerns to the Davis County Health Department. As a result, the Davis County Health Department requested assistance from the Office of Epidemiology, Utah Department of Health, in conducting an epidemiological investigation of cancer rates in the communities of Sunset and Clinton.

The communities of Sunset and Clinton are located in northern Utah, to the immediate west of Hill Air Force Base. In 1987, groundwater contamination was discovered just west of the base. The contaminants that were identified include trichloroethylene, tetrachloroethylene, carbon tetrachloride, and perchlorate. These contaminants have been determined to be contained within the shallow aquifer, which ranges between six to eight feet below ground to approximately 100 ft below ground (Hill AFB, 2001).

The purpose of this investigation is to determine if the incidence of cancer is elevated in the communities of Sunset and Clinton (census tracts 1253.01 and 1253.02) as compared to the incidence of cancer in the rest of the state of Utah for the period of 1973-1999. A map of Davis County that shows the location of the communities of Sunset and Clinton in relation to Hill Air Force Base is included in Appendix A.

METHODS

Cancer Data

Data for this investigation were obtained from the Utah Cancer Registry. The Utah Cancer Registry receives reports on each newly diagnosed case of cancer in Utah from hospitals, radiation therapy facilities, pathology laboratories, nursing homes, and physicians. Each newly diagnosed case is assigned to the census tract of residence at the time of diagnosis.

Data obtained from the Utah Cancer Registry included an enumeration of incident cancer cases (new occurrences) by primary site/type, sex, age group, races, and time period of diagnosis for residents of census tracts 1253.01 and 1253.02, respectively, and the state of Utah. The number of cases was obtained for the following time periods: 1973-1977 (five years); 1978-1982 (five years); 1983-1987 (five years); 1988-1992 (five years); 1993-1997 (five years); 1998-1999 (two years). At the time the data was requested, the most recent year for which complete data were available for this analysis was 1999.

Census Data

The Sunset and Clinton (census tracts 1253.01 and 1253.02) populations were obtained from the U.S. Census Bureau for 1970, 1980, and 1990. The intercensal populations were estimated using linear regression based on the 1970, 1980, and 1990 populations. The population estimates were

based on the assumption of a constant rate of growth in the combined communities. A table of population estimates used in this report is presented in Appendix B. The population for the state of Utah was obtained from the Surveillance, Epidemiology and End Results (SEER) Registry data provided with the cancer incidence data for the years 1973 through 1999. The SEER Registry obtains population information from the U.S. Census Bureau. The 2000 population was available, however, the 2000 cancer cases from the Utah Cancer Registry were not available. Therefore, the 2000 population was not used.

Geographic Data

Census tracts 1253.01 and 1253.02 were selected for this study based on the correspondence of the tract boundaries to the city boundaries of Sunset and Clinton, respectively. Census tracts are occasionally changed by either tract splitting or boundary modification. Tracts 1253.01 and 1253.02 were once combined in a single census tract - tract 253 in the 1970 decennial census. Census tract 253 was split for the 1980 census into the two tracts that define the cities of Sunset and Clinton. These two tracts retain the same designation and boundaries for the 1990 decennial census. The cancer cases were requested according to the period of time and corresponding census tract designation.

Comparison Population

A comparison population was selected (as a comparison to the study population) in order to evaluate whether the outcome observed in the study population is statistically different from that which would be expected if the members had not been at any special risk. The state of Utah was selected as the comparison population *minus* the population and the observed number of cases in census tracts 1253.01 and 1253.02. From this point hereafter the state of Utah will be referred to as *Utah*, unless otherwise specified.

Statistical Analysis

A Standardized Morbidity Ratio (SMR) was calculated for each period and used to determine if there is a greater risk or a lower risk of acquiring a disease or condition compared to a comparison population. The SMR is calculated by dividing the crude observed count by the expected count (Aldrich and Griffith, 1993). The ratio is then used to determine if there is a greater risk or a lower risk of acquiring a disease or condition compared to a comparison population. A SMR of one (1.0) indicates rates are equal and there is no increased risk. A SMR greater than one (1.0) indicates an increased risk for the study group (Sunset & Clinton), while a SMR less than one (1.0) indicates a decreased risk for the study group.

The *expected count* was calculated by multiplying the age specific comparison rate (Utah) by age specific population of the study population (Sunset & Clinton) and summing the results. This method uses the weighted age-specific rates in the population of interest and the proportions of the persons in the corresponding age groups within a standard population. A more detailed description of the standardization of the data is presented in Appendix C.

The confidence interval for the SMR is the range within which the true SMR value has a specified probability of being included. The specified probability is called the *confidence level*, and the endpoints of the confidence interval are called the *confidence limits*. For this investigation, a specified probability of 95 percent was employed. The confidence limits were calculated using the method of Frumkin and Kantrowitz (Frumkin and Kantrowitz, 1987). By assessing the confidence interval, information about the variability of the data and the statistical significance of the SMR was obtained. The differences between the observed versus the expected were considered significant if the confidence interval does not include one (1.0). The statistical formula for the SMR confidence interval (95 percent) was performed using Excel 2000 and is presented in Appendix C.

Cancers of Concern

The Agency for Toxic Substances and Disease Registry recommends against performing statistical analysis whenever there are fewer than three cases of the same type of cancer in a population (ATSDR, 1993). Only those cancers occurring three or more times in at lease one of the periods evaluated in the combined populations of Sunset and Clinton between 1973 and 1999 were included in this analysis. The cancer sites that occurred three or more times are as follows:

All sites (Physiological sites)	Corpus and uterus
Oral cavity	Ovary
Stomach	Prostate
Colon excluding rectum	Testis
Rectum and rectosigmoid	Urinary bladder
Gallbladder	Kidney and renal pelvis
Pancreas	Brain
Lung and bronchus	Thyroid
Other respiratory	Non-Hodgkin's lymphoma
Melanomas of the Skin	Multiple myeloma
Female breast	Myeloid leukemia
Cervix	Miscellaneous

RESULTS

Several cancers were identified as significantly elevated during two or more of the periods evaluated from 1973 through 1999 in Sunset and Clinton. These cancers include gallbladder cancer (1988-92 and 1973-1999), testicular cancer (1988-92), and cancer of the kidney and renal pelvis (1973-78, 1998-99).

Tables of the SMRs (with confidence intervals) for the significantly elevated cancers and cancers relevant to the contaminants of interest, for Sunset and Clinton, are presented in Appendix D.

Cancer of all Sites

When looking at cancer from all the sites combined both the observed number of cases and the number of cases expected are increasing steadily throughout the periods evaluated. However, no statistically significant increases of cancer from all the sites combined were found during any of the periods evaluated (Table 1).

Gallbladder Cancer

The observed number of gallbladder cancer cases are significantly elevated, nearly eight-times (SMR 7.81) from what was expected, for the period of 1988-92, with a 95% confidence interval of 1.47 to 19.15. When looking at the years cumulatively (1973-99) the observed cases are significantly elevated, three and a half times the number of cases from what would be expected. Although the number of cases were elevated in the first two periods (1973-82), they were not significantly greater from what was expected. There were no cases of gallbladder cancer in Sunset and Clinton during the periods of 1983-87, 1993-97, and 1998-99. There is no apparent pattern or trend of continued elevation across all periods (Table 2).

Lung and Bronchial Cancer

Both the observed number of cases and the expected number of cases of lung and bronchial cancer are steadily increasing. The SMR values were greater than one for the periods of 1983-87, 1993-97, 1998-99, and cumulatively from 1973-1999. However, they were not significantly elevated (Table 3).

Cervical Cancer

There were no periods that demonstrated a significant increase in the observed number of for cervical cancer. However, from 1973-87 only two cases of cervical cancer were reported, the SMRs were less than one for these periods. With the exception of the period of 1998-99, the remaining periods demonstrated a SMR slightly greater than one. The period of 1998-99 demonstrated a SMR of 3.31. The number of observed cases for this period were three times the rate of what would be expected (Table 4).

Testicular Cancer

There was only one period (1988-92) that demonstrated a significant increase in the number of testicular cancer cases (SMR 3.75, CI 1.49, 7.05). Prior to this period, only two cases were reported from 1973-87 with SMRs of less than one, and four cases were reported from 1993-99 with SMRs of 1.38 (Table 5).

Kidney and Renal Pelvis

There were two periods that demonstrated significant increases in the observed number of kidney and renal pelvis cancer cases. The period of 1973-77 (first time period) demonstrated a SMR of 4.46 (CI 1.60, 8.74). The observed number of cases exceeded the expected number by almost five times. The period of 1998-99 (last time period) demonstrated a SMR of 2.95 (CI 1.06, 5.79). This period also exceeded the expected number of cases by three times (Table 6). The cumulative (1973-99) SMR was 1.37, which was not significant.

Brain Cancer

Each of the periods evaluated demonstrated a SMR greater than one, with a cumulative (1973-99) SMR of 1.47. None of these periods demonstrated a significant increase in the observed number of cases. There was no period were the SMR or level of risk reached two-fold (Table 7).

Non-Hodgkin's lymphoma

The observed number of cases was greater than expected in the periods 1978-82, 1983-87, 1988-92, and cumulatively from 1973-99. However, these periods did not demonstrate a significant increase in the observed number of cases. The cumulative (1973-99) SMR (1.18) was slightly higher than one (Table 8).

Thyroid Cancer

There were no periods that demonstrated significant increases, including the cumulative period of 1973-99. The highest SMR (1.12) was observed in the period of 1973-1977 and the cumulative SMR was 0.81 (Table 9).

DISCUSSION

Cancer is a name applied to many diseases with many different causes. Cancers are very common. Nearly half of all men and one-third of all women in the U.S. population will develop cancer at some point in their lives and 22 percent of the population will eventually die of cancer (ACS, 1998). Statistically, it is normal for cancer rates to fluctuate in smaller communities. Some years the rates are higher, other years lower, eventually the rates tend to balance out over time.

This investigation examined the issue of whether an excess of cancer is present in the communities of Sunset and Clinton and the possible association of any excess cancer(s) to a contaminated groundwater plume originating from Hill Air Force Base. The contaminants of interest include trichloroethylene, tetrachloroethylene, carbon tetrachloride and perchlorate. Of the four contaminants, trichloroethylene was identified as the most common groundwater contaminant at Hill Air Force Base. This investigation did identify an association where occupational exposures to trichloroethylene showed higher levels of liver and biliary tract cancers and non-Hodgkin's lymphoma (See Contaminants of Concern). There were no clusters of liver cancer identified from 1973-99. In addition to exposure to trichloroethylene, non-

Hodgkin's lymphoma has also been associated with exposure to tetrachloroethylene. Non-Hodgkin's lymphoma was not significantly elevated in any of the periods evaluated.

Gallbladder cancer (1988-92 and cumulative, 1973-1999), testicular cancer (1988-92), and cancer of the kidney and renal pelvis (1973-78, 1998-99) were found to be significantly elevated in at least one of the periods evaluated by this investigation. Gallbladder cancer demonstrated an elevated SMR of 7.81 with a confidence interval of 1.47 to 19.15 for the period of 1988-92. Because of the large variance in the confidence limits, in addition to the fact that there were no increased trends observed from 1973 through 1999 (Table 2), the statistically significant increase in the observed number of cases demonstrated in the period of 1988-92 is considered a statistical artifact.

Testicular cancer was significantly elevated in one period, 1988-92 and kidney and renal pelvis was significantly elevated in two periods, 1973-78 and 1998-99. Neither of these cancers demonstrated an increased trend of occurrence from 1973 through 1999. There was no evidence found by this investigation that linked these two cancers with the contaminants of interest.

Cancer Risk Factors

Almost 75% of all cancer cases in the United States are related to tobacco and alcohol use, and diet. Research shows that about one-third of all cancer deaths are related to dietary factors and lack of physical activity. Less than 10 percent of all cancers are related to environmental factors. Environmental factors that are known to cause cancer include some viruses (most viruses do not cause cancer and unlike viral infections, cancer is not contagious), radiation (from sources such as the sun and radon), asbestos, and benzene. Pollution from the land, water, and air has been related to about 1 percent of all cancer deaths (ACS, 2000).

Other Risk Factors

Nearly a third of the population will develop cancer at some point in their lives. Cancer is a very common disease that affects all races, sexes, and ages. As of 1996, Utah males have a lifetime risk of developing cancer of approximately 20 percent and Utah females have a lifetime risk of approximately 24 percent (UCR, 1996).

Characterizing types of cancers, cancer rates, and determining causal relationships to environmental exposures without exposure measurements or data is difficult because people live and work in many environments, and are exposed to complex mixtures of toxic pollutants at home, at work, and in the ambient environment. In addition, only a relatively small percentage of cancers can be attributed to environmental factors. A breakdown in the proportion of cancer deaths attributed to various environmental factors are listed in the following table (Klaassen, 1996):

Environmental Factors	*Percentage Attributed to Cancer Mortality*
Infections	*10%*
Occupation	*4%*
Medicine and medical procedures	*1%*

Reproductive and sexual behavior	*7%*
Industrial products	*<1%*
Food additives	*<1%*
Pollution	*2%*
Alcohol	*3%*
Tobacco	*30%*
Diet	*35%*
Geophysical	*3%*
Unknown	*?%*

Therefore, of the total cancer mortality attributed to environmental factors, pollution and geophysical factors account for only 5 percent of the cancer mortality, whereas personal behavior/lifestyle accounts for approximately 75 percent of the cancer mortality.

Cancer Specific Risk Factors

The cancers found to be significantly elevated in Sunset and Clinton in any of the periods evaluated from 1973 through 1999 include: gallbladder (1988-92 and cumulatively - 1973-99); testicular (1988-92); kidney and renal pelvis (1973-77 and 1998-99).   Known risk factors associated with each of the cancers under evaluation are discussed below.

Gallbladder

An association has been observed between gallstones and the subsequent development of gallbladder cancer. Most of the risk factors for cholesterol gallstones are associated with hypersecretion and saturation of cholesterol in the bile. These factors increase in risk with age, the differential susceptibility of females, and associations observed with obesity, multiple pregnancies, and use of exogenous estrogens. In addition, gallbladder cancer occurs more frequently in woman than in men (Shottenfeld and Fraumeni, 1996). Elevated rates have been observed in married, widowed, and divorced women than in single women with a clear increase associated with a higher number of pregnancies (Moerman et al, 1994). Other risk factors associated with the etiology of gallbladder cancer include cholesterol gallstones, inflammation and infection of the biliary tract, liver flukes, ulcerative colitis, obesity, diet and alcohol consumption, tobacco use, radiation exposure, familial history, and congenital defects. Occupational risk factors include textile and metal workers, automotive workers, rubber plant workers, chemical workers, aircraft mechanics, wood finishing workers, (Shottenfeld and Fraumeni, 1996).

Lung and Bronchus Cancer

The use of tobacco (cigarette smoking) is the most frequently sited risk factor attributed to the etiology of lung and bronchus cancer. Other risk factors implicated in lung and bronchus cancer are exposure to asbestos, coal gas, nickel, polycyclic hydrocarbons, chromium, arsenic (Shottenfeld and Fraumeni, 1996), chlormethyl ethers (Gowers et al, 1993), radon (Archer et al, 1973) and miners (arsenic, asbestos and coal) (Ames et al, 1983, McDonald and McDonald, 1987, and Taylor et al, 1989). Risk increases when exposure to these contaminants occurs in

conjunction with cigarette smoking (ACS, 1992). Tuberculosis has also been identified as a risk factor for lung and bronchus cancer (Zheng et al, 1987). Currently more than two percent of the population in Utah will be affected with lung and bronchus cancer in their lifetime (UCR, 1996). As of 1995, smoking rates for Utah are at approximately 13 percent (BRFSS, 1995).

Cancer of the Cervix Uteri

Cancer of the cervix uteri is the second most common cancer among women and has recently started to increase among young white women. The increases observed in cancer of the cervix uteri have been due in part to the discovery of the etiologic role attributed to the human papillomavirus (HPV). The risk factors include the HPV type and intensity of infection, variability in the host immunologic response, co-infection with other viral or bacterial agents, parity, cigarette smoking, oral contraceptives use, sexual activity, and diet (Shottenfeld and Fraumeni, 1996).

Testicular

Testicular cancer is relatively uncommon in the United States. It is more commonly diagnosed in ages 20 – 44 years of age. Testicular cancer accounts for only one percent of all cancers in men (Shottenfeld and Fraumeni, 1996). Risk factors include cryptorchidism (undescended testicles), family history, occupational exposures, HIV infection, and belonging to the white male race. About 14% of cases of testicle cancer occur in men with a history of cryptorchidism, but up to 25% of cases occur in the normally descended testicle. Men with Klinefelter's syndrome (a sex chromosome disorder that may be characterized by low levels of male hormones, sterility, breast enlargement, and small testes) are at greater risk of developing testicular cancer (National Cancer Institute, 2001). Occupational risks include workers exposed to metals, metal dust, and cutting oils, miners, oil and gas worker, leather workers, food and beverage processing workers, janitors, and utility workers (Shottenfeld and Fraumeni, 1996)

Kidney and Renal Pelvis

In the United States, two percent of new cancers are from malignant tumors of the kidney, more in men (60%) than in women (40%). Since the 1970's, incidence rates for this type of cancer have been increasing. The five-year relative survival rate for patients with kidney and renal pelvis cancer is about 50 to 65 percent. Cigarette smoking is causally linked to this type of cancer, even more so with cancer of the renal pelvis. Smoking accounts for a large percentage of these cancers in both men and women. The best way to prevent a majority of these cancers is to avoid tobacco use. Abuse of prescription analgesics is another risk factor and has been causally linked to this type of cancer. The regular use of prescription diuretics may increase risk. Consistently, obesity has been found to be a risk factor for renal cell cancer. Coffee, tea, alcoholic drinks, and possibly increased meat consumption, are important risk factors. In some studies, asbestos-exposed workers and coke-oven workers in steel plants have an elevated risk of dying from kidney cancer (McLaughlin 2003).

Brain Cancer

In the United States 17,000 new primary cancers of the nervous system are diagnosed each year. These are among the most (rapidly) fatal of all cancers and only about half (52%) of patients are still alive one year after diagnosis. Brain cancer is the tenth most common type of death from cancer. The etiology of the majority of nervous system tumors remains unknown. Environmental agents, such as ionizing radiation, have been clearly implicated in the etiology of brain tumors. Other physical, chemical, and infectious agents suspected of being risk factors have not yet been established as etiologically relevant. Factors associated/suspected in the etiology of childhood and adult brain cancer include n-nitroso compounds, exposure to low frequency electromagnetic fields, pesticides, insecticides, radiation exposure, infections, alcohol consumption, lead, hair dye and spray, barbiturates, chemotherapy (in-utero), medications, familial history, and race (Shottenfeld and Fraumeni, 1996). Rates in Utah have been slightly lower than the national rates until recently when the Utah rate slightly exceeded the national rate (UCR, 1996).

Non-Hodgkin's Lymphoma

In the United States, non-Hodgkin's lymphoma accounts for approximately three percent of the new cancer cases and has an annual incidence rate of ten per 100,000 persons per year. The incidence rate is 50 percent higher in males than in females, and is much higher in persons 50 years and older. Risk factors involved in the etiology of non-Hodgkin's lymphoma include hydantoin therapy, immune suppression, and therapeutic irradiation (Kipen, 1994). Occupations that have been reported as risk factors for non-Hodgkin's lymphoma include rubber workers, veterinarians, uranium miners, asbestos exposed workers, lumberjacks, metal workers, female textile workers, chemist, and farmers (Kipen, 1994). Chemicals that have a reported association with the etiology of non-Hodgkin's lymphoma include benzene, butadiene, ethylene oxide, nonionizing radiation, solvents, and asbestos (Kipen, 1994).

Thyroid Cancer

Thyroid cancer is uncommon accounting for only one percent of all cancers in the United States (NCI, 1997). This type of cancer occurs more often in women than in men and is most often found in young adults and teenagers. In women, the peak occurrence of thyroid cancer is during their reproductive years. Estrogen receptor immunoreactivity has been positively correlated with the degree of differentiation in thyroid cancer (Takeichi et al, 1991). Radiation exposure is the only known etiologic factor strongly associated with an increased risk of thyroid cancer. External beam radiation treatment for medical therapy, acute gamma ray exposure from environmental sources (nuclear weapons, nuclear power plant accidents), and ingestion of short-lived radioactive iodine isotopes are the primary sources of radiation exposure, which increase the risk of benign and malignant thyroid cancer. Prescription drugs such as pentobarbital, meclizine, diphenoxylate, dicyclomine, griseofulvin, bisacodly, and senna have been etiologically associated with thyroid cancer (Shottenfeld and Fraumeni, 1996). Familial history has also been associated with the etiology of thyroid cancer.

CONTAMINANTS OF CONCERN

Groundwater contamination originating from Hill AFB includes trichloroethylene, tetrachloroethylene, carbon tetrachloride, and perchlorate. The health effects associated with exposure to these chemicals are included in the following paragraphs.

Trichloroethylene

Trichloroethylene is a colorless liquid that is used for cleaning metal parts. It was commonly used as a degreasing solvent at Hill AFB until the mid 1970s. Trichloroethylene is the most common groundwater contaminant at Hill AFB. Trichloroethylene is suspected of causing cancer in animals, but its effect on humans is not clear. Several studies with mice and rats have suggested that high levels of trichloroethylene may cause liver or lung cancer. Some studies of people exposed over long periods to high levels of trichloroethylene in drinking water or in workplace air have found evidence of increased cancer. However, these results are inconclusive because the cancer could have been caused by other chemicals (ATSDR, 1997). An occupational study found no excess of any cancer among workers exposed to trichloroethylene (Blair et al, 1998).

The International Agency for Research on Cancer (IARC) has concluded that there is limited evidence for the carcinogenicity of Trichloroethylene in humans. IARC has also concluded that there is sufficient evidence that trichloroethylene is carcinogenic in experimental animals. Three well designed studies of people with occupational exposure to trichloroethylene showed higher levels of liver and biliary tracts cancers and non-Hodgkin's lymphoma. Many other studies were either negative or had significant limitations, including small sample size, limited exposure data and exposure to other chemicals (CCOHS, 1998a).

Tetrachloroethylene

Tetrachloroethylene (also known as perchloroethylene) is a chemical used for dry cleaning and metal degreasing. Tetrachloroethylene was used at Hill AFB in very limited quantities. It is suspected of causing cancer in humans. Several human population studies have shown more esophageal cancer, non-Hodgkin's lymphoma and cervical cancer in people occupationally exposed to tetrachloroethylene. The International Agency for Research on Cancer has concluded that there is limited evidence for the carcinogenicity of tetrachloroethylene in humans. There is sufficient evidence for carcinogenicity in animals (CCOHS, 1998b).

The Department of Health and Human Services had determined that tetrachloroethylene may reasonably be anticipated to be a carcinogen. Tetrachloroethylene has been shown to cause liver tumors in mice and kidney tumors in rats (ATSDR, 1997).

Carbon Tetrachloride

Carbon tetrachloride is a chemical used in aerosols and refrigerants. It was also used as a degreasing solvent in industrial and dry cleaning operations. Direct exposure to high levels of

this chemical may cause cancer and can damage the liver, kidneys, and nervous system. The effects of long-term exposure to low levels of the chemical are unknown.

The Department of Health and Human Services has determined that carbon tetrachloride may reasonably be anticipated to be a carcinogen. Animals that ingested carbon tetrachloride over a long time developed liver cancer. It is not known whether breathing carbon tetrachloride causes cancer in animals or if breathing or ingesting it will cause cancer in people (ATSDR, 1995).

Perchlorate

Perchlorate is an oxygen-adding component in solid fuel propellant for rockets. The currently available database on the health effects and toxicology of perchlorate or its salts is very limited. The majority of human data are clinical reports of patients treated with potassium perchlorate for hyperthyroidism resulting from an autoimmune condition known as Grave's disease. The concerns surrounding perchlorate contamination involves its ability to affect the thyroid gland, which can affect metabolism, growth, and development (EPA, 2001).

LIMITATIONS OF INVESTIGATION

Factors that must be considered in the development of etiology of most cancers, but could not be evaluated in this investigation, include latency period, population migration, personal habits, diet, and familial history of cancer. The latency period or induction period for most adult cancers range from 10 to 30 years after initial exposure to a carcinogen. Therefore, ascertaining the place and time of exposure to a carcinogen is difficult. Migration of people into and out of the communities of Sunset and Clinton present a problematic issue relative to exposure and latency. Humans live and work in many environments and are exposed to complex mixtures of toxic pollutants at home and at work. Information was not available for individual occupational exposures and lifestyle factors such as smoking and alcohol consumption.

CONCLUSION

The purpose of this investigation was to examine the issue of whether an excess of cancer is present in the communities of Sunset and Clinton and the possible association of any excess cancer(s) to a contaminated groundwater plume originating from Hill Air Force Base.

The results of this investigation found no evidence or an association with the cancers (gallbladder, testicular, and kidney and renal pelvis) that were significantly elevated and the contaminants of interest (trichloroethylene, tetrachloroethylene, carbon tetrachloride, and perchlorate). In addition, this investigation found no evidence suggesting that cancer (of any type) was significantly increasing in the communities of Sunset and Clinton during the periods evaluated as compared to the remainder of Utah. The cause of the significantly elevated cancers could not be determined by this investigation.

REFERENCES

Aldrich, Tim, and Griffith, Jack (1993). Environmental Epidemiology and Risk Assessment. Van Nostrand Reinhold, New York, NY. Pp. 27-60.

Ames R. G., and Gamble, J. F. (1983). Lung Cancer, Stomach Cancer, and Smoking Status among Coal Miners. A Preliminary Test of a Hypothesis. *Scandinavian Journal of Work Environmental Health*, 5:443-448.

Archer, V.E., Wagoner, J.K., and Lunden, F.E. (1973). Lung Cancer among Uranium Miners in the United States. Health Phys., 25:351-371.

ACS, American Cancer Society (1992). Facts on Lung Cancer.

American Cancer Society (1998). "What is Cancer." http://www.cancer.org/bottomsearch.html.

American Cancer Society (2000). "What Are the Risk Factors That Can Lead to Cancer?" http://www3.cancer.org/cancerinfo.html

American Cancer Society (2000). "Testicular Cancer: Prevention and Risk." http://www3.cancer.org/cancerinfo.html

ATSDR, Agency for Toxic Substances and Disease Registry (1993). Cluster 3:1 Software System for Epidemiologic Analysis. U.S. Department of Health & Human Services, Atlanta, Georgia.

ATSDR, Agency for Toxic Substances and Disease Registry (1997). "Carbon Tetrachloride."

ATSDR, Agency for Toxic Substances and Disease Registry (1997). "Trichloroethylene."

ATSDR, Agency for Toxic Substances and Disease Registry (1997). "Tetrachloroethylene."

Blair, Aaron, et al (1998). Mortality and Cancer Incidence of Aircraft Maintenance Workers Exposed to Trichloroethylene and Other Organic Solvents and Chemicals: Extended Follow Up. Occupational and Environmental Medicine, 55:161-171.

BRFSS, Behavioral Risk Factor Surveillance System (1995). Utah Department of Health, Salt Lake City, Utah.

CCOHS, Canadian Centre for Occupational Health and Safety (1998a). "Health Effects of Trichloroethylene." http://www.ccohs.ca/oshanswers/chemicals/chem_profiles/ trichloroethylene/effects_trichloro.html

CCOHS, Canadian Centre for Occupational Health and Safety (1998b). "Health Effects of Tetrachloroethylene." http://www.ccohs.ca/oshanswers/chemicals/chem_profiles/ tetrachloroethylene/health_tetra.html

CDC, Centers for Disease Control (1998). Age Standardization of Death Rates: Implementation of the Year 2000 Standard. National Vital Statistics Reports, Vol. 47 (No. 3):1-16.

EPA, Environmental Protection Agency (2001). "Perchlorate." http://www.epa.gov/safewater/ccl/perchlor/perchlo.html

Frumkin, H., Kantrowitz, W. (1987). Cancer Clusters in the Workplace: An Approach to Investigation. *Journal of Occupational Medicine*, Vol. 29 (No. 12):949-952.

Gowers, D.S., Defonso L.R., Schaffer P., et al, (1993). Incidence of Respiratory Cancer Among Workers Exposed to Chloromethyl-Ethers. *American Journal of Epidemiology*, 137:31-42.

Hill AFB, Hill Air Force Base (2001) Infofair Information Packet: 10 January 2001, Sunset Junior High School.

Kipen, H., and Wartenberg, D. (1994). Lymphohematopoietic Malignancies. Textbook of Clinical Occupational and Environmental Medicine, 21:555-564.

Klaassen, C.D. (1996). Casarett and Doull's Toxicology: The Basic Science of Poisons, Fifth Edition. The McGraw-Hill Companies, Inc. New York, 8:201-260.

McDonald, J. C., and McDonald A. D. (1987). Epidemiology of Asbestos Related Lung Cancer. Orlando: Grune & Stranton, pp. 57-79.

McLaughlin, J. (2003). Risk Factors: Kidney. National Cancer Institute http://seer.cancer.gov/publications/raterisk/risks145.html

MMWR, Morbidity and Mortality Weekly Report (1990). Guidelines for Investigating Clusters of Health Events. U.S. Department of Health and Human Services, Vol.39/No. RR-11

Moerman, C.J., Berns (MPH), Bueno de Mesquita, H. B., and Runia, S. (1994). Reproductive History of the Biliary Tract in Women. *International Journal of Cancer*, 57:146-153.

NCI, National Cancer Institute, (1997). Background Information on Thyroid Cancer and Radiation Risk. Office of Cancer Communications, Bethesda, Maryland.

Takeichi N., Ito H., and Haruta R. (1991). Relationship Between Estrogen Receptor and Malignancy of Thyroid Cancer. *Japan Journal of Cancer Research*, 82:19-22.

Taylor, P. R., Qiao Y. L., Schatzkin A., et al. (1989). Relation of Arsenic Exposure to Lung Cancer Among Tin Miners Yunnan Province, China. *British Journal of Industrial Medicine*, 46:881-886.

UCR, Utah Cancer Registry (1996). Cancers in Utah. Salt Lake City, UT.

Zheng W., Blot W. J., Liao, M. L., et al, (1987). Lung Cancer and Prior Tuberculosis in Shanghai. *British Journal of Cancers*, 56:501-504.

APPENDIX A
Map of Study Population Location

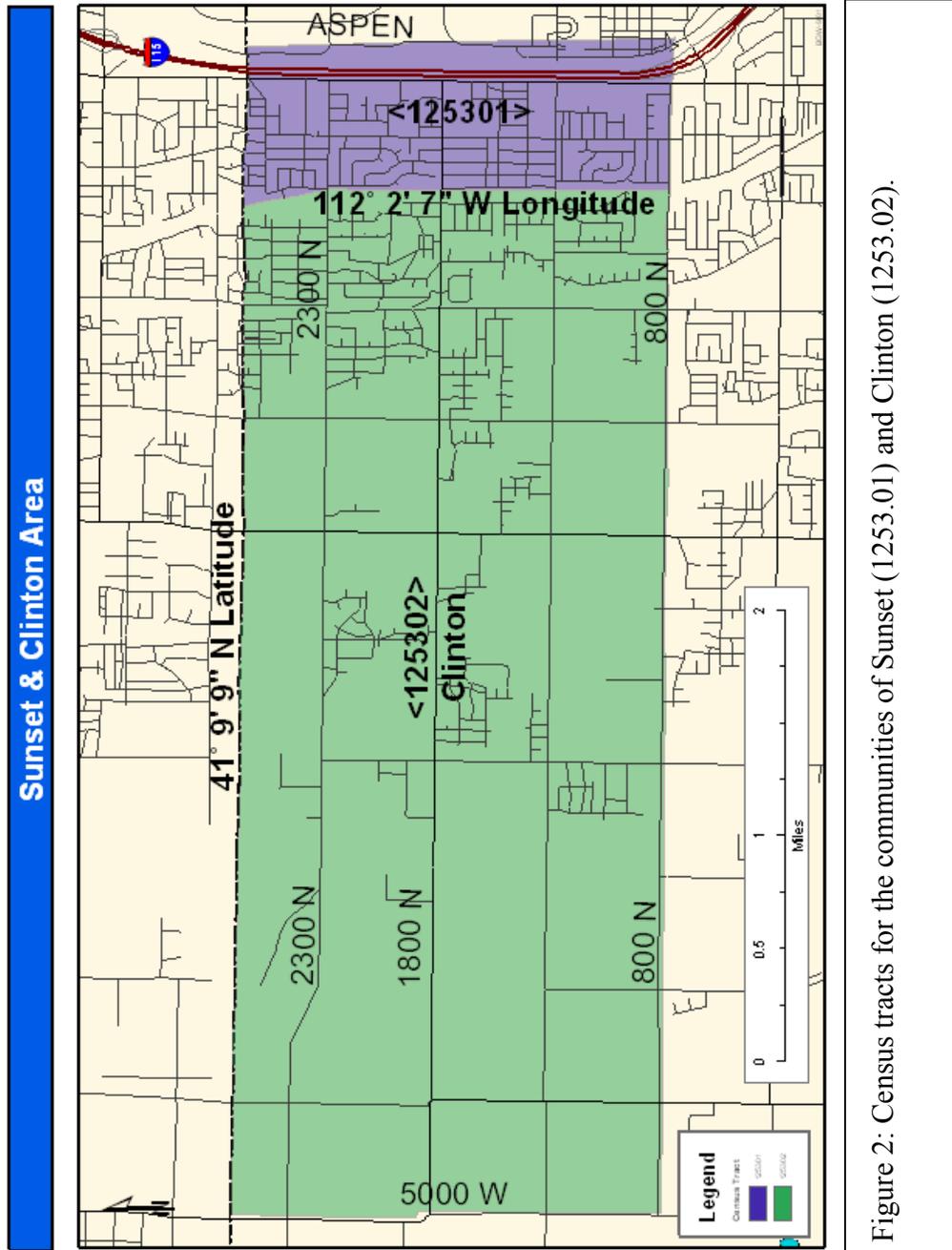Figure 1: Map presents the location of Sunset and Clinton in relation to Hill Air Force Base, Davis County, Utah.
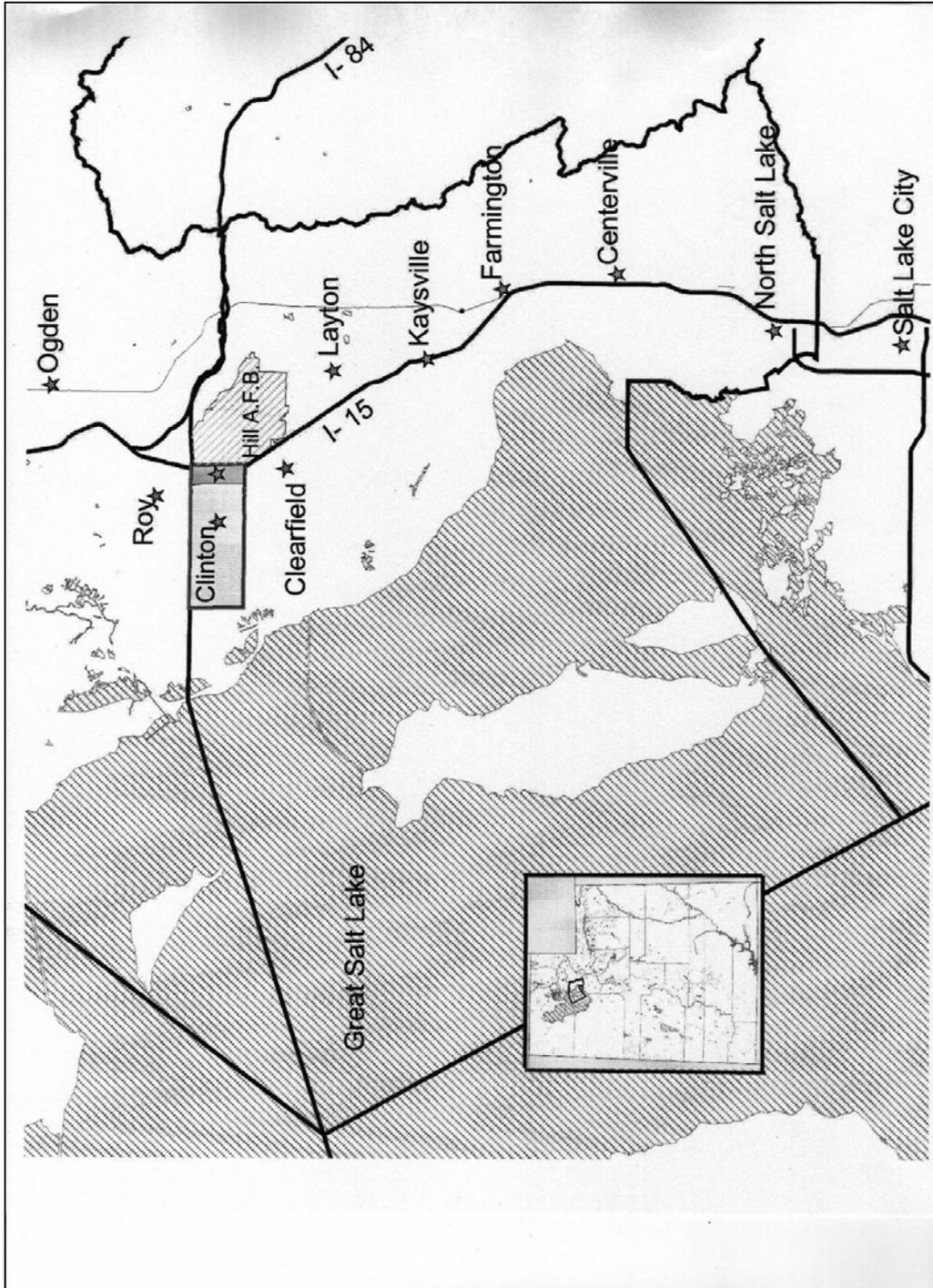
Figure 2: Census tracts for the communities of Sunset (1253.01) and Clinton (1253.02).

APPENDIX B
Population Estimates

The intercensal population estimates for the combined communities of Sunset and Clinton are presented for the years 1970 through 1999.

Population and Intercensal Estimates
Based on linear regression with 1970, 1980, and 1990 Sunset (1253.01) and Clinton (1253.02) U.S. Census data.

	Total	Male	Female
1970	8077	4020	4057
1971	8420	4196	4224
1972	8764	4373	4391
1973	9107	4549	4558
1974	9450	4726	4725
1975	9794	4902	4892
1976	10137	5078	5058
1977	10480	5255	5225
1978	10823	5431	5392
1979	1167	5608	5559
1980	11510	5784	5726
1981	11711	5880	5831
1982	11913	5976	5936
1983	12114	6073	6041
1984	12315	6169	6146
1985	12517	6265	6252
1986	12718	6361	6357
1987	12919	6457	6462
1988	13120	6554	6567
1989	13322	6650	6672
1990	13523	6746	6777
1991	13724	6842	6882
1992	13926	6938	6987
1993	14127	7035	7092
1994	14328	7131	7197
1995	14530	7227	7303
1996	14731	7323	7408
1997	14932	7419	7513
1998	15133	7516	7618
1999	15335	7612	7723

APPENDIX C
Statistical Calculations

Age-Adjustment Method (Standardized Morbidity Ratios)

Standardized morbidity ratios (SMR) were calculated using a statistical method applicable to both the direct and indirect age-adjustment or standardization methods. This method uses the age distribution of each population group and the age-specific rates for the standard population (state of Utah) to calculate the expected number of cancer cases if the rates of disease were constant as in the standard population. The observed number of incidences is then compared (divided) with the expected number of incidences in the study population of Sunset & Clinton (census tracts 1253.01 & 1253.02) and a ratio is derived, referred to as the SMR.
The formula for this ratio = $\Sigma p_{ia} n_{ia} / \Sigma p_{is} n_{ia}$

Where:
a = area chosen as the study area (Sunset & Clinton)
s = area chosen as a reference standard (state of Utah)
n_{ia} = number of individuals in ith class of study area (Sunset & Clinton)
n_{is} = number of individuals in ith class of standard area (state of Utah)
x_{ia} = number of cases in ith age class of area a (similarly for s)
$p_{ia} = x_{ia}/n_{ia}$ = incidence rate in ith age class of area a (similarly for s)

(Harold A. Kahn and Christopher T. Sempos, "Statistical Methods in Epidemiology", Oxford University Press, 1989, pp 85-136.)

The confidence interval for the SMR is the range of values for a calculated SMR with a specified probability (95%) of including the true SMR value:

$$\frac{\left[\sqrt{n} \pm (1.96 \times 0.5)\right]^2}{x}$$

Where
n is the Number of Observed.
x is the Number of Expected.

(Frumkin, H., Kantrowitz, W. (1987) Cancer Clusters in the Workplace: An Approach to Investigation. *Journal of Occupational Medicine,* Vol. 29 (No. 12):949-952.)

The confidence interval is used as a surrogate test of statistical significance (p-value). Both the p-value function and the spread of the function can be determined from the confidence interval. The difference between the observed versus the expected is considered significant if the confidence interval for the SMR does not include one (1.0) and if the SMR is greater than one (1.0).

(Rothman, K.J. (2002) Epidemiology: An Introduction, Oxford University Press, New York, NY)

APPENDIX D
Tables

The tables presented include the age-adjusted Standardized Morbidity Ratios (SMR) and confidence limits for significantly elevated cancers and cancers relating to the contaminants of interest in the Sunset and Clinton community. The state of Utah was used as the comparison population for the standardization of the data and the calculations of the SMR and the expected number of cancer cases for each time period.

Table 1. Individual periods and cumulative results of cancer cases from All Sites for the communities of Sunset and Clinton, Davis County, Utah.

Time Periods	1973-77	1978-82	1983-87	1988-92	1993-97	1998-99	All Years
Observed Cases in Sunset & Clinton	66	66	115	148	176	78	649
Expected Cases in Sunset & Clinton	65.36	84.76	109.26	149.59	185.83	86.32	670.91
Standardized Morbidity Ratio (Observed/Expected)	1.01	0.78	1.05	0.99	0.95	0.90	0.97
95% Confidence Interval	0.78-1.27	0.6-0.98	0.87-1.25	0.84-1.16	0.81-1.09	0.71-1.12	0.89-1.04

Data Source: Utah Cancer Registry, 1999.

Table 2. Individual periods and cumulative results of gallbladder cancer cases for the communities of Sunset and Clinton, Davis County, Utah.

Time Periods	1973-77	1978-82	1983-87	1988-92	1993-97	1998-99	All Years
Observed Cases in Sunset & Clinton	< 3	< 3	< 3	3	< 3	< 3	6
Expected Cases in Sunset & Clinton	0.23	0.26	0.24	0.38	0.49	0.14	1.73
Standardized Morbidity Ratio (Observed/Expected)	8.86	3.78	0.00	*7.81	0.00	0.00	*3.47
95% Confidence Interval	0.84-25.41	0-14.81	4.02-4.02	1.47-19.15	1.94-1.94	6.67-6.67	1.25-6.8

Data Source: Utah Cancer Registry, 1999.
*Significance (Statistically significantly different from the expected number of cases.)
Observed cases are presented as < 3 when the number of cases are less than three to protect confidentiality of the cases.

Table 3. Individual periods and cumulative results of lung and bronchus cancer cases for the communities of Sunset and Clinton, Davis County, Utah.

Time Periods	1973-77	1978-82	1983-87	1988-92	1993-97	1998-99	All Years
Observed Cases in Sunset & Clinton	< 3	7	12	10	19	9	58
Expected Cases in Sunset & Clinton	4.94	6.97	8.83	11.42	14.10	6.44	52.51
Standardized Morbidity Ratio (Observed/Expected)	0.20	1.00	1.36	0.88	1.35	1.40	1.10
95% Confidence Interval	0-0.79	0.4-1.88	0.7-2.24	0.42-1.5	0.81-2.02	0.63-2.46	0.84-1.41

Data Source: Utah Cancer Registry, 1999.
Observed cases are presented as < 3 when the number of cases are less than three to protect confidentiality of the cases.

Table 4. Individual periods and cumulative results of cervical cancer cases for the communities of Sunset
and Clinton, Davis County, Utah.

Time Periods	1973-77	1978-82	1983-87	1988-92	1993-97	1998-99	All Years
Observed Cases in Sunset & Clinton	0	< 3	< 3	3	3	3	11
Expected Cases in Sunset & Clinton	1.41	1.70	1.81	2.56	2.50	0.91	10.94
Standardized Morbidity Ratio (Observed/Expected)	0.00	0.59	0.55	1.17	1.20	3.31	1.01
95% Confidence Interval	0.68-0.68	0-2.3	0-2.17	0.22-2.87	0.23-2.94	0.62-8.13	0.5-1.69

Data Source: Utah Cancer Registry, 1999.
Observed cases are presented as < 3 when the number of cases are less than three to protect confidentiality of
the cases.

Table 5. Individual periods and cumulative results of testicular cancer cases for the communities of
Sunset and Clinton, Davis County, Utah.

Time Periods	1973-77	1978-82	1983-87	1988-92	1993-97	1998-99	All Years
Observed Cases in Sunset & Clinton	< 3	< 3	0	7	3	< 3	13
Expected Cases in Sunset & Clinton	1.19	1.21	1.71	1.86	2.17	0.72	9.07
Standardized Morbidity Ratio (Observed/Expected)	0.84	0.83	0.00	*3.75	1.38	1.38	1.43
95% Confidence Interval	0-3.31	0-3.25	0.56-0.56	1.49-7.05	0.26-3.39	0-5.42	0.76-2.32

Data Source: Utah Cancer Registry, 1999.
*Significance (Statistically significantly different from the expected number of cases.)
Observed cases are presented as < 3 when the number of cases are less than three to protect confidentiality of
the cases.

Table 6. Individual periods and cumulative results of kidney & renal pelvis cancer cases for the
communities of Sunset and Clinton, Davis County, Utah.

Time Periods	1973-77	1978-82	1983-87	1988-92	1993-97	1998-99	All Years
Observed Cases in Sunset & Clinton	6	0	< 3	5	< 3	6	19
Expected Cases in Sunset & Clinton	1.35	1.79	2.17	3.18	3.65	2.03	13.89
Standardized Morbidity Ratio (Observed/Expected)	*4.46	0.00	0.46	1.57	0.27	*2.95	1.37
95% Confidence Interval	1.6-8.74	0.54-0.54	0-1.81	0.5-3.26	0-1.07	1.06-5.79	0.82-2.05

Data Source: Utah Cancer Registry, 1999.
*Significance (Statistically significantly different from the expected number of cases.)
Observed cases are presented as < 3 when the number of cases are less than three to protect confidentiality of
the cases.

Table 7. Individual periods and cumulative results of brain cancer cases for the communities of Sunset
    and Clinton, Davis County, Utah.

Time Periods	1973-77	1978-82	1983-87	1988-92	1993-97	1998-99	All Years
Observed Cases in Sunset & Clinton	3	4	4	4	7	< 3	24
Expected Cases in Sunset & Clinton	1.85	2.37	2.89	3.49	4.00	1.84	16.36
Standardized Morbidity Ratio (Observed/Expected)	1.62	1.69	1.38	1.15	1.75	1.09	1.47
95% Confidence Interval	0.31-3.98	0.44-3.75	0.36-3.07	0.3-2.55	0.69-3.29	0.1-3.12	0.94-2.11

Data Source: Utah Cancer Registry, 1999.
Observed cases are presented as < 3 when the number of cases are less than three to protect confidentiality of
the cases.

Table 8. Individual periods and cumulative results for cases of non-Hodgkin's Lymphoma for the cities of
    Sunset and Clinton, Davis County, Utah.

Time Periods	1973-77	1978-82	1983-87	1988-92	1993-97	1998-99	All Years
Observed Cases in Sunset & Clinton	< 3	5	6	10	6	3	32
Expected Cases in Sunset & Clinton	2.39	3.01	4.13	6.18	8.17	4.15	27.18
Standardized Morbidity Ratio (Observed/Expected)	0.84	1.66	1.45	1.62	0.73	0.72	1.18
95% Confidence Interval	0.08-2.4	0.52-3.43	0.52-2.84	0.77-2.78	0.26-1.44	0.14-1.77	0.8-1.62

Data Source: Utah Cancer Registry, 1999.
Observed cases are presented as < 3 when the number of cases are less than three to protect confidentiality of
the cases.

Table 9. Individual periods and cumulative results for cases of thyroid cancer cases for the communities
    of Sunset & Clinton, Davis County, Utah.

Time Periods	1973-77	1978-82	1983-87	1988-92	1993-97	1998-99	All Years
Observed Cases in Sunset & Clinton	< 3	< 3	3	4	< 3	< 3	14.00
Expected Cases in Sunset & Clinton	1.79	2.21	2.86	3.62	4.54	2.43	17.32
Standardized Morbidity Ratio (Observed/Expected)	1.12	0.91	1.05	1.10	0.44	0.41	0.81
95% Confidence Interval	0.11-3.2	0.09-2.59	0.2-2.57	0.29-2.45	0.04-1.26	0-1.61	0.44-1.29

Data Source: Utah Cancer Registry, 1999.
Observed cases are presented as < 3 when the number of cases are less than three to protect confidentiality of
the cases.