

## **FINDINGS OF THE GOVERNOR OF TENNESSEE'S INDEPENDENT PANEL TO REVIEW DOE'S TSCA INCINERATOR**

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### **ABSTRACT**

The Governor charged the panel with addressing the concerns of the public, particularly the media, about the operation of the Toxic Substances Control Act (TSCA) Incinerator. The incinerator, operated for the Department of Energy by Lockheed Martin Energy Systems, Inc, is located at the East Tennessee Technology Park, formerly known as K-25 Gaseous Diffusion Plant. The incinerator is the only incinerator licensed to burn TSCA wastes together with radioactive wastes. The illnesses, described in a flyer for a community rally against the incinerator and activities in the Oak Ridge area, ranged from "loss of sex drive, memory loss, chronic fatigue, metal poisoning, rheumatic arthritis, lupus, ALS, MS, cardiovascular disease, respiratory problems, birth defects, immune problems, to endocrine malfunctions." There were numerous other allegations about the incinerator and its operation including environmental impacts, improper medical care and hazards of transportation of wastes to the incinerator.

The Panel found that the community was divided about almost everything except that there were sick workers and residents in the vicinity of the incinerator. However, there was no independent sampling of the workers or residents to see how widespread were the views we heard. We found that the incinerator facility was operating in accordance with its permit and at a small fraction of its design and permitted volume. In our independent calculations, we found that the concentrations of contaminants in the air where people worked and lived were a small fraction of the permissible levels. Most of the pollutants measured were not from the TSCA incinerator.

In the transportation, we found that there were TSCA wastes shipped from out of state but that the Oak Ridge Department of Energy facilities ship 12 times as much hazardous waste out of state as it imports, based upon weight. To date, there have been no highway accidents involving wastes being shipped to the TSCA incinerator.

The areal distribution of affected workers and members of the community conforms to no pattern, including the predominant TSCA incinerator plume directions. The diseases are not unique to specific chemicals so that the sources of the causes of illnesses are difficult to pinpoint. It is not known whether the incidence and types of illnesses are above, lower than or equal to the normal incidence. The Independent Physicians Group, after almost two years of investigation, have not been able to pinpoint causes for the illnesses.

Many of the workers and members of the public who appeared before us were not satisfied with availability, quality and extent of medical care. During our worker-led site visit we found neither unmarked sites with unsafe radiation levels nor any illegal activities. We did find situations that would not be considered best management practices. The dead pine trees along the major emission plume track appeared to be primarily due to attack by the Southern pine beetle. Without having direct observation at the time of the deterioration and the death of the trees, it is not possible to be more definitive.

The exasperation and rage expressed by some of the workers over what they perceived to be a lack of interest in finding a solution to their illnesses pervaded all of our hearings. There is a great distrust among these workers of the management of Lockheed Martin Energy Systems, Inc., DOE and the local medical community.

We concluded that there are sick workers members of the public who are not finding relief from their illnesses. The causes of their illnesses have not been determined-despite numerous attempts over the last five years.

Though we offer some recommendations to improve the situation, we recognize that there is not always a cure to illnesses nor is it always possible to uncover the causes of the illnesses. Our primary recommendation is to provide relief to the affected workers and residents even without knowing the causes of the illnesses. A scientifically valid epidemiological analysis should be conducted to determine if the rate of the illnesses being experienced is within the normal range or not. The Panel was not able to establish any direct cause and effect relationship between the operation of the incinerator and the illnesses in Oak Ridge. Therefore, we recommended that the TSCA incinerator continue to be operated taking into account our recommendations. We recommended that joint committees of workers and management be formed to respond promptly to all allegations of faulty practices. Finally, all of the recommendations listed above, while they may improve the situation, may not yield the causes of the illnesses. We recommend more basic research on why these people are sick and why some people are more susceptible to illnesses than others.

## INTRODUCTION

On February 9, 1997, *The Tennessean* began a series of articles concerning the impact of the Toxic Substances Control Act (TSCA) Incinerator upon the health of the workers at the East Tennessee Technology Park (ETTP) in Oak Ridge, Tennessee. Those articles have continued to this time and now include questions about the health of nearby members of the public and the potential effects of sources other than the incinerator. Recently, *The Tennessean* has published a series of stories that state "Mysterious health problems that doctors cannot explain are afflicting people working at and living near nuclear weapons plants and research facilities from California to New York" (September 29, 1998). Reactions to these stories have been strong. On February 12, 1997 State legislators called for hearings which were subsequently held by Committees of the Tennessee State General Assembly. The hearings concerned the illnesses in Oak Ridge and the transportation of hazardous wastes through the state to the TSCA incinerator. On May 16, 1997, Governor of Tennessee, Don Sundquist, appointed the Governor's Independent Panel on the Operations of the Department of Energy Toxic Substances Control Act (TSCA) Incinerator. The Panel of environmental scientists, engineers, and occupational health professionals was to investigate the operation of the TSCA incinerator, the burning of out-of-state wastes and the concerns and issues raised by the public about the TSCA incinerator. The Panel was to report its findings to the Governor, the legislative committees, and the Manager of the Department of Energy Oak Ridge Operations within 120 days of its inception (1). Henry Walker wrote in the Nashville Scene "Now we know: *The Tennessean's* yearlong series on health and environmental problems at Oak Ridge is based, in part on dishonest reporting. The main allegations raised by the series-the safety of the incinerator; the disposal of out-of-state wastes; the transportation of hazardous materials; the pine tree blight; the "common sense" cause of the unexplained illnesses-have been essentially demolished by the (Governor's) Panel's findings" (December 18, 1997). On October 3, 1998, *The Tennessean* reported that U.S. Energy Secretary Bill Richardson said he would investigate reports of health problems among workers and neighbors of the nation's nuclear weapons sites. *The Wall Street Journal*, November 12, 1998, front page headline read "A Newspaper Invents a Nuclear Health Scare."

The Toxic Substances Control Act (TSCA) Incinerator was put into service at the East Tennessee Technology Park (ETTP), formerly known as the K-25 complex or the Gaseous Diffusion Plant of the U.S. Department of Energy (DOE), in 1991. The East Tennessee Technology Park occupies approximately 1,500 acres in Roane County 13 miles west of downtown Oak Ridge and approximately 40 miles northwest of Knoxville. The ETTP compound is a fenced area of 700 acres supporting 118 buildings.

The incinerator was designed to destroy hazardous wastes and/or to reduce the volume of uranium contaminated waste. It is the only incinerator permitted to burn mixtures of TSCA wastes, e.g. PCBs, Resource Conservation and Recovery Act (RCRA) wastes, e.g. most other hazardous materials, and radioactive wastes.

The City of Oak Ridge is located in Anderson and Roane Counties in Eastern Tennessee. Figure 1 shows the locations of Oak Ridge and the K-25/ETTP site. The Oak Ridge community was established shortly after the inception of the Manhattan Project to develop the atomic bomb. The population, after peaking at 75,000 people, dropped to 30,000 by 1950 and has remained relatively constant. The population of the surrounding areas has continued to grow.

The 1990 per capita income for Oak Ridge residents was \$17,700, with a median family income of \$32,600 (2). The City of Oak Ridge, as well as the surrounding areas, is experiencing the impacts of the shifting missions of the Department of Energy. As DOE continues to reduce its role, the City, the surrounding area, and DOE are aggressively pursuing reindustrialization of the surplus DOE facilities at ETTP.

The Oak Ridge Gaseous Diffusion Plants (GDPs) were permanently closed in 1987. In 1989, DOE assigned a new mission to the K-25 Site: environmental restoration, waste management, and environmental technology development. In 1993, the K-25 Site was designated the Center for Environmental Technology and the Center for Waste Management. The K-25 Site has been a major source of employment for the Oak Ridge area. The number of workers at the K-25 site reached a high of over 4,000 in 1993 and is currently approximately 3,100 workers.

Since 1991, the incinerator has treated over 20,000,000 pounds of waste. The wastes consisted of approximately 19,600,000 pounds of liquids and approximately 450,000 pounds of solids (3).

## WORKERS' AND NEARBY RESIDENTS' ILLNESSES

### Heavy Metals

The Coalition for a Healthy Environment (CHE) presented a list of symptoms of illnesses for both workers and residents (4). The symptoms included immune and autoimmune disorders, cardiopulmonary dysfunction, vision and hearing loss, neurological problems, gastrointestinal problems, chronic pain and chronic fatigue. In addition, the affected workers reported skin rashes, respiratory ailments, headaches, thyroid disorders and sinus problems. Questions regarding worker and public health and safety at Oak Ridge were prominent in the media and public meetings in the early 1990s when a local physician expressed concern that heavy metal contamination in the vicinity of the ORR was causing the disease. He reported that 44 of his patients had become ill as a result of chronic metal exposure. Both workers and non-workers were affected. Eight categories of disease were elevated in his practice: neurological diseases, malignancies, immunodeficiencies, autoimmunity/inflammatory arthritis, chronic fatigue syndrome, osteomalacia, bone marrow abnormalities, and coagulopathies. He also stated that he knew of no exposure pathways to explain how toxins would have come into contact with his patients, but believed that it was the result of the heavy metals that pollute the area (5).

The Agency for Toxic Substances and Disease Registry's (ATSDR) Health Investigation Branch, after reviewing the information for 42 of Dr. Reid's patients, concluded that "Many diseases having no apparent causative agent exist, but there is not sufficient evidence at this time to associate low levels of metals with these diseases" (6).

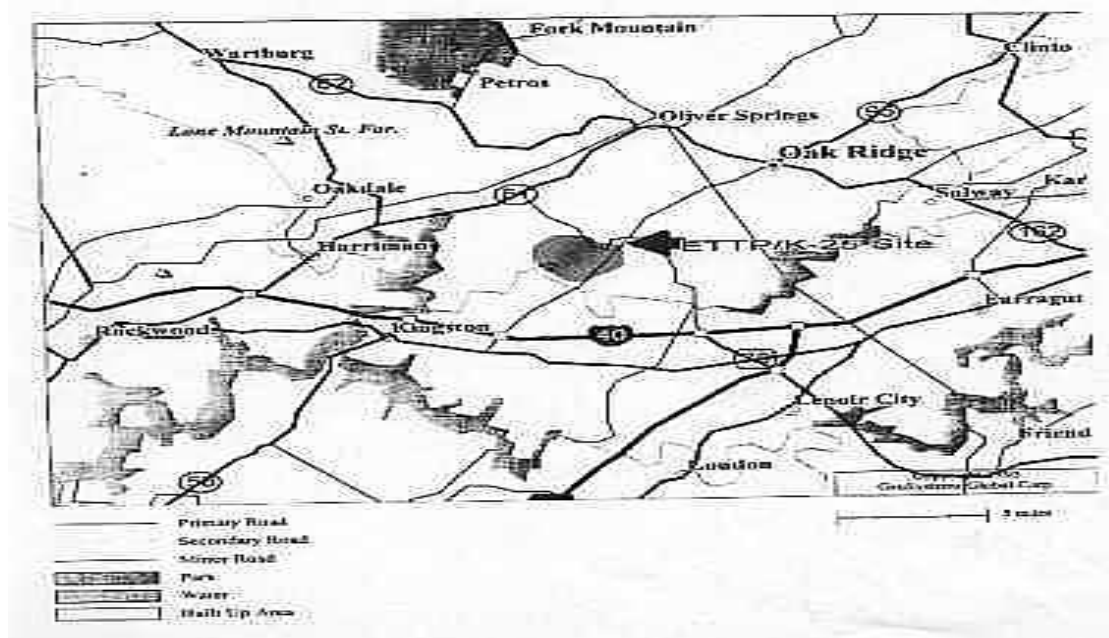


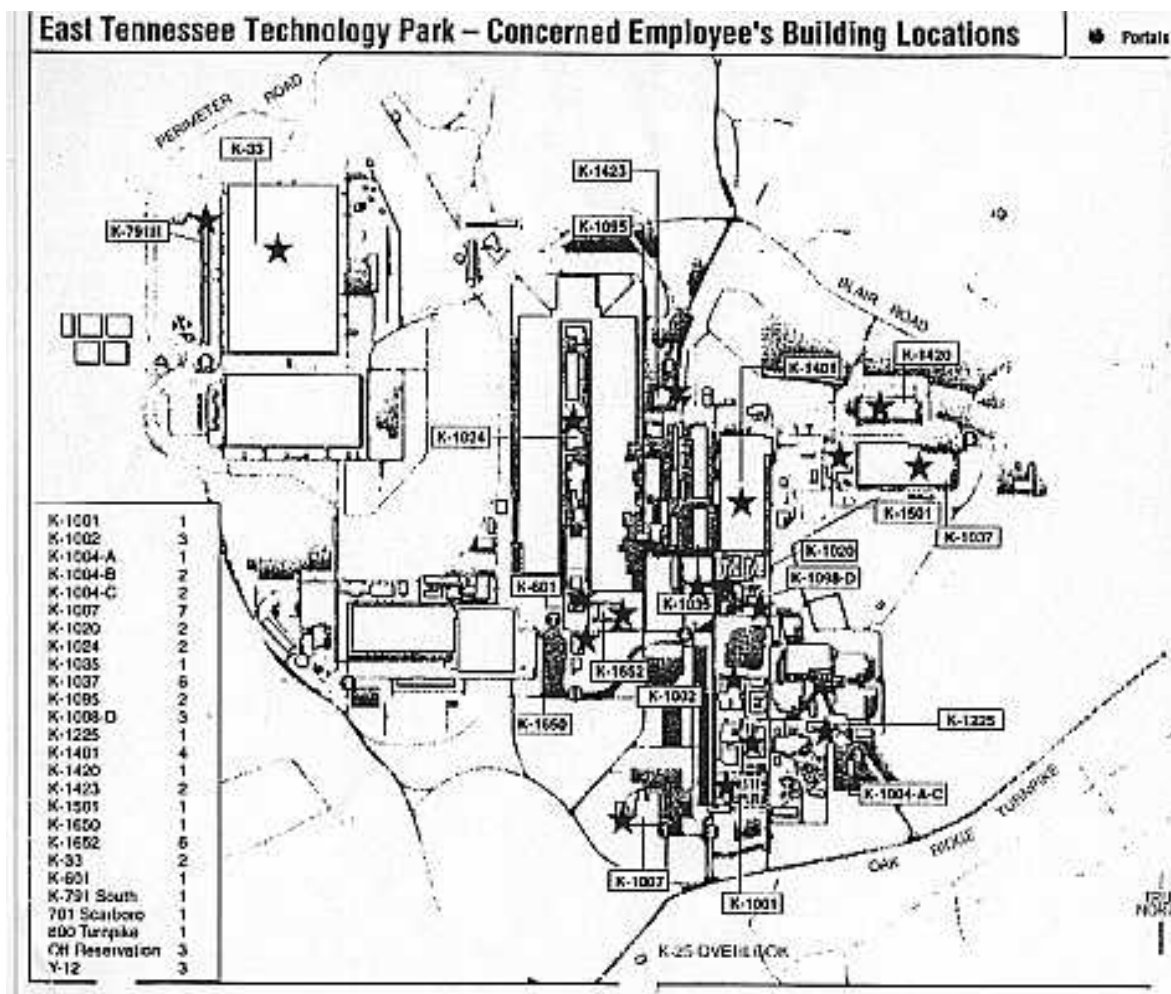
Fig. 1: Location of Oak Ridge and K-25/ETTP Site

### Cyanide Exposures

In 1995, safety concerns related to the TSCA incinerator surfaced after employees at the K-25 Site reported to the on-site medical department with symptoms of fatigue, depression, irritability, headache, muscle cramps, decreased sex drive, shortness of breath, and dizziness. Health concerns focused on the TSCA incinerator when a Lockheed-Martin Energy Systems' (LMES), the operator of the plant for the Department of Energy, physician at K-25, referred employees to their primary healthcare providers for suspected cyanide intoxication. Urine thiocyanate analysis performed by the affected employees' personal physicians showed that some of the test results were elevated above the laboratory's normal reference range. Sixty-five employees filed Medical Incident Reports related to suspected cyanide intoxication. No source of cyanide was identified through workplace monitoring by LMES and no significant source of cyanide was known to have been included in the incinerator waste feed during this period.

After examining 40 of the 65 employees who had filed worker's compensation claims with LMES, an independent occupational toxicologist concluded that: (1) the complaints were subjective, (2) no spatial or temporal relationships to jobs that could be anticipated to result in exposure to thiocyanate-producing chemicals was

determined, (3) the reference ranges to distinguish “normal” from “abnormal” levels of thiocyanate in the urine were not well documented in the scientific literature, and (4) urine thiocyanate testing is not recommended by NIOSH, OSHA, or ACGIH as a means of monitoring cyanide exposure in the workplace. It was noted that employees had not been restricted from foods and other products that could produce non-occupationally related elevations in the testing. Based on these factors, he felt that the results of the testing alone were not indicative of cyanide intoxication and that cyanide intoxication was an unlikely explanation for the symptoms exhibited by the K-25 employees (7). The locations of the workplaces of the affected people as related to the incinerator are shown in Figure 2.



**Fig. 2: ETPP – Concerned Employee's Building Locations**

On January 29, 1996, the National Institute of Occupational Safety and Health (NIOSH) initiated a health hazard evaluation at the request of a group of LMES employees at ETPP and LMES. Medical interviews were conducted with 22 employees who reported symptoms of fatigue, headaches, muscle aches, sleeplessness, and depression. No distinctions were noted in the employees with respect to age, sex, work area, and job title. It was noted that, although some of the symptoms that employees were experiencing are related to cyanide exposure, the symptoms are “very non-specific in nature.” Personal medical records for 15 workers were made available to the NIOSH team. The evaluation concluded, “The results of this evaluation indicate that the employees at the K-25 Site are not occupationally exposed to hydrogen cyanide, cyanide salts, or a wide variety of other compounds that contain the CN<sup>-</sup> ion. The results of this evaluation do not support a relationship between the health problems reported by employees at the K-25 Site and chronic, occupational cyanide intoxication” (8). The NIOSH report also stated that the testing done would not have detected nitriles, which are also metabolized to thiocyanate. The TSCA incinerator has treated wastes containing nitriles. The most significant event was the burning of approximately

72,000 of solvent acetonitrile (ACN) between July 1991 and July 1992. An estimated 1,000 to 1,500 pounds of nitriles, contained in personal protective equipment (PPE), have been processed since 1996. (9)

There was confusion among employees from conflicting medical opinions regarding the significance of urine thiocyanate levels. The dissemination of speculative information about the health effects related to chronic cyanide exposure contributed to their confusion. Because of the continued concern surrounding the employees' symptoms, the employee representatives and Lockheed-Martin agreed to each select one physician to evaluate the employees. As of this date, no agent had been identified by this independent team of doctors as the cause of acute symptomatology or disease. Some employees could have illnesses associated with the workplace, but a common source for the wide variety of symptoms being experienced has not been identified.

Some of the workers felt that they suffered from multiple chemical sensitivity (MCS). MCS occurs when patients, exposed to levels of chemical substances well below those tolerated by most persons, exhibit symptomatology that can be quantified objectively. The most widely used clinical definition of MCS is:

"MCS syndrome is an acquired disorder characterized by recurrent symptoms, referable to multiple organ systems occurring in response to many chemically unrelated compounds at doses far below those established in the general population to cause harmful effects. No single widely accepted test of physiological function can be shown to correlate with symptoms". (Cullen 1987)

Weiss (1997) wrote that most clinical and biomedical scientists are dubious regarding the authenticity of multiple chemical sensitivity, and are likely to remain so unless there is compelling evidence from credible sources. The American Medical Association's Council on Scientific Affairs (10) reported that "no scientific evidence supports the contention that MCS is a significant cause of disease or that the diagnostic tests and the treatments used have any therapeutic value. Until such accurate, reproducible, and well-controlled studies are available, the American Medical Association Council on Scientific Affairs believes that multiple chemical sensitivity should not be considered a recognized clinical syndrome".

In 1993, as part of the Health Studies Agreement, data from state health registries were reviewed to determine if they would be useful to identify trends in the public's health. Mortality data from death certificates and the state's cancer registry were the only sources of information considered. The cancer registry data was limited in that it had been in existence for only three years.

Using standard statistical methodology and death certificate data for a ten-year period, the age-adjusted total death rates in Anderson and Roane Counties (where the ETTP is located) were found to be lower than the rest of Tennessee.

The 1988-1990 age-adjusted incidence rates for total cancer cases and for 23 specific physical sites of cancer for Anderson County were compared with the comparable rates for the state. Oak Ridge and Roane County had significantly greater rates of prostate, female breast, and corpus uterine cancer than the rest of the state. Anderson County residents had significantly higher rates for female breast, corpus uterine, ovarian, prostate, and lung cancers. However, the age-adjusted death rate for cancer in Anderson County was not significantly different from the rest of the state, while the age adjusted cancer death rate for Roane County was significantly lower than the rest of the state.

## **INCINERATOR AND OTHER PLANT OPERATIONS**

One of the major allegations in the initial newspaper articles in *The Tennessean* was that the incinerator was the cause of the illnesses of the workers at the ETTP. The TSCA incinerator has obtained and is required to meet the parameters of permits required under RCRA, CWA, CAA, and TSCA.

The TSCA incinerator facility consists of seven major systems: receiving and storage, process storage, feed preparation, waste feed, incineration, process gas cleaning, and effluent liquids/solids management. The incinerator is a conventional design slagging rotary kiln for the destruction of hazardous and toxic wastes. It is fueled by natural gas and the heat content of the wastes processed. The following process equipment is incorporated into the incinerator: containerized solids airlock/ram feeder, six (6) feet inside diameter, 26 feet long, refractory lined, rotary kiln that operates at 1,800°F, wet solids ash removal system to collect coarse solids from the kiln, afterburner that operates at 2,200°F with greater than two seconds residence time, water quench to reduce flue gas temperatures to less than 187°F, venturi scrubber to remove particulate matter, packed tower for acid gas control, two ionizing wet scrubbers to remove submicron particulate matter, thermal relief valve to protect gas scrubbers, induced draft fan, and stack to disperse effluent gases.

The TSCA incinerator is permitted to burn 964 pounds/hour of solids and 1,836 pounds/hour of liquids. At these feed rates (assuming 90% on-stream time), the facility could process 7,600,000 pounds of solids and 14,500,000 pounds of liquids per year. Actual feed rates are approximately 3% and 33% of permitted levels for solids and liquids, respectively. An integral part of the incinerator's permitting process was the successful completion of a trial burn. During the trial burn, the incinerator is fed wastes spiked with specific principal organic hazardous constituent(s) (POHC) and the amount of POHCs exiting the incinerator's stack is measured. The percentage of the POHC removed or destroyed during the incineration process is then determined. The results of the trial burn are then used to develop a model of the incinerator's operation. This model is, in turn, used to determine the allowable amounts and types of wastes fed to the incinerator and to estimate the emissions from the incinerator stack (Brunner, 1989).

The incinerator was required to achieve destruction and removal efficiencies (DREs) of 99.9999% for the TSCA POHCs (primarily PCBs) and 99.99% for the RCRA POHCs. Two trial burns were held as part of the initial permitting process: a RCRA trial burn and a TSCA trial burn. The POHCs for the two trial burns were: Polychlorinated biphenyls (PCBs) – TSCA, Trichlorofluoromethane – RCRA, Carbon tetrachloride – RCRA, and Hexachloroethane – RCRA. The RCRA trial burn required the afterburner to operate at a temperature greater than 1878°F, while the TSCA trial burn required afterburner temperatures greater than 2,200°F. The TSCA incinerator surpassed all RCRA and TSCA DRE requirements during the trial burn (11).

## **OUT-OF-STATE DOE WASTES**

States, including Tennessee, which host the DOE incinerators, negotiated with DOE and the agreement stipulated the right of the states to approve shipping and treatment schedules for out-of-state wastes, required the generator to demonstrate the lack of on-site treatment capability, and established that residuals remaining after incineration may not generally be permanently stored at the treatment site (12). A 1993 Consent Order (Tennessee, 1993) allows the TSCA incinerator annually to treat off-site waste up to ten percent of the total on-site permitted treatment of Oak Ridge Reservation (ORR) wastes.

In discussions on a national incineration strategy, the issues of state equity have been considered. However, it should be noted that over the past three years approximately four (4) million pounds have been brought to Oak Ridge for the TSCA incinerator while approximately 48 million pounds of wastes have been sent out of Oak Ridge for treatment or disposal. The hazard of the waste is not linearly correlated with the mass of waste, however.

Generally, incomplete information on characterization is available concerning legacy waste, and is based mainly on process knowledge, source familiarity, and limited analysis. The TSCA incinerator has absolute control over the waste it burns and uses a large number of strict criteria in accepting waste for incineration. All waste receipts are approved, at a minimum, by the Manager of the TSCA incinerator, Health, Physics, and Industrial Hygiene. The TSCA incinerator Burn Master reviews all items against a detailed checklist and writes the permit-required approval to receive and burn specific shipments.

## **TSCA Incinerator Feed**

Waste composition and feed rates used for this analysis were based on the "Annual Incinerator Totals Cross-Tabulation Report" prepared by TSCA incinerator staff (3) (see Table I). The number of chemicals and radionuclides reported in the waste varies from year to year. In 1996, the latest complete year of data available, the report contains composition data for 30 metals, 105 organics, 29 radionuclides, plus the chlorine, fluorine, and sulfur content of the waste. Data for the years 1994, 1995, and 1996 formed the basis for this analysis. Thirty-seven pollutants were selected for analysis. These included the most toxic pollutants emitted from the incinerator, and those that were present in the waste in the greatest quantity. The pollutants are grouped into six categories: carcinogenic metals, noncarcinogenic metals, carcinogenic organics, noncarcinogenic organics, other noncarcinogens, and radionuclides. These 37 pollutants account for 480,000 pounds (14%), 264,000 pounds (13%), and 145,000 pounds (3%) of the wastes burned in the incinerator in 1996, 1995, and 1994, respectively. The annual waste generated is shown in Table II (13).

**Table II: Annual TSCA Incinerator Waste Generation**

| <b>Waste</b>   | <b>1991</b> | <b>1992</b> | <b>1993</b> | <b>1994</b> | <b>1995</b> |
|----------------|-------------|-------------|-------------|-------------|-------------|
| Ash            | 16000       | 8900        | 1300        | 2000        | 52000       |
| Blowdown Water | 170000000   | 180000000   | 170000000   | 180000000   | 140000000   |
| Sludge         | 160000      | 210000      | 100000      | 84000       | 10000       |
| Kiln Brick     | 2700        | 130000      | 9000        | 26000       | 13000       |

All wastes are shown in pounds/year (rounded)

**Table I: TSCA Incinerator Waste Feed Rates for 1994-1996**

| <b>Analyte</b>                                                                                                                                                                                                                      | <b>1996<br/>Annual Waste Feed</b> | <b>1995<br/>Annual Waste Feed</b> | <b>1994<br/>Annual Waste Feed</b> |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|
| Metals-Carcinogens (g/yr)-Arsenic, beryllium, cadmium, Chromium, Nickel                                                                                                                                                             | 520000                            | 36000                             | 130000                            |
| Metals - Noncarcinogens (g/yr) – Mercury, Antimony, Barium, Lead, Silver, Thallium                                                                                                                                                  | 1600000                           | 110000                            | 92000                             |
| Organics - Carcinogens (lb/yr) – Trichloroethane, Acrylonitrile, Acetonitrile, Benzene, Carbon Tetrachloride, Chloroform, Hexachloroethane, Methylene Chloride, PCB's, Tetrachloroethylene, Trichloroethylene, Nitrosodimethylamine | 260000                            | 170000                            | 62000                             |
| Other Noncarcinogens (lb/yr) – Acetone, Acrolein, HCl from Chlorine, HF from Fluorine, SO <sub>2</sub> from Sulfur, HCN from Nitriles, Toluene, Xylene                                                                              | 210000                            | 90000                             | 82000                             |
| Radionuclides (g/yr)-Uranium (total), Technetium-99, Protactinium-234m, Tritium, Strontium-90,                                                                                                                                      | 7.22E+05                          | 2.07E+05                          | 1.78E+05                          |
| Radionuclides (microcuries/yr) - Uranium (total), Technetium-99, Protactinium-234m, Tritium, Strontium-90                                                                                                                           | 1.02E+06                          | 2.54E+05                          | 3.96E+05                          |
| <b>Grand Total (lb/yr)</b>                                                                                                                                                                                                          | <b>4.81E+05</b>                   | <b>2.64E+05</b>                   | <b>1.45E+05</b>                   |

**EMISSIONS AND AIR QUALITY**

The ambient concentrations of air pollutants in the area surrounding the TSCA incinerator were calculated to determine the concentrations of any pollutants emitted from the TSCA incinerator. This evaluation required separate analyses of: (1) waste composition and feed rates; (2) destruction and/or removal efficiencies for the incinerator and its air pollution control equipment for each pollutant; (3) estimates of pollutant emissions from the incinerator stack; (4) dispersion modeling of the pollutants emitted to the atmosphere using a computer model to predict ambient concentrations of pollutants; and (5) a comparison of the predicted concentrations to ambient air

quality criteria established by USEPA. Where possible, predicted concentrations were also compared to concentrations measured at several air sampling sites located near the incinerator.

The best data upon which to base emission estimates would be from continuous emissions monitors on the incinerator stack. However, the current state-of-the-art does not allow continuous emissions measurements for all pollutants. The TSCA incinerator does continuously measure carbon monoxide (CO) concentration and collects a continuous sample of stack emissions for analysis of radionuclide emissions. The CO monitor is a good indicator of combustion efficiency. It typically measures 5 ppm of CO, which indicates 99.9 percent combustion efficiency (based on a typical CO<sub>2</sub> concentration in the stack gases of 5 percent).

Since detailed data on emissions from stack monitoring instrumentation are not available, the best estimate of emissions must be based on the quantity of each pollutant fed to the incinerator, multiplied by the percentage of the pollutant expected to escape destruction by the incinerator or removal by the scrubbers. Based upon the material fed into the TSCA incinerator and the destruction efficiencies in the trial burns, the average emissions over the years 1991 – 1996 and the permitted amounts are shown in Table III. For the wastes that remain after incineration, the dose from the radioactive material incinerated is also calculated for the most impacted individual.

Atmospheric dispersion modeling was performed in order to predict annual average ambient concentrations for each pollutant in the vicinity of the incinerator. EPA's Industrial Source Complex Short Term Model, Version 3 (ISCST-3) was used for the modeling. It is designed to model the emissions from single or multiple stacks, taking into account plume rise, downwash from buildings, and plume impaction on elevated terrain. The model was run using a single 100-foot high stack from the incinerator. The stack is not tall enough to avoid downwash from nearby buildings, so direction-specific building dimensions were entered to account for possible downwash. Emissions were assumed to occur at a constant rate all year. Particle deposition and depletion were not considered. Therefore, this results in an overestimate of the concentrations at a receptor further downwind and an underestimate at closer locations.

Five years of hourly meteorological data were used for modeling. Ambient concentrations were predicted in the vicinity of the incinerator to a distance of 5,000 meters. Elevations for receptors close to the incinerator and within the ETTP facility were estimated from USGS topological maps with an additional 15 meters added to estimate the height of any occupied buildings on the site. Maximum concentration estimates were made using urban dispersion coefficients to account for the surface roughness due to the "industrial" land use on the ETTP site. All other modeling conditions were consistent with EPA's regulatory default values. The source strength was set at 1 gram per second to predict concentrations "normalized" to a unit emission rate.

Typical results of the modeling are illustrated in the isopleth map shown in Figure 3. All five years showed similar patterns of air pollutant dispersion, reflecting the bi-modal prevailing wind directions for East Tennessee. Winds are predominantly out of the west, but are channeled along the northeast-southwest valley alignment due to the influences of the Cumberland Mountains to the west and the Appalachian Mountains to the east. The prevailing winds are generally out of the southwest (up-valley flow) during the daytime and out of the northeast to north-northeast (down-valley flow) during the night as shown by the wind rose in Figure 4.

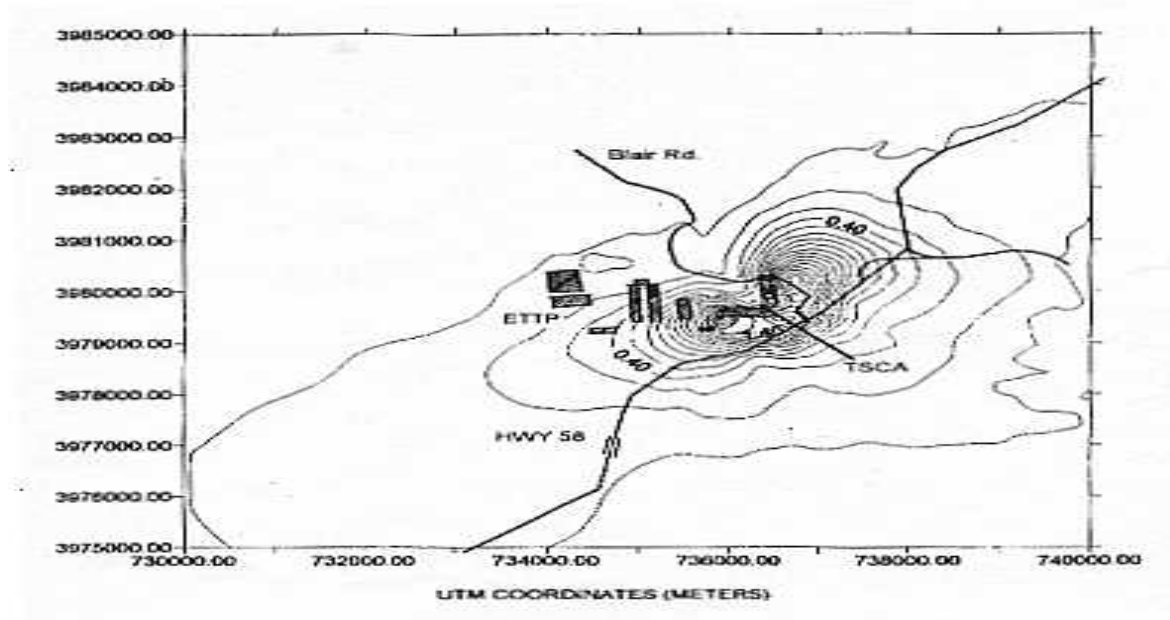
The distance to the predicted maximum concentrations was approximately 500 meters for all 5 years, but the direction to the maximum concentration was northeast of the incinerator stack three years and twice it was southwest of the incinerator stack.

The maximum predicted normalized annual mean concentration was used as the worst case. Since the maximum concentration is predicted to occur within the ETTP, any exposure is more likely to be a workplace exposure of 40 hour/week or more, instead of a 168 hour/week as might occur at a home. Furthermore, plume dispersion to the southwest of the stack where the majority of employees are located (see Figure 2) is more likely to occur at night, during down-valley drainage winds, than during the daytime when winds are more likely to be out of the southwest. No adjustments for these factors were made as part of the analysis. For these reasons, the predicted concentrations may be expected to be conservatively high.

None of the 37 pollutants evaluated showed predicted ambient concentrations high enough to exceed EPA's allowable ambient levels for hazardous waste. The highest predicted value was 0.184 for chromium, assuming conservatively that all the chromium was hexavalent, which is the most toxic form. Uranium concentrations showed the second highest index value of 0.121. This value is based on EPA air quality criteria that limits excess exposures of public to less than 10 millirem per year. A concentration of 0.0166 micrograms per cubic meter is the concentration of U-238 that would equal a 10 millirem/yr exposure. The calculation assumes that all the uranium is U-238. (Waste analysis for 1995 and 1996 show that most of the radioactivity of the uranium is due to U-238.)

The results shown in Table III indicate that only uranium and the 4 carcinogenic metals, arsenic, cadmium, chromium, and nickel, exhibit concentrations greater than one percent of the air quality criteria. None of the

noncarcinogenic metals, carcinogenic organics, or noncarcinogenic other compounds show concentrations likely to exceed even one percent of the air quality criteria. In the case of the carcinogenic organics, all of the predicted concentrations are 0.1 percent or less of the air quality criteria.



**Fig. 3: Normalized Air Contaminant Isopleth at East Tennessee Technology Park (ETTP)**

In addition to the TSCA incinerator, TVA's Kingston Steam Plant emissions were also modeled for the purpose of providing a comparison of ambient concentrations caused by TVA versus TSCA. The Kingston Steam Plant has two 1000-foot high stacks, which provide great dispersion of the plume before it reaches the ground. A screening analysis using 1987 Knoxville meteorological data showed a predicted maximum annual mean normalized concentration of approximately 0.001 microgram per cubic meter per gram per second of emissions. The location of the maximum concentration prediction was at a point approximately midway between the TVA plant and the TSCA incinerator, a point 7 kilometers west-southwest of TSCA. Unfortunately, TVA could not provide the emissions of arsenic, mercury, or lead from the Kingston Steam Plant. The best estimate was "less than a ton per year." If this is taken as an estimated 1000 pounds per year (equal to an average rate of 0.014 grams/sec) then the maximum annual predicted concentration would be 0.000014 micrograms per cubic meter. However, due to the increased dispersion from TVA's tall stacks, the maximum predicted ground level concentration due to TVA's emissions is considerably lower (less than 10 percent) than the maximum predicted for the TSCA incinerator and considerably lower (less than 3 percent) than that measured at the monitoring stations in the ETTP.

**Table III: Computed TSCA Incinerator Emission Rates**

| Year            | Beryllium<br>lbs/yr | Lead<br>lbs/yr | Mercury<br>lbs/yr | Chlorine<br>lbs/yr | Fluorine<br>lbs/yr | Sulfur<br>lbs/yr | Rad<br>(mrem) |
|-----------------|---------------------|----------------|-------------------|--------------------|--------------------|------------------|---------------|
| Average         | 0.011               | 2.56           | 3.89              | 102.7              | 3.76               | 594              | 0.18          |
| Permitted Limit | 0.73                | 1150           | 175.2             | 32240              | 5960               | 77080            | 7.5           |

## ENVIRONMENTAL IMPACT

It was asserted that the damaged and dead Pine trees northeast of the incinerator were caused by the interaction of the plumes and the deposition of particulate matter from the incinerator. Consultants to the Panel asserted they were not able to state the cause of the devastation to the pine trees northeast of the incinerator, directly in the main plume path. However, in their report in response to the question, "How likely is the damage attributable

to the emissions from the TSCA incinerator," they state, "There is a strong likelihood that impacts could occur in the direct plume of the emissions; however, no evidence of stress to the surrounding flora, other than the pine tree damage caused by the southern pine beetle, was observed during the site visit or found in the literature base." Because of the uncertainty of the cause of the environmental damage, the affected site was visited with a specialist in southern pine beetle disease. There was extensive evidence of southern pine beetle damage in the affected areas. There appeared to be no damage attributable to other causes, including the constituents of the TSCA incinerator plume. However, the Panel could not categorically exclude the premise that the plumes might have weakened the trees so that they were more susceptible to the pine beetles (14).

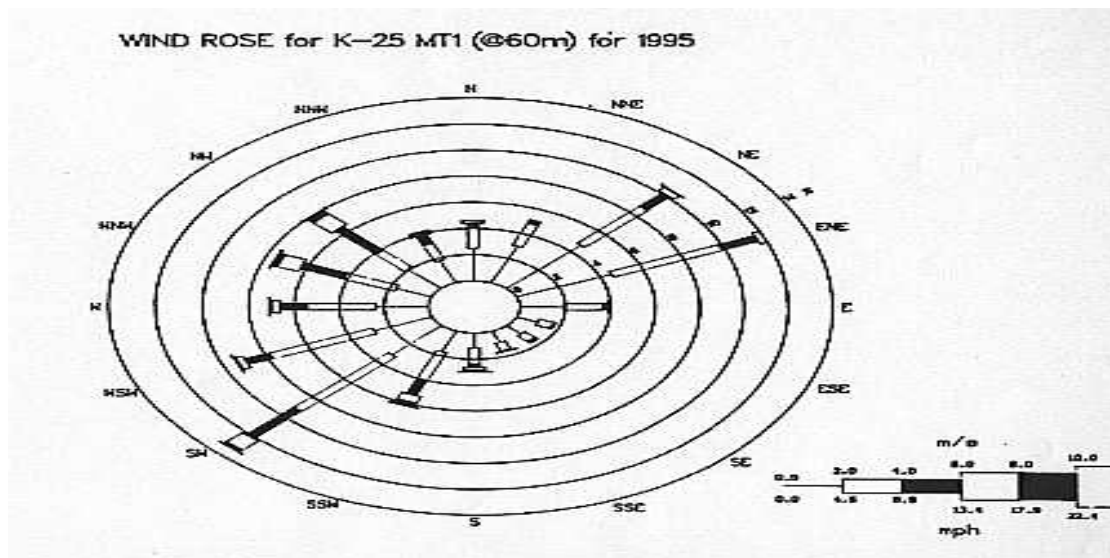


Fig. 4: Wind Rose at East Tennessee Technology Park

## FINDINGS

### A Divided Community

The Panel found unanimous agreement that there are sick workers at the ETTP and sick residents in its vicinity. Beyond that, there was no unanimity on any topic. In fact, among those views presented, there was deep polarization on almost everything. These ranged from the views expressed in the advertisement for community meetings about Oak Ridge area industry by a poster for a community meeting on September 23, 1997 at the University of Tennessee, COALITION FOR A HEALTHY ENVIRONMENT and SAVE OUR CUMBERLAND MOUNTAINS (CHE 1997), that stated:

"WHAT'S UP? - Furans, Dioxins, PCBs, Heavy Metals" ... and "What's coming DOWN on OUR TOWN? Loss of sex drive, memory loss, chronic fatigue, metal poisoning, rheumatic arthritis, lupus, ALS, MS, cardiovascular disease, respiratory problems, birth defects, immune problems, endocrine malfunctions"

to an article in *The Tennessean*, an "Op-editorial" Nashville Eye piece (October 17, 1997) by Susan Gawarecki, President of the League of Women Voters of Oak Ridge, who wrote: "The Board of the League of Women Voters of Oak Ridge wishes to inform readers of *The Tennessean* that they have been misled by this newspaper. The numerous articles published about Oak Ridge environmental issues do not accurately represent the state of health in our community nor the opinions of the vast majority of Oak Ridge residents and workers at the Department of Energy facilities." And "*The Tennessean* does a disservice to its readers when it devotes many column inches to unproven allegations while barely acknowledging scientific facts and technical accuracy. Moreover, the newspaper unjustifiably damages the reputation of the Oak Ridge community, one that by all measures has a better quality of life than most other parts of Tennessee."

### TSCA Incinerator

The TSCA incinerator was the main object of the study because of the Governor's charge and the allegations in *The Tennessean* that it was the cause of the illnesses. *The Tennessean* articles were introduced with an

icon that read "TOXIC BURN – Fear and Fire in Oak Ridge" and contained such statements as "Last year, the churning, red-hot incinerator consumed 1,500 tons of toxic cold war remnants" (February 16, 1997). However, most of the workers did not blame their illnesses on the incinerator. They did however, want relief from their illnesses, no matter what the cause.

The Panel and its incinerator consultant found that the facility and operating conditions were in harmony with its permit and had experienced few operating violations (11). The wastes fed to the TSCA incinerator are thoroughly characterized at the generation point and when received at the incinerator. The amount of wastes actually burned is a small fraction of the volume that the incinerator is designed and permitted to process. If the destruction and removal efficiencies obtained in the trial burns (required to obtain the operating permits) still pertain, the emissions of hazardous chemicals and radioactive materials are but a small fraction of the permitted emissions.

The Panel modeled the emissions from the TSCA incinerator stack and found that the calculated concentrations were far below the permitted levels. The maximum annual average concentration estimates, at the site where there are people to be exposed, 640 meters southwest of the incinerator stack, range from a maximum of 18.4% of the standard for chromium to less than 0.1% for most others. These estimates were compared to the highest measured concentrations at the site monitors. The measured concentrations were a small fraction of the permissible levels and most pollutants measured were not primarily from the TSCA incinerator, as shown by the fact that the estimated concentrations from the TSCA incinerator were only a small fraction of those measured.

The incinerator is regulated and monitored by both the U.S. Environmental Protection Agency and the State of Tennessee. If the permissible levels of pollutants in the environment are deemed adequate to protect public health, and they must be, to conform to the law, then, the TSCA incinerator is not a major contributor to the illnesses seen in the Oak Ridge area.

### **Transportation of Waste**

Department of Energy waste from out of state must be transported to the TSCA incinerator because there is no other incinerator in the country licensed to burn such wastes. DOE, to be more efficient, allocates certain waste treatment functions to certain sites. Consequently, DOE at Oak Ridge ships 12 times as much hazardous substance out of state as it imports, based upon mass. It is recognized, of course, that mass is not a true indication of hazard and risk.

Transportation of hazardous substances is regulated and monitored by the United States Department of Transportation and the State of Tennessee. The record of safety for such shipments has been exemplary. There have been approximately 230 out-of-state shipments to the TSCA incinerator traveling approximately 28,000 miles on the highways of Tennessee. To date, there have been no highway accidents involving wastes being shipped to the TSCA incinerator. This record reflects the same safety record nationwide. These hazardous substances are but a small fraction of the hazardous substances traveling daily on our highways. Calculation of the most extreme events, crash and fire on the highway in a heavily populated area, finds that projected hazard is well below the Environmental Protection Agency Guidelines for risks from hazardous wastes. The transportation of hazardous substances to the Oak Ridge TSCA incinerator and from the Oak Ridge site involves risks well within those accepted on a daily basis in the transportation of other hazardous materials, such as gasoline.

### **Out-of-State Wastes**

The volume of out-of-state DOE-generated wastes treated by the TSCA incinerator may not exceed ten percent of the total Oak Ridge Reservation on-site permitted and interim status treatment capacity. This capacity is approximately 1,350 tons per year. These wastes are subject to more rigorous inspection than the Oak Ridge wastes. Out-of-state DOE wastes then, are not the cause of the illnesses.

### **Workers and Members of the Public Illnesses**

The areal distribution of affected workers and members of the public conforms to no pattern, including the predominant TSCA incinerator plume directions. Compounding the problem of determining the cause of the illnesses is the fact that the diseases are not unique to specific chemicals, so that the sources of the causes can not be sought. It is not known whether the incidence and types of illnesses are above normal or a statistical aberration. Registries (records) of most of these illnesses are not routinely kept.

The final report of the Independent Physicians Group is not yet available. None of the other examinations by physicians available to us have been able to pinpoint a cause for the illnesses reported. Earlier studies of workers at Oak Ridge had mixed results. Some reported elevated illnesses, others did not, and many such studies are still

underway. No specific causes for the illnesses suffered by workers and members of the public could be found nor whether they are more numerous than the norm.

### **Availability, Extent and Quality of Medical Care**

Many of the workers and members of the public were not satisfied with the availability, quality, and extent of medical care. There were problems with refusal of doctors to accept patients, availability of specialists, lack of coverage of "pre-existing illnesses" for continuing workers with changing contractors, lack of medical care for non-workers, and lack of responsiveness (inordinate length of time from examination to results, etc.).

### **Environmental Effects**

The dead pine trees northeast of the TSCA incinerator, along the major emission plume path, appeared to be primarily due to attack by the Southern pine beetle. The quick regrowth of the area indicates that it is unlikely that the damage is due to a chemical pollutant. There is extensive damage by the beetle there and on other parts of the reservation. Without direct observations at the time of the deterioration and the death of the trees, it is not possible to be more definitive.

### **Unsafe and Illegal Actions at the ETPP**

During a worker-led visit of the site, neither unmarked sites with unsafe radiation levels, nor any illegal activities were found. Situations that would not be considered best management practice were found, e.g., unlocked truck trailers in public areas containing lithium which could prove hazardous, unmarked burial grounds, office spaces with cylinders of undetermined waste beneath plywood floors, etc.

All allegations of unsafe actions or conditions with sufficient specificity to be able to be investigated that were brought to the Panel's attention were investigated. While the Panel found that some cited conditions do exist, analyses including examination of records, found that they were not as serious as asserted. Other conditions were presented with such generality that the Panel was not able to examine them.

### **Communications**

The exasperation and rage expressed by some of the workers over what they perceived to be a lack of interest in finding a solution to their illnesses pervaded all discussions. There is great distrust among these workers of the management of Lockheed Martin Energy Systems Inc., DOE, and the local medical community.

## **CONCLUSIONS**

There are sick workers and members of the public who are not finding relief from their illnesses. The causes of their illnesses have not been determined – despite numerous attempts over the last five years to do so. Some of the workers and members of the public believe that the attempts to date have been inadequate. This has lead to mistrust and outrage.

None of the incinerator emissions exceed permissible levels and only one of the measured air pollutant concentrations exceeded standards for a short time (during a nearby construction project).

Some recommendations of the Panel to improve the situation are given. However, there is not always a cure to illnesses, nor is it always possible to uncover the causes of the illnesses.

## **RECOMMENDATIONS**

### **Relief to Sick People**

These affected people need relief from their illnesses to the extent that it is medically possible and relief from the suspicion that care is being withheld. Unfortunately, there are people who get sick and even the best medical care cannot bring them back to health. However, relief, to the extent possible, should be provided. This may entail problems that are much larger than the Oak Ridge situation, i.e., the delivery of health care in this country. Even if the causes of the illnesses cannot be identified, the symptoms should be treated. Counseling to help the sick people and their families also should be provided. The panel recommended that care should be provided to both workers and non-workers.

### **Epidemic or Not**

A scientifically valid epidemiological analysis should be conducted to determine if the rate of the illnesses being experienced is within the normal range or not. If not, then the causes of the specific illnesses should be sought. Epidemiology is a blunt sword to find causes. Most of the epidemiological studies conducted to date at hazardous waste sites have been inconclusive.

### **Operation of the TSCA Incinerator**

The Panel was not able to establish any direct cause-and-effect relationship between the operation of the incinerator and the illnesses at Oak Ridge. No emissions were measured or calculated that were more than a small fraction of their permissible levels. Further, the Panel found that operating practices are consistent with common expectations of such a facility. Therefore, it recommended that the TSCA incinerator continue to be operated, taking into account the recommendations made in the report.

### **Communications**

Lack of information encourages speculation as to the true state of affairs and increases mistrust. Top management at LMES is committed to open and transparent communication. Responsiveness at all levels is essential. Questions about practices should be investigated and answered promptly. The Panel recommended that joint committees, with LMES and the affected workers, such as the one on cyanide intoxication, be used, because they would do much to dispel suspicions.

### **Scientific Research**

All of the above recommendations can be quickly and easily implemented. However, they may not yield the causes of the illnesses. More basic scientific research may be needed to determine why these people are sick. The answers may not be quick in coming. After all these years and billions of dollars spent on the war on cancer, the basic causes are not known although progress has been made. At this time, why some people are more susceptible to diseases than others, is in the earliest stages of research.

### **ACKNOWLEDGEMENT**

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