CENTERIOR ENERGY

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United States Nuclear Regulatory Commission
Document Control Desk
Washington, DC 20555

Subject: 1991 Annual Radiological Environmental Operating Report

Gentlemen:

Enclosed are two (2) copies of the 1991 Annual Radiological Environmental Operating Report for the Davis-Besse Nuclear Power Station, Unit Number 1. This report was prepared in accordance with Section 6.9.1.10 of the Davis-Besse Operating License, Appendix A, Technical Specifications. Also enclosed are two (2) copies of Attachment 1 to the annual report, containing results from the analysis of radiological environmental samples and of environmental radiation measurements taken during the 1991 reporting period.

For your reference, the enclosed Table 1 provides a listing of the specific requirements and the location of the portion of the Annual Radiological Environmental Operating Report which was prepared to meet that requirement.

Should you have any questions, please contact Mr. R. W. Schrauder, Manager - Nuclear Licensing, at (419) 249-2366.

Very truly yours,

AVA/wab

Enclosures

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Utility Radiological Safety Board

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Enclosure

Table 1

Index to Report Sections
Prepared to Meet Requirements
of T. S. 6.9.1.10

Description of requirement	Location/page number(s)
Summaries, interpretations, and analyses of trends of the radiological environmental surveillance activities, and an assessment of the observed impacts of the plant	2-14 through 2-58 and Appendix E
Results of the Annual Land Use Census	3-1 through 3-8
Results of the analysis of all radiological environmental samples and of all environmental radiation measurements	Attachment 1
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At least 2 legible maps, covering all sampling locations keyed to a table giving distances and directions from the centerline of one reactor	2-17 through 2-19 and 2-30 through 2-32 and 2-42 through 2-44 and 2-55 through 2-57
The results of licensee participation in the Interlaboratory Comparison Program (required by Specification 3.12.3)	Appendix B
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ANNUAL ENVIRONMENTAL OPERATING REPORT:

for

Davis-Besse Nuclear Power Station
January 1, 1991 to December 31, 1991

Prepared by:
Radiological Environmental
Davis-Besse Nuclear Power Station
Toledo Edison Company
Toledo, Ohio

April 1992

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Summary

The Annual Environmental Operating Report is a detailed report of the Environmental Monitoring Programs conducted at the Davis-Besse Nuclear Power Station from January 1 through December 31, 1991. Reports included are the Radiological Environmental Monitoring, Land Use Census, Meteorological Monitoring, Marsh Management, Zebra Mussel Control, Water Treatment, and Chemical Waste Management Programs.

Radiological Environmental Monitoring Program

The operation of a nuclear power station results in the release of small amounts of radioactivity to the surrounding environment. These releases must comply with stringent regulations imposed by the Nuclear Regulatory Commission (NRC). The Radiological Environmental Monitoring Program (REMP) has been established to monitor the radiological condition of the environment around Davis-Besse. This program includes the sampling and analysis of environmental samples, and the evaluation of the effects of releases of radioactivity on the environment.

Radiation levels and radioactivity are monitored within a 25 mile radius around Davis-Besse. The environment around Davis-Besse has been monitored for approximately 20 years. The REMP was established about five years before Davis-Besse became operational. This program provided data on background radiation and radioactivity which is normally present in the area. Davis-Besse has continued to monitor the environment by sampling air, groundwater, milk, edible meat, fruits and vegetables, animal feed, soil, drinking water, surface water, fish, and shoreline sediments, as well as by measuring radiation directly.

Samples are collected from both indicator and control locations. Indicator locations are within approximately five miles of Davis-Besse and are expected to show naturally occuring radioactivity plus any increases of radioactivity that might occur due to the operation of Davis-Besse. Control location are greater than five miles away from Davis-Besse, and are expected to indicate the presence of only naturally occurring radioactivity. The results obtained at the samples collected from indicator locations are compared with

the results from those collected at control locations and with the concentrations present in the environment before Davis-Besse became operational. This allows for the assessment of any impact the operation of Davis-Besse might have had on the surrounding environment.

In 1991, over 2600 radiological environmental samples were collected, and over 3600 analyses for radioactivity were performed. Radionuclide concentrations measured at indicator locations were compared with concentrations measured at control locations, as well as those measured in previous studies.

The results of the REMP indicate the adequacy of the control of the release of radioactivity in effluents at Davis-Besse. These results also indicate that Davis-Besse complies with all applicable federal regulations. These results are divided into four sections: atmospheric monitoring, terrestrial monitoring, aquatic monitoring and direct radiation monitoring.

- Atmospheric Monitoring

Samples of air are collected to monitor the atmosphere. The 1991 results are similar to those observed in preoperational and previous operational programs. Only background radioactivity normally present in the environment was detected.

- Terrestrial monitoring

This includes analysis of milk, groundwater, meat, fruits, vegetables, animal feed and soil samples. The results of the sample analyses compare favorably with those of previous years. For example, cesium-137 radioactivity in soil was at an average concentration of 0.30 picocurie per gram dry weight (pCi/g) in 1991, which is at the low end of the range of 0.014 to 3.44 pCi/g dry weight observed over the past 12 years of station operation. The results of the analyses of the other terrestrial samples also indicate concentrations of radioactivity similar to previous years, and indicate no buildup of radioactivity attributable to the operation of Davis-Besse.

- Aquatic monitoring

This includes the collection and analysis of drinking water, untreated surface water, fish and shoreline sediments. The 1991 results of analyses for fish, drinking water, and shoreline sediment indicate normal background concentrations of radionuclides and show no increase or buildup of radioactivity due to station operation. In untreated water, a trace amount of tritium (884 pCi/l) that could be attributed to station operation was detected in only one

sample. This had no impact on the nearby residents or the surrounding environment.

- Direct Radiation

Direct radiation measurements averaged 15.0 mrem/91 days at indicator locations and 16.7 mrem/91 days at control locations, showing that, in 1991, radiation in the area of Davis-Besse was similar to radiation at locations greater than 5 miles away from the Station

The 1991 operation of Davis-Besse caused no significant increase in the concentrations of radionuclides in the environment and no significant change in the quality of the environment. All radioactivity released in the Station's effluents was well below the applicable federal regulatory limits. The estimated radiation dose to the general public due to the operation of Davis-Besse in 1991 was also well below all applicable regulatory limits.

In order to estimate this radiation dose, the pathways through which public exposure can occur must be known. To identify these exposure pathways, an Annual Land Use Census is performed as part of the REMP. During the census, Davis-Besse personnel travel every public road within a five mile radius of the Station vent to locate the radiological exposure pathways. The one pathway of particular concern is the pathway that, for a specific radionuclide, provides the greatest dose to a sector of the population, and is called the critical pathway. The critical pathway for 1991 remained unchanged from the 1990 Land Use Census, which is an infant/milk pathway at 4270 meters in the west-southwest sector.

Meteorological Monitoring

The Meteorological Monitoring Program at Davis-Besse is part of a program for evaluating the effects of the routine operation of the station on the surrounding environment. Meteorological Monitoring began in October 1968. Meteorological instruments measure continuously and are monitored daily by meteorological monitoring personnel.

Meteorological data recorded at Davis-Besse include wind speed, wind direction, sigma theta (standard deviation of wind direction), ambient temperature, differential temperature, dew point and precipitation. Two instrument equipped meteorological towers are used to collect data. Data recovery for 1991 was 90% or greater for all measured parameters. In 1991, the data

recovery for the six instruments required to be operational by Davis-Besse Technical Specifications was greater than 90%.

Marsh Management

Toledo Edison and the Cleveland Electric Illuminating Company co-own the Navarre Marsh which they lease to the U.S. Fish and Wildlife Service, who manage it as part of the Ottawa National Wildlife Refuge. Davis-Besse Environmental Compliance personnel are responsible for inspecting the marsh and reporting its status monthly.

Special projects conducted in 1991 included song bird and Canada goose banding. In 1991, 6432 birds were banded. In addition, unwanted and disruptive plant species, such as purple loosestrife (*Lythrum salicaria*) and the giant reed (*Phragmities australisi*), were controlled in order to enhance the ability of the marsh to support the resident wildlife.

Zebra Mussel Control

The Zebra Mussel Control Program was implemented in 1990 to study the extent of mussel infestation at Davis-Besse. Routine sampling and analyses of water from various locations at the station provide estimates of the number of zebra mussels which might enter the plant.

In addition to the sampling, Davis-Besse and the Electric Power Research Institute are conducting experiments to determine alternate methods for controlling the zebra mussel.

Water Treatment

Davis-Besse uses Lake Erie as a source of water for the site Water Treatment Plant. The water is treated onsite to provide domestic water and to produce high purity water for use in the Station's cooling systems. Principal activities in 1991 included the removal of precipitator number one from service for cleaning and maintenance and the implementation of the new Ohio Environmental Protection Agency' Drinking Water Standards which placed more stringant restrictions on turbity and additional bacteriological requirement.

Wastewater generated onsite is treated at the Davis-Besse Wastewater Treatment Plant. The wastewater is processed and then pumped to holding basins where further reduction in solid content takes place. Following many days in the basin, the wastewater is discharged, along with other Station waste waters, back into Lake Erie. During 1991, Waste Water Treatment Plant Number 1 was out of service due to damage to an interior tank. The installation of supports has corrected the problem and the plant should be back in operation early in 1992. Current plans are to remove Wastewater Treatment Plant Number 2 from service for cleaning and maintenance in 1992.

Chemical Waste Management

The Chemical Waste Management Program at Davis-Besse was developed to ensure that the offsite disposal of nonradioactive hazardous and non-hazardous chemical wastes is performed in accordance with all applicable state and federal regulations. Davis-Besse uses the best available technology, such as incineration or treatment to reduce toxicity, for offsite disposal of its chemical wastes in order to protect human health and the environment.

In 1991, as a result of waste minimization efforts, 648 pounds of hazardous waste (used solvents), 7,355 gallons of waste oil and 24 nickel cadmium battery cells were sent to recycling firms or a fuel blenders for thermal energy purposes.

As required by Superfund Amendment and Reauthorization Act (SARA), Davis-Besse reported eight hazardous products and chemicals to local and state agencies. Two of the chemicals, hydrazine and sulfuric acid, are classified as "extremely hazardous" substances.

As part of the program to remove polychorinated biphenyls (PCB) fluid from Davis-Besse, ten previously filled PCB transformers were retrofilled for the final time in 1990. These were sampled and analyzed in 1991 and re-classified to non-PCB. The last identified PCB transformer at Davis-Besse received the final retrofill in 1991. This transformer will be analyzed in 1992 and is expected to be re-classified as non-PCB .

Appendices

Appendix A contains a Glossary of terms used throughout this report. It is not meant to be a comprehensive reference source for interpreting any documents other than this 1992 Annual Environmental Operating Report.

Appendix B contains results from the Interlaboratory Comparison Program required by Davis-Besse Technical Specifications. Samples with known concentrations of radioisotopes are prepared by the Environmental Protection Agency (EPA), and then sent (with information on sample type and date of collection only) to the laboratory contracted by the Centerior Energy Corporation to analyze the REMP samples. The results are then checked by the EPA to ensure consistency with the know values. The results from both the contracted laboratory and the EPA are provided in Appendix B.

Appendix C contains data reporting conventions used in the REMP at Davis-Besse. The appendix provides an explanation of the format and computational methods used in reporting REMP data. Information on counting uncertainties, and computation of averages and standard deviations is also provided.

Appendix D lists the maximum permissible concentrations of alpha and beta emitting radioisotopes and of certain other radioisotopes in air and water samples. These concentrations are taken directly from the Code of Federal Regulations, and provide comparison values for actual REMP sampling results for 1991.

Appendix E provides a REMP sampling summary from 1991. The appendix provides a listing of the following for each sample type:

- the number and types of analyses performed
- the lower limit of detection for each analysis
- the mean and range of results for control and indicator locations
- the mean, range, and location description for the location with the highest annual mean
- the number of non-routine results

For detailed studies, Appendix F will provide more specific information than that listed in Chapter 2 of this report. Additionally, more specific information is submitted to the NRC in Annual Environmental Monitoring Report Attachment 1. This document is not distributed with the rest of the Annual Environmental Operating Report due to its large size and technical nature. The information presented in Appendices B through E were provided by Teledyne Isotopes Midwest Laboratories in their Annual Report to Toledo Edison (Part 1, Feb. 1992).

Introduction

Coal, oil, natural gas, and hydropower have been used to run this nation's electric generating stations; however, each method has its drawbacks. Coal-fired power can affect the environment through mining, acid rain, and airborne discharges. Oil and natural gas are in limited supply and are therefore costly, and hydropower is limited due to the environmental impact of damming our waterways and the scarcity of suitable sites in our country.

Nuclear energy provides an alternate source of energy which is readily available. The operation of nuclear power stations has a very small impact on the environment. In fact, the Davis-Besse Nuclear Power Station is surrounded by hundreds of acres of marshland which makes up part of the Ottawa National Wildlife Refuge, the only national refuge in Ohio.

In order to more fully understand this unique source of energy, background information on basic radiation characteristics, risk assessment, reactor operation, and effluent control, is provided in this chapter.

Fundamentals

The Atom

All matter consist of **atoms**. Simply described, atoms are made up of positively and negatively charged particles, and particles which are neutral. These particles are called **protons, electrons,** and **neutrons,** respectively (Figure 1-1). The relatively large protons and neutrons are packed tightly together in a cluster at the center of the atom, called the **nucleus**. Orbiting around this nucleus are one or more smaller electrons. In an electrically neutral atom, the negative charges of the electrons are balanced by the positive charges of the protons. Due to their dissimilar charges, the protons and electrons have a strong attraction for each other, which helps hold the atom together.

Other attractive forces between the protons and neutrons keep the densely packed protons from repelling each other, preventing the nucleus from breaking apart.

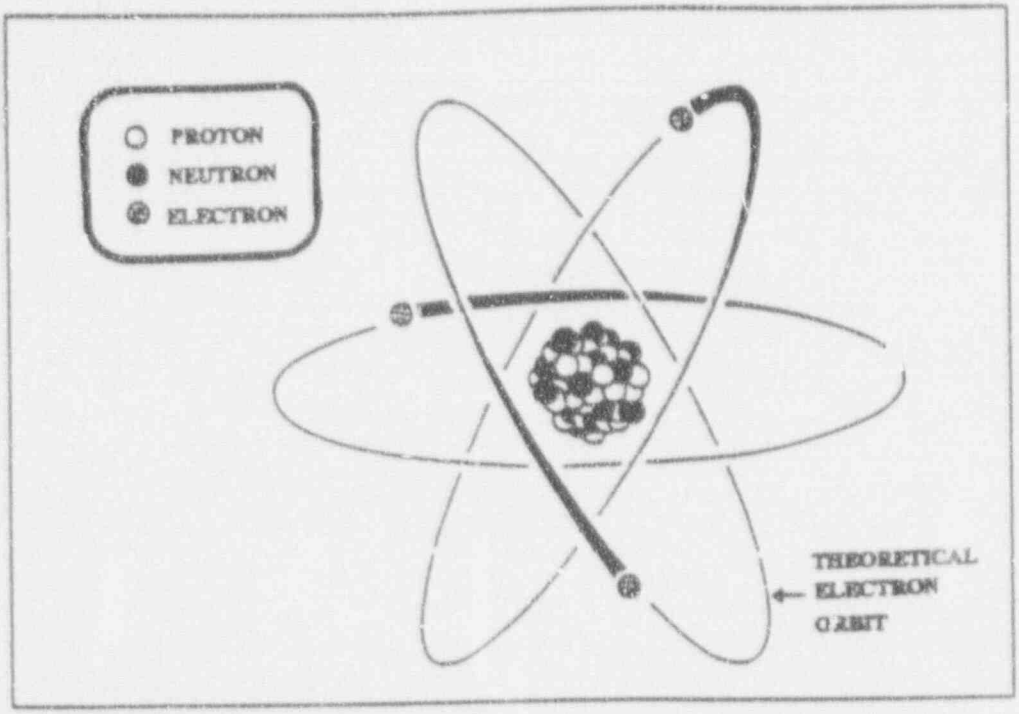


Figure 1-1: An atom consists of two parts: a nucleus containing positively charged protons and electrically neutral neutrons and one or more negatively charged electrons orbiting the nucleus. Protons and neutrons are nearly identical in size and weight, while each is about 2000 times heavier than an electron.

Isotopes

A group of identical atoms, containing the same number of protons, make up an **element.** In fact, the number of protons an atoms contains determines its chemical identity. For instance, all atoms with one proton are hydrogen atoms and all the atoms with eight protons are oxygen atoms. However, the number of neutrons in the nucleus of an element may vary. Atoms with the same number of protons, but different number of neutrons, are called **isotopes.** As an example, Table 1-1 list some of the isotopes of uranium. Different isotopes of the same element have the same chemical properties, and many are stable, or nonradioactive. An unstable or radioactive isotope of an element is called a **radioisotope.**

Radiation and Radioactivity

Radionuclides

The parts of an atom are normally in a balanced, **stable** state. If the nucleus of an atom contains an excess of energy, it is called a **radioisotope**, **radioactive atom,** or **radionuclide**. The excess energy is usually due to excess number of neutrons in the nucleus of the atom.

Radionuclides can be naturally occurring such as uranium-238, beryllium-7 and potassium-40, or man-made, such as iodine-131, cesium-137, and cobalt-60.

Table 1-1: Isotopes of Uranium

Isotope	Symbol	# of Protons	# of Neutrons
Uranium-235	U-235	92	143
Uranium-236	U-236	92	144
Uranium-237	U-237	92	145
Uranium-238	U-238	92	146
Uranium-239	U-239	92	147
Uranium-240	U-240	92	148

Radiation

Radiation is simply the conveyance of energy through space. For instance, heat emanating from a stove is a form of radiation, as are light rays, microwaves, and radio waves. **Ionizing radiation** is another type of radiation and has similar properties to those of the examples listed above.

Ionizing radiation consists of both **electromagnetic radiation** and **particulate radiation**. Electromagnetic radiation consists of rays of energy with no measurable mass that travel with a wave-like motion through space. Included in this category are **gamma rays** and **X-rays**. Particulate radiation

consists of tiny, fast moving particles which, if uninhibited, travel in a straight line through space. The three types of particulate radiation of concern to us are **alpha particles**, made up of 2 protons and 2 neutrons; **beta particles**, which are essentially free electrons (electrons not attached to an atom); and **neutrons**. The properties of these types of radiation will be described more fully in the Range and Shielding section on page 1-5 .

Radioactive Decay

Radioactive atoms attempt to reach a stable, non-radioactive state through a process known as **radioactive decay**. Radioactive decay is the release of energy from an atom through the emission of ionizing radiation. Radioactive atoms may decay directly to a stable state or may go through a series of decay stages, called a **radioactive decay series**, and produce several **daughter products** which eventually result in a stable atom. The loss of energy and/or matter through radioactive decay may transform the atom into a chemically different element. For example, when uranium-238 decays, it emits an alpha particle and, as a result, the atom loses 2 protons and 2 neutrons. As discussed previously, the number of protons in the nucleus of an atom determines its chemical identity. Therefore, when the uranium-238 atom loses the 2 protons and 2 neutrons, it is transformed into an atom of thorium-234. Thorium-234 is one of the 14 successive daughter products of uranium-238. Radon is another daughter product, and the series ends with stable lead-206. This example is part of a known radioactive decay series, called the uranium series, which begins with uranium-238 and ends with lead-206.

Half-life

Most radionuclides vary greatly in the frequency with which their atoms release radiation. Some radioactive materials, in which there are only infrequent emissions, tend to have a very long half-lives. Those radioactive materials that are very active, emitting radiation more frequently, tend to have a comparably short half-lives. The length of time an atoms remains radioactive is defined in terms of **half-lives**. Half-life is the amount of time required for a radioactive substance to lose half its activity through the process of radioactive decay. Half-lives vary from millionths of a second to millions of years.

Interaction With Matter

Ionization

Through interactions with atoms, alpha, beta, and gamma radiation lose their energy. When these forms of radiation interact with any form of material, the energy they impart may cause atoms in that material to become **ions**, or charged particles. Normally, an atom has the same number of protons as electrons. Thus, the number of positive and negative charges cancel, and the atom is electrically neutral. When one or more electrons are removed an ion is formed. Ionization is one of the processes which may result in damage to biological systems.

Range and Shielding

Particulate and electromagnetic radiation each travel through matter differently because of their different properties. Alpha particles contain 2 protons and 2 neutrons, are relatively large, and carry an electrical charge of +2. Alpha particles are ejected from the nucleus of a radioactive atom at speeds ranging from 2,000 to 20,000 miles per second. However, due to its comparatively large size, an alpha particle usually does not travel very far before it loses most of its energy through collisions and other interactions with atoms. As a result, alpha particles can easily be stopped by a sheet of paper or a few centimeters of air (Figure 1-2).

Beta particles are very small, and comparatively fast particles, traveling at speeds near the speed of light (186,000 miles per second). Beta particles have an electrical charge of either +1 or -1. Because they are so small and have a low charge, they do not collide and interact as often as alpha particles, so they can travel farther. Beta particles can usually travel through several meters of air, but may be stopped by a thin piece of metal or wood.

Gamma rays are pure energy that travel at the speed of light. They have no measurable charge or mass, and generally travel much farther than alpha or beta particles before being absorbed. After repeated interactions, the gamma ray finally loses all of its energy it and vanishes. The range of a gamma ray in air varies, depending on the ray's energy and interactions. Very high energy gamma radiation can travel a considerable distance, whereas low energy gamma radiation may travel only a few feet in air. Lead is used as shielding material for gamma radiation because of its density. Several inches of lead or concrete may be needed to effectively shield gamma rays.

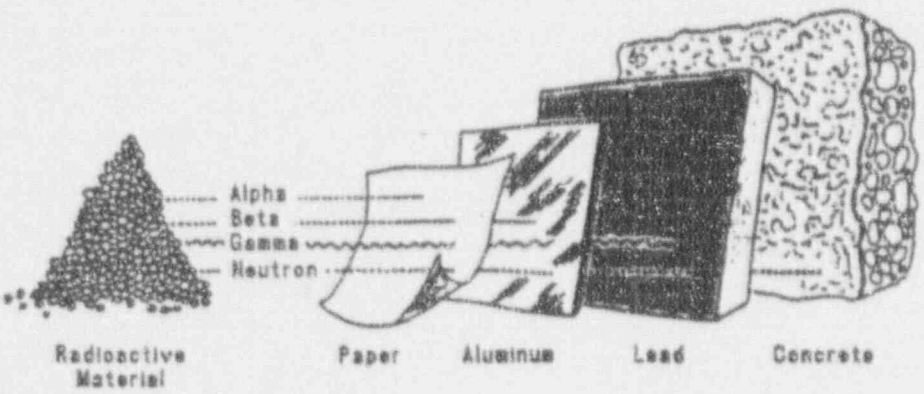


Figure 1-2: As radiation travels, it collides and interacts with other atoms and loses energy. Alpha particles can be stopped by a sheet of paper, and beta particles by a thin sheet of aluminum. Gamma radiation is shielded by highly dense materials such as lead, while hydrogenous materials (those containing hydrogen atoms), such as water and concrete, are used to stop neutrons.

Neutrons come from several sources, including the interactions of cosmic radiation with the earth's atmosphere and nuclear reactions within nuclear power reactors. However, neutrons are generally not of environmental concern since nuclear power stations are designed to keep neutrons within the containment building.

Because neutrons have no charge, they are able to pass very close to the nuclei of the material through which they are traveling. As a result, neutrons may be captured by one of these nuclei or they may be deflected, much in the way that a rolling billiard ball is deflected when it strikes another. When deflected, the neutron loses some if its energy. After a series of these deflections, the neutron has lost most of its energy. At this point, the neutron moves about as slowly as the atoms of the material through which it is traveling, and is called a **thermal neutron.** In comparison, fast neutrons are much more energetic than thermal neutrons and have greater potential for causing damage to the material through which they travel. Fast neutrons can have from 200 thousand to 200 million times the energy of thermal neutrons.

Neutron shielding is designed to slow down fast neutrons and absorb thermal neutrons. Often neutron shielding material consists of several components, including a highly dense material such as water or polyethylene, to further slow the neutrons. The shield is then completed with a material such as cadmium, to absorb the now thermal neutrons. At Davis-Besse, concrete is used to form an effective neutron shield. Concrete is used because it contains water molecules and can be easily molded around odd shapes.

Quantities and Units of Measurement

There are several quantities and units of measurement used to describe radioactivity and its effects. Four terms of particular usefulness are **activity, exposure, absorbed dose,** and **dose equivalent.**

Activity: Curie

Activity is the number of nuclei in a sample that disintegrate (decay) per unit of time. Each time a nucleus disintegrates, radiation is emitted. The **curie** (Ci) is the unit used to describe the activity of a material and indicates the rate at which the atoms of a radioactive substance are decaying. One curie indicates the disintegration of 37 billion atoms per second.

A curie is a unit of activity, not a quantity of material. Thus, the amount of material required to produce one curie varies. For example, one gram of radium-226 is the equivalent of one curie of activity, but it would take 9,170,000 grams (about 10 tons) of thorium-232 to equal one curie.

Smaller units of the curie are often used, especially when discussing the low concentrations of radioactivity detected in environmental samples. For instance, the microcurie (uCi) is equal to one millionth of a curie, while the picocurie (pCi) represents one trillionth of a curie.

Exposure: Roentgen

Exposure is a term used to describe the ability of ionizing radiation from gamma or x-rays to produce ion pairs in a certain volume of air. Exposure measures the energy of the radiation and is expressed in units called **roentgens (R).** One roentgen is the quantity of exposure that causes approximately two billion ionizing events (i.e., creation of ion pairs) per cubic centimeter of air.

A common way to describe the rate of exposure to gamma radiation is in **roentgens per hour (R/hr)**. Often a smaller unit used is **milliroentgens per hour (mR/hr)**, which is 1000 times less.

The roentgen applies only to radiation associated with gamma or X rays, and is not used to describe exposure to alpha, beta or neutron radiation. In addition, the roentgen applies only to the energy of the radiation in air, and does not account for the fact that different substances absorb different amounts of energy. Thus, another unit is necessary to describe the amount of energy absorbed by any material.

Absorbed Dose: Rad

Absorbed dose is a term used to describe the radiation energy absorbed by any material exposed to ionizing radiation, and can be used for both particulate and electromagnetic radiation. The **rad (radiation absorbed dose)** is the unit used to measure the absorbed dose. It is defined as the energy of ionizing radiation deposited per gram of absorbing material (1 rad = 100 erg/gm). The rate of absorbed dose is usually given in rad/hr.

If the biological effect of radiation was directly proportional to the energy deposited by radiation in an organism, the rad would be a suitable measurement of the biological effect. However, biological effects depend not only on the total energy deposited per gram of tissue, but on how this energy is distributed along its path. Experiments have shown that some types of radiation are more damaging per unit path of travel than others. Thus, another unit is needed to quantify the biological damage caused by ionizing radiation.

Dose Equivalent: Rem

Biological damage due to alpha, beta, gamma and neutron radiation may result from the ionization caused by these radiations. Some types of radiation, especially alpha particles which cause dense local ionization, can result in up to 20 times the amount of biological damage for the same energy imparted as do gamma or X rays. Therefore, a **quality** factor must be applied to account for the different ionizing capabilities of various types of ionizing radiation. When the quality factor is multiplied by the absorbed dose, the result is the **dose equivalent,** which is an estimate of the possible biological damage resulting from exposure to a particular type of ionizing radiation. The dose equivalent is measured in **rem (radiation equivalent man)**.

As an example of this conversion from absorbed dose to dose equivalent, the quality factor for alpha radiation is 20. Hence, 1 rad of alpha radiation is approximately equal to 20 rem. Beta and gamma radiation each have a quality factor of 1, therefore one rad of either beta or gamma radiation is approximately equal to one rem. Thermal neutrons have a quality factor of 3, and fast neutrons have a quality factor of 10. One rem produces the same amount of biological damage, regardless of the source.

In terms of environmental radiation, the rem is a large unit. Therefore, a smaller unit, the **millirem**, is often used. One millirem (mrem) is equal to 1/1000 of a rem.

Sources of Radiation

Background Radiation

Radiation is not a new creation of the nuclear power industry; it is a natural occurrence on the earth. Mankind has always lived with radiation and always will. In fact, during every second of life, over 7,000 atoms undergo radioactive decay in the body of the average adult. In addition to that which normally occurs in our bodies, it also occurs naturally in the soil, water, air, and space. All these common sources of radiation contribute to the natural background radiation to which everyone is exposed (Figure 1-3).

The earth is constantly showered by a steady stream of high energy gamma rays and particulate radiation that come from space, known as cosmic radiation. The atmosphere shields out most of this radiation, but everyone still receives about 20 to 50 mrem each year from this source. The thinner air at higher altitudes provides less protection against cosmic radiation. Therefore, people living at higher altitudes or even flying in an airplane are exposed to more cosmic radiation. For example, the dose due to cosmic radiation in Denver Colorado (elevation 5280 feet above sea level) is approximately 47 mrem per year, whereas, in Toledo, Ohio (maximum elevation 630 feet above sea level), the dose attributed to cosmic radiation is approximately 26 mrem per year. Radionuclides commonly found in the atmosphere as a result of cosmic ray interactions include beryllium-7, carbon-14, tritium, and sodium-22.

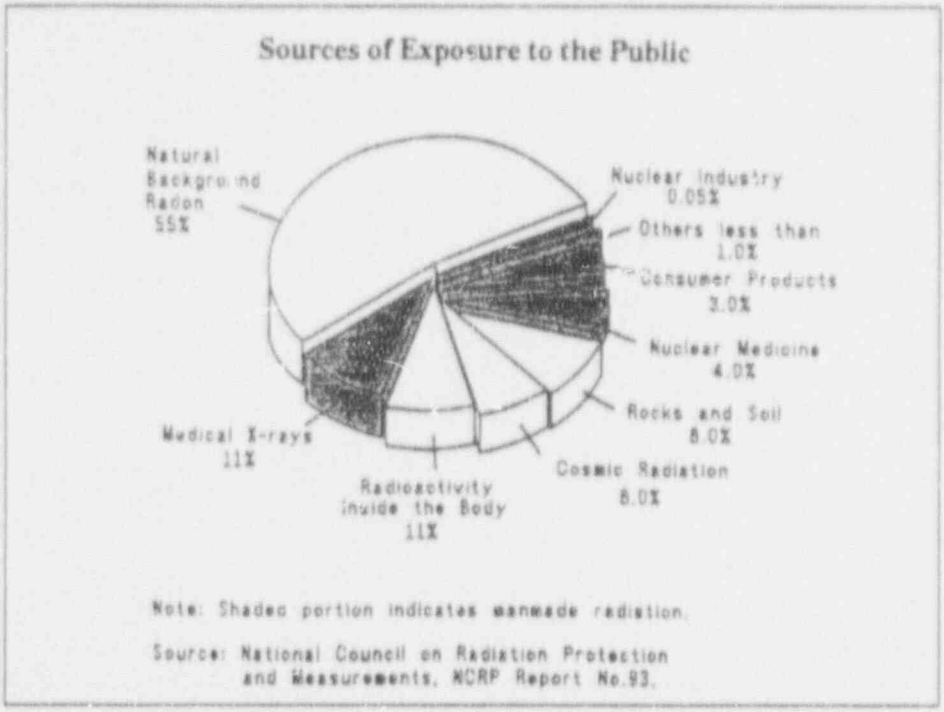


Figure 1-3: A very small annual dose to the public results from the nuclear power industry. Actually, the most significant annual dose the average individual receives is that from naturally occurring radon.

Other natural sources of radiation include the radionuclides naturally found in soil, water, food, building materials and even people. People have always been radioactive, in part because the carbon found in their bodies is a mixture of all carbon isotopes, both non-radioactive and radioactive.

In fact, because radioactive carbon-14 has a known half-life of 5730 years and exists in all living things, archaeologists can use carbon dating to determine the age of a fossil or other artifact. After an organism dies, it no longer takes up carbon, and the radioactive carbon-14 present in its body continues to decay. Thus, archaeologists can estimate the point at which it no longer assimilated radioactive carbon in its tissues (i.e., the point of death).

Another common naturally occurring radionuclide is potassium-40. About one-third of the external terrestrial and internal whole body dose from natural sources is attributable to this natural radioactive isotope of potassium. Recently, concern has been expressed over another source of background radiation-radon. According to the National Council on Radiation Protection (NCRP), over half of the radiation dose the average American receives is

attributed to radon. Radon is a colorless, odorless, radioactive gas that results from the decay of radium-226, a member of the uranium-238 decay series.

Radon atoms are produced in the soil and migrate through air-filled pores in the soil to reach the atmosphere. Radon occurs in all soils, but because it is a daughter product of uranium, it occurs in higher concentrations in rocks (and soils derived from rocks) with high concentrations of uranium, such as black shales, granites, phosphate rocks and carbonate rocks.

Radon occurs indoors as a result of radon in the soil or rock under the building or radon in building materials, water supplies, natural gas or outdoor air. Groundwater supplies can become contaminated with radon migrating through the soil. In addition, the unvented combustion of natural gas can also contribute to indoor radon concentrations. However, the primary source of indoor radon is that which diffuses into the building from the underlying soil or rock.

Radon may enter buildings through the walls, floors vents and other openings. Although radon can migrate through uncracked slabs, slabs with cracks or openings for piping, sumps, etc. may considerably increase the transmission of radon into a building. Although there is no reliable method of predicting which buildings will have greater indoor concentrations of radon, the following factors directly impact radon uptake and accumulation of uranium content of the soil:

- weather conditions
- constructions methods
- presence/absence of any cracks or openings in the foundations

Some weather conditions, such as low pressure systems or increased rain fall, act to force radon out of the soil at an increased rate. In addition, construction methods affect indoor radon concentrations. Buildings built on a slab with no crawl space, sealed to prevent energy loss, those with basements, and those without fully ventilated crawl spaces tend to be linked to higher radon concentrations.

Because uranium naturally occurs in all soils and rocks, everyone is continuously exposed to radon and its daughter products. However, radon does not typically pose a health hazard unless it is allowed to concentrate in a confined area, such as a building.

Radon-related health concerns stem from the exposure of the lungs to this radioactive gas. Radon emits alpha radiation when it decays. Alpha radiation can easily be stopped by a person's dead skin layer. However, alpha radiation can cause damage to internal tissues when ingested or inhaled. As a result, exposure to the lungs is of greatest concern, especially as the only recognized health effect associated with exposure to radon is an increased risk of lung cancer.

Radon can be detected in one of several ways. Three common methods used presently to detect radon in homes and other buildings are as follows:

- **Charcoal canister method:**
  Charcoal canisters, which absorb radon, are placed in a building, and after approximately 1 to 5 days are removed and sent to a laboratory where the radon decay products are analyzed. From this information, the laboratory can determine the approximate concentration of radon gas required to produce the decay products measured.

- **Alpha track method:**
  Alpha track detectors utilize a radiation-sensitive film. When the alpha emissions from radon strike the film, they make a track. The alpha track detector is usually placed in a building for 2 weeks to several months, and, like the charcoal canister, is sent to a laboratory for analysis. At the laboratory the number of tracks on the film are counted. This information is used to estimate the average concentration of radon in the building during the period that the film was exposed.

- **Electronic monitoring method:**
  Electronic monitors are available which continuously detect the number of negative ions produced by decaying radon and provide instantaneous information on the concentration of radon in the air.

The United States Environmental Protection Agency has provided guidelines for radon monitoring in homes and other buildings, and has developed recommendations for concentrations at which to take corrective actions. Further information on radon, its detection , and actions to reduce the radon concentration in buildings can be obtained by contacting the state radon program office at the following address:

Ohio Department of Health
P.O. BOX 118
Columbus, Onio 43266-0118
(614) 481-5800
(800) 523-4439 (in Ohio Only)

Man-Made Radiation

In addition to naturally occurring radiation and radioactivity, people are also exposed to man-made radiation. The largest sources of exposure include medical x-rays and radioactive pharmaceuticals. Small doses are also received from consumer products such as televisions, smoke detectors, and fertilizers. Fallout from nuclear weapons tests is another source of man-made exposure. Fallout radionuclides include strontium-90, cesium-137, carbon-14, and tritium. As shown in Figure 1-3, a very small percent of the annual dose a member of the public receives is due to the production of nuclear power. In fact, the maximum whole body doses to the public due to radioactivity released in liquid and gaseous effluents from Davis-Besse in 1991 were only 0.07 and 0.04 mrem, respectively. Each of these doses is less than the dose an individual would receive from one coast-to-coast jet flight (3 mrem).

Health Effects of Radiation

Studies

The effects of ionizing radiation on human health have been under study for more than eighty years. Scientists have obtained valuable knowledge through the study of laboratory animals that were exposed to radiation under extremely controlled conditions. However, it has proven difficult to relate the biological effects of irradiated laboratory animals to the potential health effects on humans. Hence, much study has been done with human populations that were radiated under various circumstances. These groups include the survivors of the atomic bomb; persons undergoing medical radiation treatment; radium dial painters, who ingested large amounts of radioactivity by "tipping" the paint brushes with their lips; uranium miners, who inhaled large amounts of radioactive dust while mining pitchblende (uranium ore); and early radiologists, who accumulated large doses of radiation while unaware of the potential hazards.

The studies performed on these groups have increased our knowledge of the health effects from large doses of radiation. However, less is known about the effects of low doses of radiation. To be on the conservative side, we assume that health effects resulting from low doses of radiation occur proportionally to those observed following large doses of radiation. Some radiation scientists agree that this assumption overestimates the risks associated with a low level radiation exposure. The effects predicted in this manner have never been actually observed in individuals exposed to low level radiation. However, this assumption provides a highly conservative model of radiation-induced health effects, because it most probably overestimates the risks associated with receiving low doses of radiation.

Health Risks

Since the actual effects of exposure to low radiation are difficult to assess, scientists often refer to the risk involved. The problem is one of evaluating alternatives, of comparing risks and weighing them against benefits. People make decisions involving risks every day, such as whether to(not to) wear seat belts; or whether to (not to) smoke cigarettes. Risks are a part of everyday life. The question is one of determining how great the risks are. We accept the inevitability of automobile accidents. Chances are that several people reading this report will be seriously injured this year as a result of automobile accidents. By building safer cars or wearing seat belts, this risk can be reduced, however, even a parked car is not risk-free. You could choose not to drive, but even as a pedestrian or a bicyclist you may be injured by cars. Reducing the risk of injury from automobiles to zero requires moving to a place where there are no automobiles.

While most people accept the risks inherent in such activities as smoking and driving to work each day, some people seem to feel that their energy needs should be met on a risk-free basis. However, this is impossible , no matter what the energy source. The burning of fossil fuels can have a negative impact on the environment, and even the use of hydropower entails risks, including that of a ruptured dam and habitat destruction that can result from damming waterways. Thus, attention should be focused on taking steps to safeguard the public, on developing a realistic assessment of the risks, and on placing these risks in perspective. One of the most widely distorted perceptions of risk is that associated with radiation exposure.

Because some people do not understand ionizing radiation and its associated risks, they may fear it. This fear is compounded by the fact that we cannot hear, smell, taste or feel ionizing radiation. Sometimes, if we have another source of information, we may believe the widespread myths about ionizing

radiation and its health effects. But this is not true of other potentially hazardous things for which we have the same lack of sensory perception such as radio waves, carbon monoxide, and small concentrations of numerous cancer causing substances. Although these risks are just as real as the risks concerning in radiation. Most risks are with us throughout our lives, and their effects can be added up over a lifetime to obtain a total effect on our lives. Table 1-2 shows a number of different factors that decrease the average life expectancy of individuals in the United States.

Table 1-2: Risk Factors
Factors Estimated Decrease in Average Life Expectancy*

Male rather than female		5.0 years
Overweight by 30%		3.6 years
Cigarette smoking:	1 pack/day	7.0 years
	2 packs/day	10.0 years
Heart diseases		5.8 years
Cancer		2.7 years
City Living (not rural)		5.0 years
125 operating nuclear power stations		less than 12 minutes

* The typical life span in the United States is now 76 years for women and 71 years for men.

The American Cancer Society estimates that about 30 percent of all Americans will develop cancer at some time in their lives from all possible causes. Thus, in a group of 10,000 people, it is expected that 3,000 of them will develop cancer. If each person in that group of 10,000 people were to receive 100 millirem in addition to the natural and man-made sources of radiation they are normally exposed to then there is an increased probability that would indicate one additional person from that group may develop cancer during his/her lifetime. This increases the risk from 30 percent to 30.01 percent. For comparison, the average offsite dose to individuals in the population due to the operation of the Davis-Besse Nuclear Power Station is significantly less than one millirem (0.001 millirem in 1991). If it is

considered that the Davis-Besse Nuclear Power Station will operate for the remainder of its license at this rate, the probability of even one person in the population developing a cancer due to the presence of the Davis-Besse Nuclear Power Station is extremely small.

The preceding table should provide you with an idea of the risks associated with nuclear power with respect to other, more significant risks that we accept as a part of our daily lives. Only when one is presented with a basis for comparison, can he or she make the decisions that he benefits derived from a particular activity (e.g., driving an automobile) outweigh the costs associated with that activity (e.g., possibility of an automobile accident). By comparing the risks associated with familiar activities, this provides people with a means to put the risks associated with nuclear power in perspective.

Benefits of Nuclear Power

Nuclear power plays an important part in meeting today's electricity needs, and will continue to serve as an important source of electric energy well into the future. In 1980, nuclear power accounted for only eleven percent of the electricity produced in the United States (Figure 1-4). By the end of 1991, however, this number was greater than twenty percent. At the same time, dependence on oil as an energy source decreased by more than half. By decreasing the nations' dependence on oil, dependence on foreign oil supplies also decreases, thereby ensuring the nation can continue to be self-sufficient in meeting the energy needs of it's private and business sectors.

Nuclear power offers several advantages over alternative sources of electric energy:

- nuclear power has an excellent safety record dating back to 1957 when the first commercial nuclear power station began operating,
- uranium, the fuel for nuclear power stations, is a relatively inexpensive fuel that is readily available in the United States,
- nuclear power is the cleanest energy source for power stations that use steam to produce electricity.

The following sections provide information on the fundamentals of and how Davis-Besse uses nuclear fuel and the fission process to produce electricity.

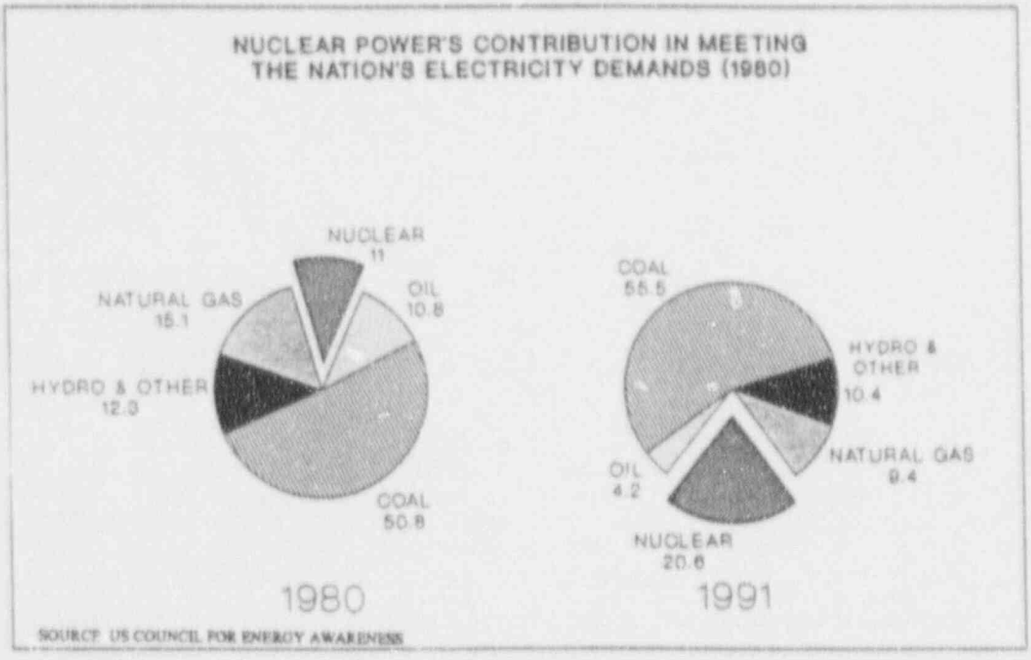


Figure 1-4-: Since 1980, the nation's dependence on nuclear power for supplying electricity has almost doubled. This has led to the decreased dependence on the amount of oil and natural gas needed to produce electricity. The advantage to this is less emission to the atmosphere which may cause acid rain.

Nuclear Power Production

Electricity is produced in a nuclear power station in essentially the same way as in a fossil-fueled station. Heat changes water to steam that turns a turbine. In a fossil-fueled station, the fuel is burned in a furnace, which is also a boiler. Inside the boiler, water is turned into steam. In a nuclear station, the furnace is replaced by a reactor containing a core of nuclear fuel, primarily uranium. Heat is produced when the atoms of uranium are split, or fissioned, inside the reactor.

What is Fission?

A special attractive force called the binding force holds the protons and neutrons together in the nucleus of the atom. The strength of this binding force varies from atom to atom. If the bond is weak enough, the nucleus can be split when bombarded by a free neutron (Figure 1-5). This causes the entire atom to split, producing smaller atoms, more free neutrons, and heat. In a nuclear reactor, a chain reaction of fission events provides the heat necessary to boil the water to produce steam.

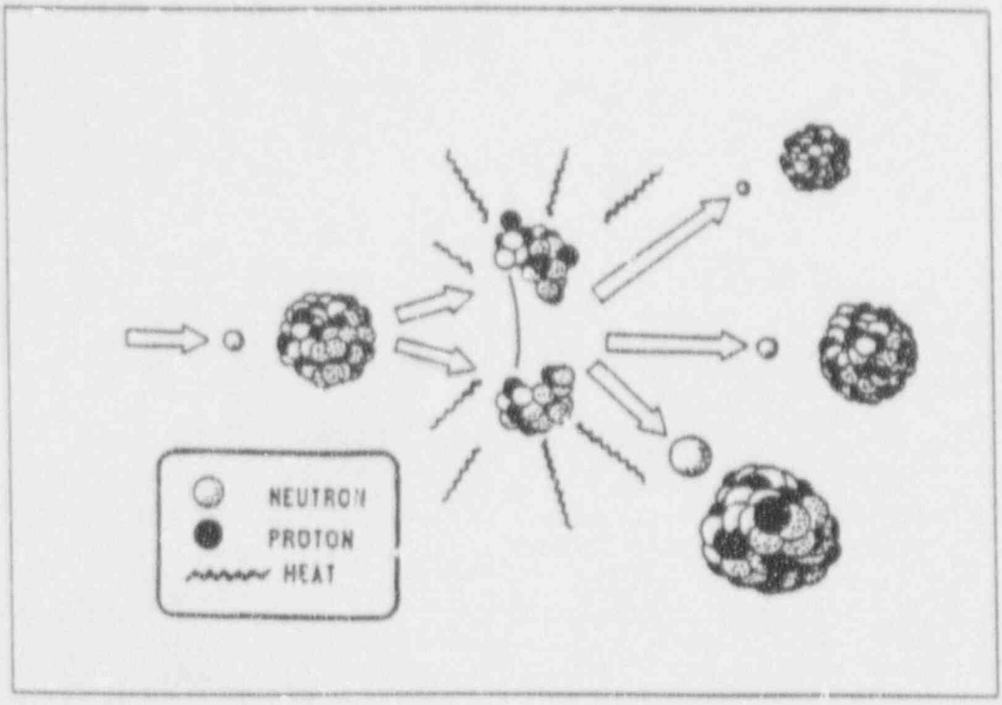


Figure 1-5: When a heavy atom, such as uranium-235 is split, or fissioned, heat, free neutrons, and fission fragments result. The free neutrons can then strike neighboring atoms causing them to fission also. In the proper environment, this process can continue indefinitely in a chain reaction.

Nuclear Fuel

The fissioning of one uranium atom releases approximately 50 million times more energy that the combustion of a single carbon atom common to all fossil fuels. Since a single small reactor fuel pellet contains trillions of atoms, each pellet can release an extremely large amount of energy. The amount of electricity that can be generated from three small fuel pellets would require about 3.5 tons of coal or 12 barrels of oil to generate.

Nuclear fission occurs spontaneously in nature, but these natural occurrences cannot sustain themselves because the freed nuetrons either are absorbed by non-fissionable atoms or quickly decay. In contrast, a nuclear reactor minimized neutron losses, thus sustaining the fission process by several means:

- using fuel that is free of impurities that might absorb the freed neutrons;

- increasing the concentration of the rarer fissionable isotope of uranium (U-235) relative to the concentration of U-238, a more common isotope that does not fission easily;
- and slowing neutrons down to increase the probability of fission by providing a "moderator" such as water.

Natural uranium contains less than one percent U-235 compared to the more abundant U-238 when it is mined. Before it can be economically used in a nuclear reactor, it is enriched to approximately three percent U-235 to U-238. In contrast, the nuclear material used in nuclear weapons has been enriched to over 97 percent. Because of the low levels of U-235 in nuclear fuel, a nuclear power station cannot explode like a bomb.

After the uranium is separated from the earth and rock in the ore, it is concentrated by a milling process. After milling the ore to a granular form and dissolving out the uranium with acid, the uranium is converted to **uranium hexafluoride (UF6).** A chemical form of uranium that exists as a gas at temperatures slightly above room temperature. The uranium is then highly purified and shipped to an enrichment facility where **gaseous diffusion converters** increase the concentration of U-235 in the fuel. The enriched gaseous UF6 is then converted into powdered **uranium dioxide** (UO_2), a highly stable ceramic material. The UO_2 powder is put under high pressure to form **fuel pellets,** each about 5/8 inch long and 3/8 inch in diameter (refer to Figure 1-6). Approximately five pounds of these pellet are placed into a 12 foot long metal tube made of zirconium alloy. The tubes constitute the **fuel cladding.** The fuel cladding is highly resistant of heat, radiation and corrosion. When the tubes are filled with fuel pellets, they are called **fuel rods.**

The Reactor Core

Two hundred eight fuel rods comprise a single **fuel assembly.** The **reactor core** at Davis-Besse contains 177 of these fuel assemblies, each approximately 14 feet tall and 2,000 pounds in weight. In addition to the fuel rods, the fuel assembly also contains 16 vacant holes for the insertion of **control rods,** and one vacant hole for an **incore monitoring probe.** This probe monitors temperature and neutron levels in the fuel assembly. The Davis-Besse reactor vessel weighs 838,000 pounds, has a diameter of 14 feet, is 39 feet high, and has 8 1/2 inch thick steel walls.

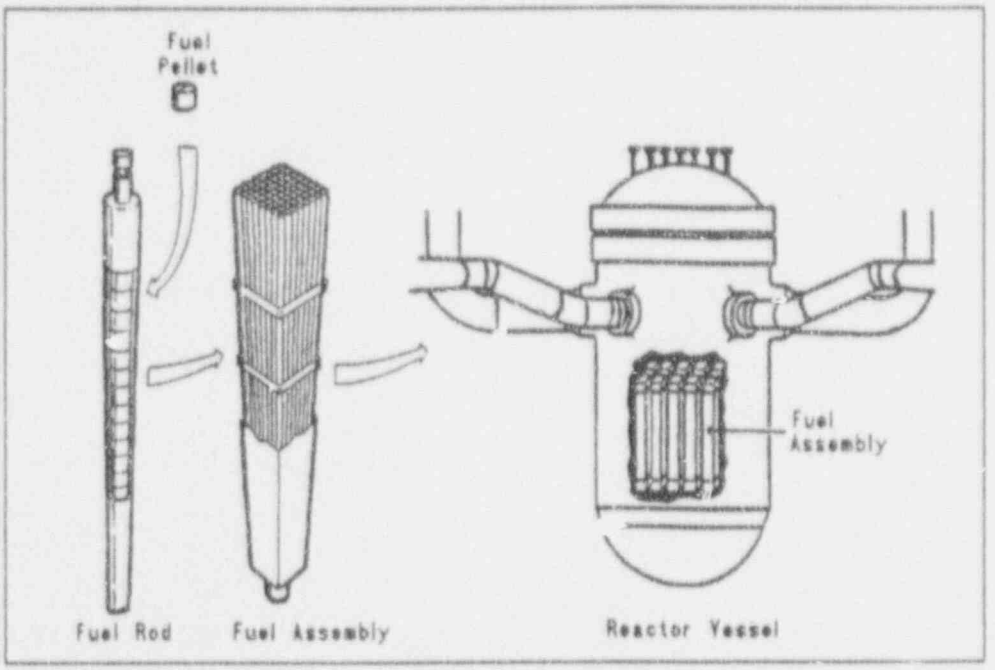


Figure 1-6: The reactor core at Davis-Besse contains 177 fuel assemblies. Each assembly contains 208 fuel rods. Each fuel rod is filled with approximately five pounds of fuel pellets, each pellet approximately 3/8 inch in diameter and 5/8 inch long.

Fission Control

The fission rate inside the reactor core is controlled by raising or lowering control **rod assemblies** into the reactor core. Each assembly consist of "fingers" containing silver. indium, and cadmium metals that absorb free neutrons, thus disrupting the fission chain reaction. When control rod assemblies are slowly withdrawn from the core, fissioning begins and heat is produced. If the control rod assemblies are inserted rapidly into the reactor core, as during a plant "trip," the chain reaction ceases. A slower acting (but more evenly distributed) method of fission control is achieved by the addition of a **neutron poison** to the reactor coolant water. At Davis-Besse, boric acid can be concentrated or diluted as necessary, in the coolant to achieve the desired level of fission. After boric acid is added to the coolant water, the acid turns into boron-10. Boron-10 readily absorbs free neutrons, hence the term "neutron poison," forming boron-11. The boron-11 in turn decays to non-radioactive lithium by the emission of an alpha particle.

Reactor Types

Virtually all of the commercial reactors in this country are either **boiling water reactors** (BWRs) or **pressurized water reactors** (PWRs). Both

types are also called **light water reactors (LWRs)** because their coolant, or medium to transfer heat, is ordinary water, containing the light isotope of hydrogen. Some reactors use the heavy isotope of hydrogen (deuterium) in the reactor coolant. Such reactions are called **heavy water reactors,** or **HWRs.**

In BWRs, water passes through the core and boils into steam. The steam passes through separators which removes water droplets. The steam then travels to dryers before entering the turbine. After passing though the turbine the water returns to the core to repeat the cycle.

In PWRs, the reactor water or coolant is pressurized to prevent it from boiling. The hot water is pumped to a **steam generator** (heat exchanger) where its heat is transferred to a separate water supply. The water inside the generator boils into steam which is used to turn the turbine. Davis-Besse uses a PWR, while the Perry Nuclear Power Plant, owned by Toledo Edison's sister company, Cleveland Electric Illuminating, uses a BWR. The Davis-Besse and Perry Nuclear Power Stations are the only two commercial reactors in the State of Ohio.

Future Reactor Types

In the future, the BWRs and PWRs may not be the only types of commercial reactors in operation in the United States. Presently, several reactor types are being designed or developed which would be licensed by design or class. The new reactors will be smaller and more modular units, approximately 80-600 Megawatts electric (MWe) in size. These proposed reactors would have more passive systems relying on gravity, natural air flow (convection) and evaporation cooling systems in the event of a loss of coolant situation. Also, these reactors could be fabricated at the manufacturers and shipped to a plant for installation. This would save money and time during construction. The following paragraphs discuss five reactors that may be licensed in this country.

Advanced Pressurized Water Reactors

The Advanced Pressurized Water Reactor (APWR) or passive water-cooled reactor by Westinghouse Electric Corporation is a 600 MWe reactor which replaces many active systems with more passive ones. The AP-600, Westinghouse's version, is similar to current PWRs with the following exceptions. The containment building is larger than usual. Safety features

that aid in the maintenance of the building pressure and the prevention of a reactor vessel rupture include cooling sprinklers located above the reactor vessel and air baffles that allow natural convection cooling. Gravity-Feed Emergency Flood Tanks located above the core allow water to free-flow down in case of a loss of coolant situation.

The reactor uses a uranium dioxide pellet as fuel and operates at 600°F. Construction of the AP-600 is estimated to take five years. Since prefabricated modules (reactors) can be purchased and installed, construction time and cost would be considerably less than building a reactor at a site.

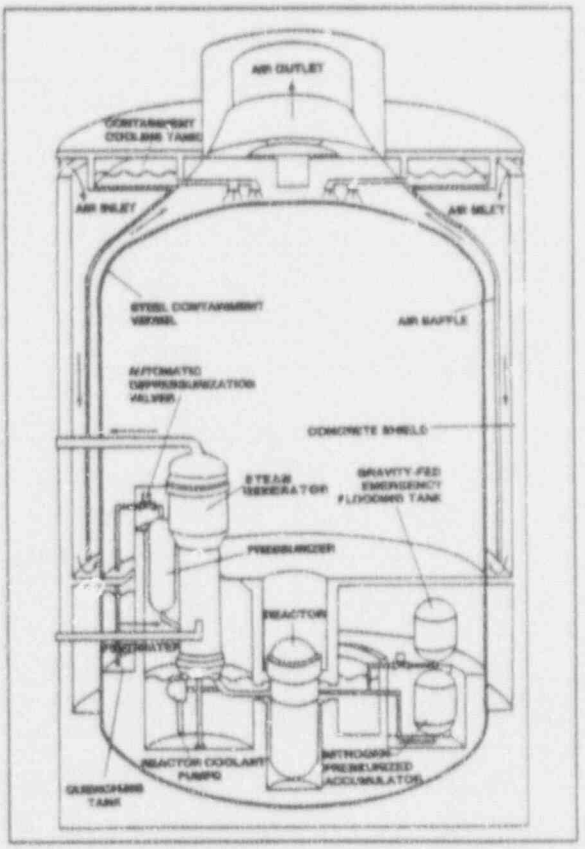


Figure 1-7: The AP600, shown here,is fabricated at the manufacturers' and shipped to a site for installation. This reduces both construction time and cost without compromising plant safety.

Advanced Boiling Water Reactor

The Advanced Boiling Water Reactor (ABWR), developed by General Electric Company, is similar to current BWRs with a few exceptions. The circulating pumps are located in the reactor vessel. This reduces the amount of shielding required and the number of welds in the system. Also, the control systems are driven electromechanically rather than hydraulically, thereby reducing maintenance. Safety systems are more redundant, requiring less operator intervention.

The ABWR would be capable of producing 1350 MWe and would use uranium dioxide as a fuel. Tokyo Electric Power Company in Japan has plans to build the first ABWR once pre-approved certification is completed. The plant construction time is estimated to take five to six years.

Simplified Boiling Water Reactor (SBWR)

The General Electric Company is also developing a second type of BWR called the Simplified Boiling Water Reactor. This design focuses on safety and simplicity, relying on gravity and natural circulation for cooling during a loss of coolant situation. The reactor core is at the bottom of the containment building. A Gravity-Feed Cooling Tank, located above the core, is used to flood the core during a loss of coolant situation. This reactor is considered an inherently safe design which means reactor operator would have 72 hours to respond to a loss of coolant situation instead of 20 minutes like current reactors. Also, this response time can be lengthened by adding more water to the core. The SBWR would produce 600 MWe and use a uranium dioxide fuel. Pre-approval certification is targeted for 1995, with construction time being 30 months.

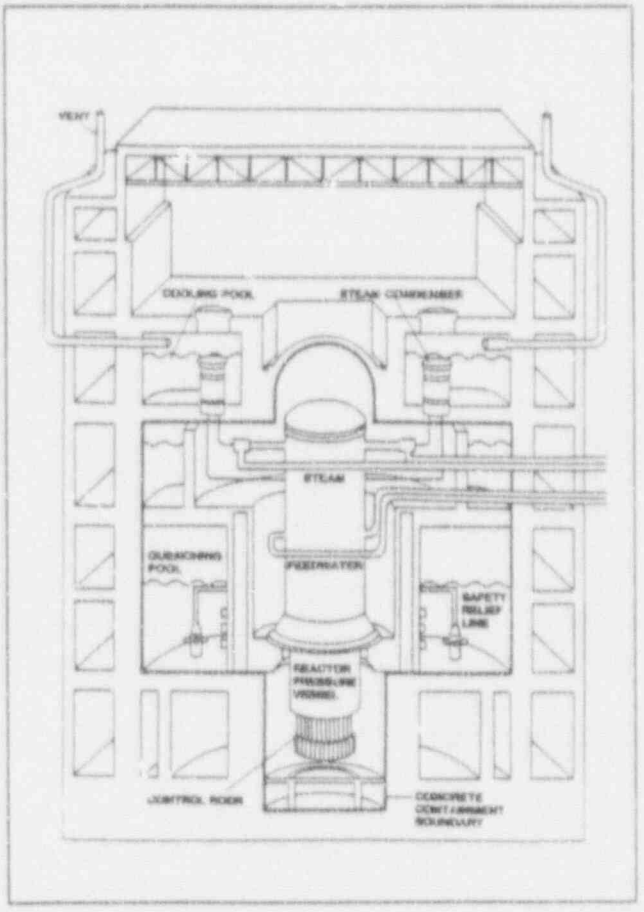


Figure 1-8: The Simplified Boiling Water Reactor by General Electric relies on gravity and natural circulation for cooling during loss of coolant situations. This gives operators 72 hours to react rather than 20 minutes as in present reactors.

Liquid Metal Reactor

Presently, General Electric Company is designing their version of a Liquid Metal Reactor (LMR) called PRISM (Power Reactor Inherently Safe Module). The PRISM is considered walk away safe because the reactor coolant surround the core is liquid (molten) sodium. Theoretically, the sodium would never reach its boiling point where it would boil into vapor and uncover the reactor core. The PRISM uses a three loop system to produce steam for the turbine. The first loop has liquid sodium passing through the core to be heated. The sodium from the first loop goes to a heat exchanger and heats the liquid sodium in the second loop. This sodium then travels to a second heat exchanger where it converts water to steam, for running the turbine. By using sodium as the coolant the primary system can operate at higher temperatures without being pressurized. Since the reactor operates at a higher temperature (1156°F), a thermal efficiency of 40% is achievable compared to 33% for current BWRs and PWRs.

A group of nine LMRs with a capacity of 155 MWe each, would form a 1345 MWe plant. The reactors are fueled with uranium-plutonium-zirconium alloy. The PRISM is a breeder reactor, which means it converts uranium-238 to plutonium-239. The Pu-239 would later be used to fuel another nuclear plant. One major draw back of the PRISM is that sodium is highly reactive with air and water, but design features eliminate most of the problems.

Modular High Temperature Gas-Cooled Reactor

The last reactor being considered in the United States is the Modular High Temperature Gas-Cooled Reactor (HTGR) which uses helium as the reactor coolant. It is being designed under the cooperation of General Atomics, Gas Cooled Reactor Associates, and Electric Power Research Institute (EPRI). In the HTGR, helium heated in the reactor core passes to a heat exchanger, then back to the reactor again. In the heat exchanger, water is converted to steam to run the turbine, just as in PWRs. Since there is no possibility of phase change of reactor coolant, the system can operate at a high temperature (1268°F) without pressurization, allowing thermal efficiency of 40%.

The core of the HTGR is made of graphite blocks with vertical and horizontal holes drilled through the blocks. In the vertical holes fuel rods, containing carbon and silicon carbide coated uranium pellets and control rods are inserted. The horizontal holes allow helium to pass through and be heated before going to the heat exchangers. This design is considered walk

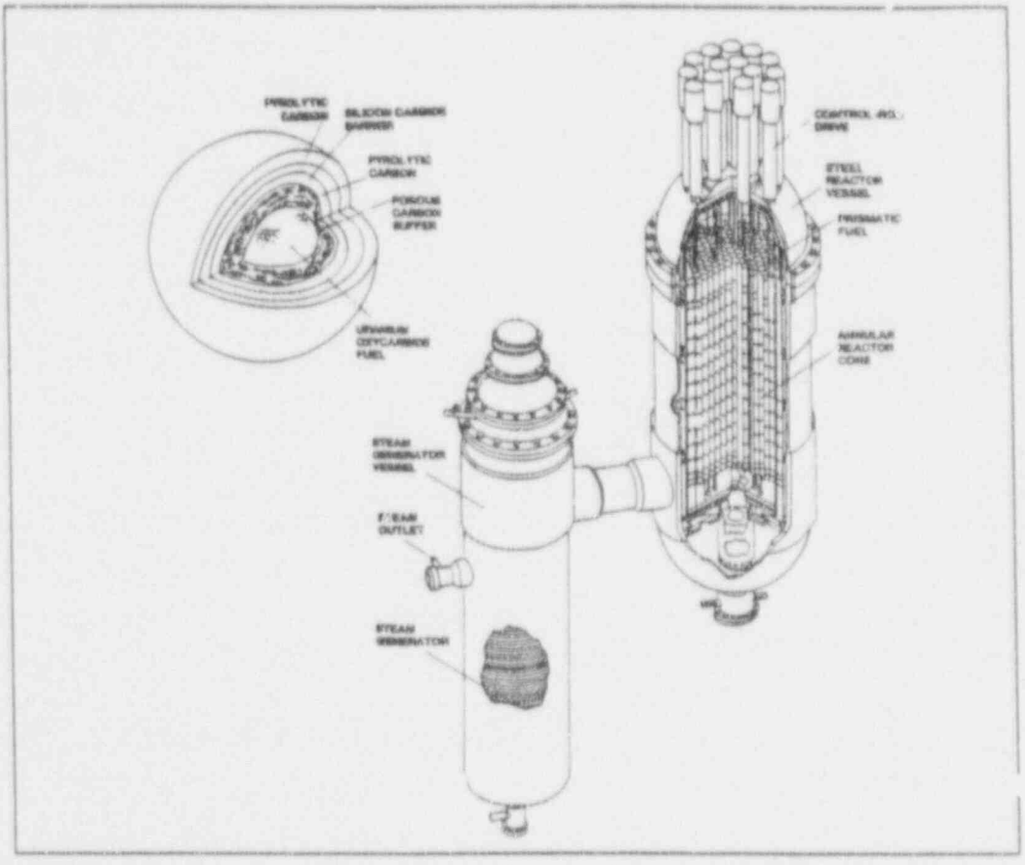


Figure 1-9: The High Temperature Gas-Cooled Reactor is considered walk-away safe because the fuel pellet, shown above, can withstand temperatures higher than that created during a loss of coolant situation.

away safe because the fuel can withstand temperatures higher than that produced during a loss of coolant situation. This design calls for four 135-MWe reactors to be grouped together to from a 540 MWe plant.

These designs are based on forty years of progressing technology and operating experience. The safety systems are less dependent on operator assistance and outside power supplies. The smaller size allows them to be more modular and facilita e construction. Utilities looking to increase their power production by a small amount may find that these newer designs will allow for this. Less time invested in the licensing and construction phases means less capital tied up for long periods of time.

Station Systems

The following paragraphs describe the various systems illustrated in Figure 1-10. Major systems in the Davis-Besse Station are assigned a different color in the figure.

FIGURE 1-10 LEGEND

GREEN - Reactor Coolant System (Primary Coolant Water)

RED - Main Steam System

BLUE - Condensate/Main Feedwater System (Secondary Coolant Water)

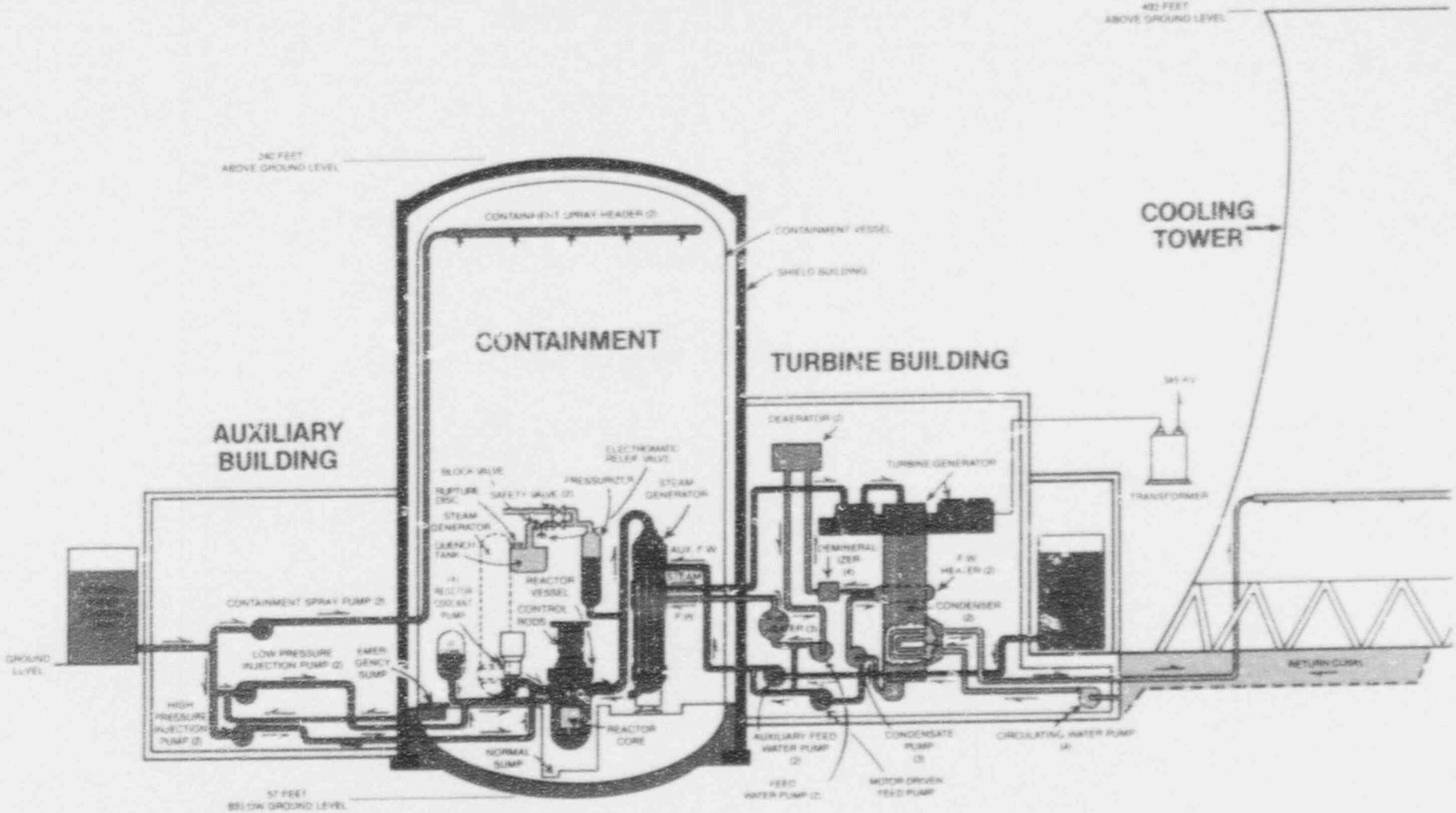
YELLOW - Circulating Water System (Tertiary Coolant Water)

GOLD - Emergency Core Cooling System

SCARLET - Auxillary Feedwater System

GREY - Pressurizer and Associated Structures

Figure 1-10: **Davis-Besse Nuclear Power Station Unit No. 1**



Containment Building and Fission Product Release Barriers

The **containment building** at Davis-Besse houses the reactor vessel, the pressurizer and two steam generators. The building is constructed of an inner 1 inch thick steel liner or **containment vessel**, and the **shield building** with steel reinforced concrete walls 2 feet thick. The shield building protects the containment vessel from a variety of environmental factors, and provides an area for a **negative pressure boundary** around the steel containment vessel. In the event that the integrity of the shield building is compromised (e.g., a crack develops), this negative pressure boundary ensures that any airborne radioactive contamination present in the containment vessel is prevented from leaking out into the environment. It accomplishes this by maintaining the pressure inside the shield building lower than that outdoors, thus forcing clean outside air to leak in, while making it impossible for the contaminated air inside the containment vessel to leak out. The free-standing containment vessel is the third in a **series of barriers** that prevent the release of fission products in the unlikely event of an accident. The first barrier to the release of fission products is the fuel cladding itself. The second barrier is the walls of the primary system, i.e. the reactor vessel, steam generator and associated piping.

The Steam Generators

The **steam generators** at Davis-Besse perform the same function as a boiler at a fossil-fueled power station. The steam generator uses the heat of the primary coolant inside the steam generator tubes to boil the secondary side **feedwater** (secondary coolant) surrounding the tubes on the outside. Fission heat must be transferred from the reactor core to the steam generator in order to provide the steam necessary to drive the turbine. However, heat must also be removed from the core even after reactor shutdown in order to prevent damage to the fuel cladding. Therefore, pumps maintain a continuous flow of coolant through the reactor and steam generator. **Primary loop water** (green in Figure 1-10) exits the reactor at approximately 606°F, passes through the steam generator, transferring some of its heat energy to the **secondary loop water** (blue in Figure 1-10) without ever actually coming in contact with it. Primary coolant water exits the steam generator at approximately 558°F to be circulated back into the reactor where it is again heated to 606°F as it passes up through the fuel assemblies. Under ordinary conditions, water inside the primary system would boil long before it reached such temperatures. However, it is kept under a pressure of approximately 2,200 pounds-per-square-inch (psi) at all times. This prevents the water from

boiling and is the reason the reactor at Davis-Besse is called a Pressurized Water Reactor. Secondary loop water enters the base of the steam generator at approximately 400°F and under 1100 psi pressure. At this pressure, the water can easily boil into steam as it passes over the tubes containing the primary coolant water.

Both the primary and the secondary coolant water are considered **closed loop systems**. This means they are designed not to come in physical contact with one another. Rather, the coolant (i.e., water) contained in each loop transfers heat energy by the process of **convection**. Convection is a method of **heat transfer** that can occur between two fluid media. It is the same process by which radiators are used to heat homes. The water circulating inside the radiator is separated from the air (a "fluid" medium) by the metal piping.

The Turbine - Generator

The turbine, main generator, and the condenser are all housed in what is commonly referred to as the **Turbine Building**. The purpose of the **turbine** is to convert the **thermal energy** of the steam produced in the steam generator (referred to as **main steam**, red in Figure 1-10) to **rotational energy** of the turbine -generator shaft. The turbine at Davis-Besse is actually composed of one six- stage high pressure turbine and two seven-stage low pressure turbines aligned on a common shaft. A **turbine stage** refers to a set of blades. Steam enters at the center of each turbine and flows outward along the shaft in opposite directions through each successive stage of blading. As the steam passes over the turbine blades, it loses pressure. Thus, the blades must be proportionally larger in successive stages to extract enough energy from the steam to rotate the shaft at the correct speed.

The purpose of the **main generator** is to convert the rotational energy of the shaft to **electrical energy** for commercial usage and support of station systems. The main generator is composed of two parts, a stationary **stator** that contains coils of copper conductors, and a **rotor** that supplies a rotating magnetic field within the coils of the stator. Electrical current is generated in the stator portion of the main generator. From this point, the electric current passes through a series of **transformers** for transmission and use throughout northern Ohio.

The Condenser

After the spent steam in the secondary loop (blue in Figure 1-10) passes through the high and low pressure turbines, it is collected in a cavernous

condenser several stories tall and containing more than 70,000 small tubes. **Circulating (circ) water** (yellow in Figure 1-10) goes to the **cooling tower** after passing through the tubes inside the condenser. As the steam from the low pressure turbines passes over these tubes, it is cooled and condensed. The condensed water is then purified and reheated before being circulated back into the steam generator again in a closed loop system. Circ water forms the third (or **tertiary**) and final loop of cooling water used at the Davis-Besse Station.

As the primary to secondary interface, the secondary to tertiary interface is based on a closed loop design. In other words, the circulating water is able to cool the steam in the condenser, without ever actually coming in contact with it, by the process of convection. Even in the event of a primary to secondary leak, the water vapor exiting the Davis-Besse cooling tower would remain non-radioactive. Closed loops are an integral part of the design of any nuclear facility. This design feature greatly reduce the chance of environmental impact from station operation.

The Cooling Tower

The cooling tower at Davis-Besse is easily the most noticeable and the most misunderstood, feature of the plant. The tower stands 493 feet high and the diameter of the base is 411 feet. The two pipes circulating 480,000 gallons of water per minute to the tower are 9 feet in diameter. This is enough water to fill a swimming pool the size of a football field 32 feet deep. The purpose of the tower is to recycle water from the condenser by cooling it.

After passing through the condenser, the circulating water has warmed to approximately 100°F. In order to cool the water back down to around 70° F, the circulating water enters the cooling tower about 40 feet above the ground. The water is sprayed evenly over a series of baffles called **fillsheets** which are suspended vertically in the base of the tower. A natural draft of air blowing up through these baffles cools the water through the process of **evaporation**. The evaporated water exits the top of the cooling tower in the form of **water vapor.**

As much as 10,000 gallons of water per minute are lost to the atmosphere via the cooling tower. Even so, approximately 98 percent of the water drawn from Lake Erie for station operation can be recycled through the cooling tower for reuse. A small portion of the circulating water is discharged back to Lake Erie at essentially the same temperature it was withdrawn earlier. In 1991, the average difference between the intake and discharge water temperatures was only 6.2°F. The slightly warmer discharge water had no

adverse environmental impact on the area of lake surrounding the discharge point.

Many power stations, both nuclear and fossil-fueled, utilize cooling towers to cool station discharge water. Federal regulations governing the water temperature of rivers, lakes, and bays require that power station operation introduce relatively small changes in water temperature. An increase in water temperature is not necessarily detrimental to aquatic life. Fishermen usually find that the best fishing areas are in the vicinity of warm water effluents from power stations. Warm water has also been found to accelerate the growth and increase the size of oysters and shrimp harvested by commercial fishermen. Unfortunately, the same warm water may also attract undesirable aquatic organisms such as the zebra mussel. In addition, an increase in water temperature during the summer months could decrease the water's oxygen content and could therefore precipitate a fish kill.

Miscellaneous Station Safety Systems

The gold system in Figure 1-10 is part of the **Emergency Core Cooling System (ECCS)** housed in the **Auxilliary Building** of the station. The ECCS consists of three overlapping means of keeping the reactor core covered with water, in the unlikely event of a Loss Of Coolant Accident (LOCA), thereby protecting the fuel cladding barrier against temperature failure. Depending upon the severity of the loss of pressure inside the primary system, the ECCS will automatically channel borated water into the reactor by either **high pressure injection pumps, a core flood tank, or low pressure injection pumps**. Borated water can also be sprayed from the ceiling of the containment vessel to cool and condense any steam that may escape from the primary system.

The grey system illustrated in Figure 1-10 is responsible for maintaining the primary coolant water in a liquid state. It accomplishes this by adjusting the pressure inside the primary system. Heaters inside the **pressurizer** turn water into steam. This steam takes up more space inside the pressurizer, therefore increasing the overall pressure inside the primary system. The pressurizer is also equipped with spray heads that shower cool water over the steam in the pressurizer. In this case, the steam condenses and the overall pressure inside the primary system drops. The **quench tank** pictured in Figure 1-10 is simply where excess steam is directed and condensed for storage.

The scarlet system in Figure 1-10 is part of the **Auxilliary Feedwater System**, a key safety system in event the main feedwater supply (blue in

Figure 1-10) to the steam generator is inadequate. Following a reactor shutdown, the Auxiliary Feedwater System can supply water to the steam generators from the **Condensate storage Tanks**. The Auxiliary Feedwater System is housed in the Turbine Building along with the turbine, main generator, and the condenser.

Reactor Safety and Summary

Nuclear power plants are inherently safe, not only by the laws of physics, but by design. Nuclear power plants cannot explode like a bomb because the concentration of fissionable material is far less than is necessary for such a nuclear explosion. Just as the battery of a flashlight provides enough energy to produce light, the amount of energy produced by the battery is not enough to cause an electrical shock to a person handling the flashlight.

Many safety features are also equipped with several backup systems to ensure that any possible accident would be prevented from causing a serious health or safety threat to the public, or serious impact on the local environment. Davis-Besse, like all U.S. nuclear units, has many overlapping, or redundant safety features. If one system should fail, there would still be back-up systems to assure the safe operation of the Station. During normal operation, the **Reactor Control System** regulates the power output by adjusting the position of the control rods The reactor can be automatically shut down by a separate **Reactor Protection System** that causes all the control rod assemblies to be quickly and completely inserted into the reactor core, stopping the chain reaction. To guard against the possibility of a Loss Of Coolant Accident, the Emergency Core Cooling System is designed to pump reserve water into the reactor automatically if the reactor coolant pressure drops below a predetermined level.

The Davis-Besse Nuclear Power Station was designed, constructed and operates to produce a reliable, safe, and environmentally sound source of electricity.

Description of the Davis-Besse Site

The Davis-Besse site is located in Carroll Township of Ottawa County, Ohio. It is on the southwestern shore of Lake Erie, just north of the mouth of the Toussaint River. The site lies north and east of Ohio State Route 2, approximately 10 miles northwest of Port Clinton, 7 miles north of Oak Harbor, and 25 miles east of Toledo, Ohio (Figure 1-11).

This section of Ohio is flat and marshy, with maximum elevations of only a few feet above the level of Lake Erie. The area originally consisted of swamp forest and marshland, rich in wildlife but unsuitable for settlement and farming. During the nineteenth century, the land was cleared and drained, and has been farmed successfully since. Today, the terrain consists of farmland with marshes extending in some places for up to two miles inland from the Sandusky Lake Shore Ridge.

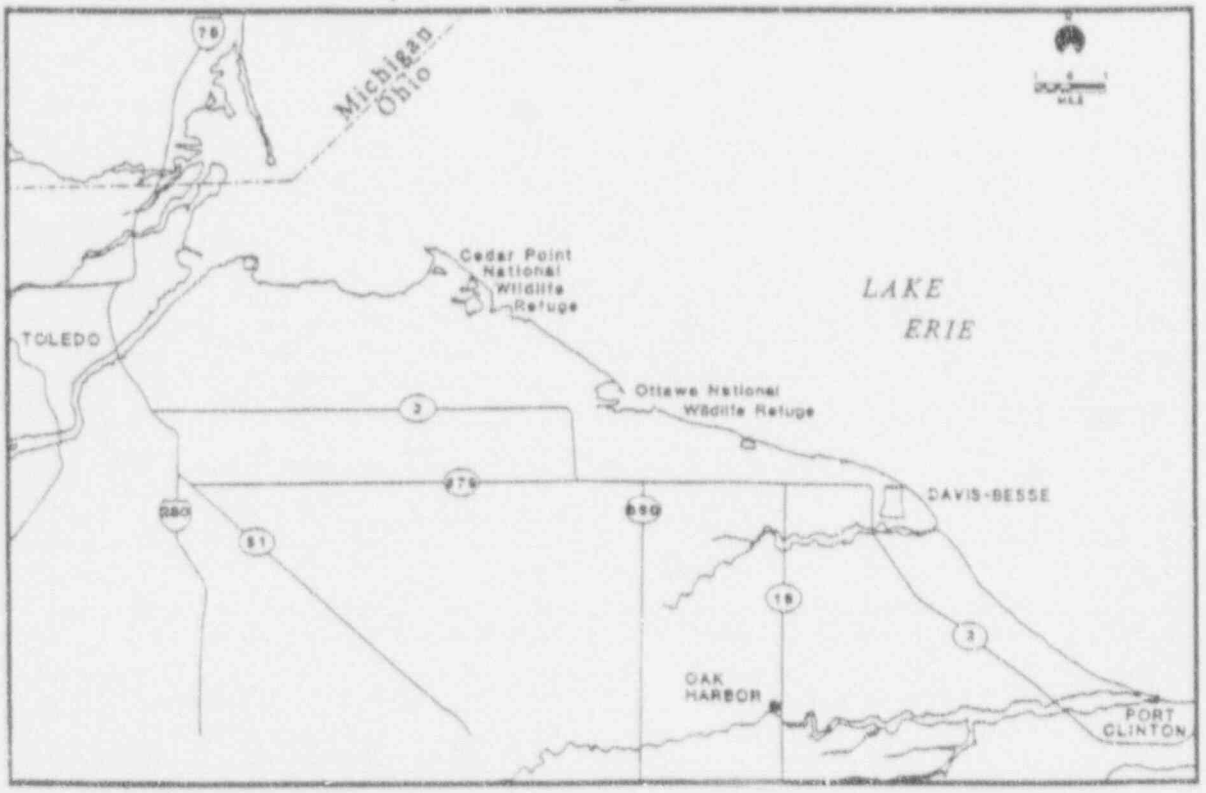


Figure 1-11: Davis-Besse is near Oak Harbor, Port Clinton and the Ottawa National Wildlife Refuge

More than half of the Davis-Besse site area is marshland. A small portion of the site was farmland. The marshes are part of a valuable ecological resource, providing a breeding ground for a variety of wildlife, and a refuge for migratory birds. Major species of birds using this portion of the Lake Erie marshes include mallards, black ducks, widgeon, egrets, great blue herons, blue-winged teal, and Canada geese. In fact, there are hundreds of geese living right on site. Bald eagles, osprey, swans, great horned owls, and a large number of hawks are also seen in the area. The site includes a tract known as Navarre Marsh, which was acquired for the U.S. Bureau of Sport Fisheries and Wildlife, Department of the Interior. In 1971, Toledo Edison purchased the 188 acre Toussaint River Marsh. The Toussaint River Marsh is contiguous with the 610-acre Navarre Marsh section of the Ottawa National Wildlife Refuge.

Most of the remaining marshes in the area have been maintained by private hunting clubs, the U.S. Fish and Wildlife Service, and the Ohio Department of Natural Resources, Division of Wildlife. There are some residences along the lake shore used mainly as summer homes. However, the major resort area of the county is farther east, around Port Clinton, Lakeside, and the Bass Islands.

The immediate area near Davis-Besse is sparsely populated; Ottawa County had a population of only 40,029 in the 1990 census. The nearest incorporated communities are:

- Port Clinton - 10 miles southeast, population 7,106
- Oak Harbor - 7 miles south, population 2,637
- Rocky Ridge - 7 miles west southwest, population 425
- Toledo (the nearest major city) - 25 miles west, population 322,943

The non-marsh areas around the Davis-Besse site are used primarily for farming. The major crops include soybeans, corn, wheat, oats, hay, fruits and vegetables. Meat and dairy animals are not major sources of income in the area. The main industries within five miles of the site are located in Erie Industrial Park, about four miles southeast of the Station.

The State of Ohio Department of Natural Resources operates many wildlife and recreational areas within 10 miles of the Station. These include Magee Marsh, Turtle Creek, Crane Creek State Park, and the Ottawa National Wildlife Refuge. Magee Marsh and Turtle Creek lie between three and six

miles WNW of the Station. Magee Marsh is a wildlife preserve allowing public fishing, nature study, and controlled hunting in season. Turtle Creek, a wooded area at the southern end of Magee Marsh, offers boating and fishing. Crane Creek State Park is adjacent to Magee Marsh and is a popular picnicking, swimming, and fishing area. The Ottawa National Wildlife Refuge lies four to nine miles WNW of the site, immediately west of Magee Marsh.

The 1991 Summary of Radioactivity Released in Liquid and Gaseous Effluents

Protection Standards

Soon after the discovery of x-rays in 1895 by Wilhelm Roentgen, the potential hazards of ionizing radiation were recognized and efforts were made to establish radiation protection standards.

The primary source of recommendations for radiation protection standards within the United States is the National Council on Radiation Protection and Measurements (NCRP). Many of these recommendations have been given legislative authority through publication in the Code of Federal Regulations (CFR) by the Nuclear Regulatory Commission (NRC).

The main objective in the control of radiation exposure is to ensure that any necessary exposures are kept as low as is reasonably achievable (ALARA). The ALARA principle applies to reducing radiation exposure both to the individual working at Davis-Besse and the general public. "Reasonably achievable" means that exposure reduction is based on sound economic decisions and operating practices. By practicing ALARA, Davis-Besse and Centerior Energy minimize health risk and environmental detriment and ensure that doses do not exceed certain specified limits.

Limits

To protect the general public, guidelines and limits have been established governing the release of radioactivity in liquid and gaseous Station effluents. The Code of Federal Regulations, Title 10, Part 50, Appendix I (10CFR50, App.I) provides guidelines for the Technical Specifications which are part of the license authorizing nuclear reactor operation. Davis-Besse's Technical Specifications restrict the release of radioactivity to the environment and the resulting dose to the public. Table 1-3 presents these limits.

Table 1-3: Dose Limits to a Member of the Public

Source	NRC Limits for Davis-Besse
Liquid Effluents	
Whole body	less than or equal to 3 mrem/year
Organ	less than or equal to 10 mrem/year
Gaseous Effluents	
Noble Gases	
gamma air dose	less than or equal to 10 mrad/year
beta air dose	less than or equal to 20 mrad/year
Iodine-131, tritium and particulates with half-lives greater than 8 days	less than or equal to 15 mrem/yr

The Davis-Besse limits are only a small fraction of the dose limits established by the Environmental Protection Agency (EPA). In its environmental dose standard, 40 CFR 190, the EPA established environmental radiation protection standards for nuclear power operations. These standards for normal operation provide that the dose from all discharges of radioactivity should not exceed:

- 25 mrem/year to the whole body,
- 75 mrem/year to the thyroid, and
- 25 mrem/year to any other organ.

Sources of Radioactivity Released

Through the normal operation of a nuclear power station, most of the fission products are retained within the fuel and fuel cladding. However, small amounts of radioactive fission products and trace amounts of the component and structure surfaces which have been activated are present in the primary coolant water. The three types of radioactive material released are noble gases, iodine and particulates, and tritium.

The noble gas fission products in the primary coolant are given off as a gas when the coolant is depressurized. These gases are then collected by a sys-

tem designed for gas collection and storage for radioactive decay prior to release.

Small releases of radioactivity in liquids may occur from valves, piping or equipment associated with the primary coolant system. These liquids are collected through a series of floor and equipment drains and sumps. All liquids of this nature are processed and carefully monitored prior to release.

Noble Gas

Some of the fission products released in airborne effluents are radioactive isotopes of noble gases, such as xenon and krypton. Noble gases are biologically and chemically nonreactive. They do not concentrate in humans or other organisms. They contribute to human radiation exposure by being a source of external whole body exposure. Xenon-133 and xenon-135, with half-lives of approximately five days and nine hours, respectively, are the major radioactive noble gases released. They are readily dispersed in the atmosphere.

In 1991, approximately 1160 curies of noble gases were released in gaseous effluents. The calculated offsite gamma and beta air doses due to the release of this activity were 0.015 mrad and 0.047 mrad, respectively, and are less than 0.25% of their respective Technical Specification limits. Additional dose information is provided in Table 1-4 and page 1-43.

Iodine and Particulates

Annual releases of radioisotopes of iodine and particulates (with half-lives greater than eight days) in gaseous and liquid effluents are small. Factors such as their high chemical reactivity and solubility in water, combined with the high efficiency of gaseous and liquid processing systems, minimize their discharge. The predominant radioiodine released is iodine-131 with a half-life of approximately eight days. The main contribution of radioactive iodine to human exposure is internal exposure of the thyroid gland, where the body concentrates iodine.

The principal radioactive particulates released are fission products (cesium-134 and cesium-137) and activation products (cobalt-58 and cobalt-60). Radioactive cesiums and cobalts contribute to internal radiation exposure of tissues such as the muscle, liver, and intestines. These particulates are also a source of external exposure if deposited on the ground.

During 1991, the amount of radioactive iodine and particulates (excluding tritium) released was approximately 0.01 curie in gaseous effluents and 0.17 curie in liquid effluents. These releases were well below all applicable regulatory limits. Additional dose information is provided in Table 1-4 on page 1-43.

Tritium

Tritium, a radioactive isotope of hydrogen, is the predominant radionuclide in liquid effluents. It is also present in gaseous effluents. Tritium is produced in the reactor coolant as a result of neutron interaction with deuterium (also a hydrogen isotope) present in the water and with the boron in the primary coolant used for reactivity control of the reactor. When tritium is ingested or inhaled it disperses throughout the body and exposes all tissues until it is eliminated.

The amount of tritium released in 1991 was approximately 64.6 curies in gaseous effluents and 325.6 curies in liquid effluents. The associated doses were well below all regulatory limits, and additional dose information is provided in Table 1-4.

Processing and Monitoring

Effluents are strictly controlled to ensure radioactivity released to the environment is minimal and does not exceed release limits. Effluent control includes the operation of monitoring systems, in-plant and environmental sampling and analysis programs, quality assurance programs for effluent and environmental programs, and procedures covering all aspects of effluent and environmental monitoring.

The radioactive waste treatment systems at Davis-Besse are designed to collect and process the liquid and gaseous wastes which contain radioactivity. For example, the Waste Gas Decay Tanks are holding tanks which allow radioactivity in gases to decay prior to release via the station vent.

Radioactivity monitoring systems are used to ensure that all releases are below regulatory limits. These instruments provide a continuous indication of the radioactivity present and are sensitive enough to measure 100 to 1000 times lower than the release limits. Each instrument is equipped with alarms with indicators in the control room. The alarm setpoints are low to ensure the limits will not be exceeded. If a monitor alarms, a release from a tank is automatically stopped.

All wastes are sampled prior to release and analyzed in a laboratory to identify the specific concentrations of radionuclides being released. Sampling and analysis provide a more sensitive and precise method of determining effluent composition than with monitoring instruments alone.

A meteorological tower is located in the southwest sector of the Station. It is linked to computers which record the meteorological data. Coupled with the effluent release data, the meteorological data are used to calculate the dose to the public.

Beyond the plant, devices maintained in conjuction with the Radiological Environmental Monitoring Program constantly sample the air in the surrounding environment. Frequent samples of other environmental media, such as water and vegetation, are also taken to determine if buildup of deposited radioactivity has occurred in the area.

Exposure Pathways

Radiological exposure pathways define the methods by which people may become exposed to radioactivity. The major pathways of concern are those which could cause the highest calculated radiation dose. These pathways are determined from the type and amount of radioactivity released, the environmental transport mechanism, and the use of the environment. The environmental transport mechanism includes consideration of physical factors, such as the hydrological (water) and meteorological (weather) characteristics of the area. Information on the water flow, wind speed and wind direction at the time of a gaseous or liquid release is used to evaluate how the radionuclides will be distributed in the area. An important factor in evaluating the exposure pathways is the use of the environment. Many factors are considered such as dietary intake of residents, recreational use of the area, and the location of homes and farms in the area.

The external and internal exposure pathways considered are shown in Figures 1-12 and 1-13. The release of radioactive gaseous effluents involves pathways such as external whole body exposure, deposition of radioactive material on plants, deposition on soil, inhalation by animals destined for human consumption, and inhalation by humans. The release of radioactive in liquid

effluents involves pathways such as drinking water, fish consumption, and direct exposure from the lake at the shoreline and while swimming.

Although radionuclides can reach humans by many different pathways, some result in more dose than others. The **critical pathway** is the exposure pathway which will provide, for a specific radionuclide, the greatest dose to a population, or to a specific group of the population, called the **critical group.** The critical group may vary depending on the radionuclides involved, the age and diet of the group, or other cultural factors. The dose may be delivered to the whole body or to a specific organ. The organ receiving the greatest fraction of the dose is called the **critical organ.**

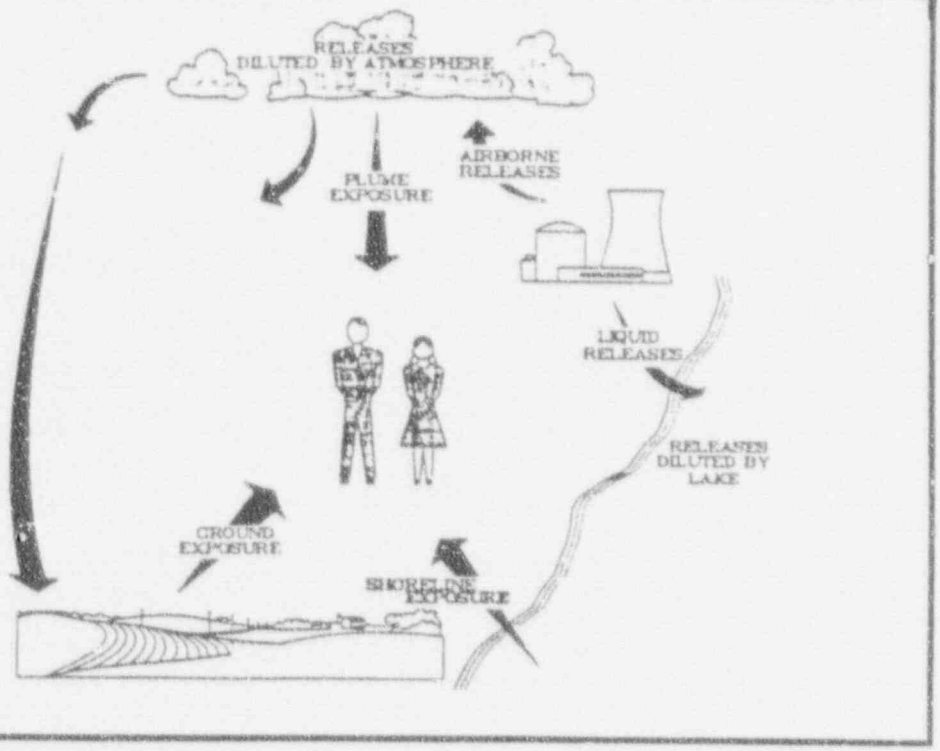


Figure 1-12 The external exposure pathways shown here, are monitored through the Radiological Environmental Monitoring Program (REMP), and are considered when calculating doses to the public.

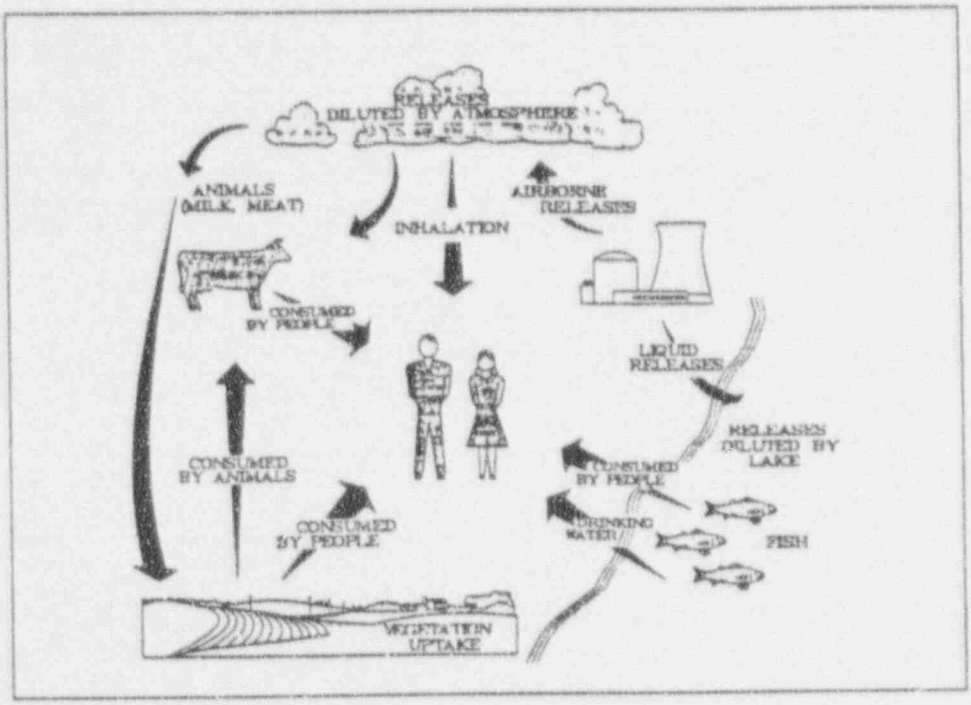


Figure 1-13: Internal exposure pathways include the methods by which radioactivity could reach people around the Station viathte foods they eat, the milk they drink, and the air they breathe.

Dose Assessment

Dose is the energy deposited by radiation in an exposed individual. Whole body radiation exposure involves the exp(ire of all organs. Most background exposures are of this form. Both non-radioactive and radioactive elements can enter the body through inhalation or ingestion. When they do, they are usually not distributed evenly. For example, iodine concentrates in the thyroid gland, cesium collects in muscle and liver tissue, and strontium collects in bone tissue.

The total dose to organs from a given radionuclide depends on the amount of radioactivity present in the organ and the amount of time that the radionuclide remains in the organ. Some radionuclides remain for very short times due to their rapid radioactive decay and/or elimination rate from the body, while other radionuclides may remain in the body for longer periods of time.

The dose to people in the area surrounding Davis-Besse is calculated for each liquid or gaseous release. The dose due to radioactivity released in gaseous effluents is calculated using factors such as the amount of radioactivity released, the concentration of radioactivity beyond the site boundary, the weather conditions at the time of the release, the locations of exposure pathways (cow milk, goat milk, vegetable gardens, and residences), and usage factors (inhalation, food consumption). The dose due to radioactivity released in liquid effluents is calculated using factors such as the total volume of radioactive liquid, the total volume of dilution water, near field dilution, and usage factors (water and fish consumption, shoreline and swimming factors). These calculations produce a conservative estimation of the dose.

Results

The results of the effluent monitoring program are reported to the Nuclear Regulatory Commission in the Semiannual Radioactive Effluent and Waste Disposal Report. For 1991, the doses from radioactivity released in gaseous and liquid effluents were a small fraction of the Davis-Besse Technical Specifications limits. The offsite whole body dose due to radioactivity released in liquid effluents was approximately 2.3% of the annual Technical Specifications limits. The offsite gamma and beta air doses due to radioactivity released in gaseous effluents were smaller; each was less than 0.39% of the annual Technical Specifications limits. Table 1-4 summarizes the dose due to radioactivity released in effluents in 1991.

Table 1-4 Annual Doses to the Public Due to Radioactivity Released in Gaseous and Liquid Effluents

	1991 Dose	Annual Limit	Percent of Limit
Liquid Effluents			
Whole Body	0.07 mrem	3 mrem	2.3%
Organ (GI-LLI)	0.11 mrem	10 mrem	1.1%
Gaseous Effluents			
Gamma air dose	0.015 mrad	10 mrad	0.15%
Beta air dose	0.047 mrad	20 mrad	0.24%
Iodine-131, tritium and particulates with half-lives greater than 8 days	0.06 mrem	15 mrem	0.40%

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Radiological Environmental Monitoring Program

Introduction

The **Radiological Environmental Monitoring Program** (REMP) was established at Davis-Besse for several reasons: to provide a supplementary check on the adequacy of containment and effluent controls, to assess the radiological impact, if any, that Station operation has on the surrounding area, and to determine compliance with applicable radiation protection guides and standards. Environmental surveillance has been a part of the radiological programs for approximately 20 years. The Radiological Environmental Monitoring Program was established in 1972, five years before the Station became operational. This **preoperational surveillance program** was established to describe and quantify the radioactivity, and its variability, in the area prior to commerical operation. When Davis-Besse became operational in 1977, the REMP continued to measure radiation and radioactivity in the surrounding areas. The **operational surveillance program** has been collecting environmental data for over 14 years.

A wide variety of environmental samples are collected as part of the REMP. The selection of sample types is based on the established critical pathways for the transfer of radionuclides through the environment to humans. The selection of sampling locations is based on sample availability, local meteorological and hydrological characteristics, local population characteristics, and land usage in the area of interest. The selection of sampling frequencies for the various environmental media is based on the radionuclides of interest, their respective half-lives, and their behavior in both the biological and physical environments.

A description of the Radiological Environmental Monitoring Program is provided in the following section. In addition, a brief history of analytical results for each sample type collected since 1972, and a more detailed summary of the analyses performed in 1991, are also provided.

Preoperational Surveillance Program

All nuclear facilities are required by the federal government to conduct radiological environmental monitoring prior to constructing the facility. This preoperational surveillance program should be aimed at collecting the data needed to identify critical pathways, including selection of the radioisotope and sample media combinations to be included in the surveillance program conducted after facility operation begins. Radiochemical analyses performed on the environmental samples should include not only those nuclides expected to be released during facility operation, but should also include typical fallout radionuclides and natural background radioactivity. All environmental media with a potential to be affected by facility operation, as well as those media directly in the critical pathways, should be sampled on at least an annual basis during the preoperational phase of the environmental surveillance program.

The preoperational surveillance design, including nuclide/media combinations, sampling frequencies and locations, collection techniques, and radioanalyses performed, should be carefully considered and incorporated in the design of the operational surveillance program. In this manner, data can be compared in a variety of ways (for example: from year to year, location to location, etc.), in order to detect any radiological impact the facility has on the surrounding environment. Total data collection during the preoperational phase should be planned to provide a comprehensive database for evaluating any future changes in the environment surrounding the nuclear facility.

Davis-Besse began its preoperational environmental surveillance program five years before the Station began producing power for commercial use in 1977. Data accumulated during those early years provide an extensive database from which Station personnel are able to identify trends in the radiological characteristics of the local environment. The environmental surveillance program at Davis-Besse will continue well after the Station has reached the end of its economically useful life and decommissioning has begun. Such a rigorous, long term environmental surveillance program provides a measure of insurance that any radiological impact the operation of Davis-Besse has had on the surrounding environment, is detected to preserve the integrity of the local environment.

Operational Surveillance Program Objectives

The operational phase of the environmental surveillance program at Davis-Besse was designed with the following objectives in mind:

- to fulfill the obligations of the radiological surveillance sections of the Stations Technical Specifications,
- to determine whether any significant increase occurs in the concentration of radionuclides in critical pathways,
- to identify and evaluate the buildup, if any, of radioactivity in the local environment, or any changes in normal background radioactivity, and
- to verify the adequacy of Station controls for the release of radioactivity.

Quality Assurance

An important part of the environmental monitoring program at Davis-Besse is the **Quality Assurance** (QA) **Program**. QA consists of all the planned and systematic actions that are necessary to provide adequate confidence in the results of an activity such as the REMP. QA is a program which checks the adequacy and validity of the monitoring program through routine audits, strict adherence to written policies and procedures, and attention to good record-keeping practices.

The QA program at Davis-Besse is conducted in accordance with the guidelines specified in NRC Regulatory Guide 4.15, "Quality Assurance for Radiological Monitoring Programs." The QA program is designed to identify possible deficiencies in the REMP so that corrective actions can be initiated promptly. Davis-Besse's Quality Assurance program also provides confidence in the results of the REMP through:

- performing regular audits (investigations) of the REMP, including a careful examination of sample collection techniques and record keeping,
- performing audits of contractor laboratories which analyze the environmental samples,
- requiring analytical contractor laboratories to participate in the United States Environmental Protection Agency Cross-Check Program,
- requiring analytical contractor laboratories to split samples for separate analysis followed by a comparison of results,
- splitting samples prior to analysis by independent laboratories, and then comparing the results for agreement, and finally,
- requiring analytical contractor laboratories to perform in-house spiked sample analyses.

QA audits and inspections of the Davis-Besse REMP are performed by groups such as Davis-Besse's QA department and representatives from the NRC. In

addition, the NRC and the Ohio Department of Health (ODH) also perform independent environmental monitoring in the vicinity of Davis-Besse. The types of samples collected and the sampling locations used by the NRC and ODH were incorporated in Davis-Besse's REMP. Hence, the analytical results from the different programs can be compared. This practice of comparing results from identical samples, collected and analyzed by different parties, provides a valuable QA tool to verify the quality of both the laboratories' analytical procedures and the data generated.

In 1987, environmental sampling personnel at Davis-Besse incorporated their own Quality Assurance program into the REMP. Duplicate samples, called quality control samples, were collected at several locations. These duplicate samples were assigned different identification numbers than the numbers assigned to the routine samples. This ensured the analytical laboratory would not know the samples were identical. The laboratory results from analyses of the quality control samples and the routine samples could then be compared for agreement. Quality control sampling has become an important part of the REMP since 1987, providing a check on the quality of analyses performed at the contracted analytical laboratory. Quality control sampling locations are changed frequently in order to duplicate as many sampling locations as possible, and to ensure the contractor laboratory has no way of correctly pairing a quality control sample with its routine sample counterpart.

Program Description

Overview

The Radiological Environmental Monitoring Program at Davis-Besse consists of the collection and analysis of a wide variety of environmental samples. Samples are collected on a routine basis either weekly, monthly, quarterly, semiannually, or annually, depending upon the sample type and nature of the radionuclides of interest. Environmental samples collected by Davis-Besse personnel are divided into four general categories:

- **atmospheric** -- including samples of airborne particulates and airborne radioiodine,
- **terrestrial** -- including samples of milk, groundwater, broad leaf vegetation, fruit, animal/wildlife feed, soil, and wild and domestic meat,
- **aquatic** -- including samples of treated and untreated surface water, fish, and shoreline sediments,

- **direct radiation** -- measured by thermoluminescent dosimeters. All environmental samples are labeled using a sampling code. Table 2-1 provides the sample codes and collection frequency for each sample type.

Table 2-1: Sample Codes and Collection Frequencies

Sample Type	Sample Code	Collection Frequency
Airborne Particulate	AP	Weekly
Airborne Iodine	AI	Weekly
Thermoluminescent Dosimeter	TLD	Quarterly, Annually
Milk	MIL	Monthly (semi-monthly during grazing season)
Groundwater	GW	Quarterly
Broad Leaf Vegetation and Fruits	BLV/ FRU	Monthly (July-September)
Surface Water - Treated	SWT	Weekly
Surface Water - Untreated	SWU	Weekly
Fish	FIS	Semiannually
Shoreline Sediments	SED	Semiannually
Soil	SOI	Semiannually
Animal/Wildlife Feed	AF	Semiannually
Meat-Domestic	Me(D)	Annually
Meat-Wild	Me(W)	Annually

Sample Analysis

When environmental samples are analyzed for radioactivity, several types of measurements may be performed to provide information about the types of radiation and radionuclides present. The major analyses that are performed on environmental samples collected for the Davis-Besse REMP include:

- Gross beta analysis
- Gamma spectral analysis
- Tritium analysis
- Strontium analysis
- Gamma dose (TLDs only)

Gross beta analysis measures the total amount of beta emitting radioactivity present in a sample. Beta radiation may be released by many different radionuclides. Since beta decay gives a continuous energy spectrum rather than the discrete lines or "peaks" associated with gamma radiation, identification of specific beta emitting nuclides is much more difficult. Therefore, gross beta analysis only indicates whether the sample contains normal or abnormal concentrations of beta emitting radioactivity; it does not identify specific radionuclides. Gross beta analysis merely acts as a tool to identify samples that may require further analysis.

Gamma spectral analysis provides more specific information than does gross beta analysis. Gamma spectral analysis identifies each radionuclide present in the sample that emits gamma radiation and the amount of radioactivity emitted by each. Each radionuclide has a very specific "fingerprint" that allows for swift and accurate identification. For example, gamma spectral analysis can be used to identify the presence and amount of iodine-131 in a sample. Iodine-131 is a man-made radioactive isotope of iodine that may be present in the environment as a result of fallout from nuclear weapons testing, routine medical uses in diagnostic tests, and routine releases from nuclear power stations.

Tritium analysis indicates whether a sample contains the radionuclide tritium (H-3) and the amount of radioactivity present as a result. As discussed in Chapter One, tritium is an isotope of hydrogen that emits low energy beta particles.

Strontium analysis identifies the presence and amount of strontium-89 and strontium-90 in a sample. These man-made radionuclides are found in the en-

vironment as a result of fallout from nuclear weapons testing. Strontium is usually incorporated into the calcium pool of the biosphere. In other words, strontium tends to replace calcium in living organisms and becomes incorporated in bone tissue. The principal strontium exposure pathway is via milk produced by cattle grazed on pastures exposed to deposition from gaseous releases.

Gamma Doses received by thermoluminescent dosimeters while in the field are read by a special laboratory procedure that is more thoroughly discussed on page 2-11.

Table 2-2 provides a listing of the types of analyses performed on environmental samples collected for the Davis-Besse REMP.

Often samples will contain little radioactivity, and may be below the lower limit of detection. The lower limit of detection (LLD) is the smallest amount of sample activity which can be detected with a reasonable degree of confidence at a predetermined level. When a measurement of radioactivity is reported as less than LLD (<LLD), it means that the radioactivity is so low that it cannot be accurately measured by that particular method for an individual analysis with any degree of confidence.

Sample History Comparison

The concentration of radioactivity present in the environment will vary due to factors such as weather or variations in sample collection techniques or sample analysis. This is one reason why the results of sample analysis are compared with results from other locations and from earlier years. Generally, the results of sample analyses are compared with preoperational and operational data. Additionally, the results of indicator and control locations are also compared. This allows REMP personnel to track and trend the radioactivity present in the environment, to assess whether a buildup of radionuclides is occurring and to determine the effects, if any, the operation of Davis-Besse is having on the environment. If any unusual radioactivity is detected, it is investigated to determine whether it is attributable to the operation of Davis-Besse, or to some other source such as nuclear weapons testing. A summary of the REMP sample analyses performed from 1972 to 1991 is provided in the following section.

Table 2-2: Radiochemical Analyses Performed on REMP Samples

Sample Type	Analyses Performed
ATMOSPHERIC MONITORING	
Airborne Particulates	Gross Beta Gamma Spectral Strontium-89 Strontium-90
Airborne Radioiodine	Iodine-131
TERRESTRIAL MONITORING	
Milk	Gamma Spectral Iodine-131 Strontium-89 Strontium-90 Stable Calcium Stable Potassium
Groundwater	Gross Beta Gamma Spectral Tritium Strontium-89 Strontium-90
Broad Leaf Vegetation and Fruits	Gamma Spectral Iodine-131 Strontium-89 Strontium-90
Animal/Wildlife Feed	Gamma Spectral
Soil	Gamma Spectral
Wild and Domestic Meat	Gamma Spectral

Table 2-2: Radiochemical Analyses Performed On REMP Samples

Sample Type	Analyses Performed
AQUATIC MONITORING	
Untreated Surface Water	Gross Beta Gamma Spectral Tritium Strontium-89 Strontium-90
Treated Surface Water	Gross Beta Gamma Spectral Tritium Strontium-89 Strontium-90 Iodine-131
Fish	Gross Beta Gamma Spectral
Shoreline Sediments	Gamma Spectral
DIRECT RADIATION MONITORING	
Thermoluminescent Dosimeters	Gamma Dose

Atmospheric Monitoring

- **Airborne Particulates**: No radioactive particulates have been detected as a result of Davis-Besse's operation. Only natural and fallout radioactivity from nuclear weapons testing and the 1986 nuclear accident at Chernobyl have been detected.
- **Airborne Radioiodine**: Radioactive iodine-131 fallout was detected in 1976, 1977, and 1978 from nuclear weapons testing, and in 1986 (0.12 to 1.2 picocuries per cubic meter) from the nuclear accident at Chernobyl.

Terrestrial Monitoring:

- **Groundwater**: Only naturally occurring background radioactivity has been detected in groundwater.
- **Milk**: Iodine-131 from nuclear weapons testing fallout was detected in 1976 and 1977 at concentrations of 1.36 and 23.9 picocuries/liter respectively. In 1986, concentrations of 8.5 picocuries/liter were detected from the nuclear accident at Chernobyl. No iodine-131 detected has been attributable to the operation of Davis-Besse.
- **Domestic and Wild Meat**: Only naturally occurring potassium-40 and very low cesium-137 activity have been detected in meat samples. Potassium-40 has ranged from 1.1 to 4.6 picocuries/gram wet weight. Cesium-137 was detected in 1974,1975, and 1981 due to fallout from nuclear weapons testing.
- **Broad Leaf Vegetation and Fruits**: Only natural background radioactivity and radioactivity from nuclear weapons testing have been detected.
- **Soil**: Only natural background radioactivity and radioactivity from nuclear weapons testing and the 1986 nuclear accident at Chernobyl have been detected.
- **Animal/Wildlife Feed**: Only natural background radioactivity and radioactivity from weapons testing have been detected.

Aquatic Monitoring

- **Surface Water (Treated and Untreated)**: In 1979 and 1980, the tritium concentrations at location T-7 were above normal background. Location T-7 is a beach well fed directly by Lake Erie. The fourth quarter sample in 1979 read 590 picocuries per liter, and the first quarter sample in 1980 had a concentration of 510 picocuries per liter compared with the normal background concentration of 450 picocuries per liter. A follow up sample was collected in Lake Erie between T-7 and the Davis-Besse liquid discharge point. This sample contained tritium at a concentration of 2737 picocuries per liter. These concentrations could be attributed to the operation of Davis-Besse. Even so, the results at T-7 were more than 39 times lower that the annual average concentration allowed by the EPA National Interim Primary Drinking Water Regulations (40CFR141), and were only 0.018% of the Maximum Permissible Concentration (MPC of 3,000,000 picocuries per liter) for tritium in unrestricted areas. The follow-up sample was less than 0.1% of the MPC. None of the subse-

quent samples indicate any significant difference between the background tritium concentration and the concentration at T-7.

- **Fish**: Only natural background radioactivity and radioactivity from nuclear testing have been detected.
- **Shoreline Sediments**: Only natural background radioactivity and radioactivity from nuclear testing and the 1986 nuclear accident at Chernobyl have been detected.

Direct Radiation Monitoring:

- **Thermoluminescent Dosimeters (TLDs)**: The annual average gamma dose rates recorded by TLDs have ranged from 42 to 87 millirems per year at control locations and between 36.8 and 86.1 millirems per year at indicator locations. No increase above natural background radiation attributable to the operation of Davis-Besse has been observed.

1991 Sampling Program

The Radiological Environmental Monitoring Program (REMP) is conducted in accordance with the Davis-Besse Nuclear Power Station Operating License, Appendix A, Technical Specifications. The program includes the collection and analysis of airborne particulates, airborne radioiodine, groundwater, milk, eggs, domestic and wild meat, fruits and broad leaf vegetation, soil, treated and untreated surface water, fish, shoreline sediments, and measurements of direct radiation (refer to Table 2-3). All samples are sent to an independent laboratory for analysis.

Although previous years' sampling programs satisfied all regulatory requirements, in 1987, a REMP Enhancement Program was initiated. In an effort to implement a more comprehensive REMP, the number of samples collected and analyzed was selectively increased. Expansion of the REMP was achieved by increasing the number of sampling locations, and types of samples collected, and by collecting duplicate, or quality control samples.

As a result of the REMP Enhancement efforts, over 2600 samples were collected during 1991. Of these samples collected, only 33% were required to satisfy regulatory requirements or Technical Specification. In addition, of the 143 sampling locations utilized in 1991, 14% were quality control locations.

Table 2-3: Sample Collection Summary

Sample Type (Remarks)	Collection Type*/ Frequency**	Number of Locations	Number of Samples Collected	Number of Samples Missed
ATMOSPHERIC				
Airborne Particulates	C/W	10	520	0
Airborne Radioiodine	C/W	10	520	0
TERRESTRIAL				
Milk (May-Oct.)	G/GM	4	36	0
(Nov.-Apr.)	G/M	4	19	0
Groundwater	G/Q	5	19	1
Edible Meat				
wild	G/A	1		0
domestic	G/A	2	2	0
Broad Leaf Vegetation/Fruit	G/M	5	22	0
Soil	G/S	11	22	0
Animal/Wildlife Feed	G/A	6	10	0
AQUATIC				
Treated Surface Water	G/WM	7	362	2
Untreated Surface Water	G/Wm	16		
	Comp./WM	5	260	0
Fish (3 species)	G/SA	2	6	6
Shoreline Sediments	G/SA	7	15	0
DIRECT RADIATION				
Thermoluminescent Dosimeters	C/Q	111	435	9
	C/A	111	105	6

* **Type of Collection:**
C/ = Continuous; G/ = Grab; Comp/ = Composite.

** **Frequency of Collection:**
/WM = Weekly composited Monthly; /W = Weekly
/SM = Semimonthly; /M = Monthly;
/Q = Quarterly; /SA = Semiannually; /A = Annually

1991 Program Deviations

Provided below is a description and explanation of 1991 environmental sample collection deviations.

- A composite sample of T-12 untreated surface water could not be collected on 1-14-91 because lines leading to compositor were frozen. A grab sample was substituted in place of the composite sample.
- Treated surface water samples at T-144 were unavailable on January 28, and March 14, 1991 because the waterline to that faucet was frozen.
- There were no data for TLD locations T-91, T-114, T-203 and T-204 for first quarter 1991. TLDs were lost due to vandalism.
- TLD locations, T-78 and T-79 were eliminated from the sampling program.
- The T-23 groundwater sample for first Quarter 1991 was unavailable from the Put-In-Bay Water Treatment Plant because their well is sealed up during the winter months.
- Precipitation / snow samples were eliminated from the 1991 sampling program.
- The treated surface water sample at T-28 for week of March 19, 1991 was inadvertently discarded. A grab sample was collected as a substitute for the lost sample.
- There was no TLD for location T-116 second quarter 1991. The TLD was lost due to vandalism.
- T-12 composite of untreated surface water for week of May 20, 1991 was not collected. The water sample container was damaged after collection of composite, the sample leaked out of the container while in transit from the intake crib back to the Toledo Water Treatment Plant Lab. A grab sample was collected as a substitute.
- There were no data for TLD locations T-93,T-203, and T-204 for third quarter 1991. TLDs lost due to vandalism.
- No fish samples were collected during October 1991 because desired fish species were unavailable.
- There were no data for TLD locations T-202 and T-204 for fourth quarter 1991. TLDs lost due to vandalism.
- The annual 1991 TLD for T-108 was lost in transit from field to laboratory.

- The annual 1991 TLD for T-108 was lost in transit from field to laboratory.
- There were no data for Annual TLDs at T-6, T-91, T-97, T-114, T-202, and T-203, these being TLDs lost due to vandalism.

Sampling Locations

REMP samples are collected at numerous locations, both onsite and up to 25 miles away from the Station. Sampling locations may be divided into two general categories: indicator and control. Indicator locations are those which would be most likely to display the effects caused by the operation of Davis-Besse. Generally, they are located within five miles of the station. Control locations are those which should be unaffected by Station operations and are typically, more than five miles away. Data obtained from the indicator locations are compared with data from the control locations. This comparison allows REMP personnel to take into account naturally occurring background radiation, or fallout from weapons testing, in evaluating any radiological impact Davis-Besse has on the surrounding environment. Data from indicator and control locations are also compared with preoperational data to determine whether significant variations or trends exist.

Atmospheric Monitoring

Air Samples

Environmental air sampling is conducted to detect any increase in the concentration of airborne radionuclides that may be inhaled by humans, or serve as an external radiation source. Inhaled radionuclides may be absorbed from the lung, gastrointestinal tract, or from the skin. Air samples collected by the REMP include both **airborne particulates** and **airborne radioiodine**. Air sampling pumps are used to draw continuous samples through particulate membrane filters and charcoal cartridges at a rate of approximately one cubic foot per minute. The samples are collected on a weekly basis.

Airborne particulate samples are collected on 47 mm diameter membrane filters. Charcoal cartridges are installed downstream of the particulate filters to sample for the presence of airborne radioiodine. The airborne samples are sent to a contractor laboratory for analysis. At the laboratory, the airborne particulate filters are stored for 72 hours before they are analyzed to allow for the decay of naturally occurring short-lived radionuclides. However, due to the short half-life of iodine-131 (approximately eight days), the airborne radioiodine cartridges are analyzed upon receipt by the contractor laboratory.

Airborne Particulates

Davis-Besse samples air for airborne radioactivity continuously at ten locations. There are six indicator locations including four around the site boundary, one at Sand Beach, and another at a local farm. There are four control locations, Oak Harbor, Port Clinton, Toledo and Magee Marsh.

Gross beta analysis is performed on each of the weekly samples. Each quarter, the filters from each location are combined (composited) and analyzed for gamma emitting radionuclides. The gross beta analyses yield an annual average of .021 pCi/m³ at indicator locations and .022 pCi/m³ at control locations for 1991. Evidence of the similarity of results of control and indicator locations may be seen in the average monthly results shown in Fig 2-1. The highest annual average (.023 pCi/m³) was detected at the Toledo location. The 1991 annual average was .021 pCi/m³ which is similar to previous years.

Beryllium-7 was the only gamma emitting radionuclide detected by the gamma spectroscopic analyses of the quarterly composites. Beryllium-7 is a naturally occurring radionuclide produced in the upper atmosphere by cosmic radiation. No other radionuclides were detected above their respective LLDs.

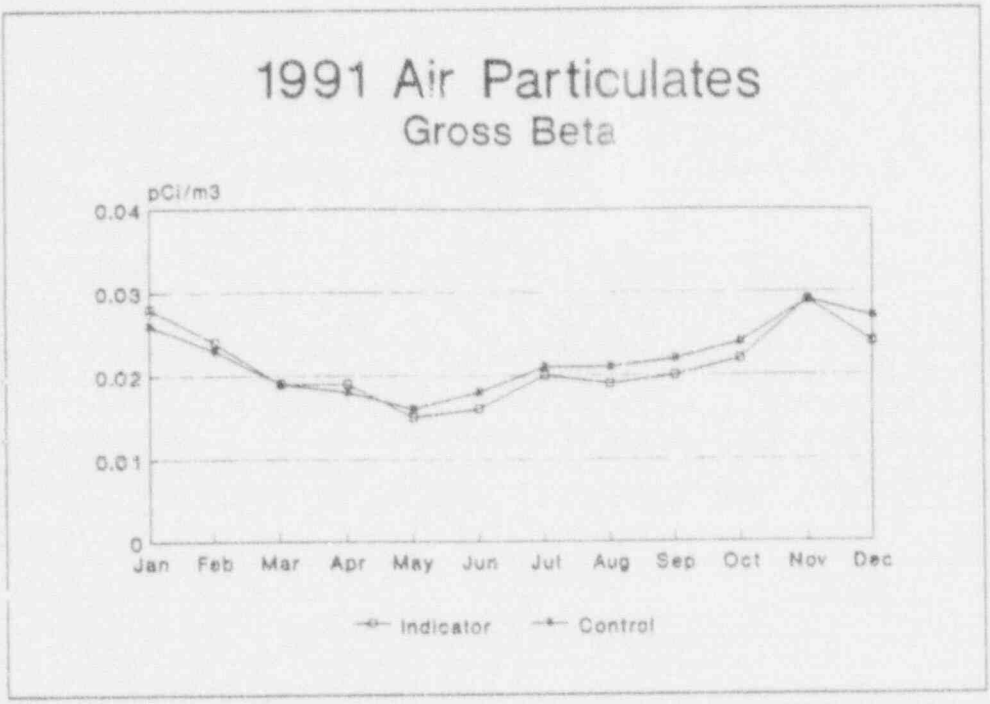


Figure 2-1: Concentration of Beta emitting radionuclides in airborne particulate samples were essentially identical at indicator and control locations.

Airborne Iodine-131

Airborne iodine-131 samples are collected at the same ten locations and with the same samplers as the airborne particulate filters to sample for the presence of airborne radioiodine. These cartridges are collected weekly, sealed in separate collection bags and sent to the laboratory for gamma spectral analysis. In all of the samples collected in 1991, there was no detectable iodine-131 above the LLD of 0.07 pCi/m^3.

Table 2-4: Air Monitoring Locations

Sample Location Number	Type of Location	Location Description
T-1	I	Site boundary, 0.6 mile ENE of Station
T-2	I	Site boundary, 0.9 mile E of Station
T-3	I	Site boundary, 1.4 miles ESE of Station
T-4	I	Site boundary, 0.8 mile S of Station
T-7	I	Sand Beach, main entrance, 0.9 mile NW of Station
T-8	I	Earl Moore Farm, 2.7 miles WSW of Station
T-9	C	Oak Harbor Substation, 6.8 miles SW of Station
T-11	C	Port Clinton Water Treatment Plant, 9.5 miles SE of Station
T-12	C	Toledo Water Treatment Plant, 23.5 miles WNW of Station
T-27	C	Crane Creek State Park, 5.3 miles WNW of Station-

*I = Indicator C = Control

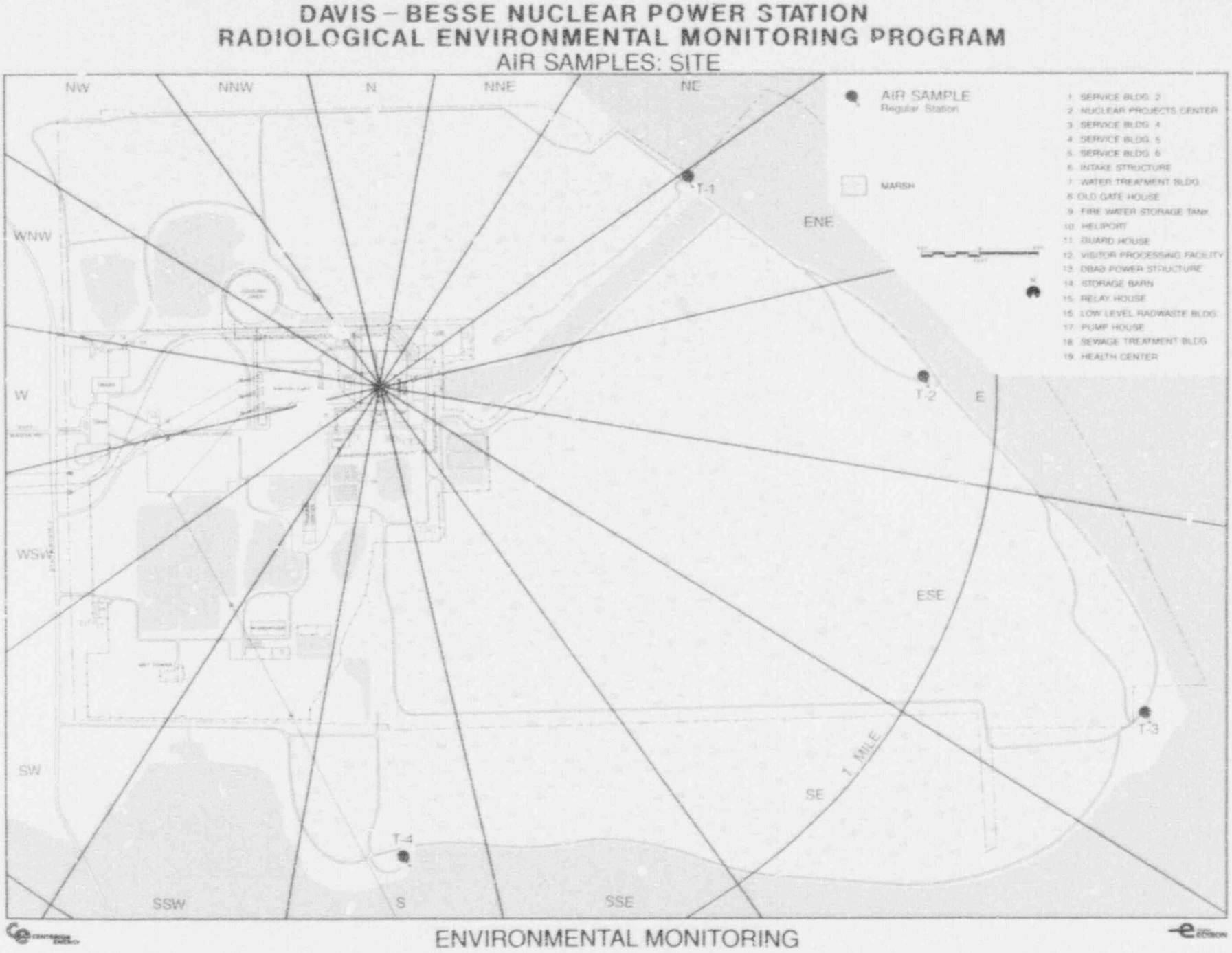
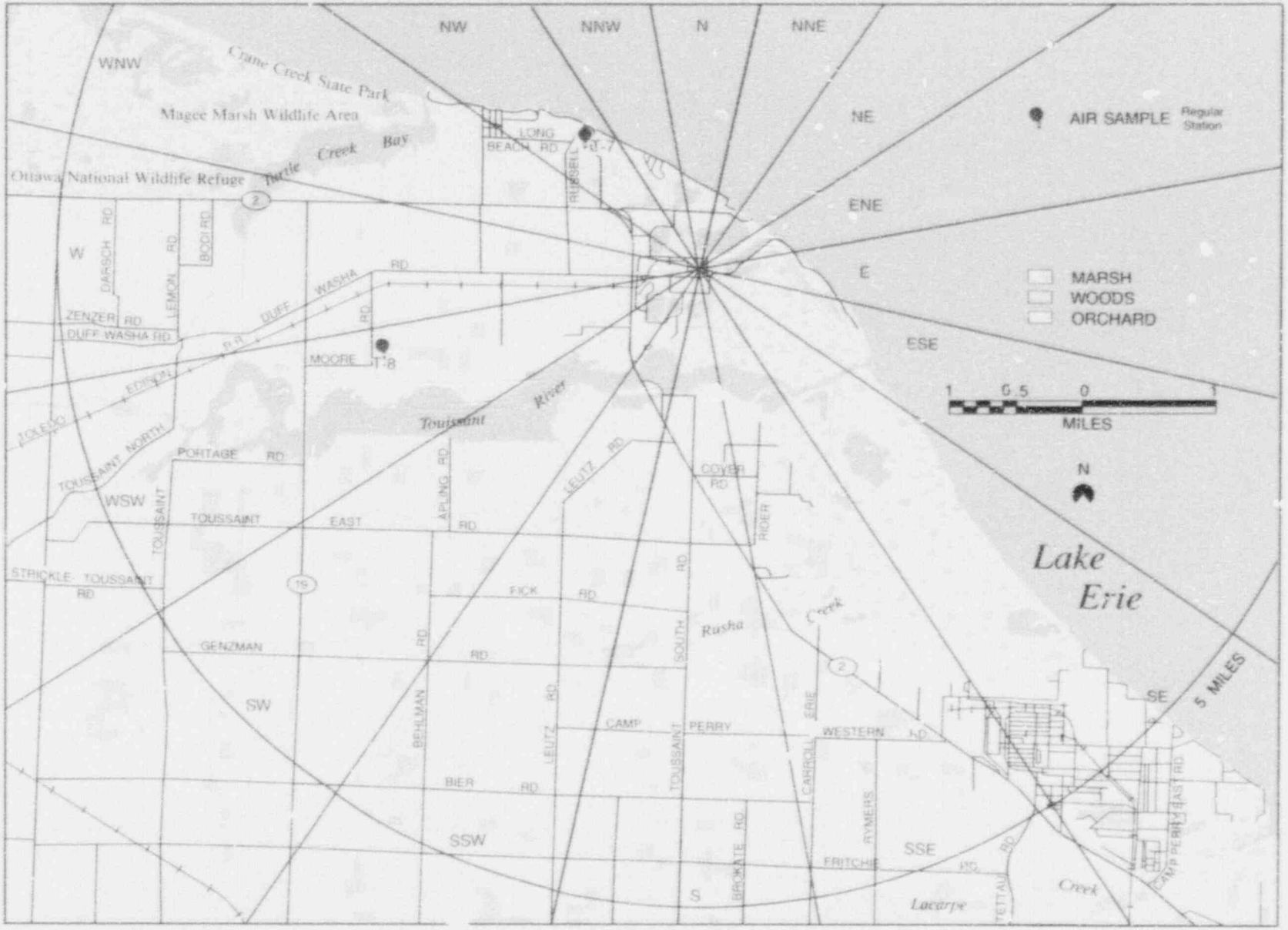

DAVIS – BESSE NUCLEAR POWER STATION
RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
AIR SAMPLES: SITE
NW
NNW
N
NNE
NE
WNW
W
WSW
SW
SSW
S
SSE
SE
ESE
E
ENE
AIR SAMPLE
Regular Station
MARSH
T-1
T-2
T-3
T-4
1 MILE
1. SERVICE BLDG. 2
2. NUCLEAR PROJECTS CENTER
3. SERVICE BLDG. 4
4. SERVICE BLDG. 5
5. SERVICE BLDG. 6
6. INTAKE STRUCTURE
7. WATER TREATMENT BLDG.
8. OLD GATE HOUSE
9. FIRE WATER STORAGE TANK
10. HELIPORT
11. GUARD HOUSE
12. VISITOR PROCESSING FACILITY
13. DRAB POWER STRUCTURE
14. STORAGE BARN
15. RELAY HOUSE
16. LOW LEVEL RADWASTE BLDG.
17. PUMP HOUSE
18. SEWAGE TREATMENT BLDG.
19. HEALTH CENTER
ENVIRONMENTAL MONITORING

Figure 2-2

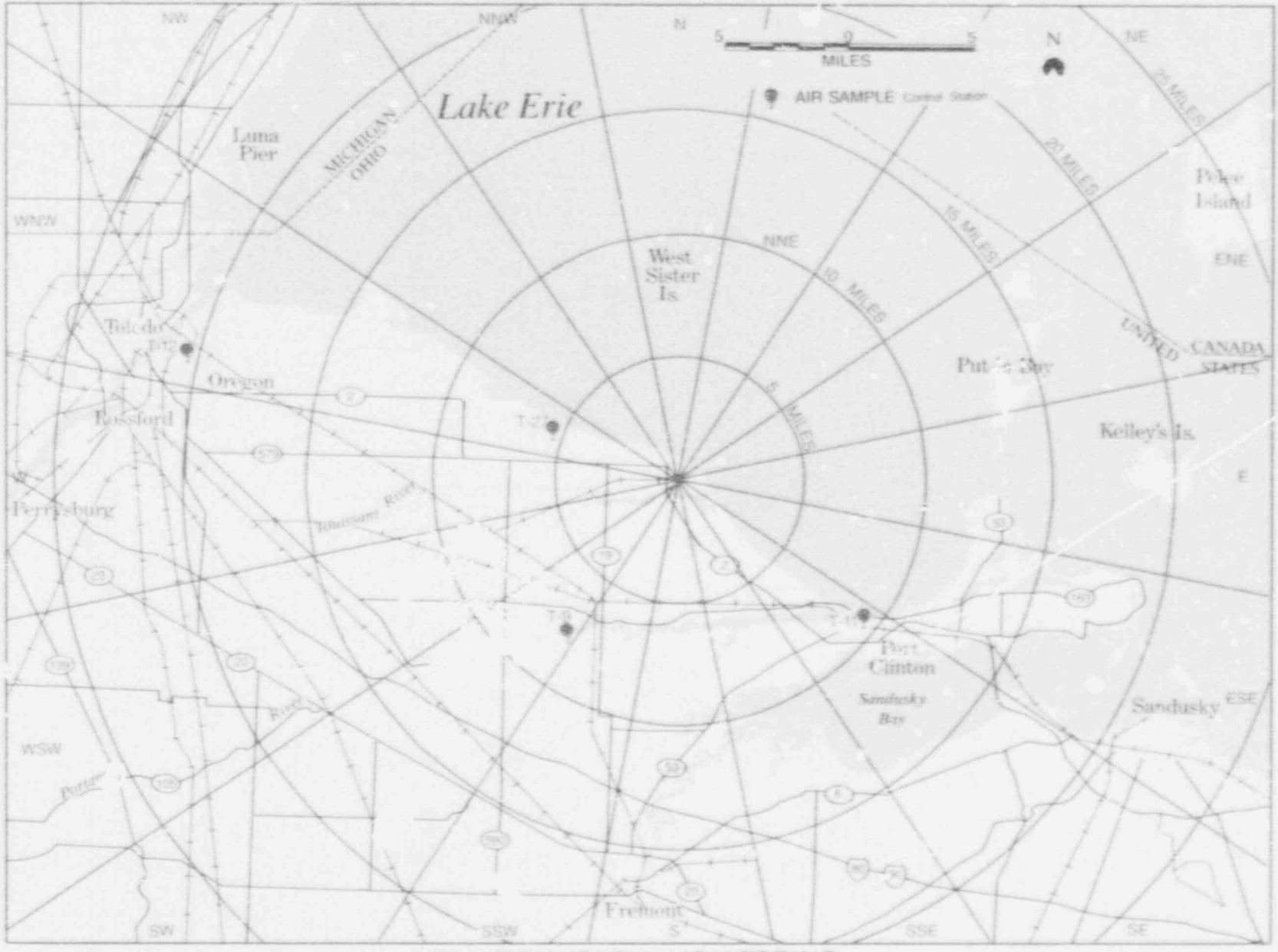
DAVIS-BESSE NUCLEAR POWER STATION
RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
AIR SAMPLES: 5 MILE RADIUS



ENVIRONMENTAL MONITORING

Figure 2-3

DAVIS-BESSE NUCLEAR POWER STATION
RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
AIR SAMPLES: 5–25 MILE RADIUS



ENVIRONMENTAL MONITORING

Figure 2-4

TERRESTRIAL MONITORING

The collection and analyses of groundwater, milk, meat, fruits and broad leaf vegetation provides data to assess the buildup of radionuclides that may be ingested by humans. Animal and wildlife feed samples provide additional information on radionuclides that may be present in the food chain. The data from soil sampling provides information on the deposition of radionuclides from the atmosphere.

Many radionuclides are present in the environment due to sources such as cosmic radiation and fallout from nuclear weapons testing. Some of the radionuclides present are:

- **tritium**, present as a result of the interaction of cosmic radiation with the upper atmosphere and as a result of routine releases from nuclear facilities.
- **beryllium-7**, present as a result of the interaction of cosmic radiation with the upper atmosphere.
- **cesium-137**, a man-made radionuclide which has been deposited in the environment, (for example, in surface soils), as a result of fallout from nuclear weapons testing and routine releases from nuclear facilities
- **potassium-40**, a naturally occurring radionuclide normally found in humans and throughout the environment..
- **fallout radionuclides** which come from nuclear weapons testing, including strontium-89, strontium-90, cesium-134, cerium-141, cerium-144, ruthenium-103. These radionuclides may also be released in minute amounts from nuclear facilities.

The radionuclides listed above are expected to be present in many of the environmental samples collected in the vicinity of Davis-Besse. The contribution of radionuclides from the plant operation is assessed by comparing sample results with preoperational data, operational data from previous years, control location data, and the types and amounts of radioactivity normally released from the Station in liquid and gaseous effluents.

Milk sampling is very important in environmental surveillance because it provides a direct basis for assessing the build up of radionuclides in the environment that may be ingested by human. Milk is particularly important because it is one of the few foods commonly consumed soon after production. The milk pathway involves the deposition of radionuclides from atmospheric releases onto forage consumed by cows. The radionuclides present in the forage eating cow become incorporated into the milk which is then consumed by humans.

Samples of milk are collected at three farms and a commercial dairy store once a month from November through April, and twice a month from May through October. Sampling is increased in the summer when the herds are usually outside on pasture and not on stored feed. The sample locations consist of one indicator and three control locations.

The milk samples are analyzed for strontium-89, strontium-90, iodine-131 and other gamma emitting radionuclides, stable calcium and potassium. A total of 55 milk samples were collected in 1991.

Strontium-89 was not detected above the LLD of 1.1 pCi/l in any of the samples. Strontium-90 activity was detected in 54 of the 55 samples collected and ranged from 0.5 to 2.1 pC/l. The annual average concentration of strontium-90 was 0.99 pCi/l at the indicator locations and 1.21 pCi/l at the control locations. For all sample sites, the annual average concentration were similar to those measured in the previous years (Fig 2-5).

A total of 55 analyses for iodine-131 in milk were performed during 1991. Iodine-131 was not detected in milk samples above the LLD of 0.4 pCi/l.

The concentrations of barium-140 and cesium-137 were below their respective LLDs in all samples collected. The results for potassium-40, a naturally occurring radionuclide, were similar at indicator and control locations, as is to be expected.

Since the chemistries of calcium and strontium, and potassium and cesiums are similar, organisms tend to deposit strontium radioisotopes in bones, and cesium radioisotopes in muscle tissue. In order to detect the potential environmental accumulation of these radionuclides, the ratios of the strontium radioisotopes radioactivity (pCi/l) to the concentration of calcium (g/l), and cesium radioisotopes radioactivity (pCi/l) to the concentration of potassium (g/l) were monitored in milk. These ratios are compared to standard values to determine if build up is occurring. No statistically significant variations in the ratios were observed. The results of the analyses performed on he milk samples collected in 1991 indicate no effect due to the operation of Davis-Besse.

ratios were observed. The results of the analyses performed on he milk samples collected in 1991 indicate no effect due to the operation of Davis-Besse.

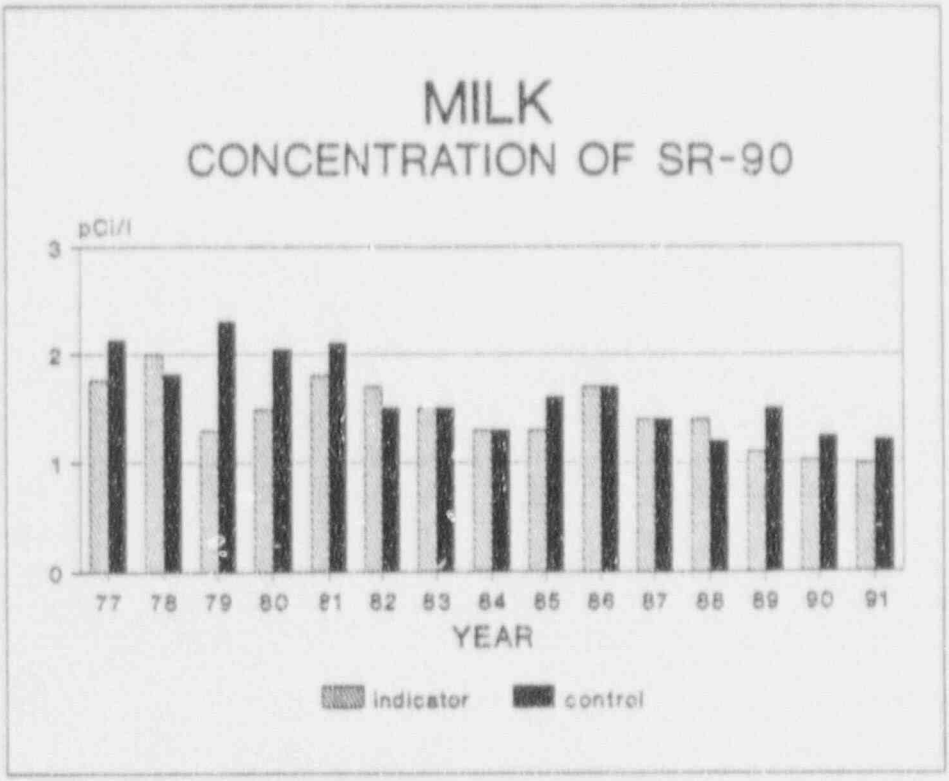


Figure 2-5: The 1991 average concentration of strontium-90 detected, in milk samples, were similar at indicator and control locations, a trend exhibited in previous years.

Table 2-5: Milk Monitoring Locations

Sample Location Number	Type of Location	Location Description
T-8	I	Moore Farm, 2.7 miles WSW of Station
T-24	C	Toft Dairy, Sandusky, 21.0 miles SE of Station
T-57	C	Meek Farm, 22.0 miles SSE of Station
T-199	C	Ewing Farm 6.5 miles SW of Station

* I = indicator C = control

Groundwater Samples

It is unlikely that groundwater will accumulate radioactivity from nuclear facilities, except for those facilities which discharge liquid effluents to the ground via cribs, pits, or trenches. This is because the soil acts as a filter and an ion exchange medium for most radionuclides. However, tritium and other radionuclides such as ruthenium-106 have a potential to seep through the soil into the groundwater. Although Davis-Besse does not discharge its liquid effluents directly to the ground, samples from local wells are collected on a quarterly basis to ensure the detection of any adverse impact on the local groundwater supplies due to Station operation. The four wells sampled include two indicator locations, and two control locations. In addition, a quality control sample is collected at one of the four wells each quarter.

The groundwater samples are analyzed for beta emitting radioactivity in dissolved and suspended solids, tritium, strontium-89, strontium-90 and gamma emitting radionuclides.

Beta emitting radionuclides concentration in suspended solids were not detected above LLD of 0.8 pCi/l. In dissolved solids, the concentration averaged 3.0 pCi/l at indicator locations and 2.0 pCi/l at control locations.

Tritium was not detected in any sample above the LLD of 330 pCi/l. Also, strontium-89 was not detected above the LLD of 1.5 pCi/l. Strontium-90 was detected in two indicator samples at an average of 0.8 pCi/l. There were no gamma emitting radionuclides detected in any of the samples collected. All sample analyses were within normal ranges and were similar to results of previous years.

Table 2-6: Groundwater Monitoring Locations

Sample Location Number	Type of Location	Location Description
T-7	I	Sand Beach, 0.9 mile NW of Station
T-23	C	Put-in-Bay Waterworks, 14.3 miles ENE of Station
T-27	C	Crane Creek State Park, 5.3 miles WNW of Station

Table 2-6: Groundwater Monitoring Locations con't

Sample Location Number	Type of Location	Location Description
T-54	I	Weis Farm, 4.8 miles SW of Station
T-141	QC	Roving Site

* I = indicator C = control QC = quality control

Broad Leaf Vegetation and Fruit Samples

Fruits and broad leaf vegetation also represent a direct pathway to humans from ingestion. Fruits and broad leaf vegetation may become contaminated from atmospheric deposition from airborne sources (nuclear weapons fallout or gaseous releases form nuclear facilities) or form irrigation water drawn from lake water receiving liquid effluents (from hospitals, nuclear facilities, etc.). Also, radionuclides from the soil may be absorbed by the roots of the plants and become incorporated into the edible portions. During the growing season (July through September) edible broad leaf vegetation and fruits are collected from farms in the vicinity of Davis-Besse.

In 1991, broad leaf vegetation samples were collected at two indicator locations and one control location. Fruit samples were collected at two indicator locations and three control locations. Broad leaf vegetation was collected once a month during the growing season and consisted of lettuce, cabbage, spinach, kale, parsley, pepper leafs, broccoli and horse radish leaves. The fruits collected were apples, and grapes. All samples were analyzed for gamma emitting radionuclides, strontium-89, strontium-90, and iodine-131.

Iodine-131 was not detected above the LLD of 0.047 pCi/g wet in any broad leaf vegetation samples. The LLD for iodine-131 could not be reached in two samples collected (T-25 and T-37) on 07-16-91 because of a delay in counting. Iodine-131 was not detected above the LLD of 0.041 pCi/g wet in fruit.

The only gamma emitting radionuclide detected in the fruit and broad leaf vegetation samples was potassium-40 which is naturally occurring. In both fruit and broad leaf vegetation, strontium-89 was not detected above LLD of 0.010 pCi/g wet. Strontium-90 was detected at a concentration of 0.005 pCi/g wet at control location T-173 for fruit samples. In broad leaf vegetation, strontium-90 averaged 0.004 pCi/g wet for indicator locations. All results of analyses were similar to results observed in previous years.

Table 2-7: Broad Leaf Vegetation and Fruit Locations

Sample Number Location	Type of Location	Location Description
T-8	I	Moore Farm, 2.7 miles WSW of Station
T-23	C	Heineman Winery, Put-IN-Bay, 14.3 miles ENE of Station.
T-25	I	Miller Farm, 3.7 miles S of Station
T-37	C	Bench Farm, 13.0 miles SW of Station
T-173	C	Firelands Winery, Sandusky, 20.0 miles SE of station.

* I = indicator C = control

Animal / Wildlife Feed Samples

As with broad leaf vegetation and fruit samples, samples of domestic animal feed, as well as vegetation consumed by wildlife, provide and indication of airborne radionuclides deposited in the vicinity of the Station. Analyses from animal/wildlife feed samples also provide data for determining radionuclide concentration in the food chain. Domestic animal feed samples are collected both at the milk and domestic meat sampling locations. Wildlife feed samples are collected from the Navarre Marsh onsite and from a local marsh within five miles of the Station. As in all terrestrial samples, naturally occurring potassium-40, cosmic ray produced radionuclides such as beryllium-7, and fallout radionuclides from nuclear weapons testing may be present in the feed samples.

- Domestic Animal Feed - Domestic animal feed was collected semi-annually at dairy farms and annually at chicken sampling locations. There are two indicator locations and two control locations. The feed collected consisted of hay, haylage, mixed feed, chicken feed and corn. All samples were analyzed for gamma emitting radionuclides.
- Wildlife Feed - Wildlife feed was collected annually at two indicator locations. The samples consisted of edible portions of cattails and smartweed. Samples were analyzed for gamma emitting radionuclides.

In both the animal and wildlife feed only naturally occurring Be-7 and K-40 were detected. All other radionuclides were below the respective LLDs.

Table 2-8: Animal / Wildlife Feed Locations

Sample Location Number	Type of Location	Location Description
T-8	I	Moore farm, 2.7 miles WSW of Station
T-31	I	Davis-Besse, onsite roving location
T-34	C	Bertsch farm, Sandusky, 20.0 miles SE of Station
T-57	C	Meek Farm, 22.0 miles SSE of Station
T-197	I	Peisman Farm 1.7 miles W of Station
T-198	I	Toussaint Creek Wildlife Area 4.0 miles WSW of Station

* I = indicator C = control

Wild and Domestic Meat Samples

Sampling of domestic and wild meat provides information on environmental radionuclide concentration that humans may be exposed to through an ingestion pathway. The principle pathways for radionuclide contamination of meat animals include atmospheric deposition from airborne releases on their food, contamination of their drinking water through atmospheric deposition or contamination of their drinking water from radionuclides released in liquid effluents.

The REMP generally collects wild meat, domestic meat, (chickens) and eggs on an annual basis. Wild animals commonly consumed by residents in the vicinity of Davis-Besse include water fowl, deer, and muskrats. Analyses from animals whose meat is eaten by humans provides general information on radionuclide concentration in the food chain. When evaluating the results from analyses performed on meat animals, it is important to consider the age, diet and mobility of the animal before drawing conclusions on radionuclide concentration in the local environment or in a species as a whole.

Both wild and domestic meat samples and eggs were sampled in 1991 as follows:

- Domestic Meat: Chickens were collected at one indicator location and one control location.
- Wild Meat: One Canada goose was collected from onsite. Four muskrats were collected from the marsh on site. All meat samples were analyzed for gamma emitting radionuclides.
- Eggs: Eggs were collected from one indicator location and one control location. The samples were analyzed for gamma emitting radionuclides.

The only radionuclide detected in both the meat and eggs samples was K-40 which is naturally occurring and not produced by nuclear power plants. Cs-137 was not detected above LLD of 0.029 pCi/g wet. These results are similar to previous years.

Table 2-9: Wild and Domestic Meat Locations

Sample Location Number	Type of Location	Location Description
T-31	I	Onsite roving location
T-34	C	Bertsch Egg Farm, Sandusky, 20.0 miles SE of Station
T-197	I	Priesman Farm, 1.7 miles W of Station.

* I = indicator C = control

Soil Samples

During June and October of 1991, soil samples were collected at all sites which are equipped with air samplers and Put-In-Bay, the top layer of soil is sampled in an effort to identify possible trends in the local environmental nuclide concentration caused by atmospheric deposition of fallout and station released radionuclides. Generally, the sites are relatively undisturbed, so that the sample will be representative of the actual deposition in the area. Ideally,

there should be little or no vegetation present, because the vegetation could affect the results of analyses. Approximately five pounds of soil are taken from the top two inches at each site. Many naturally occurring radionuclides (e.g. beryllium -7 and potassium-40) and fallout radionuclides from nuclear weapons testing are detected. Fallout radionuclides which are often detected include strontium-90, cesium-137, cerium-141 and ruthenium-106.

All soil samples were analyzed for gamma emitting radionuclides. The results show that the only gamma emitter detected in addition to naturally occurring Be-7 and K-40, was Cs-137. Cs-137 was found in both indicator and control location at a concentration of 0.21 and 0.40 pCi/g dry, respectively. The concentrations were similar to that observed in previous year (Figure 2-6).

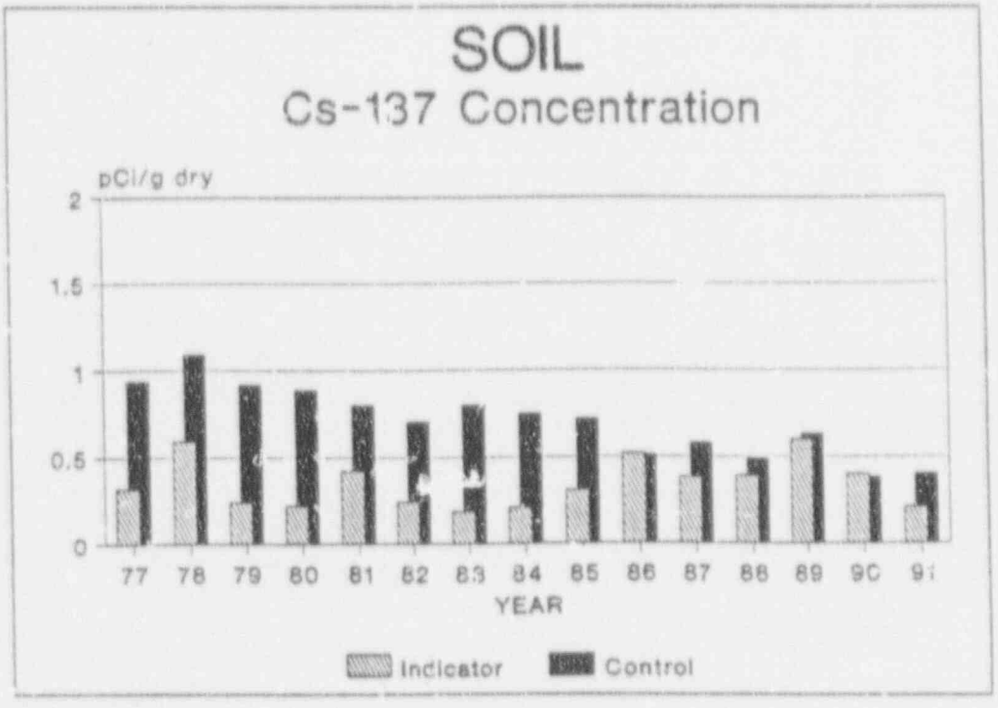


Figure 2-6: The concentration of cesium-137 in soil has remained fairly constant over the years the REMP has been conducted. The peak seen in 1978 was due to fallout form nuclear weapons testing.

Table 2-16: Soil Locations

Sample Location Number	Type of Location	Location Description
T-1	I	Site boundary, 0.6 miles ENE of Station
T-2	I	Site boundary, 0.9 miles E of Station
T-3	I	Site boundary 1.4 miles ESE of Station
T-4	I	Site boundary 0.8 miles S of Station
T-7	I	Sand Beach, main entrance, 0.9 miles NW of Station
T-8	I	Moore Farm, 2.7 miles WSW of Station
T-9	C	Oak Harbor substation, 6.8 miles SW of Station
T-11	C	Port Clinton Water Treatment Plant, 9.5 miles SE of Station
T-12	C	Toledo Water Treatment Plant, 23.5 miles WNW of Station
T-23	C	South Bass Island, 14.3 miles ENE of Station
T-27	C	Crane Creek State Park, 5.3 miles WNW of Station

* I = indicator C = control

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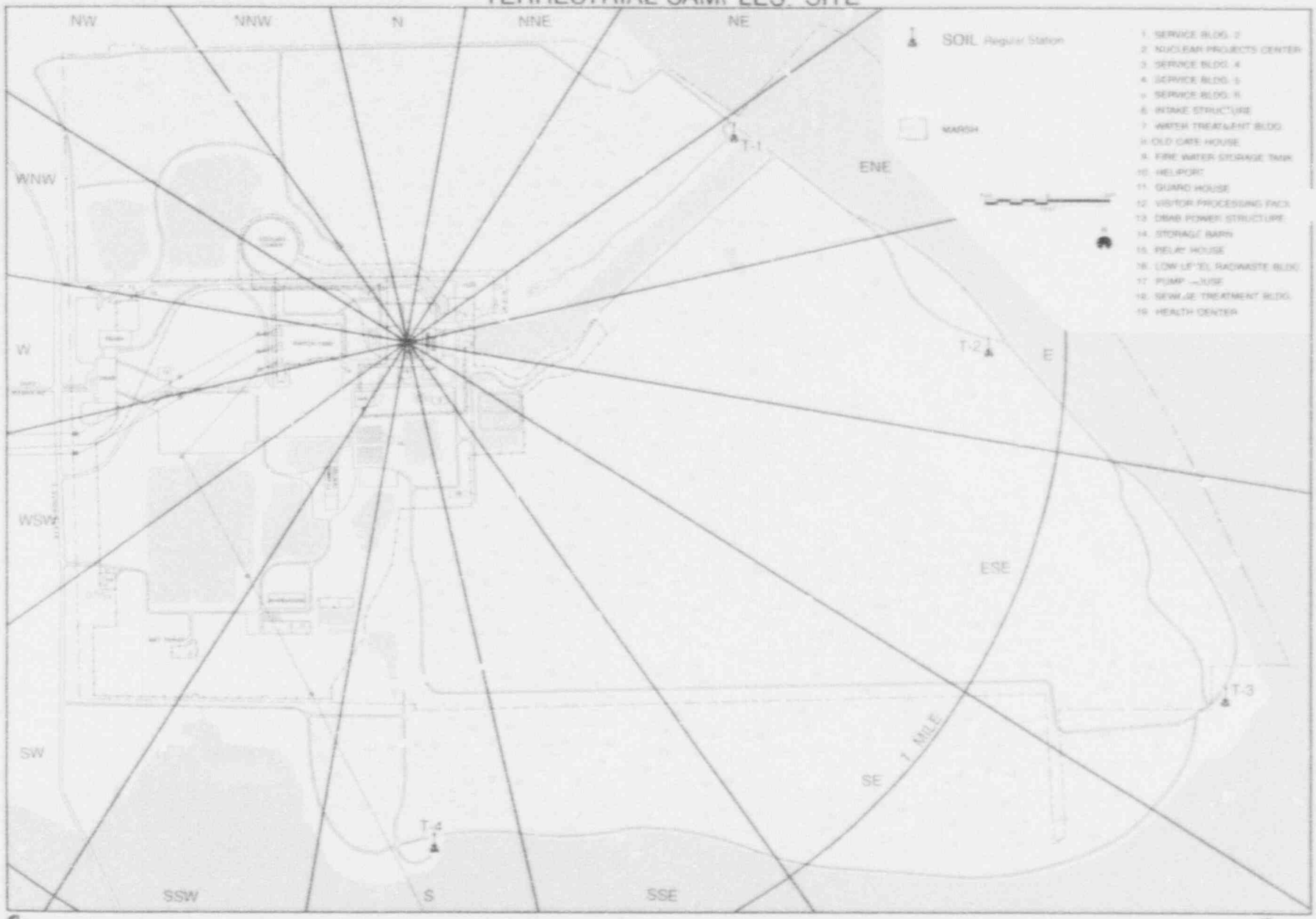
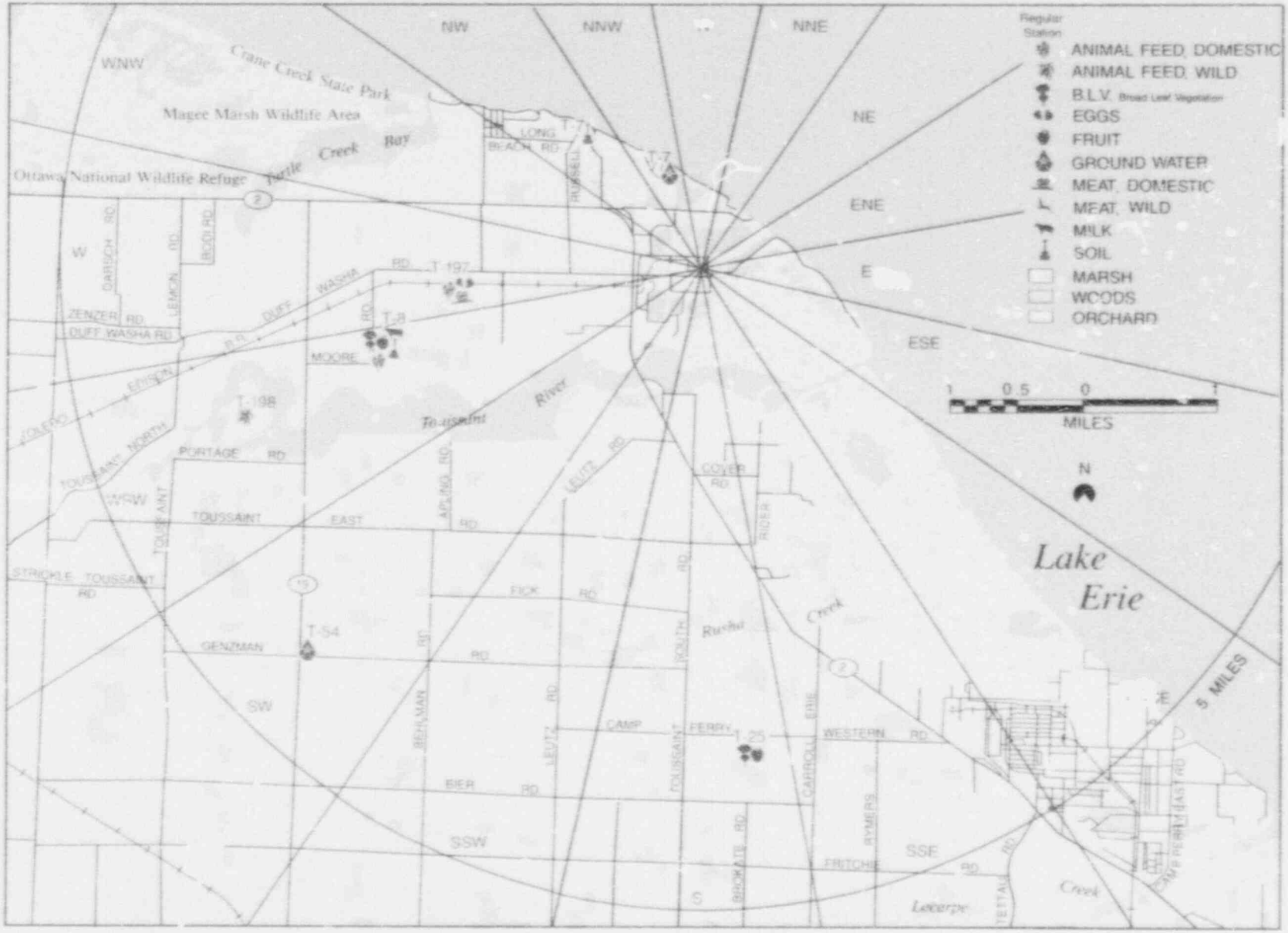
RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
TERRESTRIAL SAMPLES: SITE



ENVIRONMENTAL MONITORING

Figure 2-7

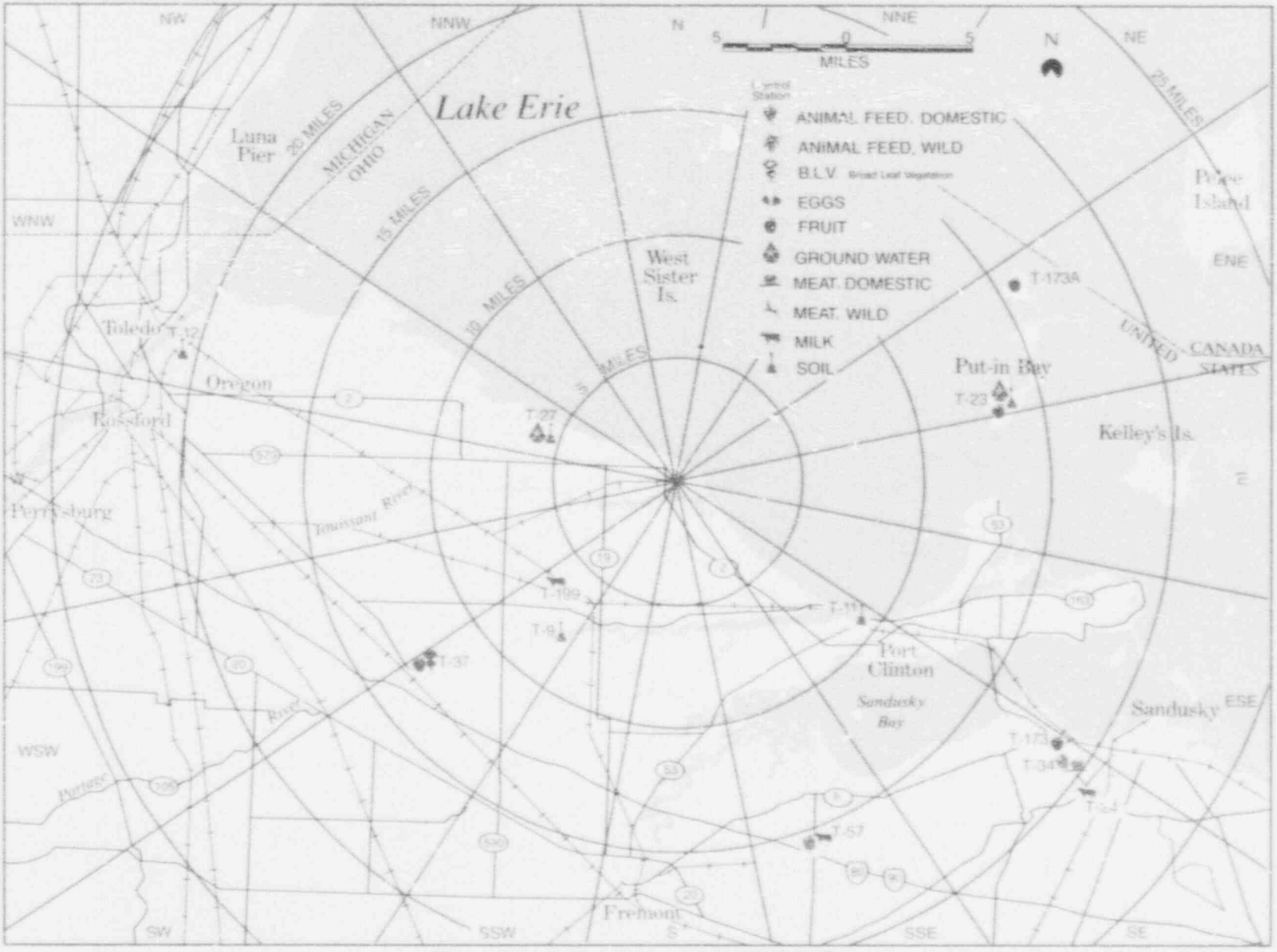
DAVIS-BESSE NUCLEAR POWER STATION
RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
TERRESTRIAL SAMPLES: 5 MILE RADIUS



ENVIRONMENTAL MONITORING

Figure 2-8

DAVIS-BESSE NUCLEAR POWER STATION
RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
TERRESTRIAL SAMPLES: 5–25 MILE RADIUS



ENVIRONMENTAL MONITORING

Figure 2-9

AQUATIC MONITORING

Radionuclides may be present in Lake Erie from many sources including atmospheric deposition, run-off/soil erosion, and releases of radioactivity in liquid effluents from hospitals or nuclear facilities. These sources provide two forms of potential radiation exposure, external and internal. External exposure can occur from the surface of the water, shoreline sediments, and the immersion (swimming) in the water. Internal exposure can occur from ingestion of radionuclides, either directly from drinking water, or as a result of the transfer of radionuclides through the aquatic food chain with eventual consumption of an aquatic organism, such as fish. To monitor these pathways, treated surface water (drinking water), untreated surface water (lake or river water), fish, and shoreline sediments are sampled and analyzed.

Treated Surface Water

Treated surface water is water from Lake Erie which has been processed for human consumption. Radiochemical analysis of this processed water provides a direct basis for assessing the dose to humans from ingestion of drinking water.

Samples of treated surface water were collected form three indicator and three control locations. These locations include the water treatment facilities for Davis-Besse, Erie Industrial Park, Port Clinton, Toledo and Put-In-Bay. Samples were collected weekly and composited monthly. The monthly composites were analyzed for beta emitting radioactivity. The samples were also composited in a quarterly sample and analyzed for strontium-89, strontium-90, gamma emitting radionuclides and tritium. One Quality Control (QC) sample was collected from a routine location which was changed each month.

In treated water samples, beta emitting radionuclides were not detected above the LLD of 0.9 pCi/l for suspended solids. The average concentration was similar in dissolved solids for indicator and control locations (2.3 and 2.2 pCi/l, respectively). The annual average for beta emitting radionuclides for all locations was similar to previous years as shown on the following page:

1972 3.4 pCi/l	1982 2.5 pCi/l
1973 2.9 pCi/l	1983 3.1 pCi/l
1974 2.3 pCi/l	1984 2.4 pCi/l
1975 2.3 pCi/l	1985 2.2 pCi/l
1976 2.3 pCi/l	1986 2.2 pCi/l
1977 2.8 pCi/l	1987 1.9 pCi/l
1978 3.1 pCi/l	1988 2.7 pCi/l
1979 2.6 pCi/l	1989 2.5 pCi/l
1980 2.5 pCi/l	1990 2.2 pCi/l
1981 2.9 pCi/l	1991 2.2 pCi/l

All quarterly tritium analyses results were less than the LLD of 330 pCi/l for all routine sites. One monthly tritium analysis on a QC sample showed some detectable concentration of tritium (393±108 pCi/l). The QC sample was collected from T-11 Port Clinton water treatment plant (a control location) and is attributed to a natural source because tritium concentrations of this level were detected during the preoperational monitoring period.

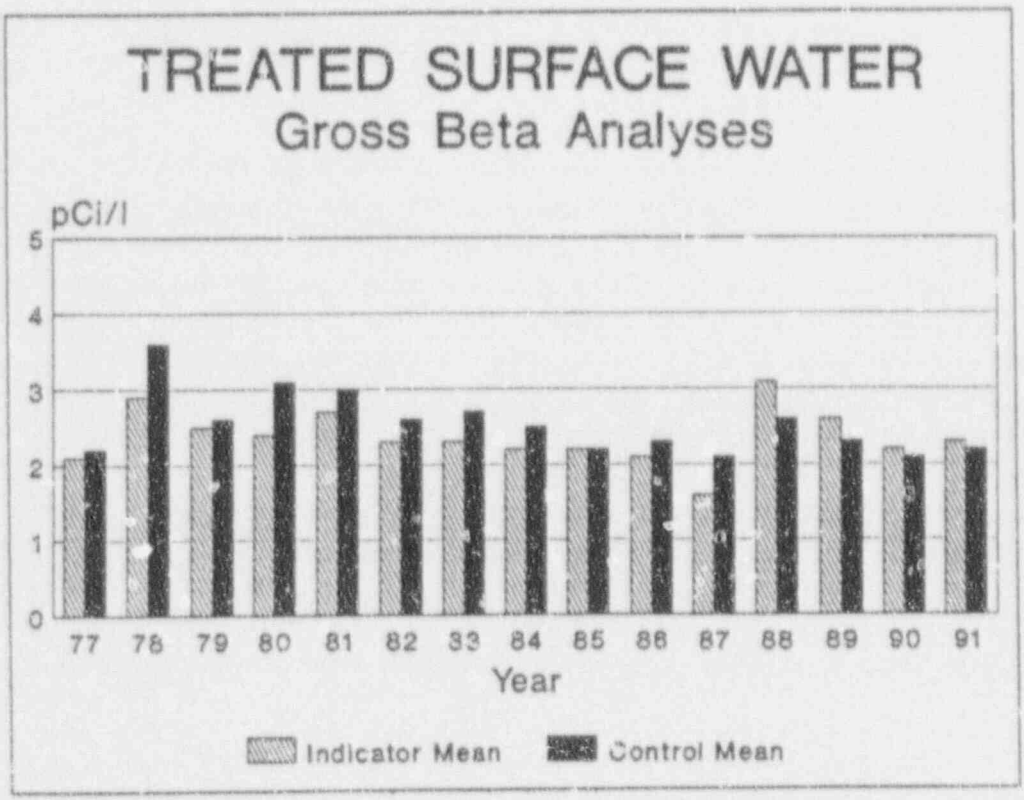


Figure 2-10: Over the past 15 years, the annual concentrations of beta emitting radionuclides in treated surface water samples collected from indicator locations have been consistant with those from control locations. This shows that Davis-Besse has had no measurable radiological impact on surface water used to make drinking water.

All cesium-137 results were less than the LLD of 10.0 pCi/l. Strontium-89 was not detected above 1.6 pCi/l in any samples. Strontium-90 was detected at an average concentration of 0.6 at both indicator and control location. These results are similar to those of previous years and indicate no significant impact on the environment resulting from the operation of Davis-Besse.

Table 2-11 Treated Surface Water Locations

Sample Location Number	Type of Location	Location Description
T-11	C	Port Clinton Water Treatment Plant 9.5 miles SE of Station
T-12	C	Toledo Water Treatment Plant 23.5 miles WNW of Station
T-23	C	Put-In-Bay water Treatment Plant 14.3 miles ENE of Station.
T-28	I	Treated water supply from Davis-Besse site
T-50	I	Erie Industrial Park, Port Clinton, 4.5 miles SE of Station
T-143	QC	Quality Control Site
T-144	I	Green Cove Condominiums, 0.9 miles NNW of Station

* I - indicator C= control QC = quality control

Untreated Surface Water

Sampling and analysis of untreated surface water provides a method of assessing the dose to humans from external exposure from the lake surface as well as immersion in the water. It also provides information on the radionuclides present which may affect drinking water, fish, and irrigated crops.

Routine Program:

The routine program is the basic sampling program which is performed year round. Untreated water samples are collected in the areas of the station intake and discharge and at the water intakes used by nearby water treatment plants. Routine samples are collected at Port Clinton, Toledo, Davis-Besse, Erie Industrial Park, and Put-In Bay Water Treatment Plants. A sample is also collected from Lake Erie at the mouth of the Toussaint River. These samples are collected weekly and composited monthly. The monthly composite is analyzed for beta emitting radionuclides, tritium, and gamma emitting radionuclides. The samples are further composited quarterly and analyzed for strontium-89 and strontium-90. A QC sample was collected weekly at a different location each month.

Summer Program:

The summer program is designed to supplement the routine untreated water sampling program in order to provide a more comprehensive study during the months of high lake recreational activity, such as boating, fishing, and swimming. These samples are obtained in areas along the shoreline of Lake Erie and around the islands.

The samples are collected weekly and composited monthly. The monthly composites are analyzed for beta emitting radioactivity, tritium, strontium-89, strontium-90 and gamma emitting radionuclides.

In untreated water samples, beta emitting radionuclides in suspended solids ranged from 0.3 to 6.8 pCi/l, with and average concentration of 0.5 and 2.8 pCi/l at indicator and control locations, respectively. In dissolved solids, the average concentration was 2.5 pCi/l at indicator and 2.4 pCi/l at control locations.

Of the 182 tritium analyses performed on the untreated water, 176 were less than the LLD of 330 pCi/l. The concentration of tritium detected in samples ranged form 333 to 884 pCi/l with an average concentration 531 and 333 pCi/l at indicator and control locations, respectively.

Only the August composite for tritium at T-130 (mouth Toussaint River) could be attributed to the routine operation of the station. The tritium concentration for that composite was 884 pCi/l. This is only .03% of the maximum permissible concentration of 3,000,000 pCi/l for tritium in an unrestricted area, as stated in 10 CFR 20, Appendix B, Part 20, Table 2. Subsequent samples

Subsequent samples collected during September and October showed that the tritium concentration has returned to below LLD of 330 pCi/l.

Cesium-137 and strontium-89 were not detectable in samples of untreated water above their LLDs of 10 pCi/l and 1.9 pCi/l, respectively. Strontium-90 was detected at both indicator and control locations and had an average concentration of 0.7 pCi/l and 0.9 pCi/l, respectively. The analysis results from untreated water samples show that the operation of Davis-Besse has not had significant impact on nearby residents or on the environment.

Each month, weekly quality control samples were collected at different location. The results of the analyses from the quality control samples were consistent with those from the routine samples. Some of the samples collected during the summer months in Lake Erie were close to the collection points of some of the routine untreated surface water samples. Thus, they served as quality control samples and helped to verify the accuracy of the measurements performed. A comparison of their results from the routine sites and nearby summer collection sites illustrates the value of using quality control samples to check the accuracy of analyses performed by the laboratory. The average concentrations of beta emitting radionuclides for these samples were 2.6 pCi/l for routine sites and 2.2 pCi/l for Lake Erie sample.

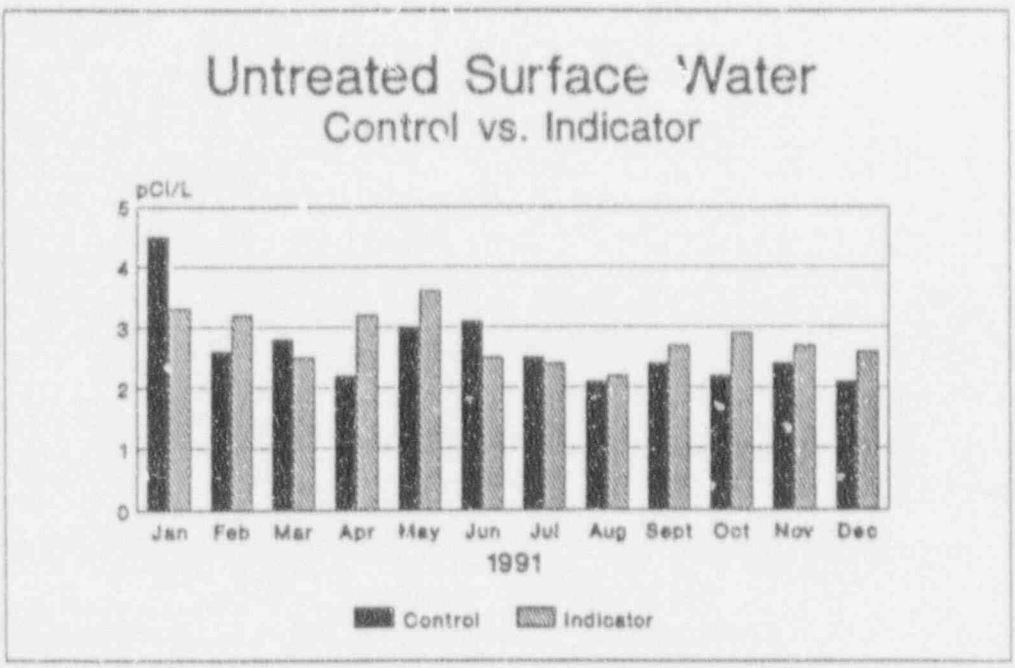


Figure 2-11: The average concentration of beta emitting radionuclides in untreated water was similiar between control and indicator locations. This demonstrates that Davis-Besse had no impact on the surrounding environment.

Table 2-12: Untreated Surface Water Locations

Sample Location Number	Type of Location	Location Description
T-3	I	Site boundary, 1.4 miles ESE of Station
T-11	C	Port Clinton Water Treatment Plant 9.5 miles SE of Station
T-12	C	Toledo Water Treatment Plant, sample taken form in take crib 11.25 miles NW of Station
T-23	C	Put-In-Bay Treatment Plant, 14.3 miles ENE of Station
T-28	I	Davis-Besse Water Treatment Plant
T-50	I	Erie Industrial Park, Port Clinton, 4.5 miles SE of Station
T-130	I	Lake Erie, 1.7 miles ESE of Station
T-131	I	Lake Erie, 0.8 mile NE of Station
T-132	I	Lake Erie, 1.0 mile E of Station
T-133	I	Lake Erie, 0.8 mile N of Station
T-134	I	Lake Erie, 1.4 miles NW of Station
T-135	I	Lake Erie, 2.5 miles WNW of Station
T-137	C	Lake Erie, 5.8 miles WNW of Station
T-138	C	Lake Erie, 11.0 miles NW of Station
T-145	QC	Roving Quality Control Site
T-152	C	Lake Erie, 15.6 miles WNW of Station
T-158	C	Lake Erie, 10.0 miles WNW of Station

Table 2-12: Untreated Surface Water Location continued

Sample Location Number	Type of Location	Location Description
T-162	C	Lake Erie, 5.4 miles SE of Station
T-164	C	Lake Erie, 9.5 miles ESE of Station
T-167	C	Lake Erie, 11.5 miles E of Station
T-168	C	Lake Erie, 15.5 miles ENE of Station

* I = indicator C = control

Shoreline Sediment

The sampling of shoreline sediments can provide an indication of the accumulation of undissolved radionuclides which may lead to internal dose to humans through the ingestion of fish, through resuspension into drinking water supplies, or as an external radiation source from shoreline dose to fishermen and swimmers.

Samples of deposited sediments in water were collected in May and October from four indicator locations and four control locations. All samples were analyzed for gamma emitting radionuclides.

Naturally occurring potassium-40 was detected at both controls and indicator locations. Cesium-137 was detected at a concentration of 0.12 pCi/g at indicator locations and 0.41 pCi/g at control locations.

Atmospheric testing of nuclear weapons has been the principal source of cesium-137 in the environment to date. Although no atmospheric nuclear weapons tests have been reported since 1980, cesium-137 is still present in shoreline sediment samples because of its long half-life (approximately 30 years). No other gamma emitting radionuclides were detected in any of the samples, and the concentrations of those detected were consistent with normal concentrations for this area.

Table 2-13: Shoreline Sediment Location

Sample Location Number	Type of Location	Location Description
T-3	I	Site boundary, 1.4 miles ESE of Station
T-4	I	Site boundary, 0.8 mile S of Station
T-23	C	South Bass Island, 14.3 miles ENE of Station
T-27	C	Crane Creek State Park, 5.3 miles WNW of Station
T-130	I	Lake Erie, 1.7 miles ESE of Station
T-132	I	Lake Erie, 1.0 mile E of Station
T-138	C	Lake Erie, 11.0 miles NW of Station
T-164	C	Lake Erie, 9.5 miles ESE of Station

* I = indicator C = control

Fish Samples

Fish are analyzed primarily to quantify the dietary radionuclide intake by humans, and secondary to serve as indicators of radioactivity in the aquatic ecosystem. The principle nuclides which may be detected in fish include naturally occurring potassium-40, as well as cesium-137, and strontium-90. Depending upon the feeding habit of the species (e.g., bottom-feeder versus predator), results from sample analyses may vary.

With the aid of local commercial fishermen, Davis-Besse routinely collects three species of fish (walleye, white bass and carp) twice a year from sampling locations near the Station's liquid discharge point and more than ten miles away from the Station where fish populations would not be expected to be impacted by the Station operation. Walleye are collected because they are a popular sport fish, white bass because they are an important commercial fish. Carp are collected because they are bottom feeders and thus would be more likely to be affected by radionuclides deposited in lake sediments. Due to seasonal unavailability no fish samples were obtained for the second half of 1991.The edible portion of fish were analyzed for beta and gamma emitting radionuclides.

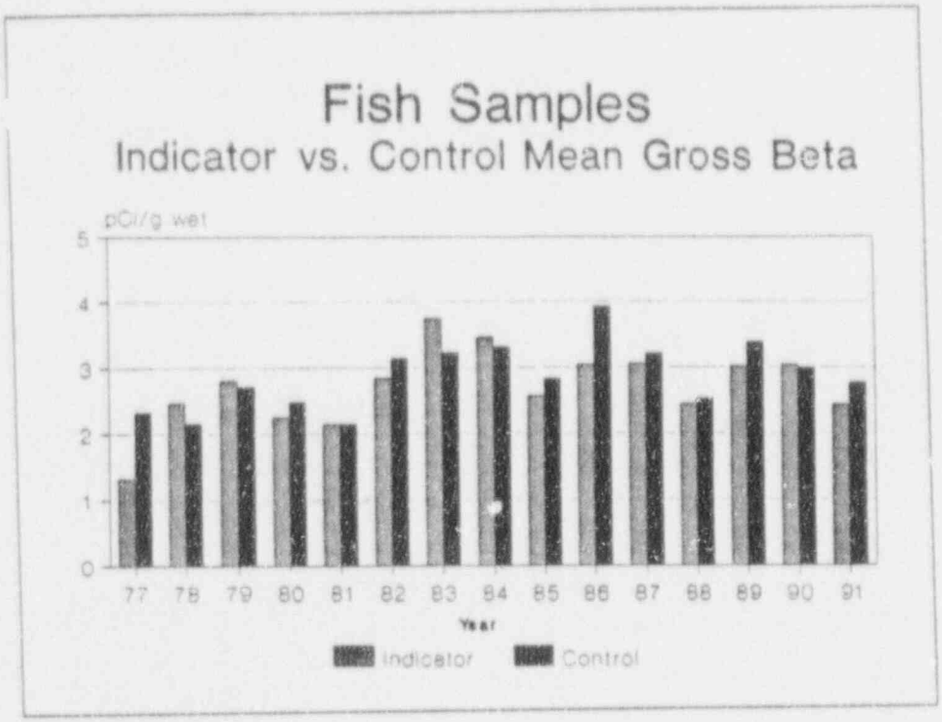


Figure 2-12: Average concentrations of beta emitting radionuclides in fish samples were similar at indicator and control locations and were within the range of results of previous years.

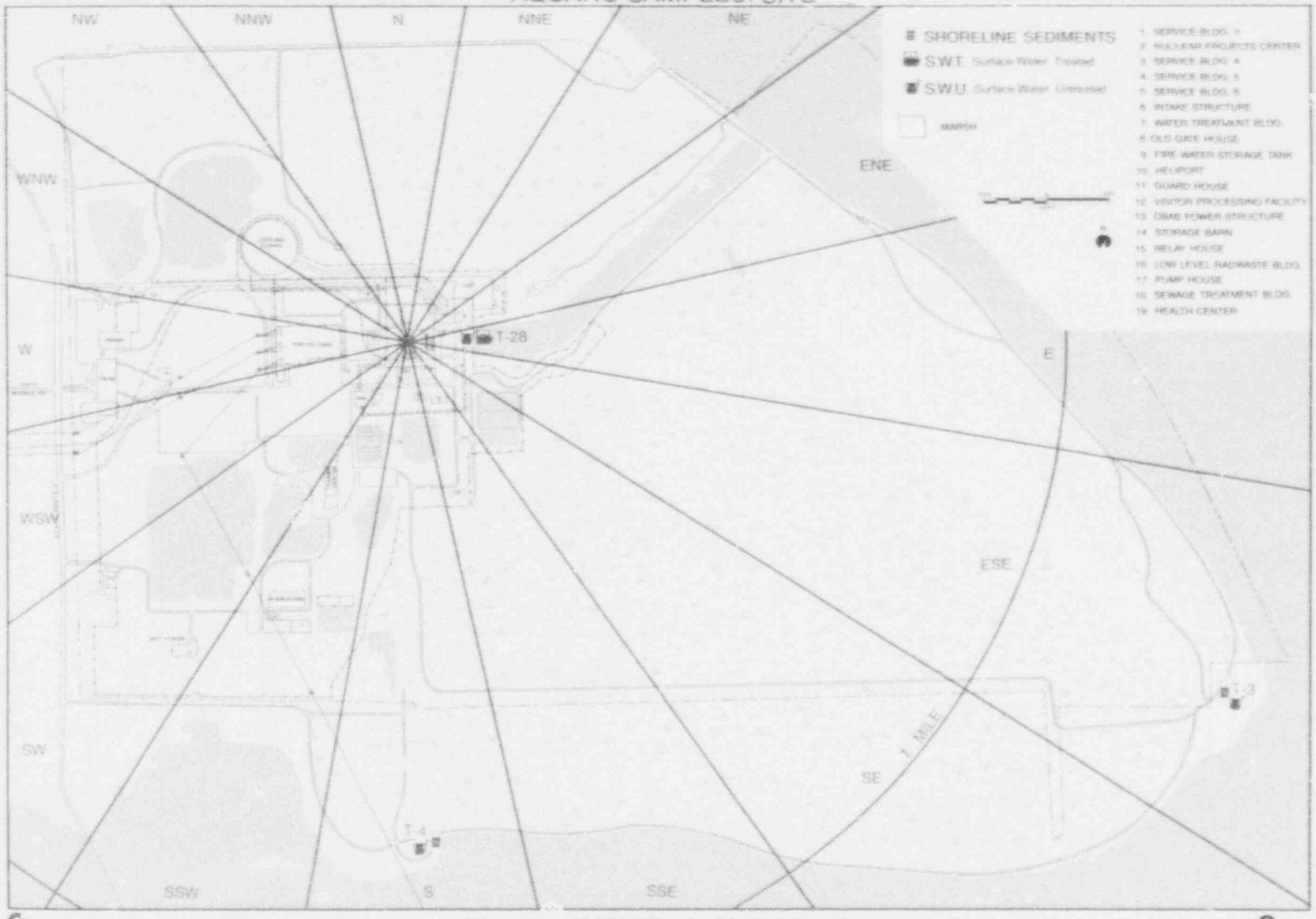
The average concentration of beta emitting radionuclides in fish muscle was similar for indicator and control location (2.46 and 2.76 pCi/g wet weight, respectively). Cesium-137 was detected in one indicator location (T-33, white bass sample) at a concentration of 0.026 pCi/g wet weight. All sample analysis results were within normal ranges compared to previous years.

Table 2- 14. Fish Locations

Sample Location Number	Type of Location	Location Description
T-33	I	Lake Erie, within 5 miles radius of Station
T-35	C	Lake Erie, greater than 10 mile radius of Station

* I = indicator C= control

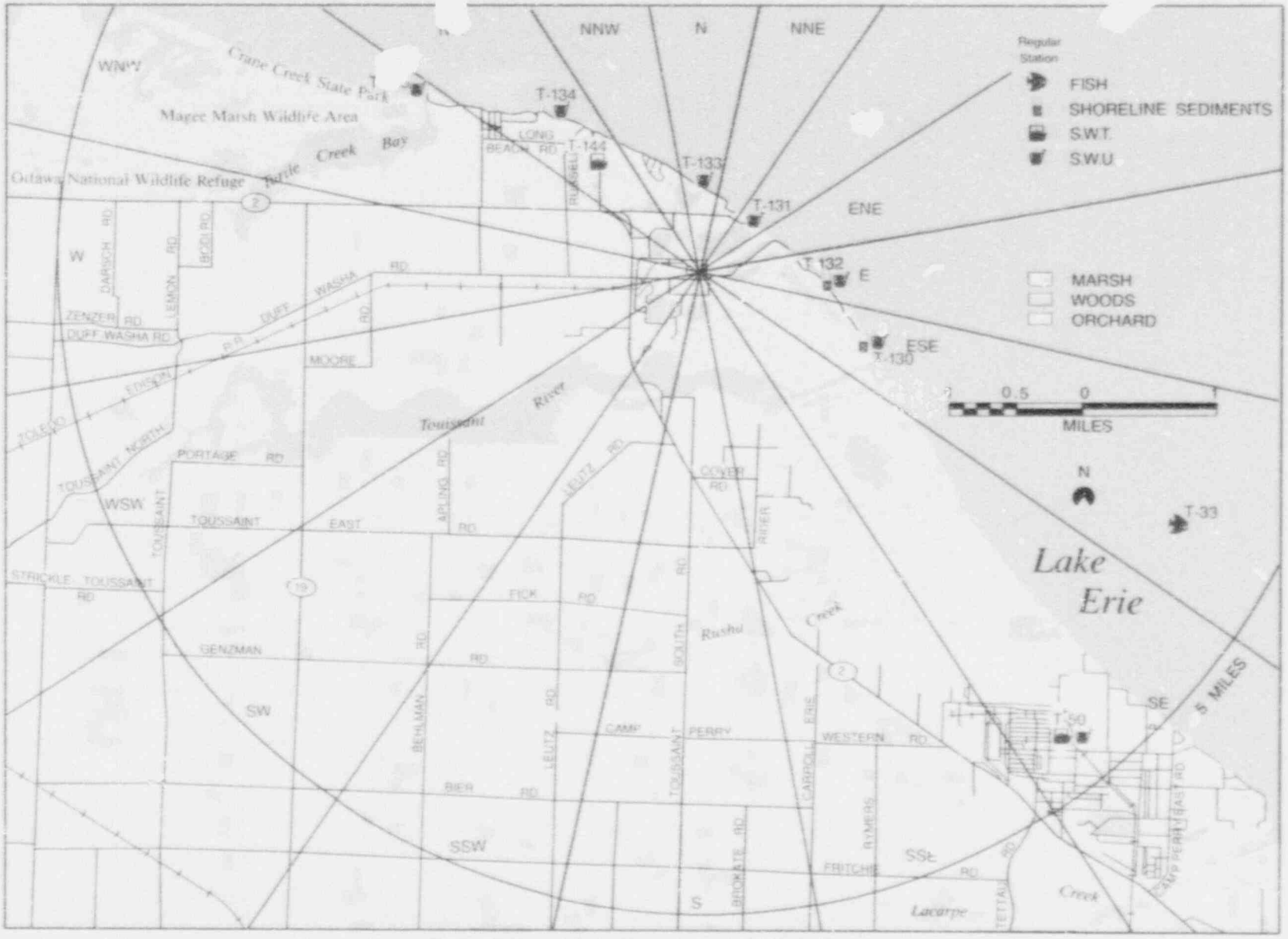
DAVIS – BESSE NUCLEAR POWER STATION
RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
AQUATIC SAMPLES: SITE



ENVIRONMENTAL MONITORING

Figure 2-13

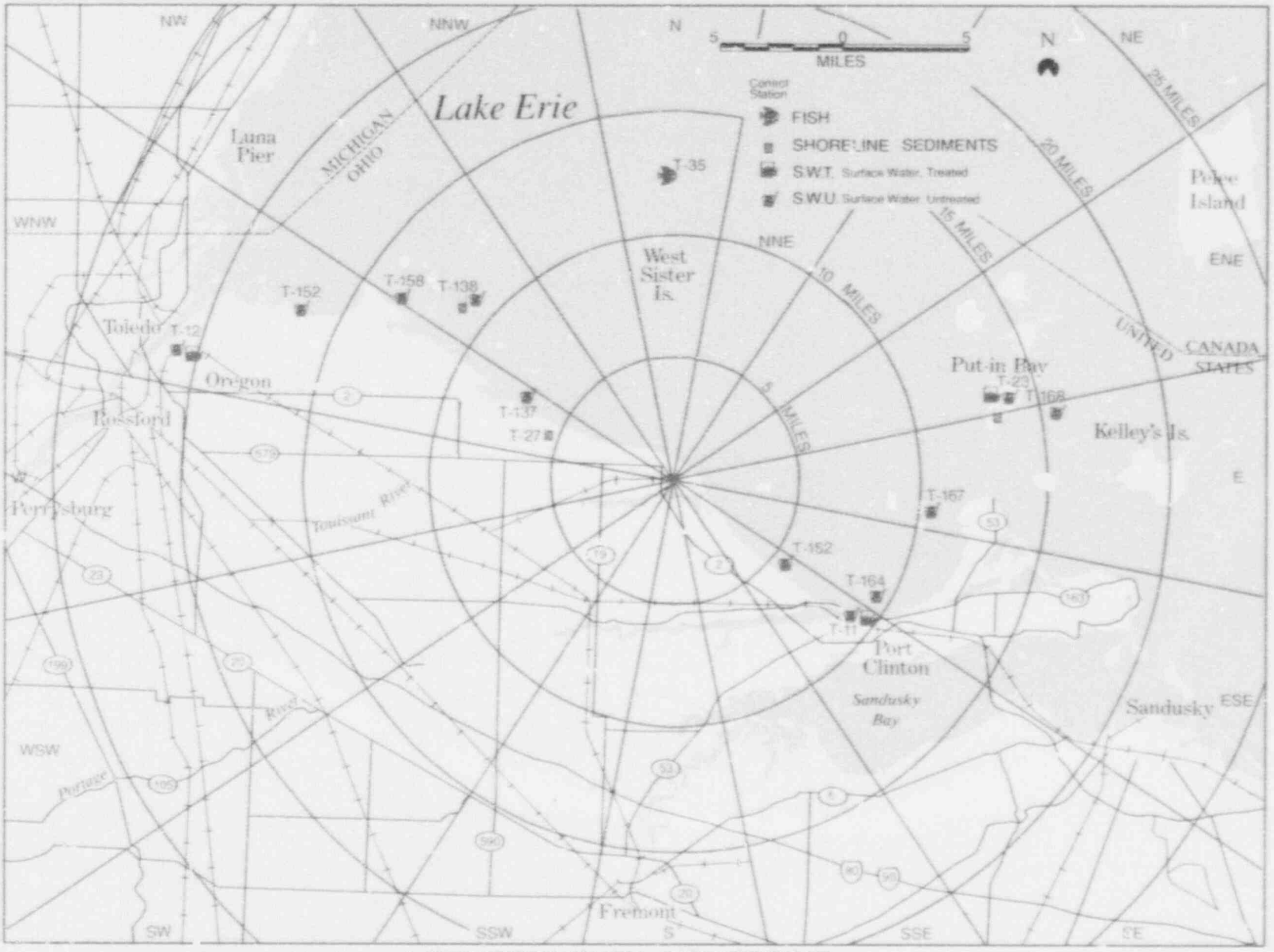
DAVIS-BESSE NUCLEAR POWER STATION
RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
AQUATIC SAMPLES: 5 MILE RADIUS



ENVIRONMENTAL MONITORING

Figure 2-14

DAVIS-BESSE NUCLEAR POWER STATION
RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
AQUATIC SAMPLES: 5–25 MILE RADIUS



ENVIRONMENTAL MONITORING

Figure 2-15

DIRECT RADIATION MONITORING

Populations may be exposed to extremely small amounts of external radiation from nuclear facilities by several pathways, including airborne radioactivity or radionuclide deposition in soil, vegetation, or lake bottom sediments. Some radiation will always be present from background sources, both man-made and natural. The amount of normal background radiation can be determined by examining preoperational measurements or data collected at control locations.

Thermoluminescent Dosimeters

Radiation at and around Davis-Besse is constantly monitored by a network of thermoluminescent dosimeters (TLDs). TLDs are small devices which store radiation dose information. The TLDs used at Davis-Besse contain a calcium sulfate: dysprosium ($CaSO_4$: Dy) card with four main readout areas. Multiple readout areas are used to ensure the precision of the measurements.

Thermoluminescence is a process by which ionizing radiation interacts with the sensitive material in the TLD, the phosphor. Energy is trapped in the TLD material and can be stored for several months or years. This provides an excellent method to measure the dose received over long periods of time. The amount of energy that was stored in the TLD as a result of interaction with radiation is removed and measured by a controlled heating process in a calibrated reading system. As the TLD is heated, the phosphor releases the stored energy as light. The amount of light detected is directly proportional to the amount of radiation to which the TLD was exposed. The heating process rezeros the TLD and prepares it for reuse.

TLD Collection

Davis-Besse has 94 TLD locations (71 indicator and 23 control) which are collected and replaced on a quarterly and annual basis. An additional seventeen QC TLDs are also collected on a quarterly and annual basis or at any given time. There are a total of 222 TLDs in the environment surrounding Davis-Besse. By collecting TLDs on a quarterly and annual basis from a single site, the two measurements serve as a quality control check on each other.

In 1991, the annual average dose for all indicator locations was 15.0 mR/91 days, and for all control locations was 16.2 mR/91 days. The annual average dose equivalent for all TLDs in 1991 was 15.3 mrem days. These averages are similar to those observed in previous years as shown on the next page:

1972 - 22.4 mrem/91 days
1973 - 14.3 mrem/91 days
1974 - 11.7 mrem/91 days
1975 - 12.8 mrem/91 days
1976 - 15.6 mrem/91 days
1977 - 16.5 mrem/91 days
1978 - 16.7 mrem/91 days
1979 - 13.4 mrem/91 days
1980 - 14.5 mrem/91 days
1981 - 14.8 mrem/91 days
1982 - 14.5 mrem/91 days
1983 - 13.2 mrem/91 days
1984 - 13.2 mrem/91 days
1985 - 14.4 mrem/91 days
1986 - 14.8 mrem/91 days
1987 - 14.5 mrem/91 days
1988 - 14.5 mrem/91 days
1989 - 15.9 mrem/91 days
1990 - 15.4 mrem/91 days
1991 - 15.3 mrem/91 days

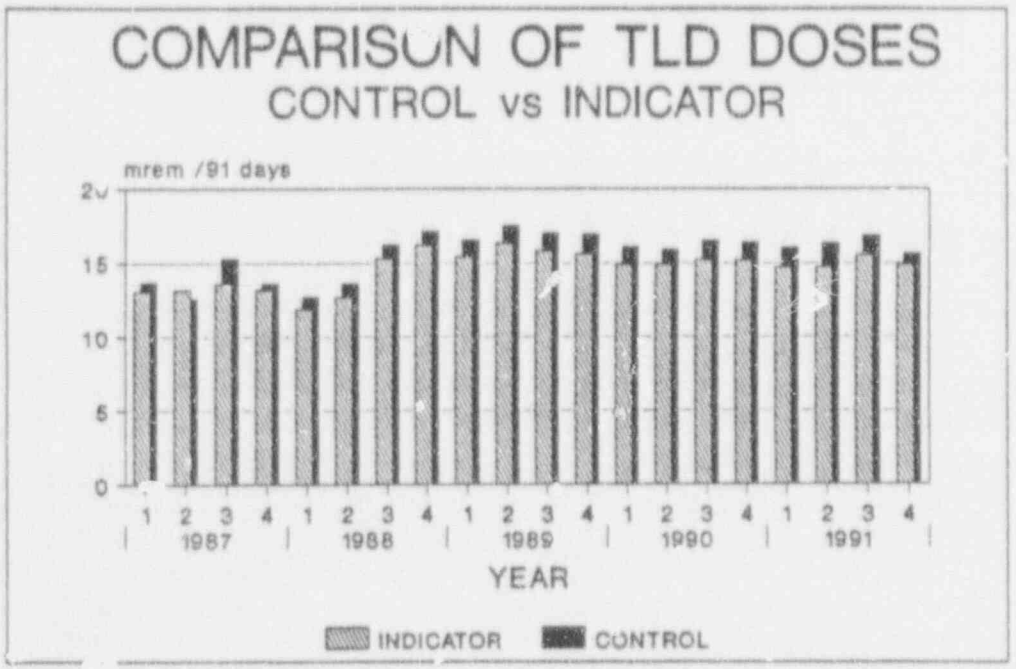


Figure 2-16: similarity between indicator and control results from the last five years demonstrated that the operation of Davis-Besse has not caused any abnormal gamma dose.

Quality Control TLDs

Duplicate TLDs have been established at 17 sites. These TLDs were placed in the field at the same time and at the same location as some of the routine TLDs, but were assigned quality control site numbers. This allows us to take several measurements at the location without the laboratory being aware that they are the same. A comparison of the quality control and routine results provides a method to check the accuracy of the measurements. The average dose equivalent at the routine TLDs averaged 14.4 mrem/91 days while the quality control TLDs yielded an average dose equivalent of 15.2 mrem/91 days. All

the quality control and routine sample results were similar demonstrating the accuracy of both the TLDs and the laboratory's measurements.

NRC TLD Monitoring

The NRC has 22 TLDs located around Davis-Besse as part of their Direct Monitoring Network Program. Davis-Besse maintains TLDs at all the NRC TLD monitoring sites. The NRC collects their TLDs on a quarterly basis, whereas Davis-Besse collects TLDs quarterly and annually at these locations. The NRC TLDs are collected and read independently of Davis-Besse's TLDs, thus providing a quality control check on both laboratories.

The NRC uses Panasonic Model UD801 TLDs, which have two elements of lithium borate: copper ($Li_2B_4O_7$: Cu) and two elements of calcium sulfate: thulium ($CaSO_4$: Tm). The difference in TLD material used by the NRC and Davis-Besse causes some variation in results.

The results of TLD monitoring at these 22 locations show good consistency for the NRC TLDs and the Davis-Besse TLDs. The average of the quarterly results are 16.2 mrem/91 days for the Davis-Besse TLDs and 16.3 mrem/91 days for the NRC TLDs (data from first, second, and third quarter). The variance in these measurements is most likely due to the differences in the TLD materials.

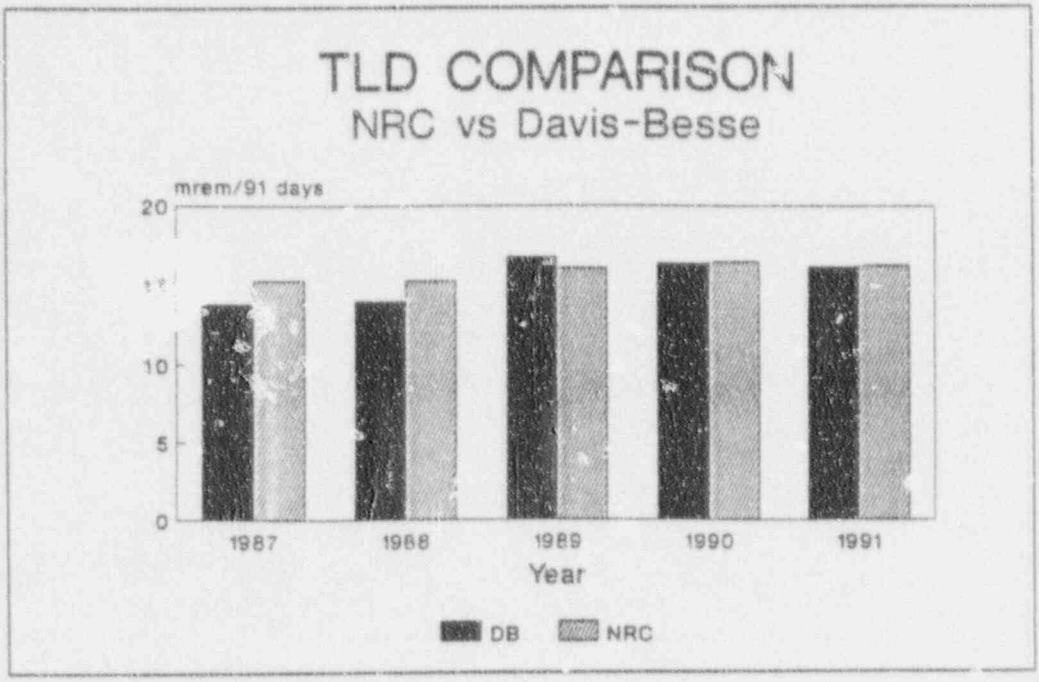


Figure 2-17: Compares NRC and Davis-Besse TL's for last five years.

Table 2-15: Thermoluminescent Dosimeters Locations

Sample Location Number	Type of Location	Location Description
T-1	I	Site boundary, 0.6 mile ENE of Station
T-2	I	Site boundary, 0.9 mile E of Station
T-3	I	Site boundary, 1.4 miles ESE of Station
T-4	I	Site boundary, 0.8 mile S of Station
T-5	I	Site boundary, 0.5 mile W of Station
T-6	I	Site boundary, 0.5 mile NNE of Station
T-7	I	Sand Beach, main entrance, 0.9 mile NW of Station
T-8	I	Earl Moore Farm, 2.7 miles WSW of Station
T-9	C	Oak Harbor Substation, 6.8 miles SW of Station
T-10	I	Site boundary, 0.5 mile SSW of Station near warehouse
T-11	C	Port Clinton Water Treatment Plant, 9.5 miles SE of Station
T-12	C	Toledo Water Treatment Plant, 23.5 miles WNW of Station
T-23	C	South Bass Island, 14.3 miles ENE of Station, near lighthouse
T-24	C	Sandusky, 21.0 miles SE of Station
T-27	C	Crane Creek State Park, 5.3 miles WNW of Station
T-38	I	Site boundary, 0.6 mile ENE of Station

Table 2-15: Thermoluminescent Dosimeters Locations continued

Sample Location Number	Type of Location	Location Description
T-39	I	Site boundary 1.2 miles ENE of Station
T-40	I	Site boundary, 0.7 mile SE of Station
T-41	I	Site boundary, 0.6 mile SSE of Station
T-42	I	Site boundary, 0.8 mile SW of Station
T-43	I	Site boundary, 0.5 mile SW of Station
T-44	I	Site boundary, 0.5 mile WSW of Station
T-45	I	Site boundary, 0.5 mile WNW of Station
T-46	I	Site boundary, 0.5 mile NW of Station
T-47	I	Site boundary, 0.5 mile N of Station
T-48	I	Site boundary, 0.5 mile NE of Station
T-49	I	Site boundary, 0.5 mile NE of Station
T-50	I	Erie Industrial Park, Port Clinton, 4.5 miles SE of Station
T-51	C	Daup Farm, 5.5 miles SSE of Station
T-52	I	Miller Farm, 3.7 miles S of Station
T-53	I	Nixon Farm, 4.5 miles S of Station
T-54	I	Weis Farm, 4.8 miles SW of Station
T-55	I	King Farm, 4.5 miles W of Station
T-60	I	Site boundary, 0.3 mile S of Station
T-61	I	Site boundary, 0.6 mile SE of Station

Table 2-15: Thermoluminescent Dosimeters Locations continued

Sample Location Number	Type of Location	Location Description
T-62	I	Site boundary, 1.0 mile SE of Station
T-63	I	Site boundary, 1.1 miles ESE of Station
T-64	I	Site boundary, 0.9 mile E of Station
T-65	I	Site boundary, 0.3 mile E of Station
T-66	I	Site boundary, 0.3 mile ENE of Station
T-67	I	Site boundary, 0.3 mile NNW of Station
T-68	I	Site boundary, 0.5 mile WNW of Station
T-69	I	Site boundary, 0.4 mile W of Station
T-70	I	Site boundary, 0.3 mile WNW of Station
T-71	I	Site boundary, 0.1 mile NNW of Station
T-73	I	Site boundary, 0.1 mile WSW of Station
T-74	I	Site boundary, 0.1 mile SSW of Station
T-75	I	Site boundary, 0.2 mile SSE of Station
T-76	I	Site boundary, 0.1 mile SE of Station
T-77	I	Site boundary, 0.1 mile ENE of Station
T-80	QC	Quality Control Site
T-82	QC	Quality Control Site
T-83	QC	Quality Control Site
T-84	QC	Quality Control Site

Table 2-15: Thermoluminescent Dosimeters Location continued

Sample Location Number	Type of Location	Location Number
T-85	QC	Quality Control Site
T-86	QC	Quality Control Site
T-88	QC	Quality Control Site
T-89	QC	Quality Control Site
T-90	I	Toussaint East and Leutz Roads, 2.0 miles SSW of Station
T-91	I	State Route 2 and Rankie Road, 2.5 miles SSE of Station
T-92	I	Locust Point Road, 2.7 miles WNW of Station
T-93	I	Twelfth Street, Sand Beach, 0.6 mile NNE of Station
T-94	I	State Route 2, 1.8 miles WNW of Station
T-95	C	State Route 579, 9.3 miles W of Station
T-96	C	State Route 2 and Howard Road 10.5 miles WNW of Station
T-97	I	Duff Washa and Zetzer Road, 1.5 miles W of Station
T-98	C	Toussaint-Portage and Bier Road, 6.0 miles SW of Station
T-99	I	Behlman Road, 4.7 miles SSW of Station
T-100	C	Ottawa County Highway Garage, Oak Harbor, 6.0 miles S of Station

Table 2-15: Thermoluminescent Dosimeters Locations continued

Sample Location Number	Type of Location	Location Description
T-101	C	Finke Street, Oak Harbor, 6.5 miles SSW of Station
T-102	C	Oak Street, Oak Harbor, 6.5 miles SSW of Station
T-103	C	Licker-Harder Road, 8.5 miles SW of Station
T-104	C	Salem-Carroll Road, 7.3 miles SW of Station
T-105	C	Lake Shore Drive Port Clinton, 6.0 miles SE of Station
T-106	C	Third Street, Port Clinton, 8.9 miles SE of Station
T-107	C	Little Portage East Road, 8.5 miles SSE of Station
T-108	C	Boysen Road, 9.0 miles S of Station
T-109	C	Stange Road, 8.0 miles W of Station
T-110	C	Toussaint North and Graytown Road, 10.0 miles WSW of Station
T-111	C	Toussaint North Road, 8.3 miles WSW of Station
T-112	I	Thompson Road, 1.5 miles SSW of Station
T-113	QC	Quality Control Site
T-114	QC	Quality Control Site
T-115	QC	Quality Control Site

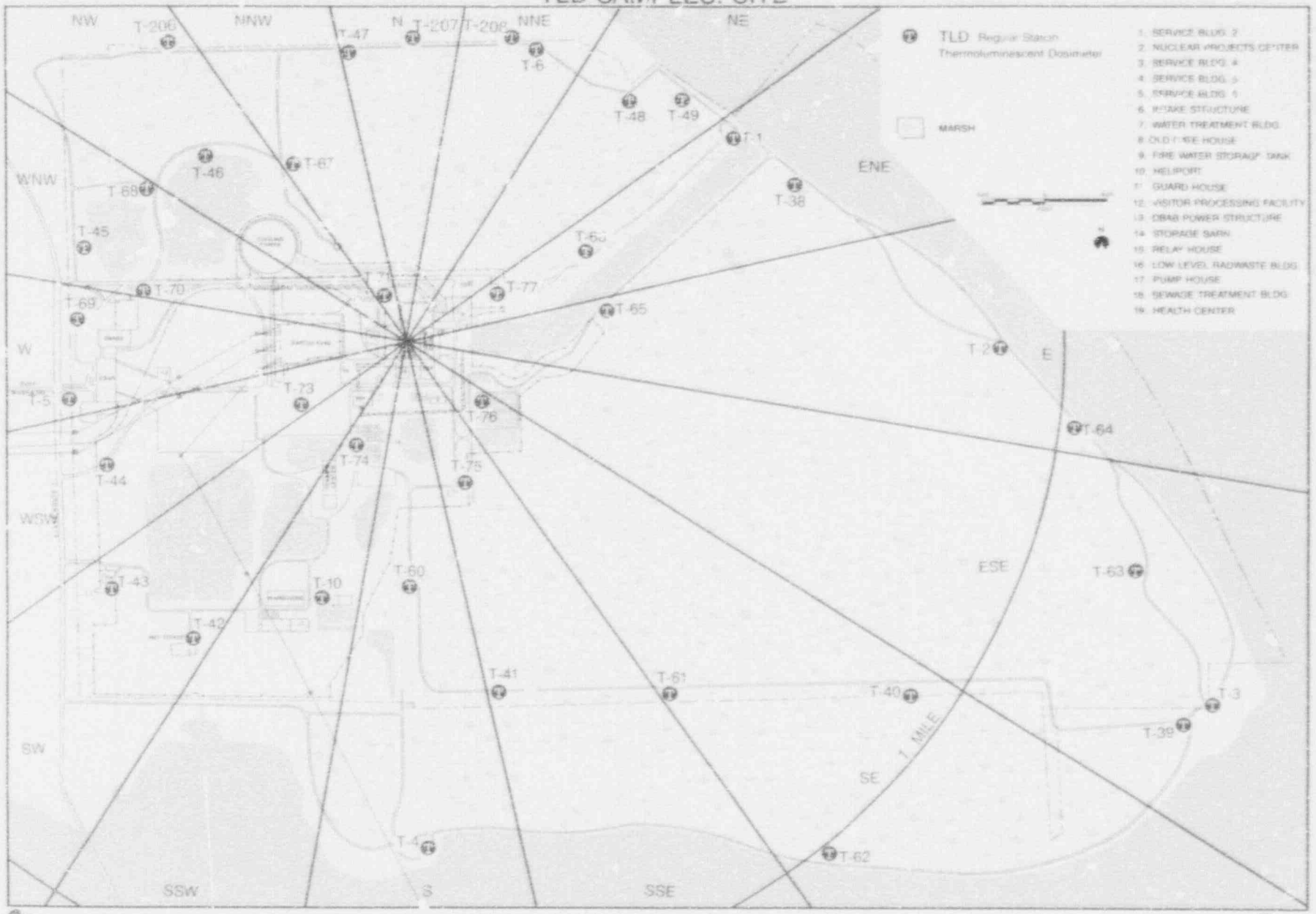
Table 2-15: Thermoluminescent Dosimeters Locations continued

Sample Location Number	Type of Location	Location Description
T-116	QC	Quality Control Site
T-117	QC	Quality Control Site
T-118	QC	Quality Control Site
T-119	QC	Quality Control Site
T-120	QC	Quality Control Site
T-121	I	State Route 19, 2.0 miles W of Station
T-122	I	Duff Washa and Humphrey Road, 1.7 miles W of Station
T-123	I	Zetzer Road, 1.6 miles WSW of Station
T-124	C	Church and Walnut Street, Oak Harbor, 6.5 miles SSW of Station
T-125	I	Behlman and Bier Roads, 4.4 miles SSW of Station
T-126	I	Camp Perry Western and Toussaint South Road, 3.7 miles S of Station
T-127	I	Camp Perry Western and Rymers Road, 4.0 miles SSE of Station
T-128	I	Erie Industrial Park, Port Clinton Road, 4.0 miles SE of Station
T-150	I	Humphrey and Hollywood Road, 2.1 miles NW of Station
T-151	I	State Route 2 and Humphrey Road, 1.8 miles WNW of Station

Table 2-15: Thermoluminescent Dosimeters Locations continued

Sample Location Number	Type of Location	Location Description
T-153	I	Leutz Road, 1.4 miles SSW of Station
T-154	I	State Route 2, 0.7 mile SW of Station
T-155	C	Fourth and Madison Street, Port Clinton, 9.5 miles SE of Sation
T-200	QC	Quality Control Site
T-201	I	Sand Beach, 1.1 miles NNW of Station
T-202	I	Sand Beach 0.8 mile NNW of Station
T-203	I	Sand Beach, 0.7 mile N of Station
T-204	I	Sand Beach. 0.7 mile N of Station
T-205	I	Sand Beach, 0.5 mile NNE of Station
T-206	I	Site Boundary, 0.6 mile NW of Station
T-207	I	Site Boundary, 0.5 mile N of Station
T-208	I	Site boundary, 0.5 mile NNE of Station.

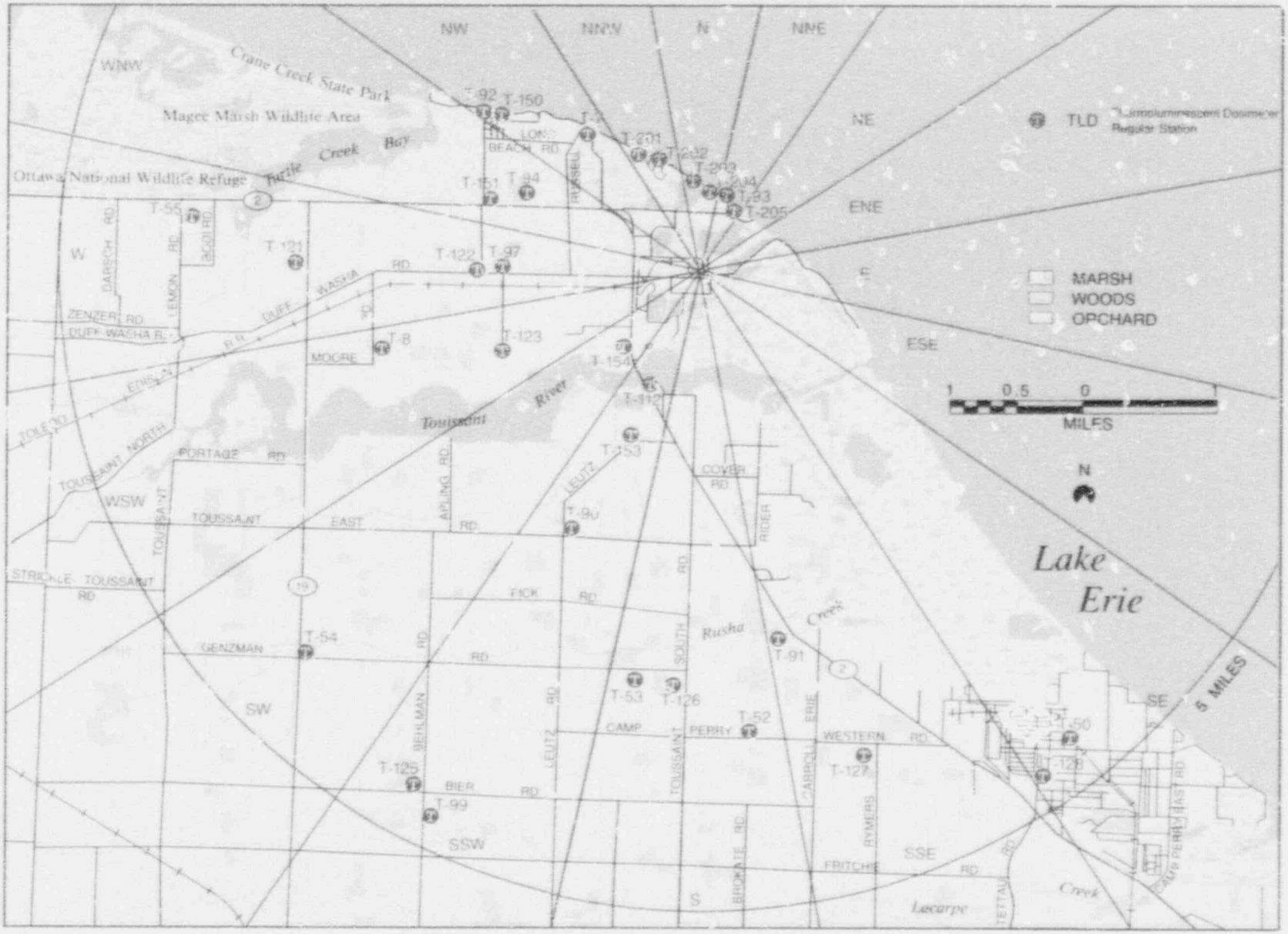
DAVIS – BESSE NUCLEAR POWER STATION
RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
TLD SAMPLES: SITE



ENVIRONMENTAL MONITORING

Figure 2-18

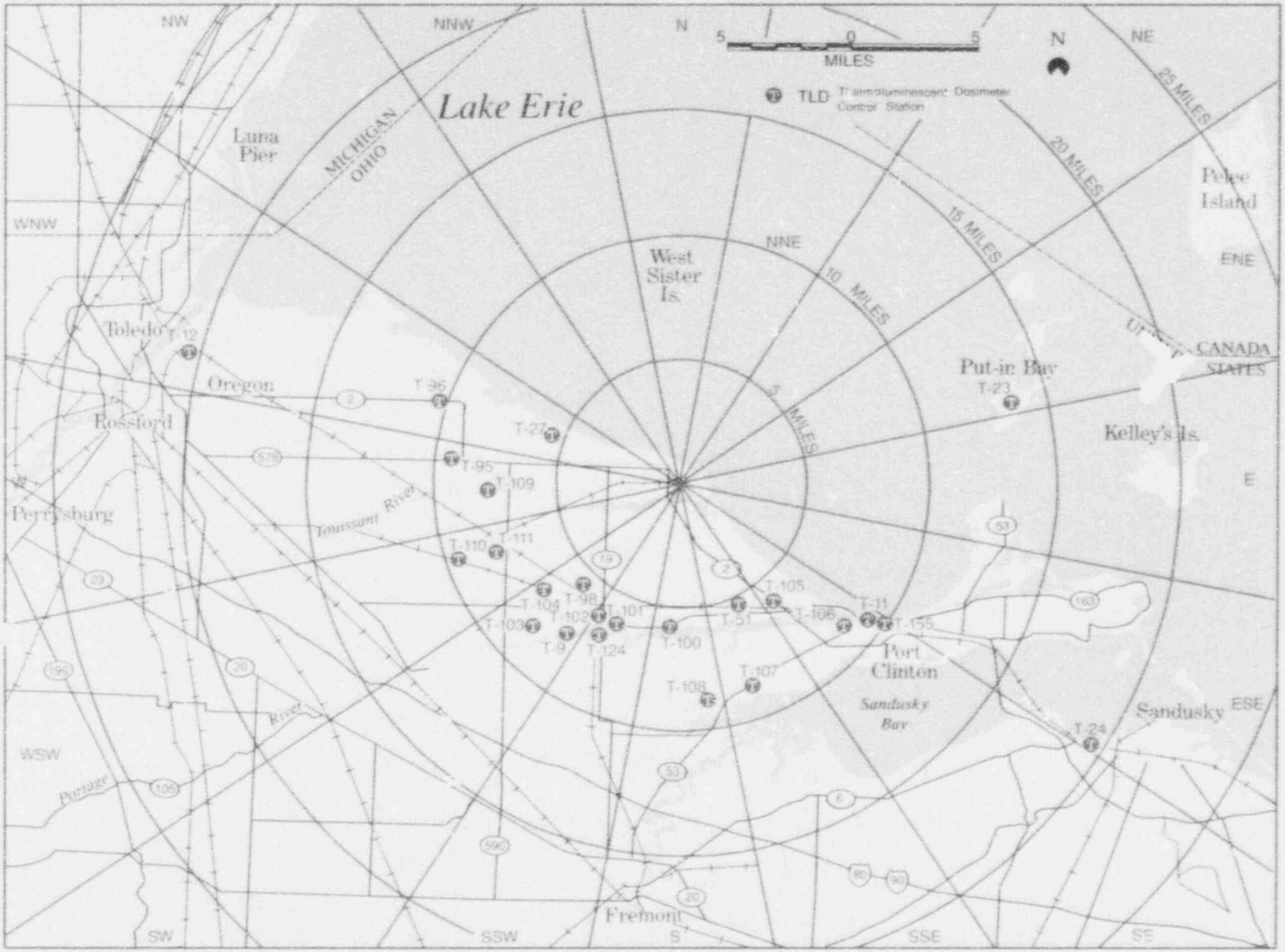
DAVIS-BESSE NUCLEAR POWER STATION
RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
TLD SAMPLES: 5 MILE RADIUS



ENVIRONMENTAL MONITORING

Figure 2-19

DAVIS-BESSE NUCLEAR POWER STATION
RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
TLD SAMPLES: 5–25 MILE RADIUS



ENVIRONMENTAL MONITORING

Figure 2-20

Conclusion

The Radiological Environmental Monitoring Program at Davis-Besse is conducted to determine the radiological impact of the Station's operation on the environment. Radionuclide concentrations measured at indicator locations were compared with concentrations measured at control locations, in previous operational studies and in the preoperational surveillance program. These comparisons indicate normal concentrations of radioactivity in all environmental samples collected in 1991. Davis-Besse's operation in 1991 had no adverse impact on the residence and environment surrounding the station. In fact, the dose to local residence from exposure to normal sourcer of radiation, both natural and man-made, is much more significant than the dose associated with the operation of Davis-Besse.

The results of the sample analyses performed during the period of January through December 1991 are summarized in Appendix E of this report.

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Land Use Census

Program Design

Each year a Land Use Census is conducted by Davis-Besse in order to gather information necessary to sample media representative of conservative radioactivity exposure pathways in the environment. The Land Use Census is required by Title 10 of the Code of Federal Regulation, Part 50, Appendix I and the Davis-Besse Technical Specifications, Section 3/4.12.2. Radiological exposure pathways, as discussed in Chapter 1 of this report, indicate the methods by which people may become exposed to radioactivity. The Land Use Census identifies the various pathways by which radioactivity may reach the population around Davis-Besse. These pathways include:

- **Inhalation Pathway**- Internal exposure as a result of breathing radioactivity carried in the air.
- **Ground Exposure Pathway**- External exposure from radioactivity deposited on the ground.
- **Plume Exposure Pathway**- External exposure directly from a plume or cloud of radioactive material.
- **Vegetation Pathway**- Internal exposure as a result of eating vegetables, fruit, etc. which have a build up of deposited radioactivity or which have absorbed radionuclides through the soil.
- **Milk Pathway**- Internal exposure as a result of drinking milk which may contain radioactivity as a result of a cow or goat grazing on a pasture contaminated by radionuclides.

The information gathered during the Land Use Census for dose assessment and input into the Radiological Environmental Monitoring Program ensures that these programs are as current as possible. For instance, if the Land Use Census identifies the presence of a dairy animal closer to the Station than was previously identified, then information from this new location can be used to estimate the potential dose to the surrounding population. Also, the milk at this location can be sought as a new sample for the Radiological Environmental Monitoring Program.

Methodology

The Land Use Census consists of recording and mapping the locations of all residences, dairy cattle and goats, and broad leaf vegetable gardens (greater than 500 square feet) within a five mile radius of Davis-Besse.

The surveillance portion of the 1991 Land Use Census was performed during the month of July. In order to gather as much information as possible, the location of residences, dairy cows, dairy goats, vegetable gardens, beef cattle, fowl, fruit trees, grapes, sheep, and swine were recorded. However, only the residences, vegetable gardens (greater than 500 square feet), and milk animals are used in the dose assessment program. The Ottawa County Cooperative Extension Agency confirmed the presence of dairy cattle and goats reported within the five mile radius.

Each residence is tabulated as having an inhalation pathway, as well as ground and plume exposure pathways. Each garden is tabulated as a vegetation pathway. Each milk animal is tabulated as a milk pathway.

All of the locations identified are plotted on a map (based on the U.S. Geological Survey 7.5 minute series of the relevant quadrangles) which has been divided into 16 equal sectors corresponding to the 16 cardinal compass points (Figure 3-1). The closest residence, milk animal, and vegetable garden in each sector are determined by measuring the distance from each to the station vent at Davis-Besse.

Results

The following changes in the pathways were recorded in the 1991 census:

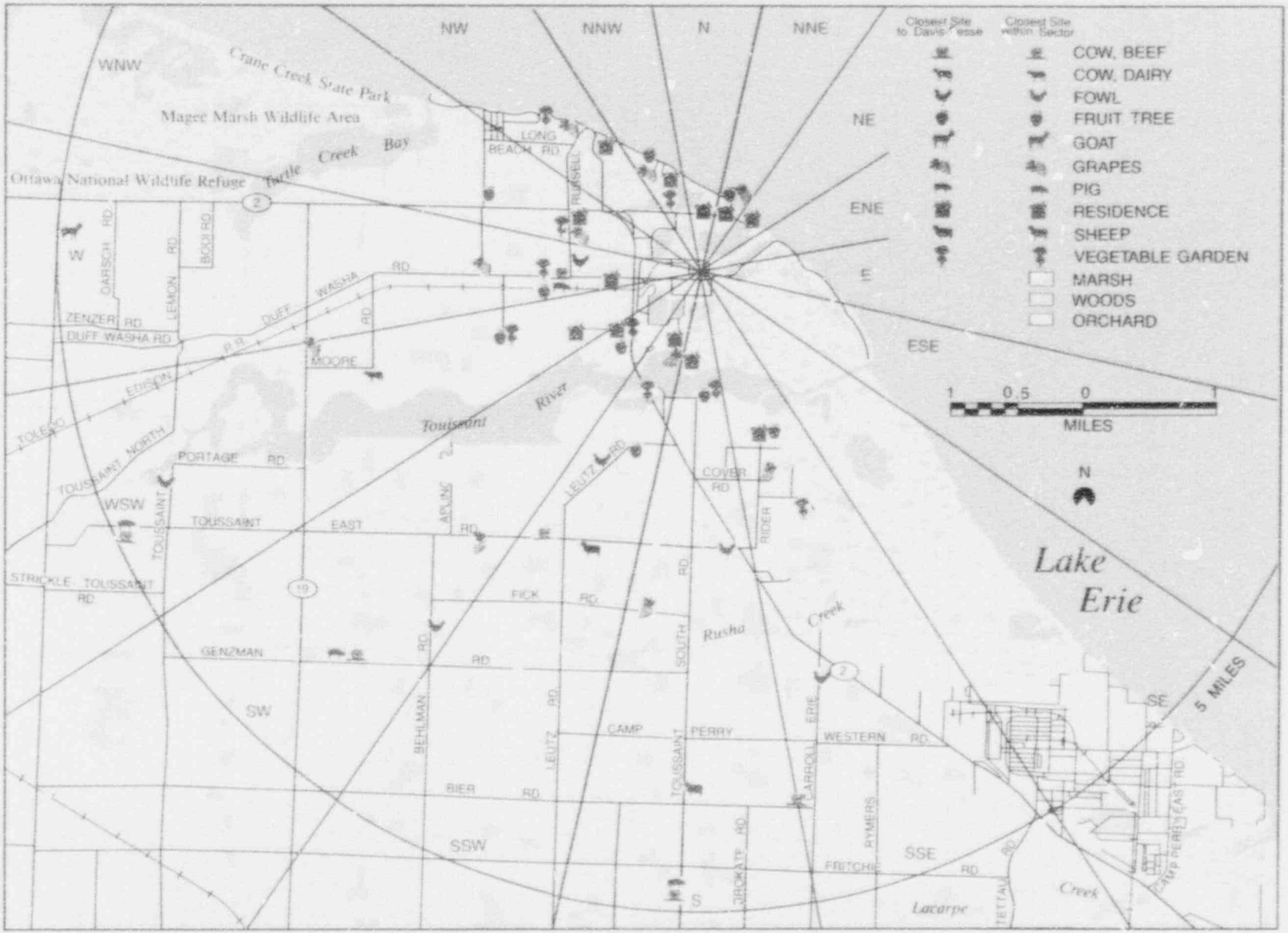
- **SSW Sector**- The vegetation pathway at 2180 meters was deleted in favor of a closer garden at 1560 meters.
- **SW Sector**- The vegetation pathway at 1340 meters was deleted in favor of a closer garden at 1050 meters.
- **W Sector** - The garden at 1050 meters was not present during the 1990 census. The vegetation pathway has changed to 1750 meters.
- **WNW Sector**- The vegetation pathway at 3290 meters was deleted in favor of a closer garden at 1750 meters.

- **NW Sector**- The garden at 2040 meters was not present during 1990. The vegetation pathway has moved to 2630 meters.

The detailed list in Table 3-1 was used to update the database of the effluent dispersion model used in dose calculations. Table 3-1 is divided by sectors and lists the distance (in meters) of the closest pathway in each meteorological sector.

Table 3-2 provided information on pathways, critical age group, atmospheric dispersion (X/Q) and deposition (D/Q) parameters for each sector. This information is used to update the Offsite Dose Calculations Manual (ODCM). The ODCM describes the methodology and parameters used in calculating offsite doses from radioactivity released in liquid and gaseous effluents, and in calculating liquid and gaseous effluent monitoring instrumentation alarm/trip setpoints.

DAVIS-BESSE NUCLEAR POWER STATION
RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
PRIMARY PATHWAYS WITHIN 5 MILE RADIUS



ENVIRONMENTAL MONITORING

Figure 3-1

Table 3-1: Closest Exposure Pathways Present in 1991

Sector	Distance from Station (meters)	Closest Pathways
N	880	Inhalation Ground Exposure Plume Exposure
NNE	870	Inhalation Ground Exposure Plume Exposure
NE	900	Inhalation Ground Exposure Plume Exposure
ENE,E,ESE,SE	N/A	Located over Lake Erie
SSE	2010	Inhalation Ground Exposure Plume Exposure
SSE	2900	Inhalation Ground Exposure Plume Exposure Vegetation
S	1070	Inhalation Ground Exposure Plume Exposure
S	1450	Inhalation Ground Exposure Plume Exposure Vegetation
SSW	980	Inhalation Ground Exposure Plume Exposure

Table 3-1: Closest Exposure Pathways Present in 1991 (continued)

Sector	Distance from Station (meters)	Closest Pathways
SSW	980	Inhalation Ground Exposure Plume Exposure
*SSW	1560	Inhalation Ground Exposure Plume Exposure Vegetation
*SW	1050	Inhalation Ground Exposure Plume Exposure Vegetation
WSW	1620	Inhalation Ground Exposure Plume Exposure
WSW	2640	Inhalation Ground Exposure Plume Exposure Vegetation
WSW	4270	Inhalation Ground Exposure Plume Exposure Vegetation Cow Milk
W	980	Inhalation Ground Exposure Plume Exposure

*Changes Since 1990

Table 3-1: Closest Exposure Pathways Present in 1991 (continued)

Sector	Distance from Station (meters)	Closest Pathways
*W	1720	Inhalation Ground Exposure Plume Exposure Vegetation
WNW	1730	Inhalation Ground Exposure Plume Exposure
*WNW	1750	Inhalation Ground Exposure Plume Exposure Vegetation
NW	1980	Inhalation Ground Exposure Plume Exposure
*NW	2630	Inhalation Ground Exposure Plume Exposure Vegetation
NNW	1210	Inhalation Ground Exposure Plume Exposure Vegetation

*Changes since 1990

Table 3-2: Pathway Locations and Corresponding Atmospheric Dispersion (X/Q) and Deposition (D/Q) Parameters

SECTOR	METERS	CRITICAL PATHWAY	AGE GROUP	X/Q (SEC/M³)	D/Q (M⁻²)
N	880	inhalation	child	9.15E-07	8.40E-09
NNE	870	inhalation	child	1.27E-06	1.47E-08
NE	900	inhalation	child	1.26E-06	1.58E-08
ENE*	----	----	----	----	----
E*	----	----	----	----	----
ESE*	----	----	----	----	----
SE*	----	----	----	----	----
SSE	2900	vegetation	child	6.80E-08	7.90E-10
S	1450	vegetation	child	1.21E-07	2.46E-09
SSW**	1560	vegetation	child	1.03E-07	2.28E-09
SW**	1050	vegetation	child	2.92E-07	5.33E-09
WSW	4270	cow/milk	infant	5.71E-08	5.31E-10
W**	1720	vegetation	child	2.47E-07	3.81E-09
WNW**	1750	vegetation	child	1.46E-07	1.72E-09
NW**	2630	vegetation	child	5.96E-08	4.50E-10
NNW	1210	vegetation	child	2.70E-07	1.92E-09

* Since these sectors are located over marsh areas and Lake Erie, no ingestion pathways are present.

** Changes since 1990.

Meteorological Monitoring

Introduction

The Meteorological Monitoring Program at Davis-Besse is required by the Nuclear Regulatory Commission (NRC) as part of the program for evaluating the effects of routine operation of nuclear power stations on the surrounding environment. Both NRC regulations and Davis-Besse Technical Specifications provide guidelines for the Meteorological Monitoring Program. These guidelines ensure that Davis-Besse has the proper equipment, in good working order, to support the Radiological Environmental Monitoring Program.

Meteorological observations at began in October 1968. The Meteorological Monitoring Program at has provided data and records of meteorological information that can be used by many other programs. The Radiological Environmental Monitoring Program uses the meteorological data to evaluate the effects of radioactivity released in Station effluents. The meteorological conditions at the time of these releases are used to calculate doses to the general public. Meteorological data are also used to evaluate where new radiological environmental monitoring sites should be located.

The meteorological monitoring system is also valuable in monitoring weather conditions, predicting the development of adverse weather conditions, and predicting the development of adverse weather trends, such as flooding or high winds. This provides an early warning system so precautions can be taken to protect the facilities and personnel at Davis-Besse. Onsite meteorological data would also be a valuable tool in the unlikely event of an emergency. Atmospheric dispersion characteristics necessary for evaluating conditions, distribution, and doses to the public could be readily obtained.

Onsite Meteorological Monitoring

This section describes the onsite Meteorological Monitoring Program at Davis-Besse. A description of the meteorological system , and data handling and analysis procedures, as well as a table and discussion of the annual data recovery are also provided.

System Description

Meteorological data collection at Davis-Besse consists of **wind speed, wind direction, sigma theta** (standard deviation of wind direction), ambient (outside air at 10 m) **temperature, differential temperature** (the air temperature at 100 or 75 m minus air temperature at 10m), **dew point temperature** (the air temperature where moisture begins to condense out of the air), and precipitation. Two towers equipped with a variety of meteorological instruments are used to gather these data.

Meteoritical Instrumentation

The meteorological system consists of one monitoring site located at a grade level of 577 feet above mean sea level. A 100 m free-standing tower located about 3,000 feet SSW of the cooling tower, and an auxiliary 10 m tower located 100 feet west of the 100 m tower, are used to gather the meteorological data. The 100 m tower has instruments for wind speed and wind direction at 100 m and 75 m. The 10 m tower is instrumented for wind speed and wind direction. The 100 m tower also measures two **differential temperatures** (***delta T's***) : 100-10m and 75-10m. Differential temperatures are used to determine stability of the lower atmosphere. This gives an indication of how fast airborne effluents can mix and disperse. Precipitation is measured by a tipping bucket rain gauge located near the base of the 10m tower. According to the Davis-Besse Nuclear Power Station Operating License, Appendix A, Technical Specification, a minimum of six instruments are required to be operable at the two lower levels (75 m and 10 m) to measure temperature, wind speed and wind direction.

The signals from each meteorological instrument are translated by modules located inside the meteorological shelter. These signals are then transmitted to various places as shown in Figure 4-1.

Meteorological System Maintenance and Calibration

Personnel at Davis-Besse inspect the meteorological site and instrumentation regularly. Tower instrumentation maintenance and semi-annual calibrations are performed by inhouse facilities and a outside consulting firm.

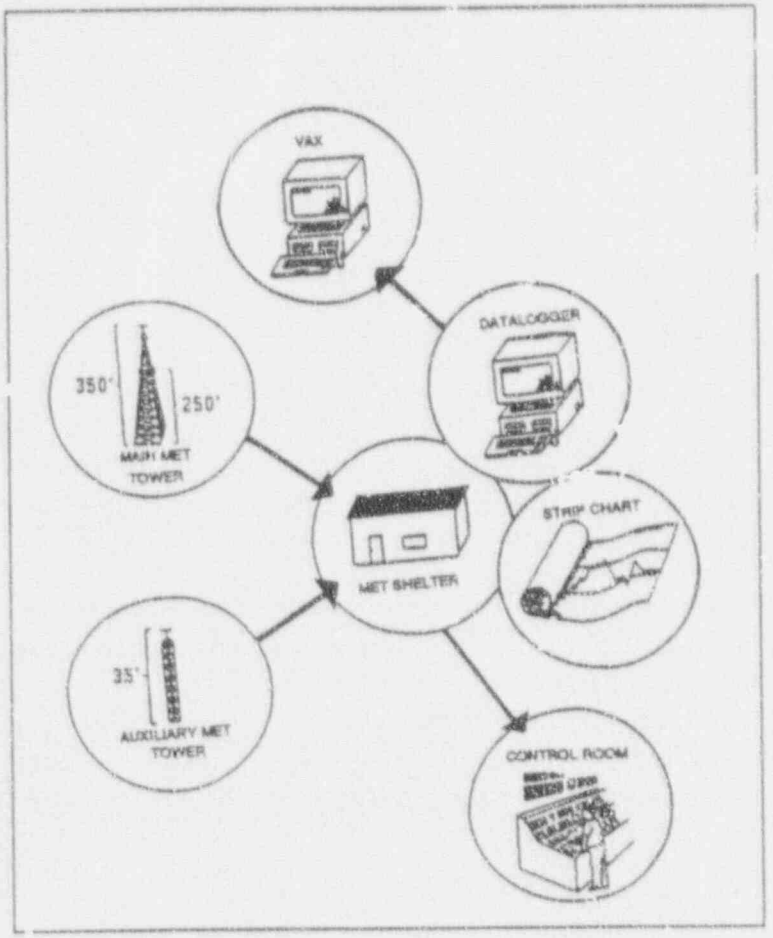


Figure 4-1: The signals from the two meteorological towers are transmitted to many computers located onsite. The information from these towers aid in calculating population doses.

Meteorological Data Handling and Reduction

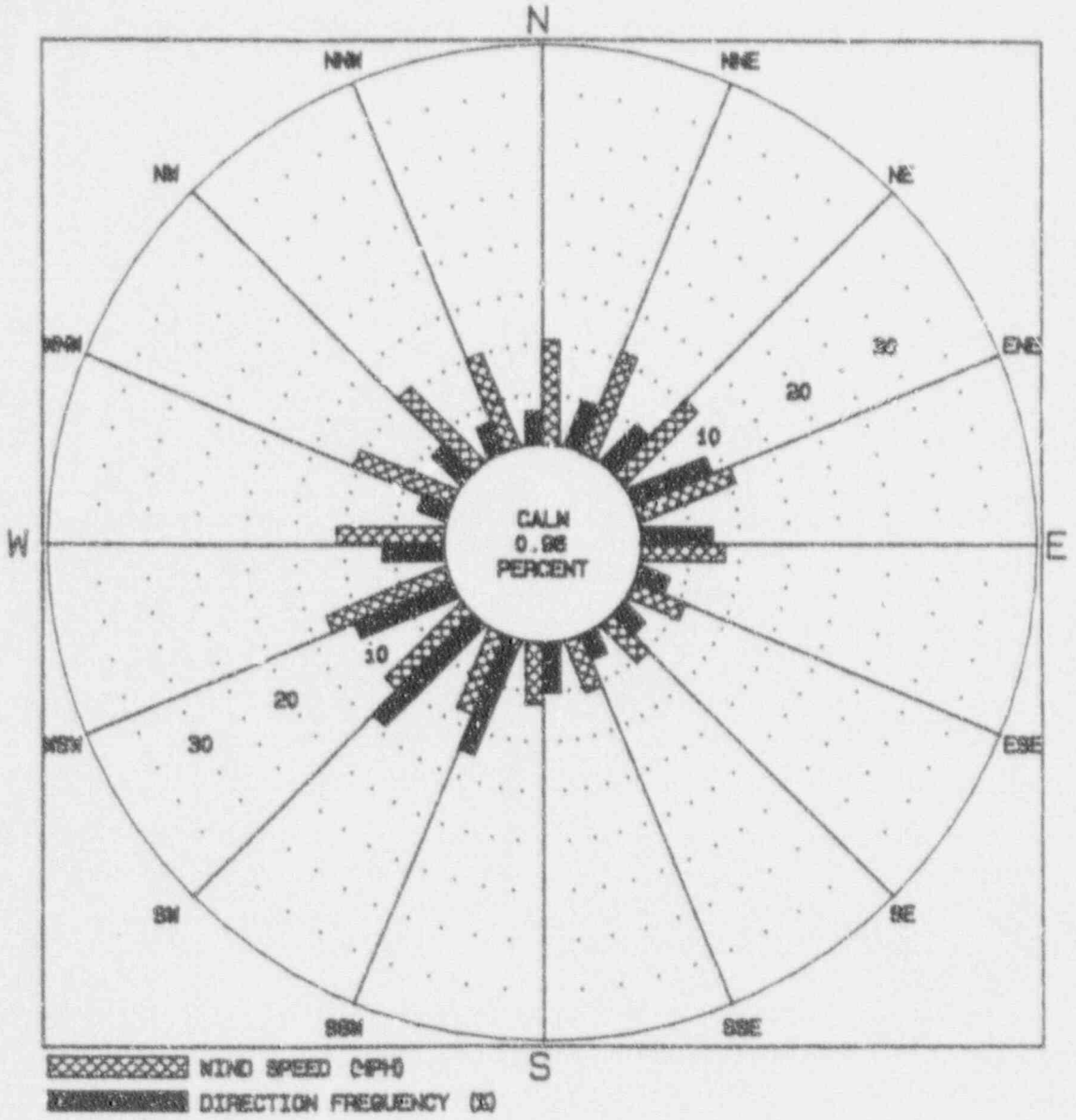
The Campbell Datalogger 21X in the meteorological shelter communicates data to the PDP 11/84. The PDP 11/84 take 900 averages and stores them for each hour in a disk files. This information is then transferred to the vax system. The data are processed and analyzed by several computer programs. Computer listings of the data are generated and values are compared to specified range and rate-of-chance criteria in order to identify anomalies.

Summary statistics and Joint Frequency Distributions (JFDs) of wind and stability data are generated and the results are reviewed for consistency in terms of known site characteristic and regional climatology The end result of the review process is a validated final database suitable for use by atmospheric dispersion models and for site meteorological characterizations.

Meteorological Data Recovery

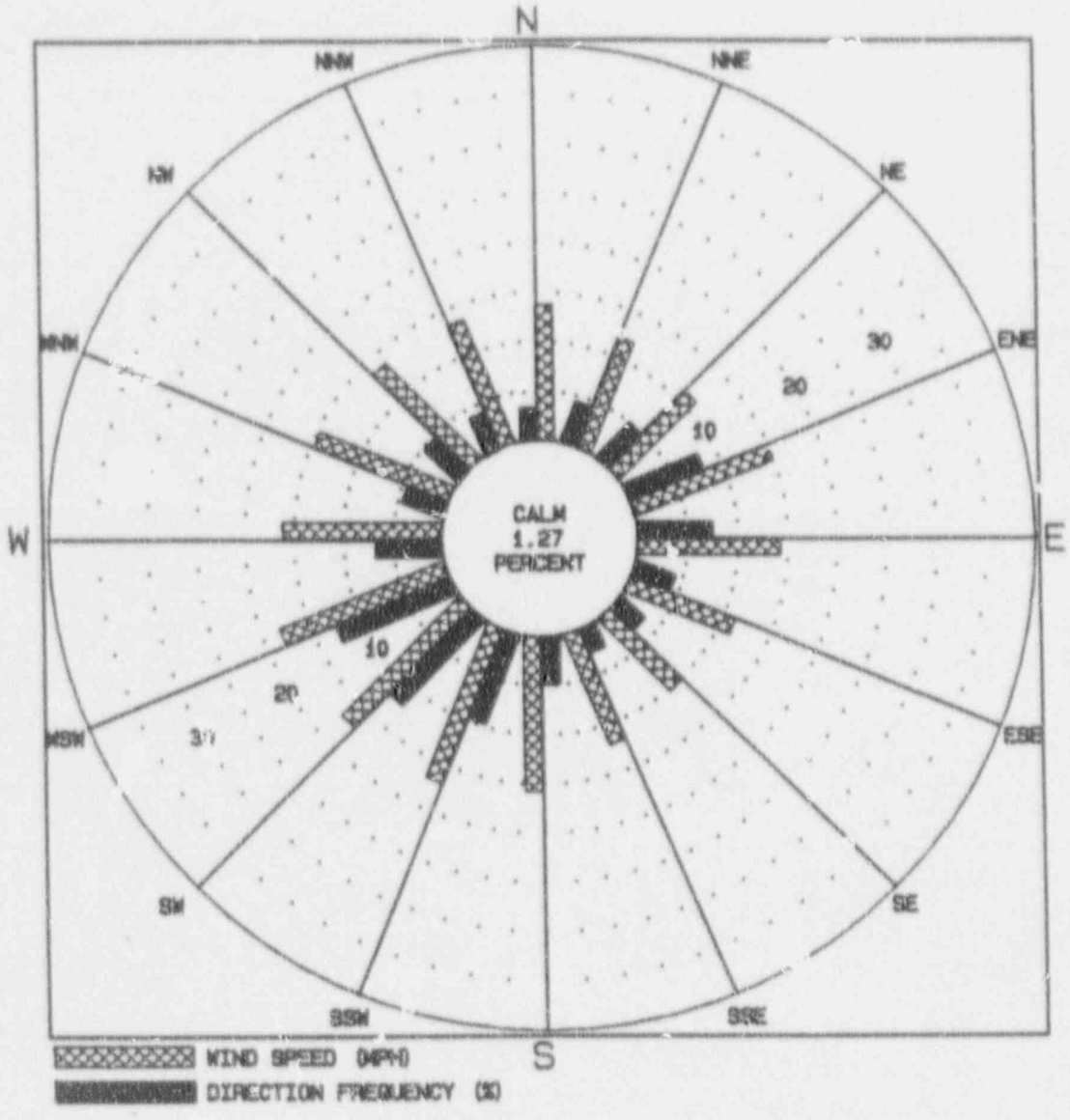
The monthly and annual data recovery statistics for all parameters measured during 1991 are provided in Table 4-1. Data recoveries in Table 4-1 represent the percentage of time a given instrument was operable for the month/year divided by the maximum number of hours in that month/year that the instrument could be operable . Data recovery for 1991 was above 90 percent for all measured parameters. Data recovery for 1991 for the six instruments required by Technical Specification to be operable was also above 90 percent. Table 4-1 also gives monthly and annual recovery rates for joint operability of wind measurements and delta T (differential temperature) for 1991. Annual joint recovery rates were above 90 percent for all combinations of wind and stability data, and above 90 percent for the six instruments required to be operable . Minor losses of data occurred during routine instrument maintenance and calibration and data validation.

Figure 4-2: 10 meter Wind Rose for January through December 1991



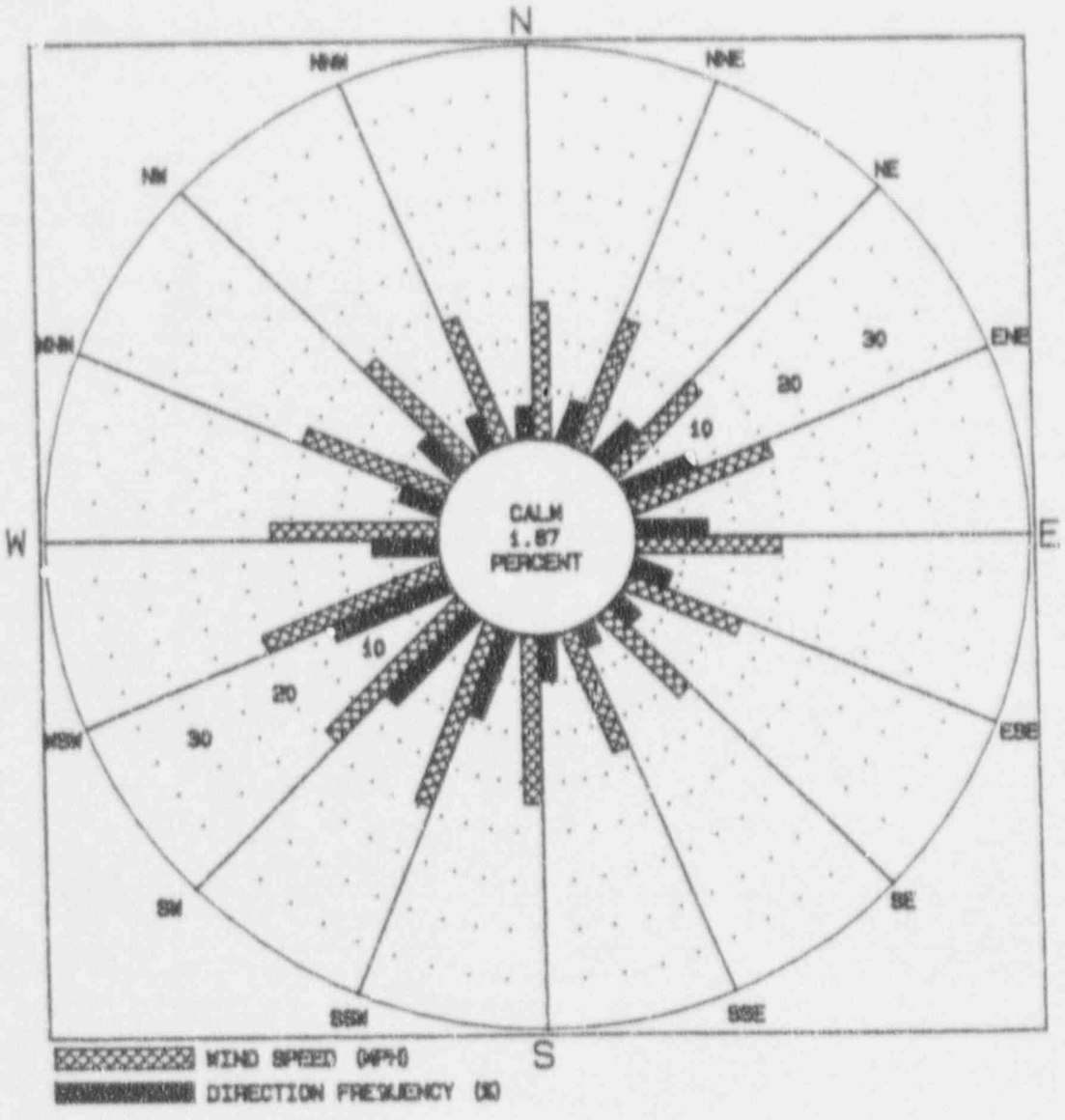
DAVIS-BESSE
ANNUAL 1991
10M LEVEL

Figure 4-3: 75 meter Wind Rose for January through December 1991



DAVIS-BESSE
ANNUAL 1991
75M LEVEL

Figure 4-4: 100 meter Wind Rose for January through December 1991



DAVIS-BESSE
ANNUAL 1991
100M LEVEL

Table 4-1

Summary Of Meteorological Data Recovery For The Davis-Besse Nuclear Power Station
January 1, 1991 Through December 31, 1991*

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
100m Wind Speed	99.73	82.59	100.00	100.00	95.56	100.00	96.51	98.12	99.72	100.00	99.03	99.87	97.56
100m Wind Direction	99.73	99.85	100.00	100.00	95.56	100.00	100.00	98.39	99.72	100.00	97.50	99.87	99.21
75m Wind Speed	99.73	99.85	100.00	100.00	95.56	100.00	100.00	97.85	99.72	98.66	99.03	99.87	98.09
75m Wind Direction	99.73	99.85	100.00	100.00	95.56	100.00	100.00	97.85	99.72	99.06	99.03	99.87	99.22
10m Wind Speed	99.73	88.39	100.00	100.00	95.56	100.00	100.00	98.12	99.72	100.00	99.03	99.87	99.20
10m Wind Direction	99.73	99.85	100.00	100.00	95.56	100.00	100.00	98.39	99.72	100.00	97.36	99.87	99.20
10m Ambient Air Temp	100.00	99.11	99.87	99.31	95.43	100.00	99.60	98.25	99.58	99.06	97.92	99.87	99.02
10m Dew Point Temp	100.00	99.70	100.00	99.58	95.43	100.00	100.00	98.25	99.58	100.00	97.92	05.24	91.13
Delta T (100m-10m)	100.00	99.40	99.87	99.58	95.83	100.00	99.60	98.39	99.44	99.06	07.92	99.87	99.08
Delta T (75m-10m)	100.00	99.85	89.78	99.58	95.83	100.00	99.60	98.39	99.58	99.06	97.92	99.87	98.26
Joint 100m winds and Delta T (100m-10m)	99.73	82.14	99.87	99.58	93.28	100.00	96.10	98.12	99.44	99.06	97.50	99.87	97.16
Joint 75m winds and Delta T (100m-10)	99.73	85.27	99.87	99.58	94.62	100.00	99.60	97.72	99.44	97.18	97.50	99.87	97.16
Joint 75m winds and Delta T (75m-10m)	99.73	85.71	89.78	99.58	94.62	100.00	99.60	97.72	99.58	97.18	97.50	99.87	96.80
Joint 10m winds and Delta T (75m-10m)	99.73	88.39	89.87	99.58	94.62	100.00	99.60	98.12	99.58	99.06	95.83	99.87	97.07

* All data for individual monthes expressed as percent of time instrument was operable during the month, divided by the maximum number of hours in that month that the instrument could be operable. Values for annual data recoveries = percent of time instrument was operable during the year, divided by the number of hours in the year that the instrument was operable.

Table 4-2

Summary of Meteorological Data Measured at Davis-Besse Nuclear Power Station
January 1, 1991 through December 31, 1991

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
100m Wind												
Max Speed (mph)	42.9	34.0	51.4	38.7	35.8	27.1	51.2	33.7	30.8	38.1	45.1	45.1
Date of Max Speed	23	22	28	15	18	3	7	20	16	5	30	14
Min Speed (mph)	1.7	2.4	1.3	2.1	1.3	1.3	2.1	1.6	1.8	1.4	0.5	1.7
Date of Min Speed	6	28	11	28	21	8	10	2	5	30	8	19
75m Wind												
Max Speed (mph)	40.7	31.3	49.7	56.6	33.8	24.8	23.4	29.8	29.5	36.7	44.1	42.5
Date of Max Speed	23	22	28	15	18	15	7	3	16	5	30	14
Min Speed (mph)	1.0	2.6	1.3	2.6	1.8	1.0	2.1	1.1	1.4	0.8	0.2	1.8
Date of Min Speed	29	28	11	24	21	8	16	20	21	26	8	11
10m Wind												
Max Speed (mph)	33.2	21.8	39.1	42.4	27.1	20.7	15.9	25.6	22.3	27.6	39.2	32.2
Date of Max speed	23	22	28	15	7	3	5	8	16	5	12	14
Min Speed (mph)	1.3	1.4	1.1	1.1	1.1	1.3	1.2	1.1	1.4	1.9	0.5	0.7
Date of Min Speed	5	1	10	25	21	8	15	12	6	12	9	14
10m Ambient Temp												
Max (°F)	45.6	55.6	71.3	80.9	88.0	91.5	91.9	88.0	90.8	NA	63.8	60.4
Date of Max	15	4	21	7	16	15	20	1	15	NA	20	8
Min (°F)	6.7	6.0	23.6	30.7	44.2	59.3	60.2	57.4	39.7	33.0	15.7	10.1
Date of Min	22	16	12	2	3	14	25	21	27	20	8	5

Table 4-2

Summary of Meteorological Data Measured at Davis-Besse Nuclear Power Station January 1, 1991 through December 31, 1991 (con't)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
10m Dew Point Temp												
Mean (°F)	20.3	24.5	31.1	42.8	56.6	60.9	62.7	62.1	52.3	44.4	31.7	26.3
Max (°F)	40.9	47.5	60.0	67.4	78.8	73.3	75.4	73.5	72.9	63.9	59.5	32.6
Date of Max	16	19	27	29	9	15	22	28	9	25	19	1
Min (°F)	-3.5	-1.5	11.2	13.6	33.1	42.0	51.3	45.6	27.0	21.3	6.7	17.1
Date of Min	21	1	30	2	2	13	28	11	23	16	6	2
Precipitation												
Total (inches)	2.79	1.15	1.08	3.74	3.61	2.07	1.36	10.54	1.68	6.19	3.10	NA

NA- Not Available

Marsh Management

Navarre Marsh

The Navarre Marsh is approximately 733 acres of low lying wetland which surrounds the Davis-Besse Nuclear Power Station, located on the southwestern shore of Lake Erie. The Toledo Edison and Cleveland Electric Illuminating Compa[illegible]-own the marsh. It is leased to the U.S. Fish and Wildlife Servic (USF[illegible] manages it as part of the Ottawa National Wildlife Refug[illegible] access roads in the marsh are maintained by the To[illegible] Environmental Compliance (EC) personnel at Davis-Bes[illegible] responsible for conducting marsh inspections and generating monthly status reports, recommending management actions, and actively controlling undesirable plant species. Results from the marsh inspections are compared to the activity levels expected by the USFWS for each seasonal period, and from this comparison an evaluation of the marsh progress is made.

The Navarre Marsh is completely enclosed by a system of dikes and revetments to protect it from flooding and the wave action of Lake Erie. A **dike** is a retaining structure designed to hold back water for purposes of flood control and to aid in managing a marsh for waterfowl and wildlife. Dikes are also routinely used to convert wetlands into land suitable for farming. When used as a marsh management tool, dikes aid in controlling the water levels required to obtain the desired vegetation beneficial to wildlife. Manipulating water levels is one of the most important management tools used in the Navarre Marsh. Simply by lowering or raising water levels within the marsh, certain plant species can be encouraged or discouraged to grow. From a wildlife management standpoint, plant species that provide either food (e.g. smartweed) or shelter (e.g. cattails) for native wildlife, are more desirable that plant species than serve do not provide these (e.g. purple loosestrife).

A **revetment** is also a retaining structure designed to hold back water for purposes of erosion control and to encourage beach formation. Revetments are built at a gentler slope (e.g. a ratio of three to one). As waves strike the gradual slope of a revetment, their energy dissipates, allowing the sediment load to drop out at the base of the revetment. Because a revetment extends

well out into the water, it actually encourages beach formation by this passive deposition of sediment.

A marsh is generally found in low-lying flat areas and are characterized by a wide diversity of plant life as the elevation changes. The Navarre Marsh has a varied landscape with different plants found in each elevation. The majority of vegetation is found in the **fresh water marsh**. Three kinds of vegetation grow here: **emergents, submergents,** and **floating plants**. Emergents grow in wet soil or out of the water and include cattails, smartweed, and arrowhead. Submergents, such as pondweed and water milfoil, thrive beneath the water's surface. Floating on the water are greater and lesser duckweed , and water lilies. All these plants provide food, cover and nesting areas essential to wildlife.

The Navarre Marsh is bordered by a narrow, dry beach ridge along the lake front. The beach supports a limited number of woody plants and has many standing dead trees, frequently occupied by birds of prey such as bald eagles. Extending out from the beach is a sandbar which formed over the last several years after the revetment was constructed in early 1988. As discussed earlier, the revetment helps dissipate lake wave action, allowing suspended particles in the water to settle out and accumulate, eventually forming a sandbar. The sandbar then acts as a natural barrier, protecting the shore from storms and wave action. In addition to protecting the shoreline, the sandbar also benefits local wildlife. Shorebirds and waterfowl are often seen resting and feeding in this area. Lower lake levels in 1989 also exposed shorelines that were underwater during previous years. These lower levels also contributed to the formation of the beach at the base of the revetment.

The Navarre Marsh also supports a variety of other habitats, including a swamp forest and wet meadows. Bluejoint grass and rice-cut grass are the major wet meadow plants. In the swamp forest, the soil is poorly drained or underwater for part of the growing season. The swamp forest supports woody plants such as cottonwood, willows, buttonbush and several understory plants such as poison ivy, sumac, and swamp loosestrife. Navarre Marsh is unique to this area because of the buttonbush found in the swamp forest. Buttonbush (*Cephalanthus Occidentalis*) is becoming rare along Lake Erie and so it is becoming increasingly important to protect those habitats that support the buttonbush population. Studies have shown that 90% of Navarre Marsh's black-crowned night heron use the buttonbush swamp for feeding and resting. Green herons have also been observed resting in the area (Meeks and Hoffman, 1979).

A wide variety of birds utilize Navarre Marsh. The best-known resident is the Canada goose, abundant throughout the marsh and around the site. Besides natural nesting sites, several artificial nesting structures, such as wood duck boxes and goose tubs, are provided. The boxes and tubs represent a collective effort of U.S. Fish and Wildlife Service, Ohio Department of Natural Resources (ODNR), and Davis-Besse personnel. The marsh also provides waterfowl with a feeding and resting place during their migration. Besides waterfowl, raptors such as owls, hawks, and eagles also frequent the marsh. In the spring and fall, warblers, vireos, kinglets and a variety of other songbirds stop here during their migration. Great blue herons and great egrets use the marsh as a feeding and resting area during the breeding season. Gulls, rails, killdeer and a wide variety of other wading birds can be observed throughout the year in the Navarre Marsh.

Mammals also use the Navarre Marsh throughout the year. The most noticeable resident is the muskrat. The marsh is dotted with muskrat houses which serve a dual purpose: they provide homes for muskrats and nesting places for waterfowl. The muskrat population in Navarre Marsh is kept in balance by trappers who are supervised by personnel from the Ottawa National Wildlife Refuge. Other mammals inhabiting the Navarre Marsh include raccoon, red fox, mink, and whitetail deer.

Special Projects in 1991

Toledo Edison is committed to protecting the Navarre Marsh and has gone to great lengths to preserve this valuable resource. This is best illustrated by the extensive dike system built to protect the area from flooding, and by the many special projects conducted in the marsh each year. In 1991, these special projects included controlling undesirable plant species, songbird banding, Canada goose banding and nesting surveys, wood duck banding and nesting box relocation. A brief description of each of these projects is provided in the following paragraphs.

Not all of the plants found in Navarre Marsh are beneficial to wildlife. **Purple loosestrife** *(Lythrum salicaria)* is one such undesirable species. This exotic plant, introduced from Europe, is an aggressive species which tends to crowd out valuable plants. Each summer, Environmental Compliance personnel record and map the locations of all purple loosestrife plants found within the marsh. Once sighted, the staff attempts to control the spread of the species through the use of approved herbicides and by removing smaller individual plants.

One other undesirable plant species found in Navarre Marsh is the **giant reed** *(Phragmites australis)*. These tall plants often grow thick, dense stand which crowd out more beneficial plant species. Environmental Compliance personnel attempt to control the giant reed through limited herbicide spraying under the direction of the U.S. Fish and Wildlife Service. In controlling these undesirable plant species, the rich plant diversity in the Navarre Marsh is maintained.

The songbird banding project was conducted in cooperation with the ODNR from March through June 1991. The project involved capturing and banding song birds migrating through the area. A total of 6,932 individual birds were banded.

Many of the wood duck boxes installed in 1990 were used in 1991. Several of the boxes housed families of wood ducks. Other boxes were utilized by a hooded merganser, starlings and screech owls. Similar efforts for providing nest structures will be taken in 1992. Potential species for which artificial structures will be provided include: wood duck, black duck, mallards, martins, and bats.

References

1. "The Audubon Society Nature Guides: Wetlands," National Audubon Society, Inc. (Marsh 1985).

2. "The Ecology of Coastal Marshes of Western Lake Erie: A Community Profile,"Biological 85(7.9), U.S. Fish and Wildlife Service, Dept. of Interior and Corps of Engineers, U.S. Department of Army (February 1987).

3. Meeks and Hoffman, "Bird Populations Common to the Sister Islands, the Role of the Navarre Marsh", (1979).

Zebra Mussel Control

Introduction

(*Dreissena polymorpha*), is more commonly known as the zebra mussel because of its striated shell, is a native European bivalve that was accidentally introduced into North American waters in 1988 and was discovered in Lake Erie in 1989. Zebra mussels are prolific breeders which rapidly colonize an area by secreting byssal threads which enable them to attach to solid surfaces and to each other. Because of their ability to attach like this, they may form layers several inches deep. This poses a problem to facilities that rely on water intakes from Lake Erie because mussels may attach to the intake structures and restrict water flow. Zebra mussels have not yet caused significant problems at Davis-Besse, but mussels were found attached to the intake crib (the structure that allows water to be pulled in from the lake) and the first section of the intake conduit (the pipe that connects the crib to the intake canal). However, mussels have not attached to the latter portion of the conduit of the intake canal which supplies water to the plant. The mussel were removed from the crib with high pressure water which also destroys the mussels as well. In 1991, zebra mussels were found covering approximately 80% of the trash racks (moving screens which filter out large debris),however, this did not affect plant operations.

At Davis-Besse, zebra mussels are monitored to estimate their population density, which will determine the severity of the problems they may cause. The life cycle of the mussel and the effects of certain variables (wind, temperature, and chemicals) on mussels and veligers, the larvae stage of the mussel, are being studied to determine a means of controlling mussel population.

Monitoring

The Zebra Mussel Monitoring Program, implemented by the Environmental Compliance Unit, has been in place since April 1990. The program involves the collection of several types of samples which are observed for the presence of adult zebra mussels or the free-swimming larval forms, veligers. The frequency of sampling is determined by lake water temperature. Samples are only taken when the lake temperature is above 12 ^{0} C because this is the

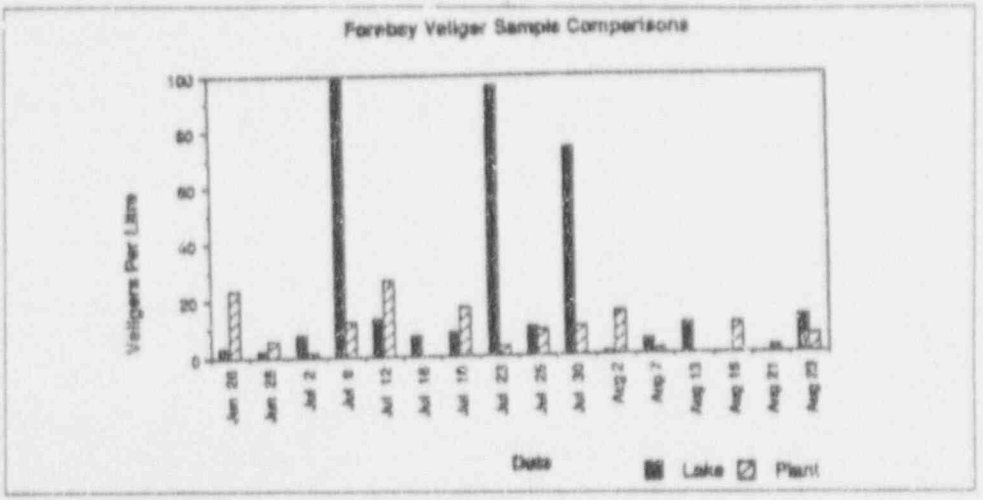


Figure 6-1: The graph (above) shows the peaks in veliger population during July 1991 and that the veliger population is less dense in the intake near the station compared to the veligers near the lake.

temperature at which spawning may occur. At temperatures above 18°C, when spawning conditions are most favorable, more frequent samples are taken. Weather data and water temperatures are also recorded to determine their effects on mussel population.

Water samples are collected monthly in the Toussaint River and bi-weekly in the station's intake forebay. These samples are collected using a plankton net sampler: a net support system with a straining bucket used for plankton-size (microscopic) organisms which include veligers. One milliliter from each sample is observed under a microscope to check for the presence of veligers to determine the average number of veligers per liter. Then a standard comparison may be made from water samples of different volumes (Figure 6-1).

One other type of sample is collected, but it is observed for the presence of adult mussels rather than for veliger stages. This sample is taken from the bottom of the screenwash basin which collects debris from the water intake traveling screen. It is collected by using a device called an Eckman Dredge. The dredge has a pair of spring loaded jaws that close to trap a sediment sample. The sample is then dumped onto a screen and sifted through to count the number of adult mussels.

Research

The Environmental Compliance Unit is involved with the Electric Power Research Institute (EPRI) in studying the effects of proprietary and commercial

cals on zebra mussels. The purpose of the study is to determine what may influence mussel mortality and/or detachment. Figure 6-2, shows a skid designed by EPRI to roughly simulate an in-plant water system was constructed for use at Davis-Besse. The skid consists of four different-sized cells, ranging from 1-1/2" to 3" in diameter with a valve connected to each that allows the water flow to be adjusted. Mussels are placed inside the cells then water is pumped from the forebay through the system. A chemical feed pump is connected to the system so that chemicals can be introduced into three of the cells. The fourth is the control cell that enables comparisons to be made with different chemical conditions in the other cells.

The skid was used in the summer and fall of 1991 to test the efficiency of a Union Carbide molluscide. The chemical was shown to be very effective against zebra mussels in higher water temperatures (approximately 23°C). However, the chemical was found to be rather ineffective in lower water temperatures below 15 °C. Present plans for 1992 are continuing experimentation with molluscides to determine the effectiveness on controlling zebra mussels.

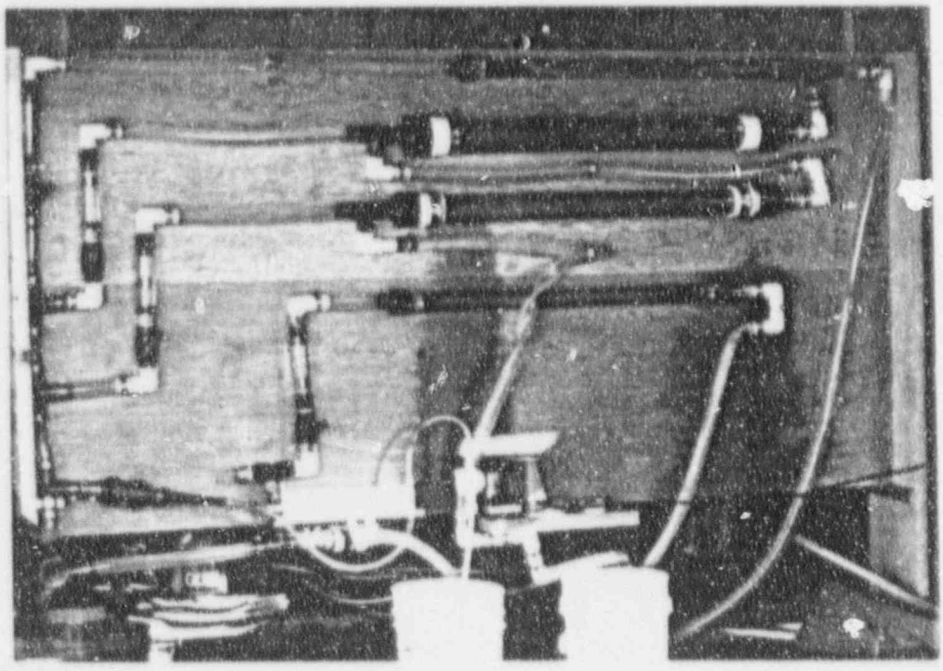


Figure 6-2: The skid designed by EPRI that is used for zebra mussel experimentation at Davis-Besse.

Water Treatment

Water Treatment Plant Operation

Description

The Davis-Besse Nuclear Power Station uses Lake Erie as a water source for its water treatment plant. The lake water is treated with chlorine, lime, sodium aluminate, and coagulant aid to make the water clean and safe for consumption. This water may also be further treated by a demineralizing process to produce water which is used by much of the Station's equipment, including the turbine. This process is used to produce high purity water to maintain plant system integrity.

Operation of the water treatment plant falls under the purview of the Ohio Environmental Protection Agency (OEPA) and the Ohio Department of Health. The operation of the facility is reviewed by a certified operator, Public Water Supply. Activities at the water treatment plant are conducted in compliance with the Safe Drinking Water Act, and the regulations for public water supply as set forth by the OEPA.

Monthly operational reports, required by the OEPA, are completed and submitted to the agency. These reports include the Drinking Water Operation Report (OEPA form 5002) and the Drinking Water Contaminant Report (OEPA form 5001). These reports contain sample dates and analytical results, which are compared to standards established by the OEPA. Operation of the water treatment plant is maintained by the Chemistry Department and monitored by the Environmental Compliance (EC) Unit through weekly inspections. Operational data are also reviewed for compliance with the limits set by the OEPA. As a further means of monitoring water quality, drinking water is sampled annually for pesticides, herbicides, and heavy metals (such as chromium, arsenic, mercury, lead) and quarterly for radioactivity and certain organic chemicals. The health and safety of the water treatment plant operators and other site personnel are ensured through weekly housekeeping inspection of the facility.

Clarifier Operation

The water treatment plant at Davis-Besse uses upflow clarifiers, or precipitators, to remove sediment, organic debris and dissolved agents from the raw water prior to filtration. Clarifiers combine the conventional treatment steps of coagulation, flocculation, and sedimentation into a single unit. Coagulation is the process by which a chemical, called a coagulant, is added, causing the small particles in the water to adhere to each other and form larger particles. During flocculation, the water is gently circulated, allowing these conglomerate particles to mass together further. Finally, during sedimentation, large conglomerate particles settle to the bottom of the clarifier. These processes normally require large separate tanks. However, the use of clarifiers saves both space and the manpower needed to operate the treatment plant.

The sediment removed during clarification is routed to settling basins. The sediment settles to the bottom of the basin, allowing the clear supernatant to be discharged to the lake.

The water treatment plant has two precipitators with separate chemical addition systems, allowing for operation of one or both of the units. Throughout 1991, precipitator number two was operational while precipitator number one was out of service for cleaning and maintenance.

New Drinking Water Rules

The OEPA has issued several new rules for water treatment plants utilizing surface water sources, which includes Davis-Besse. More rigid turbidity standards and additional bacteriological monitoring requirements are among those new rules which took effect in 1991.

The OEPA has also issued additional rules concerning disinfection requirements and turbidity standards which will take effect in June 1993. These additional requirements are more stringent than current rules. Some modifications to the water treatment plant will be required. For example, the new disinfection requirements may require baffling of the clearwell in order to increase the amount of time the water remains in the treatment system. Also, new continuous monitoring equipment and additional computer access to data are being considered in order to better comply with these requirements, as well as those of the future.

Wastewater Treatment Plant Operation

The wastewater treatment plant (WWTP) operation is supervised by a state certified Wastewater Operator. Wastewater generated by site personnel is treated at an onsite extended aeration package treatment facility designed to accommodate a flow of 38,000 gallons per day (gpd). This facility (Figure 7-1) consists of two units, WWTP Number 1 is a 15,000 gpd plant, and WWTP Number 2 is a 23,000 gpd plant. In the treatment process, wastewater from the various collection points around the site, called lift stations, enters the facility at the equalization chamber. This structure is simply a chamber which collects raw wastewater and distributes it to the surge tanks of the treatment plants.

The wastewater is then pumped into the aeration tanks. Here, organic materials are digested by microorganisms which must be provided with a source of oxygen. This is accomplished through the use of blowers. The mixture of organics, microorganisms, and decomposed wastes are called activated sludge. The treated wastewater settles in a clarifier, and the clear liquid (supernatant) passes over a weir, leaving the plant by an effluent trough. The activated sludge contain the organisms necessary for continued treatment, and is pumped back to the front of the plant to digest more incoming wastewater. The effluent leaving the plant is disinfected with chlorine and is pumped to the wastewater treatment basin (NPDES Outfall 601) where further reduction in solids content and in Biochemical Oxygen Demand (BOD) takes place.

Summary of 1991 Wastewater Treatment Plant Operations

WWTP Number 1 was taken out of service in early May 1989 after operators observed that the walls separating two of the plant's treatment tanks were bowing several inches. The plant was completely drained and supports were installed to alleviate this problem. The plant was also painted at that time. The plant was originally scheduled to be returned to service in 1991, but due to delays caused by the refueling outage and other activities, work was not completed until the end of 1991. Current plans are to place WWTP Number 1 back into service early in 1992. Later that year WWTP Number 2 will be removed from service for cleaning and maintenance.

The domestic water supply for the wastewater treatment facility was disrupted for most of 1991. The first time this occurred was in March when a ruptured pipe was discovered. The pipe was repaired and the domestic water supply was returned in August. The water supply was disrupted again in

October, when another ruptured water pipe was discovered. Repair to the line is currently in progress.

Biochemical Oxygen Demand (BOD) is an analytical procedure designed to determine how polluted the water is. The more organically active the wastewater is, the more oxygen it will consume. Hence, BOD measures the demand for this oxygen; the higher the BOD, the greater the treatment required. In 1991, water entering the treatment system had an average BOD of 163 mg/L, while water leaving the system averaged only 5 mg/L. This represents a total BOD reduction of 97%.

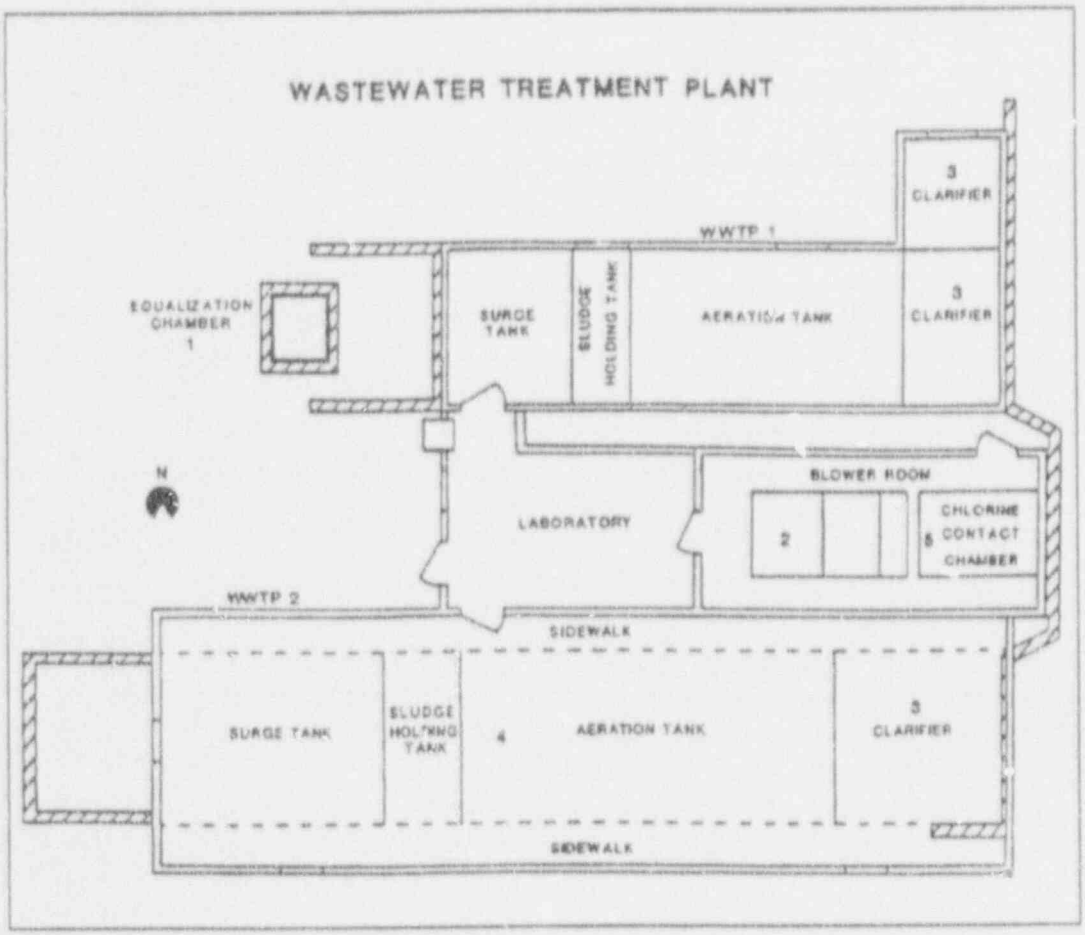


Figure 7-1: A diagram of the Wastewater Treatment Plant.

National Pollutant Discharge Elimination System (NPDES) Reporting

The OEPA has established limits on the amount of pollutants that Davis-Besse may discharge to the environment. These limits are regulated through the Station's National Pollutant Discharge Elimination System (NPDES) permit, number 2IB00011 * ED. Parameters such as chlorine, suspended solids and pH are monitored under the NPDES permit. Davis-Besse personnel prepare the NPDES Reports and submit them to the OEPA by the fifteenth day of each month.

Davis-Besse has six sampling points described in the NPDES permit. Five of these locations are discharged points, or *outfalls*, and one is a temperature monitoring location. Descriptions of these sampling points follow:

Outfall 001

Collection Box: At a point representative of discharge to Lake Erie.
Source of Wastes: Low volume wastes (Outfalls 601 and 602), circulation system blow down and occasional service water (sample collected at Davis-Besse Beach Sampling Station).

Outfall 002

Area Runoff: Discharge to Toussaint River.
Source of Wastes: Storm water runoff, turbine building drains, circulating pump house sumps (sample collected at discharge of Training Center Pond).

Outfall 003

Screenwash Catch Basin: Outfall to Navarre Marsh.
Source of Wastes: Wash debris from water intake screens (sample collected at overflow of screenwash basin).

Outfall 601

Wastewater Plant Tertiary Treatment Basin: Discharge from wastewater treatment system.
Sources of Wastes: Wastewater Treatment Facility.

Outfall 602

Low Volume Wastes: Discharge from settling basins.
Sources of Wastes: Water treatment residues, condensate polishing resins (sample collected at overflow number 2 basin),and condensate pit sumps.

Sampling Point 801

Intake Temperature: Intake water prior to cooling operation (temperature taken at the east end of the intake forebay).

1991 NPDES Summary

Outfall 001

Through conscientious operation and careful monitoring of discharges, chlorine levels at the outfall were consistently well below established limits, while pH values remained within the required range.

Outfall 002

The discharge gate was isolated from March until August due to station drainage to the pool 3 via the station storm water system. The gate was opened in late August due to high flow condition resulting from heavy rains. The discharge was again isolated at the end of October due to station drainage, but it was opened in November in preparation for the winter months.

Outfall 003

The screenwash catch basin overflow requires a single total suspended solids analysis each month and has no set limitations. No significant problems occurred at this outfall in 1991.

Outfall 601

Algae populations thrive on the nutrient-rich water in the wastewater treatment basin. Although algae play an important role in tertiary, or final clean-up, excessive numbers can adversely impact effluent quality. Algae concentrations in 1991 were surprisingly moderate. A single algicide treatment and isolation of the basin stabilized conditions. The established limits for outfall 601 were not exceeded in 1991.

ment and isolation of the basin stabilized conditions. The established limits for outfall 601 were not exceeded in 1991.

Outfall 602

The established limits for Outfall 602 were not exceeded in 1991. No significant problems occurred at this outfall.

Sampling Point 801

The intake temperature is monitored continuously. Temperature variations between intake and discharge temperatures only ranged as high as 12°F. An average difference of 6.2°F was recorded for the year.

Storm Water Monitoring

In 1991, the United States Environmental Protection Agency (USEPA) issued new requirements for storm water discharges. These requirements have been part of the NPDES program for several years, but no formal requirements for monitoring were issued until 1991.

In this new program, the USEPA requires all industries who discharge storm water to waterways of the state to monitor all such outfalls and submit applications to the USEPA for the issuance of a permit to discharge. Davis-Besse has three required discharge points which are currently being monitored. The parameters monitored vary at each discharge location according to what is expected to be discharged, but these parameters are very similar to those in the NPDES program.

Sampling of these discharge points is conducted during storm events with average duration and quantity of rain fall. Sampling consists of collecting a grab sample of water during the first thirty minutes of discharge and grab samples every twenty minutes thereafter up to four hours. All samples are combined to make a single composite sample. Flow measures are taken simultaneously with each grab samples in order to get a flow-weighted composite. Only one set of data for each discharge point is required for the permit application, but sampling may be conducted as often as time permits.

All applications must be submitted to the USEPA by November 1992. After that time, the USEPA will evaluate the information and provide additional guidance as to what is required for each industry and each discharge location on a case-by-case basis.

CHEMICAL WASTE MANAGEMENT PROGRAM

Introduction

The Chemical Waste Management Program for chemical, hazardous and non-hazardous wastes generated at the Davis-Besse Nuclear Power Station was developed to ensure wastes are managed and disposed of off site in accordance with all applicable state and federal regulations.

The Chemical Waste Management Program is regulated by the United States Environmental Protection Agency (USEPA) under the Resource Conservation and Recovery Act (RCRA); the Hazardous and Solid Waste Amendment (HSWA); the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund); the Toxic Substance Control Act (TSCA); and the Clean Air Act. The waste transported from Davis-Besse is also regulated by Ohio Department of Transportation (DOT) under the Transportation Safety Act. A brief description of these programs is provided in the following paragraphs.

Waste Management

Resource Conservation and Recovery Act

The Resource Conservation and Recovery Act (RCRA) is the federal law which regulates solid hazardous waste. Solid waste is defined as a solid, liquid, semisolid or contained gaseous material. The major goals of RCRA are to establish a hazardous waste regulatory program to protect human health and the environment and to encourage the establishment of solid waste management, resource recovery, and resource conservation systems. The intent of the hazardous waste management program is to control hazardous wastes from the time they are generated until they are properly disposed of, commonly referred to as "cradle to grave" management. Anyone who generates, transports, stores, treats or disposes of hazardous waste is subject to regulation under RCRA.

Hazardous and Solid Waste Amendment

The Hazardous and Solid Waste Amendment (HSWA) is an important addition to the RCRA. The goals of HSWA are to significantly increase federal regulation of hazardous waste management and to ban the land disposal of most hazardous wastes. In cases where it is not possible to entirely ban hazardous waste from landfills, the regulations state that the waste should be treated according to guidelines and stored or disposed of in a manner that minimizes the present and future threat to human health and the environment. This amendment also promotes the recycling, recovery, or reuse of waste by sending it to waste-to-energy facilities, distillation facilities, and fuel blending facilities. These activities would result in a reduction of waste being disposed of in our nation's dwindling landfill space. An additional HSWA goal is to minimize the generation of waste through such methods as source reduction, product substitution, technology/process modification and raw material modification.

The Davis-Besse Nuclear Power Station has been designated as a large quantity generator of hazardous waste. This limits the Station to a maximum storage period of 90 days for hazardous waste. RCRA also mandates other requirements for large quantity generators, such as the use of proper storage and shipping containers, labels, manifests, reports, personnel training, spill control plan and an accident contingency plan, all of which are part of the Chemical Management Program at Davis-Besse. In 1991, 7,533 gallons of hazardous waste were transported off site for disposal. An additional 323 gallons of non-hazardous waste were disposed of in 1991. The following are completed as part of the hazardous waste management program to ensure compliance with the RCRA regulations

- Inspections

Chemical Waste Storage and Accumulation Areas are designed throughout the site to ensure proper handling and disposal of chemical waste. The Chemical Waste Accumulation and Storage Areas are routinely patrolled by security personnel and inspected weekly by Environmental Compliance personnel. Inspection log sheets, inspection reports and maintenance work requests are completed as needed after each inspection. The log sheets and in-spection reports are retained for three years. All areas used for storage or accumulation of hazardous waste are posted as such with warning signs, and drums are color-coded for easy identification of waste categories by Davis-Besse employees. EC personnel also periodically inspect the Hazardous Waste Emergency Equipment and areas throughout the Station and site to ensure wastes are not stored in unapproved areas.

- Waste Inventory Forms

Inventory forms are placed on waste accumulation drums or pasted in the accumulation area to allow employees to record the waste type and amount as it is added to the drum. This ensures that incompatible wastes are not mixed and also identifies the drum contents for proper disposal. It also ensures that nonhazardous waste is not mixed with hazardous waste. This eliminates the possibility of unnecessarily increasing the volume and number of containers of hazardous waste and increasing disposal costs.

- Testing of Waste Oil

The majority of waste oil generated at Davis-Besse is not disposed of, but is removed to a recycling facility for thermal energy recovery. Before removal for recycling, the oil is tested to determined that it is nonhazardous. Waste oil that contains less than 1,000 parts per million of halogens and has a flash point above 140° F is considered to be nonhazardous waste. This testing minimizes waste due to the fact that the nonhazar us waste oil is recyclable. Also, disposal cost is minimized due to the lower cost of waste oil recycling than hazardous waste disposal.

- Waste Minimization

Davis-Besse reduced the volume of waste sent to disposal facilities by sending 648 pounds of hazardous waste (used solvents), 7,355 gallons of waste oil and 24 nickel-cadmium battery cells to recycling firms and fuel blenders for thermal energy recovery purposes.

Other measures in waste minimization include the return of polystyrene resins to a plastic manufacturer for reuse, drum recycling and return, and inventorying unused materials being sent to the Centerior Investment Program.

Emergency Response Planning

Comprehensive Environmental Response, Compensation and Liability Act

The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA, sometimes referred to as Superfund) established a federal authority and source of funding for responding to spills and other releases of hazardous materials, pollutants, and contaminants into the environment. Superfund establishes "reportable quantities" for several hundred hazardous material, and regulates the cleanup of abandoned hazardous waste disposal sites.

Superfund Amendment and Reauthorization Act (SARA)

Superfund was amended in October 1986 to establish new reporting programs dealing with emergency preparedness and community right-to-know laws. As part of this program, CERCLA is enhanced by ensuring that the potential for release of hazardous substances is minimized and adequate and timely responses are made to protect surrounding populations. Also, the regulation required the USEPA to develop a list of extremely hazardous substances (EHS), and to established threshold planning quantities (TPQ) for each chemical. Any facility that has these EHS at or greater than the TPQ must submit reports to the State Emergency Response Commission (SERC). The SERC will in turn provide this information to local emergency planning committees to aid in the implementation of emergency response plans.

Davis-Besse conducts site-wide inspections to identify and record all hazardous products and chemicals onsite as required by SARA. Determinations were made as to which products and chemicals were in sufficient quantities to report and, in 1991, the following list was:

- diesel fuel
- hydrazine
- lubricating (petroleum) oils
- Nalco Surecool 1332 (aqueous mixture of organophosphorous compound and acrylic polymer)
- sodium hydroxide
- sodium hypochlorite
- sulfuric acid
- unleaded gasoline

These chemicals are found onsite in quantities greater than or equal to 10,000 pounds. Two of these chemicals, hydrazine and sulfuric acid, are extremely hazardous substances (EHS and exceed the TPQ of 500 lbs). Any new chemicals found to be present in sufficient quantities to report or at threshold planning quantities prior to the next reporting year (1992), must be reported within 90 days of discovery. The TPQ is simply a limit at which certain reporting is required. This allows for the appropriate regulation and tracking of these chemicals. In 1992, the required reporting quantity was the same pound limits as in 1991. Annual SARA reports are submitted by March 1 for the preceding calendar year.

Fifty-five gallon drums containing protective equipment and spill control equipment are maintained throughout the Station at chemical storage areas and at appropriate hazardous chemical and oil use points. Equipment in the kits includes such items as waterproof coveralls, gloves, absorbent cloth, goggles, and warning signs. The spill kits are strategically placed throughout the Station and inspected on a periodic basis to allow for fast and easy response in the event of a chemical or oil spill.

Other Regulating Acts

The Toxic Substance Control Act (TSCA) was enacted to provide the USEPA with the authority to require testing of new chemical substances for potential health effects before they are introduced into the environment, and to regulate them where necessary. This law would have little impact on utilities except for the fact that one family of chemicals, polychlorinated biphenyls (PCBs), has been singled out by TSCA. This has resulted in an extensive PCB management system, very similar to the hazardous waste management system established under RCRA.

Although TSCA requires inspections every three months, the Davis-Besse PCB Program requires that PCB transformers are inspected on a weekly basis to ensure effective management of PCBs. Visual inspection of the transformers are conducted to detect leakage and avoid potential problems which may arise. In 1991, Davis-Besse continued an aggressive program of reducing the number of PCB transformers on site. There were originally eleven PCB transformers located in the Auxiliary Building, Water Treatment Plant, near Service Building Two and the Personnel Processing Facility.

In 1991, ten of these PCB transformers underwent the final retrofill cycle and were reclassified as "non-PCB". A retrofill cycle involves flushing the PCB fluid out of the transformer, refilling it with PCB-leaching solvents and allowing the solvent to circulate in the transformer during operation. The transformers are retrofilled three times with a leaching solvent and twice with silicone fluid. The entire process takes two to three years and will extract almost all of the PCBs. The transformers were tested in 1991 for PCB levels, and were less than 50 parts per million (ppm), allowing the transformers to be reclassified as non-PCB. The eleventh PCB transformer has received the final retrofill and will be analyzed for non-PCB status in 1992. In 1991, 4,708 kilograms of PCB waste were disposed of.

Clean Air Act

The Clean Air Act identifies several substances which are considered hazardous air pollutants. Of particular significance is asbestos removal from renovation and demolition projects for which USEPA has outlined specific regulations concerning handling, removal, environmental protection and disposal. Also the Occupational Safety and Health Protection Administration (OSHA) strictly regulates asbestos with a concern for worker protection. Removal teams must meet medical surveillance, respirator fit tests, and training requirements prior to removing asbestos-containing material.

In 1991, a notification letter was prepared and submitted to the EPA concerning the removal and disposal of asbestos-containing material from Davis-Besse. The Davis-Besse cooling tower was renovated and approximately 180 cubic yards of cement boards containing nonfriable asbestos were removed and replaced with non-asbestos cement boards. Asbestos is not considered an RCRA hazardous waste, but the EPA does require special handling and disposal of this waste under the Clean Air Act.

Transportation Safety Act

The transportation of hazardous chemicals, including chemical waste, is regulated by the Transportation Safety Act of 1976. These regulations are enforced by the United States Department of Transportation (DOT) and cover all aspects of transporting hazardous materials, including packing, handling, labeling, marking, and placarding. For DOT purposes, the term "hazardous material" encompasses a wide range of materials including explosives, compressed gases, poisonous materials, inhalation hazards, flammable materials, oxidizing materials, irritants, corrosive materials, radioactive materials, and hazardous wastes. Before any wastes are transported off site, Davis-Besse must ensure that the wastes are identified, labeled and marked according to DOT regulations, including verification that the vehicle has appropriate placards and it is in good operating condition.

As stated under RCRA, hazardous wastes are transported for disposal within 90 days from the date accumulation and storage began. Before shipping the waste, approval for disposal is received from the Treatment, Storage and Disposal Facility (TSDF). Prior to transportation, a Uniform Hazardous Waste Manifest is completed and signed by both the generator and the transporter. Once the transporter has delivered the waste to the designated TSDF, the TSDF signs the manifest for shipment receipt and returns the completed manifest to DB.

Other Programs

Underground Storage Tanks

According to RCRA, facilities with Underground Storage Tanks (USTs) are required to notify the State. This regulation was implemented in order to provided protection from tank contents leaking and causing damage to the environment. An UST includes the tank system and its piping which has at least 10% of its volume underground. Additional standards require leak detection systems and performance standards for new tanks. At Davis-Besse the two 40,000-gallon and one 8,000-gallon diesel fuel storage tanks, and the one 2,000-gallon waste oil tank are regulated as USTs.

Burn Permits

As required by the EPA under the Clean Air Act, burn permits for Davis-Besse were submitted for approval. The Station has a small area on site for training employees on proper fire-fighting techniques. Most instruction is on the proper use of a fire extinguisher. A burn permit is submitted every three months to remain in compliance with the Ohio EPA regulations.

Summary

Davis-Besse will continue to remain dedicated to protecting the environment and human health through the use aggressive chemical waste management practices. These practices include recycling of waste oil and batteries and thermal energy recovery for waste solvents. Also, Davis-Besse will continue training employees on the proper handling, storage and disposal of chemical waste.

Glossary

A

absorbed dose — The amount of radiation energy absorbed by any material exposed to ionizing radiation.

ALARA — Acronym for "As Low As Reasonably Achievable," a basic concept of radiation protection that specifies radioactive discharges from nuclear plants and radiation exposure to personnel be kept as far below regulatory limits as possible.

alpha particle — A positively charged particle ejected from the nuclei of some radioactive elements.

atom — The smallest portion of an element that shares the general characteristics of that element and cannot be divided or broken up by chemical means.

atomic number — The number of protons in the nucleus of an atom.

atomic weight — The number of neutrons and protons in the nucleus of an atom.

B

background radiation — The radiation in man's environment, including cosmic rays from space and radiation that exists everywhere in the air, in the earth, and in man-made materials that surround us.

beta particle	A charged particle emitted from a nucleus during radioactive decay, with a mass equal to 1/1837 that of a proton. A negatively charged beta particle is identical to an electron. A positively charged beta particle is called a positron. Beta particles are easily stopped by a thin sheet of metal, plastic, or wood.
borated water	Water containing the element boron used to cool the reactor core in the event of a Loss Of Coolant Accident. Borated water can be sprayed inside the containment building, thus protecting the Reactor Coolant System. Borated water can also be flushed into the reactor vessel. The boron in the water actually absorbs free neutrons, thus removing the catalysts required to drive the nuclear fission process.

C

calibrate	To standardize a measuring instrument by determining its deviation from a standard. The deviation determined allows one to apply a correction factor to a measured value to yield the true value.
chain reaction	A reaction that stimulates its own repetition. In a fission chain reaction, a fissionable nucleus absorbs a neutron and splits, releasing additional neutrons which perpetuate the fission reaction in the nuclei of neighboring atoms.
charged particle	An ion. An elementary particle carrying a positive or negative electric charge.
cladding	The thin-walled tube of zirconium alloy that forms the outer jacket of a fuel rod. The cladding is highly resistant to heat, corrosion and radiation, and comprises the first barrier to the release of fission products.

composite sample	A sample made of grab or continuous samples combined to represent a particular location or a set period of time.
containment vessel	A steel liner inside the concrete shield building. Designed to isolate the primary system from the environment and other systems.
continuous sample	A sample that is collected non-stop and is used to evaluate conditions over a specific period of time.
control location	A sample collection location generally more than 5 miles away from Davis-Besse. It is used to measure the normal background radiation levels.
control rod	A rod containing material such as hafnium or boron, used to control the power of a nuclear reactor. By absorbing neutrons, control rods slow down and eventually stop the fission process.
coolant	A fluid, usually water, used to cool the nuclear reactor core by transferring the heat energy emitted during the fission process into the fluid medium.
cooling tower	A heat exchanger designed to aid in the cooling of water that was used to cool exhaust steam exiting the turbines of the power plant. The cooling tower transfers exhaust heat into the air instead of into a body of water.
cosmic radiation	Penetrating ionizing radiation, both particulate and electromagnetic, that originates in space.
critical group	The segment of the population that could receive the greatest radiation dose.
critical organ	The body organ receiving a radiation dose that could result in the greatest overall effect.

critical pathway	The exposure pathway that will provide, for a given radionuclide, the greatest radiation dose to a population, or to a specific segment of the population.
curie (Ci)	The basic unit used to describe the intensity of radioactivity in a sample or material. One curie is equal to 37 billion disintegrations per second, which is approximately the rate of decay of one gram of radium. A curie is also a quantity of any radionuclide that decays at a rate of 37 billion disintegrations per second.

D

daughter products	Isotopes that are formed by the radioactive decay of other radionuclides.
decay series	A radioactive sequence which an unstable element goes through before reaching a stable state; it usually involves the loss or gain of energy and/or matter.
dike	A retaining structure designed to hold back water for flood control
dissolved solids	Solids incapable of removal through physical means, e.g., via filtration.
dose	A quantity (total or accumulated) of ionizing radiation received in tissue.
dose rate	The radiation dose delivered per unit of time. Measured, for example, in rem per hour

E

effluent	In general, a waste material, such as smoke, liquid, industrial refuse, or sewage discharged into the environment.

electromagnetic	A travelling wave motion resulting from simultaneous changes electric and magnetic fields. Familiar electromagnetic waves range from X rays and gamma rays of short wavelength, through the ultra-violet, visible, and infrared regions, to radar and radio-waves of relatively long wavelength.
electron	An elementary particle with a negative charge and a mass 1/1837 that of the proton. Electrons orbit around the positively charged nucleus and can determine the chemical property of the atom.
element	One of the 103 known chemical substances that cannot be broken down further without changing its chemical properties. Some examples include carbon, hydrogen, nitrogen, gold, lead, and uranium.
external radiation	Irradiation by a source located outside the body.

F

fission	The splitting or breaking apart of a heavy atom into two or more fragments. When a heavy atom such as uranium is split, large amounts of energy in the form of heat, radiation and one or more neutrons are released.
fission products	The nuclei (fission fragments) formed by the fission of heavy elements, plus the nuclides formed by the radioactive decay of the fragments.
fuel assembly	A cluster of fuel rods or plates. Also called a fuel element. Many fuel assemblies make up a reactor core.
fuel rod	A long, slender tube that holds fissionable material (fuel) for nuclear reactor use. Fuel rods are assembled into bundles called fuel elements or fuel assemblies, which are loaded individually into the reactor core.

G

gamma ray — High energy, short wavelength electromagnetic radiation emitted from the nucleus of a radioactive atom. Gamma radiation frequently accompanies alpha and beta emissions and always accompanies fission. Gamma rays are very penetrating but may be shielded by dense materials, such as lead or concrete. Gamma rays are similar to X rays, but are usually more energetic.

grab samples — A grab sample represents a single sample collected in a finite period of time.

H

half-life — The time in which half the atoms of a particular radioactive substance disintegrate to another nuclear form. Measured half-lives vary from millionths of a second to billions of years.

I

indicator location — A sample collection location generally within 5 miles of Davis-Besse. It is used to measure the effects of Davis-Besse on the surrounding environment.

internal radiation — Nuclear radiation resulting from radioactive substances in the body. Some examples are iodine-131 deposited in the thyroid gland, and strontium-90 and plutonium-239, deposited in bone tissue.

ion	An atom that carries a positive or negative electric charge as a result of having lost or gained one or more electrons. May also refer to a free electron, i.e., an electron that is not associated (in orbit) with a nucleus.
ionization	The process of adding or removing one ore more electrons to from atoms or molecules, thereby creating ions. High temperatures, electrical discharges, or ionizing (atomic) radiation may cause ionization.
ionizing radiation	Any radiation capable of displacing electrons from atoms or molecules, thereby producing ions.
isotope	One of two or more atoms with the same number of protons, but different numbers of neutrons in their nuclei.

J K L

lower limit of detection	The smallest amount of sample activity that will give a net count, for which there is a confidence at a predetermined level that the activity is present.

M

micro-	A prefix that divides a basic unit by one million.
milli-	A prefix that divides a basic unit by one thousand.

N

neutron	An uncharged elementary particle with a mass slightly greater than that of a proton, and found in the nucleus of every atom heavier than hydrogen-1.

noble gas	A gaseous chemical element that does not readily enter into chemical combi..ation with other elements. An inert gas such as krypton, xenon, neon or argon.
nucleus nuclei (plural)	The central, positively charged region of an atom that contains essentially all of the mass of that atom. Except for the nucleus of ordinary hydrogen, which has a single proton, all atomic nuclei contain both protons and neutrons. The number of protons determines the total positive charge, or atomic number; this is the same for all the isotopes of a given chemical element. The total number of neutrons and protons is called the mass number.
nuclide	A general term referring to all known isotopes, both stable (279) and unstable (about 5000), of the chemical elements.

O P

pico-	A prefix that divides a basic unit by one trillion.
proton	An elementary particle that carries a positive charge and has a mass of 1.67×10^{-24} gram.

Q R

quality factor	The factor by which the absorbed dose is multiplied to obtain a quantity (rem) that expresses, on a common scale the potential for biological damage to exposes persons.
rad	An acronym for "radiation absorbed dose". The basic unit of absorbed dose of radiation. One rad equals the absorption of 100 ergs (a small but measurable amount of energy) per gram of absorbing material.
radiation	The conveyance of energy through space, for example, the radiation of heat from a stove. Ionizing radiation

	is the emission of particles or gamma rays from the nucleus of an unstable (radioactive) atom as a result of radioactive decay.
radioactive contamination	Radioactive material in an undesirable location. Contamination can be loose on surfaces, fixed on surfaces (soaked or ground into the surface) or airborne.
radioactive decay	The decrease in the amount of radioactivity with the passage of time due to the spontaneous emission of particulate or electromagnetic radiation from the atom nuclei.
radioactivity	The spontaneous emission of radiation from the nucleus of an unstable isotope. Radioactivity is a process and radiation is the product.
radionuclide	A radioactive isotope of an element.
reactor trip	A sudden shutting down of a nuclear reactor, usually by rapid insertion of control rods, either automatically or manually by the reactor operator. A reactor trip is sometimes called a scram.
rem	Acronym for ("roentgen equivalent man") . The unit of dose of any ionizing radiation that produces the same biological effect as a unit of absorbed dose of x rays.
revetment	A retaining structure designed to hold back water for purposes of erosion control.
roentgen	A unit of exposure to ionizing radiation. It is that amount of gamma or x rays required to produce ions carrying one electrostatic unit of electrical charge in one cubic centimeter of dry air at standard temperature and pressure.

S

shielding	Any material or obstruction that absorbs radiation and thus tends to protect personnel or materials from the effects of ionizing radiation.

spent fuel	Nuclear reactor fuel that has been used to the extent that it can no longer effectively sustain a chain reaction.
steam generator	A piece of equipment used to transfer heat from the primary system (reactor coolant) to the secondary (steam) system without the water of the two systems actually touching.
suspended solids	Solids capable of removal through a filter such as a screen.

T

Technical Specifications (Tech Specs)	A part of the operating license for any nuclear facility insured by the Nuclear Regulatory Commission (NRC), the Tech Specs delineate the requirements the facility must meet in order to maintain its operating license.
terrestrial radiation	The portion of natural radiation (background) that is emitted by naturally occurring radioactive materials in the earth.
tritium	A radioactive isotope of hydrogen (one proton, two neutrons). Because it is chemically identical to natural hydrogen, tritium can easily be taken into the body by any ingestion path. Tritium decays by beta emission. Its radioactive half-life is about 12-1/2 years.

U V W

whole-body dose	An exposure of the body to radiation in which the entire body rather than an isolated part is irradiated.

X Y Z

X rays — Penetrating electromagnetic radiation (photon) having a wavelength that is much shorter than that of visible light. In nuclear reactions, it is customary to refer to photons originating in the nucleus as gamma rays, and to those originating in the electron field of the atom as X rays.

APPENDIX B
Interlaboratory Comparison program

Appendix B

Interlaboratory Comparison Program Results

Teledyne Isotopes Midwest Laboratory (formerly Hazleton Environmental Sciences) has participated in interlaboratory comparison (crosscheck) programs since the formulation of its quality control program in December 1971. These programs are operated by agencies which supply environmental-type samples (e.g., milk or water) containing concentrations of radionuclides known to the issuing agency but not to participant laboratories. The purpose of such a program is to provide an independent check on the laboratory's analytical procedures and to alert it to any possible problems.

Participant laboratories measure the concentration of specified radionuclides and report them to the issuing agency. Several months later, the agency reports the known values to the participant laboratories and specifies control limits. Results consistently higher or lower than the known values or outside the control limits indicate a need to check the instruments or procedures used.

The results in Table B-1 were obtained through participation in the environmental sample crosscheck program for milk, water, air filters, and food samples during the period January 1988 through November 1991. This program has been conducted by the U.S. Environmental Protection Agency Intercomparison and Calibration Section, Quality Assurance Branch, Environmental Monitoring and Support Laboratory, Las Vegas, Nevada.

The results in Table B-2 were obtained for thermoluminescent dosimeters (TLDs) during the period 1976, 1977, 1979, 1980, 1984, and 1985-86 through participation in the Second, Third, Fourth, Fifth, Seventh, and Eighth International Intercomparison of Environmental Dosimeters under the sponsorships listed in Table B-2. Also Teledyne testing results are listed.

Table B-3 lists results of the analyses on in-house spiked samples.

Table B-4 lists results of the analyses on in-house "blank" samples.

Attachment B lists acceptance criteria for "spiked" samples.

Addendum to Appendix B provides explanation for out-of-limit results.

Table B-1. U.S. Environmental Protection Agency's crosscheck program, comparison of EPA and Teledyne Isotopes Midwest Laboratory results for milk, water, air filters, and food samples, 1988 through 1991.[a]

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L[b] TIML Result ±2σ[c]	EPA Result[d] 1s, N=1	Control Limits
STW-521	Water	Jan 1988	Sr-89	27.3±5.0	30.0±5.0	21.3-38.7
			Sr-90	15.3±1.2	15.0±1.5	12.4-17.6
STW-523	Water	Jan 1988	Gr. alpha	2.3±1.2	4.0±5.0	0.0-12.7
			Gr. beta	7.7±1.2	8.0±5.0	0.0-16.7
STW-524	Food	Jan 1988	Sr-89	44.0±4.0	46.0±5.0	37.3-54.7
			Sr-90	53.0±2.0	55.0±2.8	50.2-59.8
			I-131	102.3±4.2	102.0±10.2	84.3-119.7
			Cs-137	95.7±6.4	91.0±5.0	82.3-99.7
			K	1011±158	1230±62	1124-1336
STW-525	Water	Feb 1988	Co-60	69.3±2.3	69.0±5.0	60.3-77.7
			Zn-65	99.0±3.4	94.0±9.4	77.7-110.3
			Ru-106	92.7±14.4	105.0±10.5	86.8-123.2
			Cs-134	61.7±8.0	64.0±5.0	55.3-72.7
			Cs-137	99.7±3.0	94.0±5.0	85.3-102.7
STW-526	Water	Feb 1988	H-3	3453±103	3327±362	2700-3954
STW-527	Water	Feb 1988	Uranium	3.0±0.0	3.0±6.0	0.0-13.4
STW-528	Milk	Feb 1988	I-131	4.7±1.2	4.0±0.4	3.3-4.7
STW-529	Water	Mar 1988	Ra-226	7.1±0.6	7.6±1.1	5.6-9.6
			Ra-228	NA[e]	7.7±1.2	5.7-9.7
STW-530	Water	Mar 1988	Gr. alpha	4.3±1.2	6.0±5.0	0.0-14.7
			Gr. beta	13.3±1.3	13.0±5.0	4.3-21.7
STAF-531	Air Filter	Mar 1988	Gr. alpha	21.0±2.0	20.0±5.0	11.3-28.7
			Gr. beta	48.0±0.0	50.0±5.0	41.3-58.7
			Sr-90	16.7±1.2	17.0±1.5	14.4-19.6
			Cs-137	18.7±1.3	16.0±5.0	7.3-24.7
STW-532	Water	Apr 1988	I-131	9.0±2.0	7.5±0.8	6.2-8.8

Table B 1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L[b] TIML Result ±2σ[c]	EPA Result[d] 1s, N=1	Control Limits
STW-533 534	Water (Blind)	Apr 1988				
	Sample A		Gr. alpha	ND[f]	46.0±11.0	27.0-65.0
			Ra-226	ND	6.4±1.0	4.7-8.1
			Ra-228	ND	5.6±0.8	4.2-7.0
			Uranium	6.0±6.0	6.0±6.0	0.0-16.4
	Sample B		Gr. beta	ND	57.0±5.0	48.3-65.7
			Sr-89	3.3±1.2	5.0±5.0	0.0-13.7
			Sr-90	5.3±1.2	5.0±1.5	2.4-7.6
			Co-60	63.3±1.3	50.0±5.0	41.3-58.7
			Cs-134	7.7±1.2	7.0±5.0	0.0-15.7
			Cs-137	8.3±1.2	7.0±5.0	0.0-15.7
STU-535	Urine	Apr 1988	H-3	6483±155	6202±620	5128-7276
STW-536	Water	Apr 1988	Sr-89	14.7±1.3	20.0±5.0	11.3-28.7
			Sr-90	20.0+2.0	20.0±1.5	17.4-22.6
STW-538	Water	Jun 1988	Cr-51	331.7±13.0	302.0±30.0	250.0-354.0
			Co-60	16.0±2.0	15.0±5.0	6.3-23.7
			Zn-65	107.7±11.4	101.0±10.0	83.7-118.3
			Ru-106	191.3±11.0	195.0±20.0	160.4-229.6
			Cs-134	18.3±4.6	20.0±5.0	11.3-28.7
			Cs-137	26.3±1.2	25.0±5.0	16.3-33.7
STW-539	Water	Jun 1988	H-3	5586±92	5565±557	4600-6530
STW-541	Milk	Jun 1988	Sr-89	33.7±11.4	40.0±5.0	31.3-48.7
			Sr-90	55.3±5.8	60.0±3.0	54.8-65.2
			I-131	103.7±3.1	94.0±9.0	78.4-109.6
			Cs-137	52.7±3.1	51.0±5.0	42.3-59.7
			K	1587±23	1600±80	1461-1739
STW-542	Water	Jul 1988	Gr. alpha	8.7±4.2	15.0±5.0	6.3-23.7
			Gr. beta	5.3±1.2	4.0±5.0	0.0-12.7
STF-543	Food	Jul 1988	Sr-89	ND[f]	33.0±5.0	24.3-41.7
			Sr-90	ND	34.0±2.0	30.5-37.5
			I-131	115.0±5.3	107.0±11.0	88.0-126.0
			Cs-137	52.7±6.4	49.0±5.0	40.3-57.7
			K	1190±66	1240±62	1133-1347

Table B-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L[b] TIML Result ±2σ[c]	EPA Result[d] 1s, N=1	Control Limits
STW-544	Water	Aug 1988	I-131	80.0±0.0	76.0±8.0	62.1-89.9
STW-545	Water	Aug 1988	Pu-239	11.0±0.2	10.2±1.0	8.5-11.9
STW-546	Water	Aug 1988	Uranium	6.0±0.0	6.0±6.0	0.0-16.4
STAF-547	Air Filter	Aug 1988	Gr. alpha	8.0±0.0	8.0±5.0	0.0-16.7
			Gr. beta	26.3±1.2	29.0±5.0	20.3-37.7
			Sr-90	8.0±2.0	8.0±1.5	5.4-10.6
			Cs-137	13.0±2.0	12.0±5.0	3.3-20.7
STW-548	Water	Sep 1988	Ra-226	9.3±0.5	8.4±2.6	6.2-10.6
			Ra-228	5.8±0.4	5.4±1.6	4.0-6.8
STW-549	Water	Sep 1988	Gr. alpha	7.0±2.0	8.0±5.0	0.0-16.7
			Gr. beta	11.3±1.2	10.0±5.0	1.3-18.7
STW-550	Water	Oct 1988	Cr-51	252.0±14.0	251.0±25.0	207.7-294.3
			Co-60	26.0±2.0	25.0±5.0	16.3-33.7
			Zn-65	158.3±10.2	151.0±15.0	125.0-177.0
			Ru-106	153.0±9.2	152.0±15.0	126.0-178.0
			Cs-134	28.7±5.0	25.0±5.0	16.3-33.7
			Cs-137	16.3±1.2	15.0±5.0	6.3-23.7
STW-551	Water	Oct 1988	H-3	2333±127	2316±350	1710-2927
STW-552 553	Water (Blind)	Oct 1988				
	Sample A		Gr. alpha	38.3±8.0	41.0±10.0	23.7-58.3
			Ra-226	4.5±0.5	5.0±0.8	3.6-6.4
			Ra-228	4.4±0.6	5.2±0.8	3.6-6.4
			Uranium	4.7±1.2	5.0±6.0	0.0-15.4
	Sample B		Gr. beta	51.3±3.0	54.0±5.0	45.3-62.7
			Sr-89	3.7±1.2	11.0±5.0	2.3-19.7
			Sr-90	10.7±1.2	10.0±1.5	7.4-12.6
			Cs-134	15.3±2.3	15.0±5.0	6.3-23.7
			Cs-137	16.7±1.2	15.0±5.0	6.3-23.7

Table B-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L[b] TIML Result ±2σ[c]	EPA Result[d] 1s, N=1	Control Limits
STM-554	Milk	Oct 1988	Sr-89	40.3±7.0	40.0±5.0	31.3-48.7
			Sr-90	51.0±2.0	60.0±3.0	54.8-65.2
			I-131	94.0±3.4	91.0±9.0	75.4-106.6
			Cs-137	45.0±4.0	50.0±5.0	41.3-58.7
			K	1500±45	1600±80	1461-1739
STU-555	Urine	Nov 1988	H-3	3030±209	3025±359	2403-3647
STW-556	Water	Nov 1988	Gr. alpha	9.0±3.5	9.0±5.0	0.3-17.7
			Gr. beta	9.7±1.2	9.0±5.0	0.3-17.7
STW-557	Water	Dec 1988	I-131	108.7±3.0	115.0±12.0	94.2-135.8
STW-559	Water	Jan 1989	Sr-89	40.0±8.7	40.0±5.0	31.3-48.7
			Sr-90	24.3±3.1	25.0±1.5	22.4-27.6
STW-560	Water	Jan 1989	Pu-239	5.8±1.1	4.2±0.4	3.5-4.9
STW-561	Water	Jan 1989	Gr. alpha	7.3±1.2	8.0±5.0	0.0-16.7
			Gr. beta	5.3±1.2	4.0±5.0	0.0-12.7
STW-562	Water	Feb 1989	Cr-51	245±46	235±24	193.4-276.6
			Co-60	10.0±2.0	10.0±5.0	1.3-18.7
			Zn-65	170±10	159±16	139.2-186.7
			Ru-106	181±7.6	178±18	146.8-209.2
			Cs-134	9.7±3.0	10.0±5.0	1.3-18.7
			Cs-137	11.7±1.2	10.0±5.0	1.3-18.7
STW-563	Water	Feb 1989	I-131	109.0±4.0	106.0±11.0	86.9-125.1
STW-564	Water	Feb 1989	H-3	2820±20	2754±356	2137-3371
STW-565	Water	Mar 1989	Ra-226	4.2±0.3	4.9±0.7	3.7-6.1
			Ra-228	1.9±1.0	1.7±0.3	1.2-2.2
STW-566	Water	Mar 1989	U	5.0±0.0	5.0±6.0	0.0-15.4
STAF-567	Air Filter	Mar 1989	Gr. alpha	21.7±1.2	21.0±5.0	12.3-29.7
			Gr. beta	68.3±4.2	62.0±5.0	53.3-70.7
			Sr-90	20.0±2.0	20.0±1.5	17.4-22.6
			Cs-137	21.3±1.2	20.0±5.0	11.3-28.7

Table B-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L[b] TIML Result ±2σ[c]	EPA Result[d] 1s, N=1	Control Limits
STW-568 569	Water (Blind)	Apr 1989				
	Sample A		Gr. alpha	22.7±2.3	29.0±7.0	16.9-41.2
			Ra-226	3.6±0.6	3.5±0.5	2.6-4.4
			Ra-228	2.6±1.0	3.6±0.5	2.7-4.5
			U	3.0±0.0	3.0±6.0	0.0-13.4
	Sample B		Gr. beta	52.3±6.1	57.0±5.0	43.3-65.7
			Sr-89	9.3±5.4	8.0±5.0	0.0-16.7
			Sr-90	7.0±0.0	8.0±1.5	5.4-10.6
			Cs-134	21.0±5.2	20.0±5.0	11.3-28.7
			Cs-137	23.0±2.0	20.0±5.0	11.3-28.7
STM-570	Milk	Apr 1989	Sr-89	26.0±10.0	39.0±5.0	30.3-47.7
			Sr-90	45.7±4.2	55.0±3.0	49.8-60.2
			Cs-137	54.0±6.9	50.0±5.0	41.3-58.7
			K-40	1521±208	1600±80	1461-1739
STW-571[g]	Water	May 1989	Sr-89	<0.7	6.0±5.0	0.0-14.7
			Sr-90	5.0±1.0	6.0±1.5	3.4-8.6
STW-572	Water	May 1989	Gr. alpha	24.0±2.0	30.0±8.0	16.1-43.9
			Gr. beta	49.3±15.6	50.0±5.0	41.3-58.7
STW-573	Water	Jun 1989	Ba-133	50.7±1.2	49.0±5.0	40.3-57.7
			Co-60	31.3±2.3	31.0±5.0	22.3-39.7
			Zn-65	167±10	165±17	135.6-194.4
			Ru-106	123±9.2	128±13	105.5-150.5
			Cs-134	40.3±1.2	39±5	30.3-47.7
			Cs-137	22.3±1.2	20±5	11.3-28.7
STW-574	Water	Jun 1989	H-3	4513±136	4503±450	3724-5282
STW-575	Water	Jul 1989	Ra-226	16.8±3.1	17.7±2.7	13.0-22.4
			Ra-228	13.8±3.7	18.3±2.7	13.6-23.0
STW-576	Water	Jul 1989	U	40.3±1.2	41.0±6.0	30.6±51.4
STW-577	Water	Aug 1989	I-131	84.7±5.8	83.0±8.0	69.1-96.9
STAF-579	Air Filter	Aug 1989	Gr. alpha	6.0±0.0	6.0±5.0	0.0-14.7
			Cs-137	10.3±2.3	10.0±5.0	1.3-18.7

Table B-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L[b] TIML Result ±2σ[c]	EPA Result[d] 1s, N=1	Control Limits
STW-580	Water	Sep 1989	Sr-89	14.7±1.2	14.0±5.0	5.3-22.7
			Sr-90	9.7±1.2	10.0±1.5	7.4-12.6
STW-581	Water	Sep 1989	Gr. alpha	5.0±0.0	4.0±5.0	0.0-12.7
			Gr. beta	8.7±2.3	6.0±5.0	0.0-14.7
STW-583	Water	Oct 1989	Ba-133	60.3±10.0	59.0±6.0	48.6-69.4
			Co-60	29.0±4.0	30.0±5.0	21.1-38.7
			Zn-65	132.3±6.0	129.0±13.0	106.5-151.5
			Ru-106	155.3±6.1	161.0±16.0	133.3-188.7
			Cs-134	30.7±6.1	29.0±5.0	20.3-37.7
			Cs-137	66.3±4.6	59.0±5.0	50.3±67.7
STW-584	Water	Oct 1989	H-3	3407±150	3496±364	2866±4126
STW-585 586	Water (Blind)	Oct 1989				
	Sample A		Gr. alpha	41.7±9.4	49.0±12.0	28.2-69.8
			Ra-226	7.9±0.4	8.4±1.3	6.2-10.6
			Ra-228	4.4±0.8	4.1±0.6	3.1-5.1
			U	12.0±0.0	12.0±6.0	1.6-22.4
	Sample B		Gr. beta	31.7±2.3	32.0±5.0	23.3-40.7
			Sr-89	13.3±4.2	15.0±5.0	6.3-23.7
			Sr-90	7.0±2.0	7.0±3.0	4.4-9.6
			Cs-134	5.0±0.0	5.0±5.0	0.0-13.7
			Cs-137	7.0±0.0	5.0±5.0	0.0-13.7
STW-587	Water	Nov 1989	Ra-226	7.9±0.4	8.7±1.3	6.4-11.0
			Ra-228	8.9±1.2	9.3±1.2	6.9-11.7
STW-588	Water	Nov 1989	U	15.0±0.0[g]	15.0±6.0	4.6-25.4
STW-539	Water	Jan 1990	Sr-89	22.7±5.0	25.0±5.0	16.3-33.7
			Sr-90	17.3±1.2	20.0±1.5	17.4-22.6
STW-591	Water	Jan 1990	Gr. alpha	10.3±3.0	12.0±5.0	3.3-20.7
			Gr. beta	12.3±1.2	12.0±5.0	3.3-20.7

Table B-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L[b] TIML Result ±2σ[c]	EPA Result[d] 1s, N=1	Control Limits
STW-592	Water	Jan 1990	Co-60	14.7±2.3	15±5.0	6.3-23.7
			Zn-65	135.0±6.9	139.0±14.0	114.8-163.2
			Ru-106	133.3±13.4	139.0±14.0	114.8-163.2
			Cs-134	17.3±1.2	18.0±5.0	9.3-26.7
			Cs-137	19.3±1.2	18.0±5.0	9.3-26.7
			Ba-133	78.0±0.0	74.0±7.0	61.9-86.1
STW-593	Water	Feb 1990	H-3	4827±83	4976±498	4113-5839
STW-594	Water	Mar 1990	Ra-226	5.0±0.2	4.9±0.7	4.1-5.7
			Ra-228	13.5±0.7	12.7±1.9	9.4-16.0
STW-595	Water	Mar 1990	U	4.0±0.0	4.0±5.0	0.0-14.4
STAF-596	Air Filter	Mar 1990	Gr. alpha	7.3±1.2	5.0±5.0	0.0-13.7
			Gr. beta	34.0±0.0	31.0±5.0	22.3-39.7
			Sr-90	10.0±0.0	10.0±1.5	7.4-12.6
			Cs-137	9.3±1.2	10.0±5.0	1.3-18.7
STW-597 598	Water (Blind)	Apr 1990				
	Sample A		Gr. alpha	81.0±3.5	90.0±23.0	50.1-129.9
			Ra-226	4.9±0.4	5.0±0.8	3.6-6.4
			Ra-228	10.6±0.3	10.2±1.5	7.6-12.8
			U	18.7±3.0	20.0±6.0	9.6-30.4
	Sample B		Gr. beta	51.0±10.1	52.0±5.0	43.3-60.7
			Sr-89	9.3±1.2	10.0±5.0	1.3-18.7
			Sr-90	10.3±3.1	10.0±1.5	8.3-11.7
			Cs-134	16.0±0.0	15.0±5.0	6.3-23.7
			Cs-137	19.0±2.0	15.0±5.0	6.3-23.7
STM-599	Milk	Apr 1990	Sr-89	21.7±3.1	23.0±5.0	14.3-31.7
			Sr-90	21.0±7.0	23.0±5.0	14.3-31.7
			I-131	98.7±1.2	99.0±10.0	81.7-116.3
			Cs-137	26.0±6.0	24.0±5.0	15.3-32.7
			K	1300.0±69.2	1550.0±78.0	1414.7-1685.3
STW-600	Water	May 1990	Sr-89	6.0±2.0	7.0±5.0	0.0-15.7
			Sr-90	6.7±1.2	7.0±5.0	0.0-15.7
STW-601	Water	May 1990	Gr. alpha	11.0±2.0	22.0±6.0	11.6-32.4
			Gr. beta	12.3±1.2	15.0±5.0	6.3-23.7

Table B-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L[b] TIML Result ±2σ[c]	EPA Result[d] 1s, N=1	Control Limits
STW-602	Water	Jun 1990	Co-60	25.3±2.3	24.0±5.0	15.3-32.7
			Zn-65	155.0±10.6	148.0±15.0	130.6-165.4
			Ru-106	202.7±17.2	210.0±21.0	173.6-246.4
			Cs-134	23.7±1.2	24.0±5.0	18.2-29.8
			Cs-137	27.7±3.1	25.0±5.0	16.3-33.7
			Ba-133	100.7±8.1	99.0±10.0	81.7-116.3
STW-603	Water	Jun 1990	H-3	2927±306	2933±358	2312-3554
STW-604	Water	Jul 1990	Ra-226	11.8±0.9	12.1±1.8	9.0-15.2
			Ra-228	4.1±1.4	5.1±1.3	2.8-7.4
STW-605	Water	Jul 1990	U	20.3±1.7	20.8±3.0	15.6-26.0
STW-606	Water	Aug 1990	I-131	42.0±1.2	39.0±6.0	28.6±49.4
STW-607	Water	Aug 1990	Pu-239	10.0±1.7	9.1±0.9	7.5-10.7
STAF-608	Air Filter	Aug 1990	Gr. alpha	14.0±0.0	10.0±5.0	1.3-18.7
			Gr. beta	65.3±1.2	62.0±5.0	53.3-70.7
			Sr-90	19.0±6.9	20.0±5.0	11.3-28.7
			Cs-137	19.0±2.0	20.0±5.0	11.3-28.7
STW-609	Water	Sep 1990	Sr-89	9.0±2.0	10.0±5.0	1.3-18.7
			Sr-90	9.0±2.0	9.0±5.0	0.3-17.7
STW-610	Water	Sep 1990	Gr. alpha	8.3±1.2	10.0±5.0	1.3-18.7
			Gr. beta	10.3±1.2	10.0±5.0	1.3-18.7
STM-611	Milk	Sep 1990	Sr-89	11.7±3.1	16.0±5.0	7.3-24.7
			Sr-90	15.0±0.0	20.0±5.0	11.3-28.7
			I-131	63.0±6.0	58.0±6.0	47.6-68.4
			Cs-137	20.0±2.0	20.0±5.0	11.3-28.7
			K	1673.3±70.2	1700.0±85.0	1552.5-1847.5
STW-612	Water	Oct 1990	Co-60	20.3±3.1	20.0±5.0	11.3-28.7
			Zn-65	115.3±12.2	115.0±12.0	94.2-135.8
			Ru-106	152.0±8.0	151.0±15.0	125.0-177.0
			Cs-134	11.0±0.0	12.0±5.0	3.3-20.7
			Cs-137	14.0±2.0	12.0±5.0	3.3-20.7
			Ba-133	116.7±9.9	110.0±11.0	90.9-129.
STW-613	Water	Oct 1990	H-3	7167±330	7203±720	5954-8452

Table B-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L[b] TIML Result ±2σ[c]	EPA Result[d] 1s, N=1	Control Limits
STW-614 615	Water	Oct 1990				
	Sample A		Gr. alpha	68.7±7.2	62.0±16.0	34.2-89.8
			Ra-226	12.9±0.3	13.6±2.0	10.1-17.1
			Ra-228	4.2±0.6	5.0±1.3	2.7-7.3
			U	10.4±0.6	10.2±3.0	5.0-15.4
	Sample B		Gr. beta	55.0±8.7	53.0±5.0	44.3-61.7
			Sr-89	15.7±2.9	20.0±5.0	11.3-28.7
			Sr-90	12.0±2.0	15.0±5.0	6.3-23.7
			Cs-134	9.0±1.7	7.0±5.0	0.0-15.7
			Cs-137	7.7±1.2	5.0±5.0	0.0-13.7
STW-616	Water	Nov 1990	Ra-226	6.8±1.0	7.4±1.1	5.5-9.3
			Ra-228	5.3±1.7	7.7±1.9	4.4-11.0
STW-617g	Water	Nov 1990	U	35.0±0.4	35.5±3.6	29.3±41.7
STW-618	Water	Jan 1991	Sr-89	4.3±1.2	5.0±5.0	0.0 -13.7
			Sr-90	4.7±1.2	5.0±5.0	0.0-13.7
STW-619	Water	Jan 1991	Pu-239	3.6±0.2	3.3±0.3	2.8-3.8
STW-620	Water	Jan 1991	Gr. alpha	6.7±3.0	5.0±5.0	0.0-13.7
			Gr. beta	6.3±1.2	5.0±5.0	0.0-13.7
STW-621	Water	Feb 1991	Co-60	41.3±8.4	40.0±5.0	31.3-48.7
			Zn-65	166.7±19.7	149.0±15.0	123.0-175.0
			Ru-106	209.7±18.6	186.0±19.0	153.0-219.0
			Cs-134	5.0±2.0	8.0±5.0	0.0-16.7
			Cs-137	9.7±1.2	8.0±5.0	0.0-16.7
			Ba-133	85.7±9.2	75.0±8.0	61.1-88.9
STW-622	Water	Feb 1991	I-131	81.3±6.1	75.0±8.0	61.1-88.9
STW-623	Water	Feb 1991	H-3	4310.0±144.2	4418.0±442.0	3651.2-5184.8
STW-624	Water	Mar 1991	Ra-226	31.4±3.2	31.8±4.8	23.5-40.1
			Ra-228	ND[h]	21.1±5.3	11.9-30.3
STW-625	Water	Mar 1991	U	6.7±0.4	7.6±3.0	2.4-12.8

Table B-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L[b] TIML Result 2σ[c]	EPA Result[d] 1s, N=1	Control Limits
STAF-626	Filter	Mar 1991	Gr. alpha	38.7±1.2	25.0±6.0	14.6-35.4
			Gr. beta	130.0±4.0	124.0±6.0	113.6-134.4
			Sr-90	35.7±1.2	40.0±5.0	31.3-48.7
			Cs-137	33.7±4.2	40.0±5.0	31.3-48.7
STW-627 623	Water	Apr 1991				
	Sample A		Gr. alpha	51.0±6.0	54.0±14.0	29.7-78.3
			Ra-226	7.0±0.8	8.0±1.2	5.9-10.1
			Ra-228	9.7±1.9	15.2±3.8	8.6-21.8
			U	27.7±2.4	29.8±3.0	24.6-35.0
	Sample B		Gr. beta	93.3±6.4	115.0±17.0	85.5-144.5
			Sr-89	21.0±3.5	28.0±5.0	19.3-36.7
			Sr-90	23.0±0.0	26.0±5.0	17.3-34.7
			Cs-134	27.3±3.2	24.0±5.0	15.3-32.7
			Cs-137	29.0±2.0	25.0±5.0	16.3-33.7
STM-629	Milk	Apr 1991	Sr-89	27.0±8.7	32.0±5.0	23.3-40.7
			Sr-90	28.0±2.0	32.0±5.0	23.3-40.7
			I-131	65.3±14.7	60.0±6.0	49.6-70.4
			Cs-137	54.7±11.0	49.0±5.0	40.3-57.7
			K	1591.7±180.1	1650.0±83.0	1506.0-1794.0
STW-630	Water	May 1991	Sr-89	40.7±2.3	39.0±5.0	30.3-47.7
			Sr-90	23.7±1.2	24.0±5.0	15.3-32.7
STW-631	Water	May 1991	Gr. alpha	27.7±5.8	24.0±6.0	13.6-34.4
			Gr. beta	46.0±0.0	46.0±5.0	37.3-54.7
STW-632	Water	Jun 1991	Co-60	11.3±1.2	10.0±5.0	1.3-18.7
			Zn-65	119.3±16.3	108.0±11.0	88.9-127.1
			Ru-106	162.3±19.0	149.0±15.0	123.0-175.0
			Cs-134	15.3±1.2	15.0±5.0	6.3-23.7
			Cs-137	16.3±1.2	14.0±5.0	5.3-22.7
			Ba-133	74.0±6.9	62.0±6.0	51.6-72.4
STW-633	Water	Jun 1991	H-3	13470.0±385.8	12480.0±1248.0	10314.8-14645.2
STW-634	Water	Jul 1991	Ra-226	14.9±0.4	15.9±2.4	11.7-20.1
			Ra-228	17.6±1.8	16.7±4.2	9.4-24.0

Table B-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L[b] TIML Result ±2σ[c]	EPA Result[d] 1s, N=1	Control Limits
STW-635	Water	Jul 1991	U	12.8±0.1	14.2±3.0	9.0-19.4
STW-636	Water	Aug 1991	I-131	19.3±1.2	20.0±6.0	9.6-30.4
STW-637	Water	Aug 1991	Pu-239	21.4±0.5	19.4±1.9	16.1-22.7
STW-638	Filter	Aug 1991	Gr. alpha	33.0±2.0	25.0±6.0	14.6-35.4
			Gr. beta	88.7±1.2	92.0±10.0	80.4-103.6
			Sr-90	27.0±4.0	30.0±5.0	21.3-38.7
			[illegible]	26.3±1.2	30.0±5.0	21.3-38.7
STW-639	Water	Sep 1991	Sr-89	47.0±10.4	49.0±5.0	40.3-57.7
			Sr-90	24.0±2.0	25.0±5.0	16.3-33.7
STW-640	Water	Sep 1991	Gr. alpha	12.0±4.0	10.0±5.0	1.3-18.7
			Gr. beta	20.3±1.2	20.0±5.0	11.3-28.7
STM-641	Milk	Sep 1991	Sr-89	20.3±5.0	25.0±5.0	16.3-33.7
			Sr-90	19.7±3.1	25.0±5.0	16.3-33.7
			I-131	130.7±16.8	108.0±11.0	88.9-127.1
			Cs-137	33.7±3.2	30.0±5.0	21.3-38.7
			K	1743.3±340.8	1740.0±87.0	1589.1-1890.9
STW-642	Water	Oct 1991	Co-60	29.7±1.2	29.0±5.0	20.3-37.7
			Zn-65	75.7±8.3	73.0±7.0	60.9-85.1
			Ru-106	196.3±15.1	199.0±20.0	164.3-233.7
			Cs-134	9.7±1.2	10.0±5.0	1.3-18.7
			Cs-137	11.0±2.0	10.0±5.0	1.3-18.7
			Ba-133	94.7±3.1	98.0±10.0	80.7-115.3
STW-643	Water	Oct 1991	H-3	2640.0±156.2	2454.0±352.0	1843.3-3064.7
STW-644 645	Water Sample A	Oct 1991	Gr. alpha	73.0±13.1	82.0±21.0	45.6-118.4
			Ra-226	20.9±2.0	22.0±3.3	16.3-27.7
			Ra-228	19.6±2.3	22.2±5.6	12.5-31.9
			U	13.5±0.6	13.5±3.0	8.3-18.7
	Sample B		Gr. beta	55.3±3.1	65.0±10.0	47.7-82.3
			Sr-89	9.7±3.1	10.0±5.0	1.3-18.7
			Sr-90	8.7±1.2	10.0±5.0	1.3-18.7
			Co-60	20.3±1.2	20.0±5.0	11.3-28.7
			Cs-134	9.0±5.3	10.0±5.0	1.3-18.7
			Cs-137	14.7±5.0	11.0±5.0	2.3-19.7

Table B-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L[b] TIML Result ±2σ[c]	EPA Result[d] 1s, N=1	Control Limits
STW-646	Water	Nov 1991	Ra-226	5.6±1.2	6.5±1.0	4.8-8.2
			Ra-228	9.6±0.5	8.1±2.0	4.6-11.6
STW-647	Water	Nov 1991	U	24.7±2.3	24.9±3.0	19.7-30.1

[a] Results obtained by Teledyne Isotopes Midwest Laboratory as a participant in the environmental sample crosscheck program operated by the Intercomparison and Calibration Section, Quality Assurance Branch, Environmental Monitoring and Support Laboratory, U.S. Environmental Protection Agency (EPA), Las Vegas, Nevada.

[b] All results are in pCi/l, except for elemental potassium (K) data in milk, which are in mg/l; air filter samples, which are in pCi/filter; and food, which is in mg/kg.

[c] Unless otherwise indicated, the TIML results are given as the mean ± 2 standard deviations for three determinations.

[d] USEPA results are presented as the known values and expected laboratory precision (1s, 1 determination) and control limits as defined by EPA.

[e] NA = Not analyzed.

[f] ND = No data; not analyzed due to relocation of lab.

[g] Sample was analyzed but the results not submitted to EPA because deadline was missed (all data on file).

[h] ND = No data; sample lost during analyses.

Table B-2. Crosscheck program results, thermoluminescent dosimeters (TLDs).

Lab Code	TLD Type	Measurement ±2σ[a]	mR		
			Teledyne Result Value[c]	Known	Average ±2σ[d] All Participants)
2nd International Intercomparison[b]					
115-2	CaF_2:Mn Bulb	Field	17.0±1.9	17.1	16.4±7.7
		Lab	20.8±4.1	21.3	18.8±7.6
3rd International Intercomparison[e]					
115-3	CaF_2:Mn Bulb	Field	30.7±3.2	34.9±4.8	31.5±3.0
		Lab	89.6±6.4	91.7±14.6	86.2±24.0
4th International Intercomparison[f]					
115-4	CaF_2:Mn Bulb	Field	14.1±1.1	14.1±1.4	16.0±9.0
		Lab (Low)	9.3±1.3	12.2±2.4	12.0±7.4
		Lab (High)	40.4±1.4	45.8±9.2	43.9±13.2
5th International Intercomparison[g]					
115-5A	CaF_2:Mn Bulb	Field	31.4±1.8	30.0±6.0	30.2±14.6
		Lab at beginning	77.4±5.8	75.2±7.6	75.8±40.4
		Lab at the end	96.6±5.8	88.4±8.8	90.7±31.2
115-5B	LiF-100 Chips	Field	30.3±4.8	30.0±6.0	30.2±14.6
		Field at beginning	81.1±7.4	75.2±7.6	75.8±40.4
		Lab at the end	85.4±11.7	88.4±8.8	90.7±31.2
7th International Comparison[h]					
115-7A	LiF-100 Chips	Field	75.4±2.6	75.8±6.0	75.1±29.8
		Lab (Co-60)	80.0±3.5	79.9±4.0	77.9±27.6
		Lab (Cs-137)	66.6±2.5	75.0±3.8	73.0±22.2

Table B-2. Crosscheck program results, thermoluminescent dosimeters (TLDs).

Lab Code	TLD Type	Measurement ±2σ[a]	mR		
			Teledyne Result Value[c]	Known	Average ±2σ[d] (All Participants)
115-7B	CaF_2:Mn Bulbs	Field	71.5±2.6	75.8±6.0	75.1±29.8
		Lab (Co-60)	84.8±6.4	79.9±4.0	77.9±27.6
		Lab (Cs-137)	78.8±1.6	75.0±3.8	73.0±22.2
115-7C	$CaSO_4$:Dy Cards	Field	76.8±2.7	75.8±6.0	75.1±29.8
		Lab (Co-60)	82.5±3.7	79.9±4.0	77.9±27.6
		Lab (Cs-137)	79.0±3.2	75.0±3.8	73.0±22.2
8th International Intercomparison[i]					
115-8A	LiF-100 Chips	Field Site 1	29.5±1.4	29.7±1.5	28.9±12.4
		Field Site 2	11.3±0.8	10.4±0.5	10.1±9.06
		Lab (Cs-137)	13.7±0.9	17.2±0.9	16.2±6.8
115-8B	CaF_2:Mn Bulbs	Field Site 1	32.3±1.2	29.7±1.5	28.9±12.4
		Field Site 2	9.0±1.0	10.4±0.5	10.1±9.0
		Lab (Cs-137)	15.8±0.9	17.2±0.9	16.2±6.8
115-8C	$CaSO_4$:Dy Cards	Field Site 1	32.2±0.7	29.7±1.5	28.9±12.4
		Field Site 2	10.6±0.6	10.4±0.5	10.1±9.0
		Lab (Cs-137)	18.1±0.8	17.2±0.9	16.2±6.8
Teledyne Testing[j]					
89-1	LiF-100 Chips	Lab	21.0±0.4	22.4	–
89-2	Teledyne $CaSO_4$:Dy Cards	Lab	20.9±1.0	20.3	–

Table B-2. (continued)

Lab Code	TLD Type	Measurement ±2σ[a]	mR		
			Teledyne Result Value[c]	Known	Average ±2σ[d] (All Participants)
Teledyne Testing[j]					
90-1[k]	Teledyne $CaSO_4$:Dy Cards	Lab	20.6±1.4	19.6	–
90-1[l]	Teledyne $CaSO_4$:Dy Cards	Lab	100.8±4.3	100.0	–
91-1[m]	Teledyne $CaSO_4$:Dy Cards	Lab	33.4±2.0	32.0	–
			55.2±4.7	58.8	–
			87.8±6.2	85.5	–

[a] Lab result given is the mean ±2 standard deviations of three determinations.

[b] Second International Intercomparison of Environmental Dosimeters conducted in April of 1976 by the Health and Safety Laboratory (HASL), New York, New York, and the School of Public Health of the University of Texas, Houston, Texas.

[c] Value determined by sponsor of the intercomparison using continuously operated pressurized ion chamber.

[d] Mean ±2 standard deviations of results obtained by all laboratories participating in the program.

[e] Third International Intercomparison of Environmental Dosimeters conducted in summer of 1977 by Oak Ridge National Laboratory and the School of Public Health of the University of Texas, Houston, Texas.

[f] Fourth International Intercomparison of Environmental Dosimeters conducted in summer of 1979 by the School of Public Health of the University of Texas Houston, Texas.

[g] Fifth International Intercomparison of Environmental Dosimeters conducted in fall of 1980 at Idaho Falls, Idaho and sponsored by the School of Public Health of the University of Texas, Houston, Texas and Environmental Measurements Laboratory, New York, New York, U.S. Department of Energy.

[h] Seventh International Intercomparison of Environmental Dosimeters conducted in the spring and summer of 1984 at Las Vegas, Nevada, and sponsored by the U.S. Department of Energy, The U.S. Nuclear Regulatory Commission, and the U.S. Environmental Protection Agency.

[i] Eighth International Intercomparison of Environmental Dosimeters conducted in the fall and winter of 1985-1986 at New York, New York, and sponsored by the U.S. Department of Energy.

[j] Chips were submitted in September 1989 and cards were submitted in November 1989 to Teledyne Isotopes, Inc., Westwood, NJ for irradiation.

[k] Cards were irradiated by Teledyne Isotopes, Inc., Westwood, NJ on June 19, 1990.

[l] Cards were irradiated by Dosimetry Associates, Inc., Northville, MI on October 30, 1990.

[m] Irradiated cards were provided by Teledyne Isotopes, INC., Westwood, NJ. Irradiated on October 8, 1991.

Table B-3. In-house spiked samples.

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L TIML Result n=1	Known Activity	Expected Precision 1s, n=1[a]
QC-MI-16	Milk	Feb 1988	Sr-89	31.8±4.7	31.7±6.0	8.7
			Sr-90	25.5±2.7	27.8±3.5	5.2
			I-131	26.4±0.5	23.2±5.0	10.4
			Cs-134	23.8±2.3	24.2±6.0	8.7
			Cs-137	26.5±0.8	25.1±6.0	8.7
QC-MI-17	Milk	Feb 1988	I-131	10.6±1.2	14.3±1.6	10.4
QC-W-35	Water	Feb 1988	I-131	9.7±1.1	11.6±1.1	10.4
QC-W-36	Water	Mar 1988	I-131	10.5±1.3	11.6±1.0	10.4
QC-W-37	Water	Mar 1988	Sr-89	17.1±2.0	19.8±8.0	8.7
			Sr-90	18.7±0.9	17.3±5.0	5.2
QC-MI-18	Milk	Mar 1988	I-131	33.2±2.3	26.7±5.0	10.4
			Cs-134	31.3±2.1	30.2±5.0	8.7
			Cs-137	29.9±1.4	2[illegible]2±5.0	8.7
QC-W-38	Water	Apr 1988	I-131	17.1±1.1	14.2±5.0	10.4
QC-W-39	Water	Apr 1988	H-3	4439±31	4176±500	724
QC-W-40	Water	Apr 1988	Co-60	23.7±0.5	26.1±4.0	8.7
			Cs-134	25.4±2.6	29.2±4.5	8.7
			Cs-137	26.6±2.3	26.2±4.0	8.7
QC-W-41	Water	Jun 1988	Gr. alpha	12.3±0.4	13.1±5.0	8.7
			Gr. beta	22.6±1.0	20.1±5.0	8.7
QC-MI-19	Milk	Jul 1988	Sr-89	15.1±1.6	16.4±5.0	8.7
			Sr-90	18.0±0.6	18.3±5.0	5.2
			I-131	88.4±4.9	86.6±8.0	10.4
			Cs-137	22.7±0.8	20.8±6.0	8.7
QC-W-42	Water	Sep 1988	Sr-89	48.5±3.3	50.8±8.0	8.7
			Sr-90	10.9±1.0	11.4±3.5	5.2
QC-W-43	Water	Oct 1988	Co-60	20.9±3.2	21.4±3.5	8.7
			Cs-134	38.7±1.6	38.0±6.0	8.7
			Cs-137	19.0±2.4	21.0±3.5	8.7
QC-W-44	Water	Oct 1988	I-131	22.2±0.6	23.3±3.5	10.4

Table B-3. In-house spiked samples(continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L TIML Result n=1	Known Activity	Expected Precision 1s, n=1[a]
QC-W-45	Water	Oct 1988	H-3	4109±43	4153±500	724
QC-MI-20	Milk	Oct 1988	I-131	59.8±0.9	60.6±9.0	10.4
			Cs-134	49.6±1.8	48.6±7.5	8.7
			Cs-137	25.8±4.6	24.7±4.0	8.7
QC-W-46	Water	Dec 1988	Gr. alpha	11.5±2.3	15.2±5.0	8.7
			Gr. beta	26.5±2.0	25.7±5.0	8.7
QC-MI-21	Milk	Jan 1989	Sr-89	25.5±10.3	34.0±10.0	8.7
			Sr-90	28.2±3.2	27.1±3.0	5.2
			I-131	540±13	550±20	10.4
			Cs-134	24.5±2.6	22.6±5.5	8.7
			Cs-137	24.0±0.6	20.5±5.0	8.7
QC-W-47	Water	Mar 1989	Sr-89	15.2±3.8	16.1±5.0	8.7
			Sr-90	16.4±1.7	16.9±3.0	5.2
QC-MI-22	Milk	Apr 1989	I-131	36.3±1.1	37.2±5.0	10.4
			Cs-134	20.8±2.8	20.7±8.0	8.7
			Cs-137	22.2±2.4	20.4±8.0	8.7
QC-V	Water	Apr 1989	Co-60	23.5±2.0	25.1±8.0	8.7
			Cs-134	24.2±1.1	25.9±8.0	8.7
			Cs-137	23.6±1.2	23.0±8.0	8.7
QC-W-49	Water	Apr 1989	I-131	37.2±3.7	37.2±5.0	10.4
QC-W-50	Water	Apr 1989	H-3	3011±59	3089±500	724
QC-W-51	Water	Jun 1989	Gr. alpha	13.0±1.8	15.0±5.0	8.7
			Gr. beta	26.0±1.2	25.5±8.0	8.7
QC-MI-23	Milk	Jul 1989	Sr-89	19.4±6.5	22.0±10.0	8.7
			Sr-90	27.6±3.5	28.6±3.0	5.2
			I-131	46.8±3.2	43.4±5.0	10.4
			Cs-134	27.4±1.8	28.3±6.0	8.7
			Cs-137	24.1±1.8	20.8±6.0	8.7
QC-MI-24	Milk	Aug 1989	Sr-89	25.4±2.7	27.2±10.0	8.7
			Sr-90	46.0±1.1	47.8±9.6	8.3
QC-W-52	Water	Sep 1989	I-131	9.6±0.3	9.7±1.9	10.4

Table B-3. In-house spiked samples (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L TIML Result n=1	Known Activity	Expected Precision 1s, n=1[a]
QC-W-53	Water	Sep 1989	I-131	19.0±0.2	20.9±4.2	10.4
QC-W-54	Water	Sep 1989	Sr-89	25.8±4.6	24.7±4.0	8.7
			Sr-90	26.5±5.3	29.7±5.0	5.2
QC-MI-25	Milk	Oct 1989	I-131	70.0±3.3	73.5±20.0	10.4
			Cs-134	22.1±2.6	22.6±8.0	8.7
			Cs-137	29.4±1.5	27.5±8.0	8.7
QC-W-55	Water	Oct 1989	I-131	33.3±1.3	35.3±10.0	10.4
QC-W-56	Water	Oct 1989	Co-60	15.2±0.9	17.4±5.0	8.7
			Cs-134	22.1±4.4	18.9±8.0	8.7
			Cs-137	27.2±1.2	22.9±8.0	8.7
QC-W-57	Water	Oct 1989	H-3	3334±22	3379±500	724
QC-W-58	Water	Nov 1989	Sr-89	10.9±1.4[d]	11.1±1.0[d]	8.7
			Sr-90	10.4±1.0[d]	10.3±1.0[d]	5.2
QC-W-59	Water	Nov 1989	Sr-89	101.0±6.0[d]	104.1±10.5[d]	17.5
			Sr-90	98.0±3.0[d]	95.0±10.0[d]	17.0
QC-W-60	Water	Dec 1989	Gr. alpha	10.8±1.1	10.6±4.0	8.7
			Gr. beta	11.6±0.5	11.4±4.0	8.7
QC-MI-26	Milk	Jan 1990	Cs-134	19.3±1.0	20.8±8.0	8.7
			Cs-137	25.2±1.2	22.8±8.0	8.7
QC-MI-27	Milk	Feb 1990	Sr-90	18.0±1.6	18.8±5.0	5.2
QC-MI-28	Milk	Mar 1990	I-131	63.8±2.2	62.6±6.0	6.3
QC-MI-61	Water	Apr 1990	Sr-89	17.9±5.5	23.1±8.7	8.7
			Sr-90	19.4±2.5	23.5±5.2	5.2
QC-MI-29	Milk	Apr 1990	I-131	90.7±9.2	82.5±8.5	10.4
			Cs-134	18.3±1.0	19.7±5.0	8.7
			Cs-137	20.3±1.0	18.2±5.0	8.7
QC-W-62	Water	Apr 1990	Co-60	8.7±0.4	9.4±5.0	8.7
			Cs-134	20.0±0.2	19.7±5.0	8.7
			Cs-137	28.7±1.4	22.7±5.0	8.7

Table B-3. In-house spiked samples (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L TIML Result n=1	Known Activity	Expected Precision 1s, n=1[a]
QC-W-63	Water	Apr 1990	I-131	63.5±8.0	66.0±6.7	6.6
QC-W-64	Water	Apr 1990	H-3	1941±130	1826.0±350.0	724
QC-W-65	Water	Jun 1990	Ra-226	6.4±0.2	6.9±1.0	1.0
QC-W-66	Water	Jun 1990	U	6.2±0.2	6.0±6.0	6.0
QC-MI-30	Milk	Jul 1990	Sr-89	12.8±0.4	18.4±10.0	8.7
			Sr-90	18.2±1.4	18.7±6.0	5.2
			Cs-134	46.0±1.3	49.0±5.0	8.7
			Cs-137	27.6±1.3	25.3±5.0	8.7
QC-W-68	Water	Jun 1990	Gr. alpha	9.8±0.3	10.6±5.0	8.7
			Gr. beta	11.4±0.6	11.3±7.0	8.7
QC-MI-31	Milk	Aug 1990	I-131	68.8±1.6	61.4±12.3	10.4
QC-W-69	Water	Sep 1990	Sr-89	17.7±1.6	19.2±10.0	8.7
			Sr-90	13.9±1.6	17.4±10.0	5.2
QC-MI-32	Milk	Oct 1990	I-131	34.8±0.2	32.4±6.5	8.7
			Cs-134	25.8±1.2	27.3±10.0	8.7
			Cs-137	25.3±2.0	22.4±10.0	8.7
QC-W-70	Water	Oct 1990	H-3	2355±59	2276±455	605
QC-W-71	Water	Oct 1990	I-131	55.9±0.9	51.8±10.4	10.4
QC-W-73	Water	Oct 1990	Co-60	18.3±2.7	16.8±5.0	8.7
			Cs-134	28.3±2.3	27.0±5.0	8.7
			Cs-137	22.7±1.3	22.4±5.0	8.7
QC-W-74	Water	Dec 1990	Gr. alpha	21.4±1.0	26.1±6.5	11.3
			Gr. beta	25.9±1.0	22.3±5.6	9.7
QC-MI-33	Milk	Jan 1991	Sr-89	20.7±3.3	21.6±5.0	5.0
			Sr-90	19.0±1.4	23.0±3.0	3.0
			Cs-134	22.2±1.7	19.6±5.0	5.0
			Cs-137	26.1±1.6	22.3±5.0	5.0
QC-MI-34	Milk	Feb 1991	I-131	40.7±1.8	40.1±6.0	6.0
QC-W-75	Water	Mar 1991	Sr-89	18.8±1.5	23.3±5.0	5.0
			Sr-90	16.0±0.8	17.2±3.0	3.0

Table B-3. In-house spiked samples (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L TIML Result n=1	Known Activity	Expected Precision 1s, n=1 [a]
QC-W-76	Water	Apr 1991	I-131	56.5±1.7	59.0±5.9	5.9
QC-W-77	Water	Apr 1991	Co-60	16.4±2.2	15.7±5.0	5.0
			Cs-134	23.8±2.5	22.6±5.0	5.0
			Cs-137	25.0±2.4	21.1±5.0	5.0
QC-W-78	Water	Apr 1991	H-3	4027±188	4080±408	408
QC-MI-35	Milk	Apr 1991	I-131	48.0±0.8	49.2±6.0	6.0
			Cs-134	19.2±2.0	22.6±5.0	5.0
			Cs-137	22.8±2.2	22.1±5.0	5.0
QC-W-79	Water	Jun 1991	Gr. alpha	7.4±0.7	7.8±5.0	5.0
			Gr. beta	11.0±0.7	11.0±5.0	5.0
QC-MI-36	Milk	Jul 1991	Sr-89	28.1±2.1	34.0±10.0	10.0
			Sr-90	11.6±0.7	11.5±3.0	3.0
			I-131	14.4±1.9	18.3±5.0	5.0
			Cs-137	34.3±3.0	35.1±5.0	5.0
QC-W-80	Water	Oct 1991	Sr-89	27.4±6.9	24.4±5.0	5.0
			Sr-90	11.7±1.4	14.1±5.0	5.0
QC-W-81	Water	Oct 1991	I-131	19.1±0.7	20.6±4.2	4.2
QC-W-82	Water	Oct 1991	Co-60	22.6±2.7	22.1±5.0	5.0
			Cs-134	15.5±1.8	17.6±5.0	5.0
			Cs-137	17.5±2.1	17.6±5.0	5.0
QC-W-83	Water	Oct 1991	H-3	4639±137	4382±438	438
QC-MI-37	Milk	Oct 1991	I-131	23.6±3.2	25.8±5.0	5.0
			Cs-134	22.7±2.8	22.1±5.0	5.0
			Cs-137	38.3±3.0	35.1±5.0	5.0
QC-W-84	Water	Dec 1991	Gr. alpha	6.2±0.6	7.8±5.0	5.0
			Gr. beta	11.0±0.7	11.0±5.0	5.0

[a] n=3 unless noted otherwise.
[b] n=2 unless noted otherwise.
[c] n=1 unless noted otherwise.
[d] Concentration in pCi/ml.

Table B-4. In-house "blank" samples.

Lab Code	Sample Type	Date Collected	Analysis	Concentration (pCi/L) Results (4.66 σ)	Concentration (pCi/L) Acceptance Criteria (4.66 σ)
SPS-5386	Milk	Jan 1988	I-131	<0.1	<1
SPW-5448	"Dead" Water	Jan 1988	H-3	<177	<300
SPS-5615	Milk	Mar 1988	Cs-134	<2.4	<10
			Cs-137	<2.5	<10
			I-131	<0.3	<1
			Sr-89	<0.4	<5
			Sr-90	2.4±0.5[a]	<1
SPS-5650	D.I. Water	Mar 1988	Th-228	<0.3	<1
			Th-230	<0.04	<1
			Th-232	<0.05	<1
			U-234	<0.03	<1
			U-235	<0.03	<1
			U-238	<0.03	<1
			Am-241	<0.06	<1
			Cm-241	<0.01	<1
			Pu-238	<0.08	<1
			Pu-240	<0.02	<1
SPS-6090	Milk	Jul 1988	Sr-89	<0.5	<1
			Sr-90	1.8±0.5	<1
			I-131	<0.4	<1
			Cs-137	<0.4	<10
SPW-6209	Water	Jul 1988	Fe-55	<0.8	<1
SPW-6292	Water	Sep 1988	Sr-89	<0.7	<1
			Sr-90	<0.7	<1
SPS-6477	Milk	Oct 1988	I-131	<0.2	<1
			Cs-134	<6.1	<10
			Cs-137	<5.9	<10
SPW-6478	Water	Oct 1988	I-131	<0.2	<1
SPW-6479	Water	Oct 1988	Co-60	<5.7	<10
			Cs-134	<3.7	<10
			Cs-137	<4.3	<10
SPW-6480	Water	Oct 1988	H-3	<170	<300

Table B-4. In-house "blank" samples (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration (pCi/L) Results (4.66 σ)	Acceptance Criteria (4.66 σ)
SPW-6625	Water	Dec 1988	Gr. alpha	<0.7	<1
			Gr. beta	<1.9	<4
SPS-6723	Milk	Jan 1989	Sr-89	<0.6	<5
			Sr-90	1.9±0.5[a]	<1
			I-131	<0.2	<1
			Cs-134	<4.3	<10
			Cs-137	<4.1	<10
SPW-6877	Water	Mar 1989	Sr-89	<0.4	<5
			Sr-90	<0.6	<1
SPS-6963	Milk	Apr 1989	I-131	<0.3	<1
			Cs-134	<5.9	<10
			Cs-137	<6.2	<10
SPW-7561	Water	Apr 1989	H-3	<150	<300
SPW-7207	Water	Jun 1989	Ra-226	<0.2	<1
			Ra-228	<0.6	<1
SPS-7208	Milk	Jun 1989	Sr-89	<0.6	<5
			Sr-90	2.1±0.5[a]	<1
			I-131	<0.3	<1
			Cs-134	<6.4	<10
			Cs-137	<7.2	<10
SPW-7588	Water	Jun 1989	Gr. alpha	<0.2	<1
			Gr. beta	<1.0	<4
SPS-7322	Milk	Aug 1989	Sr-89	<1.4	<5
			Sr-90	4.8±1.0[a]	<1
			I-131	<0.2	<1
			Cs-134	<6.9	<10
			Cs-137	<8.2	<10
SPW-7559	Water	Sep 1989	Sr-89	<2.0	<5
			Sr-90	<0.7	<1
SPW-7560	Water	Oct 1989	I-131	<0.1	<1
SPW-7562	Water	Oct 1989	H-3	<140	<300

Table B-4. In-house "blank" samples (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration (pCi/L) Results (4.66 σ)	Acceptance Criteria (4.66 σ)
SPS-7605	Milk	Nov 1989	I-131	<0.2	<1
			Cs-134	<8.6	<10
			Cs-137	<10	<10
SPW-7971	Water	Dec 1989	Gr. alpha	<0.4	<1
			Gr. beta	<0.8	<4
SPW-8039	Water	Jan 1990	Ra-226	<0.2	<1
SPS-8040	Milk	Jan 1990	Sr-89	<0.8	<5
			Sr-90	<1.0	<1
SPS-8208	Milk	Jan 1990	Sr-89	<0.8	<5
			Sr-90	1.6±0.5[a]	<1
			Cs-134	<3.5	<10
			Cs-137	<4.7	<10
SPS-8312	Milk	Feb 1990	Sr-89	<0.3	<5
			Sr-90	1.2±0.3[a]	<1
SPW-8312A	Water	Feb 1990	Sr-89	<0.6	<5
			Sr-90	<0.7	<5
SPS-8314	Milk	Mar 1990	I-131	<0.3	<1
SPS-8510	Milk	May 1990	I-131	<0.2	<1
			Cs-134	<4.6	<10
			Cs-137	<4.8	<10
SPW-8511A	Water	May 1990	H-3	<200	<300
SPS-8600	Milk	Jul 1990	Sr-89	<0.8	<5
			Sr-90	1.7±0.6[a]	<1
			I-131	<0.3	<1
			Cs-134	<5.0	<10
			Cs-137	<7.0	<10
SPM-8877	Milk	Aug 1990	I-131	<0.2	<1
SPW-8925	Water	Aug 1990	H-3	<200	<300

Table B-4. In-house "blank" samples (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration (pCi/L) Results (4.66 σ)	Concentration (pCi/L) Acceptance Criteria (4.66 σ)
SPW-8926	Water	Aug 1990	Gr. alpha	<0.3	<1
			Gr. beta	<0.7	<4
SPW-8927	Water	Aug 1990	U-234	<0.01	<1
			U-235	<0.02	<1
			U-238	<0.01	<1
SPW-8928	Water	Aug 1990	Mn-54	<4.0	<5
			Co-58	<4.1	<5
			Co-60	<2.4	<5
			Cs-134	<3.3	<5
			Cs-137	<3.7	<5
SPW-8929	Water	Aug 1990	Sr-89	<1.4	<5
			Sr-90	<0.6	<1
SPW-69	Water	Sep 1990	Sr-89	<1.8	<5
			Sr-90	<0.8	<1
SPW-106	Water	Oct 1990	H-3	<180	<300
			I-131	<0.3	<1
SPM-107	Milk	Oct 1990	I-131	<0.4	<1
			Cs-134	<3.3	<5
			Cs-137	<4.3	<5
SPW-370	Water	Oct 1990	Mn-54	<1.7	<5
			Co-58	<2.6	<5
			Co-60	<1.6	<5
			Cs-134	<1.7	<5
			Cs-137	<1.8	<5
SPW-372	Water	Dec 1990	Gr. alpha	<0.3	<1
			Gr. beta	<0.8	<4
SPS-406	Milk	Jan 1991	Sr-89	<0.4	<5
			Sr-90	1.8±0.4[a]	<1
			Cs-134	<3.7	<5
			Cs-137	<5.2	<5
SPS-421	Milk	Feb 1991	I-131	<0.3	<1
SPW-451	Water	Feb 1991	Ra-226	<0.1	<1
			Ra-228	<0.9	<1

Table B-4. In-house "blank" samples (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration (pCi/L) Results (4.66 σ)	Concentration (pCi/L) Acceptance Criteria (4.66 σ)
SPW-514	Water	Mar 1991	Sr-89	<1.1	<5
			Sr-90	<0.9	<1
SPW-586	Water	Apr 1991	I-131	<0.2	<1
			Co-60	<2.5	<5
			Cs-134	<2.4	<5
			Cs-137	<2.2	<5
SPS-587	Milk	Apr 1991	I-131	<0.2	<1
			Cs-134	<1.7	<5
			Cs-137	<1.9	<5
SPW-837	Water	Jun 1991	Gr. alpha	<0.6	<1
			Gr. beta	<1.1	<4
SPM-953	Milk	Jul 1991	Sr-89	<0.7	<5
			Sr-90	0.4±0.3[a]	<1
			I-131	<0.2	<1
			Cs-137	<4.9	<5
SPM-1236	Milk	Oct 1991	I-131	<0.2	<1
			Cs-134	<3.7	<5
			Cs-137	<4.6	<5
SPW-1254	Water	Oct 1991	Sr-89	<2.8	<5
			Sr-90	<0.7	<1
SPW-1256	Water	Oct 1991	I-131	<0.4	<1
			Co-60	<3.6	<5
			Cs-134	<4.0	<5
			Cs-137	<3.6	<5
SPW-1259	Water	Oct 1991	H-3	<160	<300
SPW-1444	Water	Dec 1991	Gr. alpha	<0.4	<1
			Gr. beta	<0.8	<4

[a] Low level of Sr-90 concentration in milk (1 - 5 pCi/L) is not unusual.

ATTACHMENT B

ACCEPTANCE CRITERIA FOR "SPIKED" SAMPLES

LABORATORY PRECISION: ONE STANDARD DEVIATION VALUES FOR VARIOUS ANALYSES[a]

Analysis	Level	One Standard Deviation for Single Determination
Gamma Emitters	5 to 100 pCi/liter or kg	5 pCi/liter
	>100 pCi/liter or kg	5% of known value
Strontium-89[b]	5 to 50 pCi/liter or kg	5 pCi/liter
	>50 pCi/liter or kg	10% of known value
Strontium-90[b]	2 to 30 pCi/liter or kg	3.0 pCi/liter
	>30 pCi/liter or kg	10% of known value
Potassium	>0.1 g/liter or kg	5% of known value
Gross alpha	<20 pCi/liter	5 pCi/liter
	>20 pCi/liter	25% of known value
Gross beta	<100 pCi/liter	5 pCi/liter
	>100 pCi/liter	5% of known value
Tritium	<4,000 pCi/liter	1s = (pCi/liter) = $169.85 \times (\text{known})^{.0933}$
	>4,000 pCi/liter	10% of known value
Radium-226, -228	<0.1 pCi/liter	15% of known value
Plutonium	0.1 pCi/liter, gram, or sample	10% of known value
Iodine-131, Iodine-129[b]	<55 pCi/liter	6 pCi/liter
	>55 pCi/liter	10% of known value
Uranium-238, Nickel-64[b], Technetium-99[b]	<35 pCi/liter	6 pCi/liter
	>35 pCi/liter	15% of known value
Iron-55[b]	50 to 100 pCi/liter	10 pCi/liter
	>100 pCi/liter	10% of known value

[a] From EPA publication, "Environmental Radioactivity Laboratory Intercomparison Studies Program, Fiscal Year, 1981-1982, EPA-600/4-81-004.

[b] TIML limit.

ADDENDUM TO APPENDIX B

The following is an explanation of the reasons why certain samples were outside the control limit specified by the Environmental Protection Agency for the Interlaboratory Comparions Program starting January 1988.

Lab Code	Analysis	TIML Result (pCi/L)[a]	EPA Control Limit (pCi/L)[a]	Explanation
STF-524	K	1010.7±158.5[b]	1123.5-1336.5[b]	Error in transference of data. Correct data was 1105±33 mg/kg. Results in the past have been within the limits and TIML will monitor the situation in the future.
STW-532	I-131	9.0±2.0	6.2-8.8	Sample recounted after 12 days. The average result was 8.8±1.7 pCi/L (within EPA control limits). The sample was recounted in order to check the decay. Results in the past have been within the limits and TIML will continue to monitor the situation in the future.
STW-534	Co-60	63.3±1.3	41.3-58.7	High level of Co-60 was due to contamination of beaker. Beaker was discarded upon discovery of contamination and sample was recounted. Recount results were 53.2±3.6 and 50.9±2.4 pCi/L.
STM-554	Sr-90	51.0±2.0	54.8-65.2	The cause of low result was due to very high fat content of milk. It should be noted that 63% of all participants failed this test. As such, the average for all participants was 54.0 pCi/L before the Grubb and 55.8 pCi/L after the Grubb.
STW-560	Pu-239	5.8±1.1	3.5-4.9	The cause of high results is not known though it is suspected that the standard was not properly calibrated by supplier and is under investigation. New Pu-236 standard was obtained and will be used for the next test.
STW-568	Ra-228	2.6±1.0	2.7-4.5	The cause of low results is not known. Next EPA cross check results were within the control limits. No further action is planned.

Lab Code	Analysis	TIML Result (pCi/L)[a]	EPA Control Limit (pCi/L)[a]	Explanation
STM-570	Sr-89 Sr-90	26.0±10.0 45.7±4.2	30.3-47.7 49.8-60.2	The cause of low results was falsely high recovery due to suspected incomplete calcium removal. Since EPA sample was used up, internal spike was prepared and analyzed. The results were within control limits (See table B-3, sample QC-MI-24). No further action is planned.
STW-589	Sr-90	17.3±1.2	17.4-22.6	Sample was reanalyzed in triplicate; results of reanalyses were 18.8±1.5 pCi/L. No further action is planned.
STM-599	K	1300.0±59.2[c]	1414.7-1685.3[c]	Sample was reanalyzed in triplicate. Results of reanalyses were 1421.7±95.3 mg/L. The cause of low results is unknown.
STW-601	Gr. alpha	11.0±2.0	11.6-32.4	Sample was reanalyzed in triplicate. Results of reanalyses were 13.4±1.0 pCi/L.
STAF-626	Gr. alpha	38.7±1.2	14.6-35.4	The cause of high results is the difference in geometery between standard used in the TIML lab and EPA filter.
STW-632	Ba-133	74.0±6.9	51.6-72.4	Sample was reanalyzed. Results of the reanalyses were 63.8±6.9 pCi/L within EPA limit.
STW-641	I-131	130.7±16.8	88.9-127.1	The cause of high result is unknown. In-house spike sample was prepared with activity of I-131 68.3±6.8 pCi/L. Result of the analysis was 69.1±9.7 pCi/L.

[a] Reported in pCi/L unless otherwise noted.

[b] Concentrations are reported in mg/kg.

[c] Concentrations are reported in mg/L.

APPENDIX C - Data Reporting Conventions

Data Reporting Conventions

1.0. All activities, except gruss alpha and gross beta, are decay corrected to collection time or the end of the collection period.

2.0. Single Measurements

Each single measurement is reported as follows:

$$x \pm s$$

where x = value of the measurement;

s = 2σ counting uncertainty (corresponding to the 95% confidence level).

In cases where the activity is found to be below the lower limit of detection L it is reported as

$$<L$$

where L = is the lower limit of detection based on 4.66σ uncertainty for a background sample.

3.0. Duplicate Analyses

3.1. Individual results: $x_1 \pm s_1$
$x_2 \pm s_2$

Reported result: $x \pm s$

where $x = (1/2)(x_1 + x_2)$

$$s = (1/2)\sqrt{s_1^2 + s_2^2}$$

3.2. Individual results: $<L_1$
$<L_2$

Reported result: $<L$

where L = lower of L_1 and L_2

3.3. Individual results: $x \pm s$
$<L$

Reported result: $x \pm s$ if $x \geq L$;
otherwise

4.0. Computation of Averages and Standard Deviations

4.1 Averages and standard deviations listed in the tables are computed from all of the individual measurements over the period averaged; for example, an annual standard deviation would not be the average of quarterly standard deviations. The average $\bar{x}$ and standard deviation(s) of a set of n numbers $x_1, x_2, \ldots x_n$ are defined as follows:

$$\bar{x} = \frac{1}{n} \Sigma x$$

$$s = \sqrt{\frac{\Sigma (x-\bar{x})^2}{n-1}}$$

4.2 Values below the highest lower limit of detection are not included in the average.

4.3 If all of the values in the averaging group are less than the highest LLD, the highest LLD is reported.

4.4 If all but one of the values are less than the highest LLD, the single value and associated two sigma error is reported.

4.5. In rounding off, the following rules are followed:

4.5.1. If the figure following those to be retained is less than 5, the figure is dropped, and the retained figures are kept unchanged. As an example, 11.443 is rounded off to 11.44.

4.5.2 If the figure following those to be retained is greater than 5, the figure is dropped, and the last retained figure is raised by 1. As an example, 11.446 is rounded off to 11.45.

4.5.3. If the figure following those to be retained is 5, and if there are no figures other than zeros beyond the five, the figure 5 is dropped, and the last-place figure retained is increased by one if it is an odd number or it is kept unchanged if an even number. As an example, 11.435 is rounded off to 11.44, while 11.425 is rounded off to 11.42.

APPENDIX D - Maximum Permissible Concentrations of Radioactivity in Air and Water Above Natural Background in Unrestricted Areas

Table D-1 Maximum permissible concentrations of radioactivity in air and water above natural background in unrestricted areas.[a]

Air			Water	
Gross alpha	3	pCi/m^3	Strontium-89	3,000 pCi/l
Gross beta	100	pCi/m^3	Strontium-90	300 pCi/l
Iodine-131[b]	0.14	pCi/m^3	Cesium-137	20,000 pCi/l
			Barium-140	20,000 pCi/l
			Iodine-131	300 pCi/l
			Potassium-40[c]	3,000 pCi/l
			Gross alpha	30 pCi/l
			Gross beta	100 pCi/l
			Tritium	3×10^6 pCi/l

[a] Taken from Code of Federal Regulations Title 10, Part 20, Table II and appropriate footnotes. Concentrations may be averaged over a period not greater than one year.

[b] From 10 CFR 20 but adjusted by a factor of 700 to reduce the dose resulting from the air-grass-cow-milk-child pathway.

[c] A natural radionuclide.

Appendix E - REMP Sampling Summary

Table E-1 Environmental Radiological Monitoring Program Summary

Name of Facility Davis-Besse Nuclear Power Station Docket No. 50-346

Location of Facility Ottawa, Ohio (County, State) Reporting Period January - December 1991

Sample Type (Units)	Type and Number of Analyses[a]	LLD[b]	Indicator Locations Mean (f)[c] Range[c]	Location with Highest Annual Mean		Control Locations Mean (f)[c] Range[c]	Number of Non-routine Results[e]
				Location[d]	Mean (f)[c] Range[c]		
Airborne Particulates (pCi/m^3)	GB 520	0.005	0.021 (312/312) (0.006-0.041)	T-12, Toledo Water Treatment Plant 23.5 mi WNW	0.023 (52/52) (0.009-0.042)	0.022 (208/208) (0.007-0.044)	0
	Sr-89 40	0.0013	<LLD	-	-	<LLD	0
	Sr-90 40	0.0006	<LLD	-	-	<LLD	0
	GS 40						
	Be-7	0.015	0.054 (24/24) (0.041-0.066)	T-2, Site Boundary 0.9 mi E	0.058 (4/4) (0.050-0.066)	0.054 (16/16) (0.04 - 0.066)	0
				T-8, Farm 2.7 mi WSW	0.058 (4/4) (0.050-0.063)		
				T-9, Oak Harbor Substation 5.8 mi SW	0.058 (4/4) (0.051-0.061)		
	K-40	0.029	<LLD	-	-	<LLD	0
	Nb-95	0.0033	<LLD	-	-	<LLD	0
	Zr-95	0.0032	<LLD	-	-	<LLD	0
	Ru-103	0.0016	<LLD	-	-	<LLD	0
	Ru-106	0.014	<LLD	-	-	<LLD	0
	Cs-134	0.0013	<LLD	-	-	<LLD	0
	Cs-137	0.0016	<LLD	-	-	<LLD	0
	Ce-141	0.0027	<LLD	-	-	<LLD	0
	Ce-144	0.0081	<LLD	-	-	<LLD	0

Table E-1 Environmental Radiological Monitoing Program Summary (continued)

Name of Facility Davis-Besse Nuclear Power Station Docket No. 50-346

Location of Facility Ottawa, Ohio (County, State) Reporting Period January - December 1991

Sample Type (Units)	Type and Number of Analyses[a]	LLD[b]	Indicator Locations Mean (F)[c] Range[c]	Location with Highest Annual Mean		Control Locations Mean (F)[c] Range[c]	Number of Non-routine Results[e]
				Location[d]	Mean (F)[c] Range[c]		
Airborne Iodine (pCi/m³)	I-131 520	0.07	<LLD	-	-	<LLD	0
TLD (Quarterly) (mR/91 days)	Gamma 369	1.0	15.0 (277/277) (8.2-22.7)	T-66, Site boundary 0.3 mi ENE	21.5 (4/4) (20.2-22.1)	16.2 (92/92) (8.20-20.6)	0
TLD (Annual) (mR/365 days)	Gamma 88	1.0	60.5 (65/65) (30.8-88.5)	T-66 Site Boundary 0.3 mi ENE	83.4 (1/1) -	58.6 (23/23) (43.7-64.8)	0
Milk (pCi/L)	I-131 55	0.4	<LLD	-	-	<LLD	0
	Sr-89 55	1.1	<LLD	-	-	<LLD	0
	Sr-90 55	0.5[f]	1.0 (17/18) (0.5-1.4)	T-199, Farm 8.5 mi SW	2.4 (1/1)	1.2 (37/37) (0.6-2.4)	0
	GS 55						
	K-40	100	1240 (18/18) (1100-1500)	T-57, Farm 22.0 mi SSE	1250 (18/18) (1050-1460)	1250 (37/37) (1050-1460)	0
	Cs-137	10	<LLD	-	-	<LLD	0
	Ba-140	10	<LLD	-	-	<LLD	0
	Ca 55	0.50	0.84 (18/18) (0.50-1.01)	T-199, Farm 8.5 mi SW	0.96 (1/1)	0.91 (37/37) (0.61-1.18)	0
	K (stable) 55	0.04	1.43 (18/18) (1.27-1.73)	T-57, Farm 22.0 mi ESE	1.46 (18/18) (1.21-1.69)	1.45 (37/37) (1.21-1.69)	0
	Sr-90/Ca 55	0.369	1.15 (17/18) (0.59-2.12)	T-199, Farm 8.5 mi SW	2.50 (1/1)	1.39 (37/37) (0.58-2.59)	0
	Cs-137/K 55	0.26	<LLD	-	-	<LLD	0

Table E-1 Environmental Radiological Monitoing Program Summary (continued)

Name of Facility Davis-Besse Nuclear Power Station Docket No. 50-346

Location of Facility Ottawa, Ohio (County, State) Reporting Period January - December 1991

Sample Type (Units)	Type and Number of Analyses[a]	LLD[b]	Indicator Locations Mean (F)[c] Range[c]	Location with Highest Annual Mean Location[d]	Location with Highest Annual Mean Mean (F)[c] Range[c]	Control Locations Mean (F)[c] Range[c]	Number of Non-routine Results[e]
Ground Water	GB (SS) 15	0.8	<LLD	-	-	<LLD	0
	GB (DS) 15	2.3	3.0 (8/8) (2.4-3.3)	I-54, Farm 4.8 mi SW	3.1 (4/4) (2.4-3.3)	2.3 (2/7) (2.3-2.3)	0
	GB (TR) 15	2.3	3.0 (8/8) (2.4-3.3)	I-54, Farm 4.8 mi SW	3.1 (4/4) (2.4-3.3)	2.4 (5/8) (2.0-2.8)	0
	H-3 15	330	<LLD	-	-	<LLD	0
	Sr-89 15	1.5	<LLD	-	-	<LLD	0
	Sr-90 15	0.9	0.9 (1/8)	I-7, Sand Beach 0.9 mi NW	0.9 (1/1)	<LLD	0
	GS 15						
	Cs-137	10.0	<LLD	-	-	<LLD	0
Edible Meat (pCi/g wet)	GS 4						
	K-40	0.1	2.03 (3/3) (1.47-2.71)	I-197, Farm 1.7 mi W	2.71 (1/1)	1.94 (1/1)	0
	Cs-137	0.029	<LLD	-	-	<LLD	0
Fruits and Vegetables (pCi/g wet)	Sr-89 6	0.006	<LLD	-	-	<LLD	0
	Sr-90 6	0.001	0.004 (1/3)	I-173, Firelands winery Sandusky 20.0 mi SE	0.005 (1/3)	0.005 (1/3)	0
	I-131 6	0.033	<LLD	-	-	<LLD	0

Table E-1 Environmental Radiological Monitoing Program Summary (continued)

Name of Facility Davis-Besse Nuclear Power Station Docket No. 50-346

Location of Facility Ottawa, Ohio (County, State) Reporting Period January - December 1991

Sample Type (Units)	Type and Number of Analyses[a]	LLD[b]	Indicator Locations Mean (F)[c] Range[c]	Location with Highest Annual Mean		Control Locations Mean (F)[c] Range[c]	Number of Non-routine Results[e]
				Location[d]	Mean (F)[c] Range[c]		
Fruits and Vegetables (pCi/g wet) (continued)	GS 6						
	K-40	0.50	2.09 (3/3) (0.91-4.27)	T-8, Farm 2.7 mi WSW	2.59 (2/2) (0.91-4.27)	1.68 (3/3) (1.06-2.20)	0
	Nb-95	0.022	<LLD	-	-	<LLD	0
	Zr-95	0.032	<LLD	-	-	<LLD	0
	Cs-137	0.018	<LLD	-	-	<LLD	0
	Ce-141	0.026	<LLD	-	-	<LLD	0
	Ce-144	0.11	<LLD	-	-	<LLD	0
Broad Leaf Vegetation (pCi/g wet)	Sr-89 16	0.009	<LLD	-	-	<LLD	0
	Sr-90 16	0.004	0.005 (5/13) (0.004-0.005)	T-8, Farm 2.7 mi WSW	0.005 (4/7) (0.004-0.005)	<LLD	0
	I-131 16	0.047	<LLD	-	-	<LLD	0
	GS 16						
	K-40	0.1	5.30 (13/13) (3.13-8.91)	T-25, Farm 3.7 mi S	6.51 (6/6) (4.09-8.91)	1.79 (3/3) (1.57-2.06)	0
	Nb-95	0.036	<LLD	-	-	<LLD	0
	Zr-95	0.052	<LLD	-	-	<LLD	0
	Cs-137	0.030	<LLD	-	-	<LLD	0
	Ce-141	0.049	<LLD	-	-	<LLD	0
	Ce-144	0.14	<LLD	-	-	<LLD	0

Table E-1 Environmental Radiological Monitoing Program Summary (continued)

Name of Facility Davis-Besse Nuclear Power Station Docket No. 50-346

Location of Facility Ottawa, Ohio (County, State) Reporting Period January - December 1991

Sample Type (Units)	Type and Number of Analyses[a]	LLD[b]	Indicator Locations Mean (F)[c] Range[c]	Location with Highest Annual Mean Location[d]	Mean (F)[c] Range[c]	Control Locations Mean (F)[c] Range[c]	Number of Non-routine Results[e]
Eggs (pCi/g wet)	GS 2						
	K-40	0.01	1.01 (1/1) -	I-34, Offsite roving location	1.33 (1/1) -	1.33 (LLD)	0
	Nb-95	0.035	<LLD	-	-	<LLD	0
	Zr-95	0.047	<LLD	-	-	<LLD	0
	Ru-103	0.023	<LLD	-	-	<LLD	0
	Ru-106	0.16	<LLD	-	-	<LLD	0
	Cs-137	0.018	<LLD	-	-	<LLD	0
	Ce-141	0.039	<LLD	-	-	<LLD	0
	Ce-144	0.11	<LLD	-	-	<LLD	0
Animal - Wildlife Feed (pCi/g wet)	GS 10						
	Be-7	0.36	1.02 (2/7) (0.84-1.3)	I-19B, Toussaint Creek, 4.0 mi WSW	1.20 (1/1) -	0.70 (1/3)	0
	K-40	0.1	5.50 (7/7) (2.03-12.70)	I-8, Farm 2.7 mi WSW	9.08 (3/3) (2.03-12.70)	7.64 (3/3) (2.59-16.40)	0
	Nb-95	0.050	<LLD	-	-	<LLD	0
	Zr-95	0.082	<LLD	-	-	<LLD	0
	Ru-103	0.043	<LLD	-	-	<LLD	0
	Ru-106	0.26	<LLD	-	-	<LLD	0
	Cs-137	0.036	<LLD	-	-	<LLD	0
	Ce-141	0.060	<LLD	-	-	<LLD	0
	Ce-144	0.23	<LLD	-	-	<LLD	0

Table E-1 Environmental Radiological Monitoing Program Summary (continued)

Name of Facility Davis-Besse Nuclear Power Station Docket No. 50-346

Location of Facility Ottawa, Ohio (County, State) Reporting Period January - December 1991

Sample Type (Units)	Type and Number of Analyses[a]	LLD[b]	Indicator Locations Mean (F)[c] Range[c]	Location with Highest Annual Mean		Control Locations Mean (F)[c] Range[c]	Number of Non-routine Results[e]
				Location[d]	Mean (F)[c] Range[c]		
Soil (pCi/g dry)	GS 22						
	Be-7	0.56	0.98 (1/12)	T-8, Farm 2.7 mi WSW	0.98 (1/2)	<LLD	0
	K-40	1.0	13.79 (12/12) (7.33-23.68)	T-8, Farm 2.7 mi WSW	22.92 (2/2) (22.15-23.68)	15.33 (10/10) (9.92-20.18)	0
	Zr-95	0.086	<LLD	-	-	<LLD	0
	Nb-95	0.13	<LLD	-	-	<LLD	0
	Ru-103	0.063	<LLD	-	-	<LLD	0
	Ru-106	0.98	<LLD	-	-	<LLD	0
	Cs-137	0.043	0.23 (9/12) (0.084-0.36)	T-9, Oak Harbor Substation 6.8 mi SW	0.56 (2/2) (0.39-0.73)	0.40 (10/10) (0.15-0.73)	0
	Ce-141	0.12	<LLD	-	-	<LLD	0
	Ce-144	0.41	<LLD	-	-	<LLD	0
Treated Surface Water (pCi/L)	GB (SS) 72	0.9	<LLD	-	-	<LLD	0
	GB (DS) 72	1.0	2.3 (36/36) (1.6-3.3)	T-144, Green Cove Cond., 0.9 mi NNW	2.5 (12/12) (1.7-3.3)	2.2 (36/36) (1.8-2.6)	0
	GB (TR) 72	1.0	1.6 (36/36) (1.6-3.3)	T-144, Green Cove Cond., 0.9 mi NNW	2.5 (12/12) (1.7-3.3)	2.2 (36/36) (1.8-2.6)	0
	H-3 24	330	<LLD	-	-	<LLD	0
	Sr-89 24	1.6	<LLD	-	-	<LLD	0
	Sr-90 24	0.6	0.7 (2/12) (0.6-0.8)	T-144, Green Cove Cond., 0.9 mi NNW	0.8 (1/4)	0.6 (2/12) (0.6-0.6)	0
	GS 24						
	Cs-137	10.0	<LLD	-	-	<LLD	0

Table E-1 Environmental Radiological Monitoing Program Summary (continued)

Name of Facility Davis-Besse Nuclear Power Station Docket No. 50-346

Location of Facility Ottawa, Ohio (County, State) Reporting Period January - December 1991

Sample Type (Units)	Type and Number of Analyses[a]	LLD[b]	Indicator Locations Mean (F)[c] Range[c]	Location with Highest Annual Mean		Control Locations Mean (F)[c] Range[c]	Number of Non-routine Results[e]
				Location[d]	Mean (F)[c] Range[c]		
Untreated Surface Water (pCi/L)	GB (SS) 156	0.9	<LLD	T-12, Toledo Water Treatment Plant 11.25 mi NW	2.7 (2/78) (1.2-4.2)	2.7 (2/78) (1.2-4.2)	0
	GB (DS) 156	1.0	2.6 (78/78) (1.5-4.4)	T-3, Site boundary 1.4 mi ESE	3.0 (12/12) (1.9-3.6)	2.3 (78/78) (1.6-4.1)	0
	GB (TR) 156	1.0	2.6 (78/78) (1.5-4.4)	T-12, Toledo Water Treatment Plant 11.25 mi NW	3.1 (12/12) (2.1-8.3)	2.4 (78/78) (1.6-8.3)	0
	H-3 156	330	531 (5/7)) (337-884)	T-130, Lake Erie 1.7 mi ESE	884 (1/6) -	333 (1/72) -	0
	Sr-89 108	2.3	<LLD	-	-	<LLD	0
	Sr-90 108	0.9	1.1 (3/54) (0.9-1.2)	T-158, Lake Erie 10.0 mi WNW	1.4 (1/6)	1.1 (7/54) (0.9-1.4)	0
	GS 156						
	Cs-137	10	<LLD	-	-	<LLD	0
Fish	GB 6	0.1	2.43 (3/3) (2.20-2.66)	T-35, Lake Erie >10 mi radius	2.76 (3/3) (2.27-3.31)	2.76 (3/3) (2.27-3.31)	0
	GS 6						
	K-40	0.1	2.42 (3/3) (1.90-3.17)	T-33, Lake Erie 1.5 mi NE	2.42 (3/3) (1.90-3.17)	2.12 (3/3) (1.87-2.56)	0
	Cs-137	0.035	<LLD	--	--	<LLD	0

Table E-1 Environmental Radiological Monitoing Program Summary (continued)

Name of Facility Davis-Besse Nuclear Power Station Docket No. 50-346

Location of Facility Ottawa, Ohio (County, State) Reporting Period January - December 1991

Sample Type (Units)	Type and Number of Analyses[a]	LLD[b]	Indicator Locations Mean (F)[c] Range[c]	Location with Highest Annual Mean		Control Locations Mean (F)[c] Range[c]	Number of Non-routine Results[e]
				Location[d]	Mean (F)[c] Range[c]		
Shoreline Sediments (pCi/g dry)	GS 15						
	K-40	0.1	12.97 (9/9) (9.57-17.80)	T-136, Lake Erie 11.0 mi NW	15.46 (2/2) (13.10-17.82)	12.07 (6/6) (9.70-17.82)	0
	Cs-137	0.062	0.14 (3/9) (0.11-0.20)	T-138, Lake Erie 11.0 mi NW	0.52 (2/2) (0.47-0.57)	0.52 (2/6) (0.47-0.57)	0

a GB = gross beta, GS = gamma scan, SS = suspended solids, DS = dissolved solids, TR = total residue.

b LLD = nominal lower limit of detection based on 4.66 sigma counting error for background sample.

c Mean based upon detectable measurements only. Fraction of detectable measurements at specified locations is indicated in parentheses (F).

d Locations are specified by station code (Table 4.1) and distance (miles) and direction relative to reactor site.

e Non-routine results are those which exceed ten times the control station value.

f One result (<0.7 pCi/l) was excluded in the determination of Sr-90 in milk. The elevated LLD resulted from low carrier recovery.

g One result (<1.40 pCi Sr-90/g Ca) was excluded in the determination of LLD of Sr-90/Ca. The elevated LLD resulted from high LLD for Sr-90.

ATTACHMENT 1

to the

ANNUAL ENVIRONMENTAL OPERATING REPORT:

Radiological Environmental Monitoring

Program Sample Analys s Results

for

DAVIS-BESSE NUCLEAR POWER STATION

January 1, 1991 to December 31, 1991

Prepared by:
Radiological Environmental
Davis-Besse Nuclear Power Station
Toledo Edison Company
Toledo, Ohio

April 1992

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Introduction

Attachment 1 to the Davis-Besse Nuclear Power Station 1991 Annual Environmental Operating Report (AEOR) includes the results of analysis of all radiological environmental radiation measurements taken as part of the 1991 Radiological Environmental Monitoring Program (REMP). The summaries provided in Appendix B and thoughout the text of the 1991 AEOR are based on the data presented in the following table.

Data tabulation and sample analyses results were provided by Teledyne Isotopes Midwest Laboratory (TIML) in the TIML annual report to Toledo Edison (Part II, Feb 1992).

Table 1. Airborne particulates and iodine collected at Location T-1, analyses for gross beta and iodine-131.[a]

Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)	Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)
01-07-91	304	0.028±0.003	07-08-91	288	0.017±0.003
01-14-91	298	0.025±0.003	07-15-91	274	0.014±0.003
01-21-91	297	0.032±0.004	07-22-91	301	0.034±0.004
01-28-91	305	0.021±0.003	07-29-91	280	0.014±0.003
02-04-91	298	0.026±0.003	08-05-91	282	0.016±0.003
02-11-91	299	0.029±0.004	08-12-91	292	0.016±0.003
02-18-91	297	0.015±0.003	08-19-91	305	0.013±0.003
02-25-91	309	0.021±0.003	08-26-91	285	0.014±0.003
03-04-91	299	0.020±0.003	09-02-91	284	0.022±0.002
03-11-91	281	0.025±0.004	09-09-91	283	0.020±0.003
03-18-91	275	0.015±0.003	09-16-91	279	0.021±0.003
03-25-91	285	0.016±0.004	09-23-91	202	0.027±0.003
04-01-91	283	0.016±0.003	09-30-91	260	0.012±0.002
1st Qtr. mean ± s.d.		0.022±0.006	3rd Qtr. mean ± s.d.		0.018±0.006
04-08-91	285	0.028±0.004	10-07-91	255	0.029±0.004
04-15-91	277	0.020±0.003	10-14-91	287	0.020±0.003
04-22-91	278	0.008±0.003	10-21-91	287	0.019±0.003
04-29-91	276	0.024±0.003	10-28-91	284	0.022±0.002
05-06-91	204	0.016±0.004	11-04-91	313	0.025±0.003
05-13-91	283	0.016±0.003	11-11-91	294	0.024±0.003
05-20-91	279	0.014±0.003	11-18-91	270	0.035±0.003
05-27-91	285	0.016±0.002	11-25-91	281	0.025±0.004
06-03-91	282	0.021±0.003	12-02-91	285	0.030±0.004
06-10-91	284	0.009±0.003	12-09-91	287	0.022±0.004
06-17-91	282	0.018±0.003	12-16-91	287	0.030±0.004
06-24-91	285	0.021±0.003	12-23-91	284	0.021±0.004
07-01-91	285	0.020±0.003	12-30-91	285	0.024±0.004
2nd Qtr. mean ± s.d.		0.018±0.006	4th Qtr. mean ± s.d.		0.025±0.005

[a] Iodine-131 concentrations are <0.07 pCi/m^3 unless noted otherwise in Appendix C.

Table 2. Airborne particulates and iodine collected at Location T-2, analyses for gross beta and iodine-131.[a]

Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)	Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)
01-07-91	290	0.032±0.004	07-08-91	299	0.020±0.003
01-14-91	289	0.022±0.003	07-15-91	300	0.012±0.003
01-21-91	293	0.030±0.004	07-22-91	301	0.030±0.004
01-28-91	291	0.022±0.003	07-29-91	298	0.014±0.003
02-04-91	289	0.026±0.003	08-05-91	302	0.018±0.003
02-11-91	288	0.032±0.004	08-12-91	296	0.015±0.003
02-18-91	286	0.018±0.003	08-19-91	299	0.025±0.004
02-25-91	288	0.020±0.003	08-26-91	305	0.020±0.003
03-04-91	286	0.019±0.003	09-02-91	299	0.026±0.003
03-11-91	289	0.022±0.003	09-09-91	298	0.023±0.003
03-18-91	285	0.012±0.003	09-16-91	296	0.023±0.003
03-25-91	291	0.022±0.004	09-23-91	287	0.016±0.002
04-01-91	291	0.017±0.003	09-30-91	289	0.012±0.002
1st Qtr. mean ± s.d.		0.023±0.006	3rd Qtr. mean ± s.d.		0.020±0.006
04-08-91	289	0.022±0.004	10-07-91	300	0.020±0.003
04-15-91	285	0.021±0.003	10-14-91	304	0.023±0.003
04-22-91	291	0.011±0.003	10-21-91	297	0.021±0.003
04-29-91	295	0.022±0.002	10-28-91	291	0.025±0.002
05-06-91	297	0.011±0.003	11-04-91	298	0.027±0.003
05-13-91	297	0.020±0.003	11-11-91	290	0.026±0.004
05-20-91	298	0.015±0.003	11-18-91	288	0.040±0.003
05-27-91	303	0.016±0.002	11-25-91	293	0.028±0.004
06-03-91	266	0.007±0.003	12-02-91	289	0.031±0.004
06-10-91	299	0.010±0.003	12-09-91	283	0.022±0.004
06-17-91	296	0.016±0.003	12-16-91	293	0.031±0.004
06-24-91	291	0.018±0.003	12-23-91	285	0.016±0.003
07-01-91	296	0.021±0.003	12-30-91	289	0.026±0.004
2nd Qtr. mean ± s.d.		0.016±0.005	4th Qtr. mean ± s.d.		0.026±0.006

[a] Iodine-131 concentrations are <0.07 pCi/m^3 unless noted otherwise in Appendix C.

Table 3. Airborne particulates and iodine collected at Location T-3, analyses for gross beta and iodine-131.[a]

Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)	Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)
01-07-91	287	0.032±0.004	07-08-91	285	0.023±0.004
01-14-91	284	0.024±0.003	07-15-91	278	0.014±0.003
01-21-91	293	0.032±0.004	07-22-91	285	0.032±0.004
01-28-91	282	0.022±0.003	07-29-91	283	0.016±0.003
02-04-91	298	0.028±0.003	08-05-91	285	0.017±0.003
02-11-91	288	0.032±0.004	08-12-91	292	0.017±0.003
02-18-91	274	0.018±0.003	08-19-91	292	0.023±0.003
02-25-91	279	0.024±0.003	08-26-91	290	0.018±0.003
03-04-91	274	0.024±0.003	09-02-91	291	0.025±0.003
03-11-91	279	0.025±0.004	09-09-91	284	0.019±0.003
03-18-91	271	0.013±0.003	09-16-91	293	0.025±0.004
03-25-91	282	0.019±0.004	09-23-91	292	0.019±0.002
04-01-91	265	0.018±0.004	09-30-91	293	0.010±0.002
1st Qtr. mean ± s.d.		0.024±0.006	3rd Qtr. mean ± s.d.		0.020±0.006
04-08-91	282	0.025±0.004	10-07-91	293	0.023±0.003
04-15-91	278	0.018±0.003	10-14-91	287	0.024±0.004
04-22-91	273	0.010±0.003	10-21-91	293	0.019±0.003
04-29-91	275	0.019±0.002	10-28-91	280	0.016±0.002
05-06-91	284	0.010±0.003	11-04-91	305	0.024±0.003
05-13-91	284	0.019±0.003	11-11-91	292	0.022±0.003
05-20-91	271	0.015±0.003	11-18-91	296	0.037±0.003
05-27-91	307	0.014±0.002	11-25-91	297	0.026±0.003
06-03-91	274	0.006±0.002	12-02-91	294	0.026±0.003
06-10-91	277	0.009±0.003	12-09-91	294	0.020±0.003
06-17-91	278	0.011±0.003	12-16-91	295	0.028±0.004
06-24-91	280	0.020±0.003	12-23-91	297	0.016±0.003
07-01-91	307	0.021±0.003	12-30-91	296	0.021±0.003
2nd Qtr. mean ± s.d.		0.015±0.006	4th Qtr. mean ± s.d.		0.023±0.006

[a] Iodine-131 concentrations are <0.07 pCi/m^3 unless noted otherwise in Appendix C.

Table 4. Airborne particulates and iodine collected at Location T-4, analyses for gross beta and iodine-131.[a]

Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)	Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)
01-07-91	294	0.031±0.004	07-08-91	267	0.022±0.004
01-14-91	285	0.025±0.003	07-15-91	273	0.014±0.003
01-21-91	298	0.036±0.004	07-22-91	272	0.034±0.004
01-28-91	284	0.024±0.004	07-29-91	269	0.014±0.003
02-04-91	292	0.029±0.004	08-05-91	277	0.016±0.003
02-11-91	277	0.029±0.004	08-12-91	265	0.016±0.003
02-18-91	270	0.016±0.003	08-19-91	272	0.031±0.004
02-25-91	292	0.020±0.003	08-26-91	266	0.018±0.003
03-04-91	282	0.021±0.003	09-02-91	269	0.026±0.003
03-11-91	283	0.024±0.004	09-09-91	274	0.026±0.004
03-18-91	278	0.017±0.003	09-16-91	268	0.024±0.004
03-25-91	291	0.021±0.004	09-23-91	270	0.017±0.002
04-01-91	288	0.018±0.003	09-30-91	226	0.008±0.002
1st Qtr. mean ± s.d.		0.024±0.006	3rd Qtr. mean ± s.d.		0.020±0.007
04-08-91	279	0.023±0.004	10-07-91	243	0.022±0.004
04-15-91	277	0.021±0.003	10-14-91	293	0.021±0.003
04-22-91	286	0.006±0.003	10-21-91	243	0.018±0.004
04-29-91	282	0.021±0.002	10-28-91	293	0.025±0.002
05-06-91	236	0.018±0.004	11-04-91	298	0.026±0.003
05-13-91	269	0.020±0.003	11-11-91	293	0.026±0.003
05-20-91	270	0.019±0.003	11-18-91	288	0.038±0.003
05-27-91	278	0.014±0.002	11-25-91	299	0.028±0.004
06-03-91	272	0.012±0.003	12-02-91	288	0.026±0.004
06-10-91	279	0.012±0.002	12-09-91	285	0.022±0.004
06-17-91	270	0.016±0.003	12-16-91	296	0.031±0.004
06-24-91	271	0.020±0.003	12-23-91	286	0.021±0.004
07-01-91	275	0.020±0.003	12-30-91	292	0.021±0.003
2nd Qtr. mean ± s.d.		0.017±0.005	4th Qtr. mean ± s.d.		0.025±0.005

[a] Iodine-131 concentrations are <0.07 pCi/m^3 unless noted otherwise in Appendix C.

Table 5. Airborne particulates and iodine collected at Location T-7, analyses for gross beta and iodine-131.[a]

Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)	Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)
01-07-91	264	0.027±0.004	07-08-91	308	0.020±0.003
01-14-91	271	0.025±0.004	07-15-91	296	0.016±0.003
01-21-91	275	0.031±0.004	07-22-91	298	0.033±0.004
01-28-91	274	0.024±0.004	07-29-91	298	0.016±0.003
02-04-91	295	0.025±0.003	08-05-91	298	0.019±0.003
02-11-91	275	0.026±0.004	08-12-91	299	0.016±0.003
02-18-91	268	0.014±0.003	08-19-91	297	0.027±0.004
02-25-91	273	0.021±0.003	08-26-91	308	0.018±0.003
03-04-91	274	0.021±0.003	09-02-91	298	0.025±0.002
03-11-91	273	0.020±0.003	09-09-91	300	0.027±0.004
03-18-91	270	0.019±0.003	09-16-91	297	0.031±0.004
03-25-91	282	0.019±0.004	09-23-91	290	0.018±0.002
04-01-91	270	0.018±0.004	09-30-91	298	0.012±0.002
1st Qtr. mean ± s.d.		0.022±0.004	3rd Qtr. mean ± s.d.		0.021±0.006
04-08-91	269	0.021±0.004	10-07-91	299	0.030±0.004
04-15-91	260	0.020±0.004	10-14-91	298	0.023±0.003
04-22-91	256	0.008±0.003	10-21-91	298	0.019±0.003
04-29-91	283	0.020±0.002	10-28-91	299	0.030±0.003
05-06-91	276	0.008±0.003	11-04-91	298	0.029±0.004
05-13-91	272	0.018±0.003	11-11-91	297	0.023±0.003
05-20-91	277	0.017±0.003	11-18-91	298	0.041±0.003
05-27-91	277	0.016±0.002	11-25-91	298	0.032±0.004
06-03-91	269	0.015±0.003	12-02-91	300	0.028±0.004
06-10-91	278	0.009±0.003	12-09-91	296	0.024±0.004
06-17-91	270	0.018±0.003	12-16-91	285	0.032±0.004
06-24-91	274	0.017±0.003	12-23-91	283	0.022±0.004
07-01-91	278	0.020±0.003	12-30-91	285	0.024±0.004
2nd Qtr. mean ± s.d.		0.016±0.005	4th Qtr. mean ± s.d.		0.027±0.006

[a] Iodine-131 concentrations are <0.07 pCi/m^3 unless noted otherwise in Appendix C.

Table 6. Airborne particulates and iodine collected at Location T-8, analyses for gross beta and iodine-131.[a]

Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)	Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)
01-07-91	286	0.033±0.004	07-08-91	279	0.020±0.003
01-14-91	276	0.022±0.003	07-15-91	287	0.010±0.003
01-21-91	291	0.034±0.004	07-22-91	284	0.030±0.004
01-28-91	284	0.027±0.004	07-29-91	289	0.015±0.003
02-04-91	305	0.027±0.003	08-05-91	286	0.016±0.003
02-11-91	311	0.028±0.003	08-12-91	285	0.014±0.003
02-18-91	260	0.018±0.003	08-19-91	283	0.022±0.004
02-25-91	286	0.022±0.003	08-26-91	298	0.021±0.003
03-04-91	251	0.023±0.004	09-02-91	292	0.024±0.002
03-11-91	277	0.026±0.004	09-09-91	287	0.024±0.004
03-18-91	273	0.012±0.003	09-16-91	291	0.024±0.003
03-25-91	270	0.018±0.004	09-23-91	288	0.019±0.002
04-01-91	261	0.020±0.003	09-30-91	296	0.013±0.002
1st Qtr. mean ± s.d.		0.024±0.006	3rd Qtr. mean ± s.d.		0.019±0.006
04-08-91	272	0.034±0.004	10-07-91	292	0.013±0.003
04-15-91	256	0.019±0.004	10-14-91	295	0.025±0.003
04-22-91	282	0.005±0.003	10-21-91	297	0.020±0.003
04-29-91	289	0.024±0.002	10-28-91	296	0.024±0.002
05-06-91	272	0.011±0.003	11-04-91	300	0.023±0.003
05-13-91	288	0.020±0.003	11-11-91	292	0.022±0.003
05-20-91	270	0.017±0.003	11-18-91	294	0.040±0.003
05-27-91	266	0.016±0.002	11-25-91	298	0.025±0.003
06-03-91	289	0.015±0.003	12-02-91	300	0.026±0.003
06-10-91	284	0.010±0.003	12-09-91	292	0.022±0.004
06-17-91	285	0.018±0.003	12-16-91	302	0.027±0.004
06-24-91	283	0.018±0.003	12-23-91	293	0.016±0.003
07-01-91	281	0.017±0.003	12-30-91	289	0.021±0.003
2nd Qtr. mean ± s.d.		0.017±0.007	4th Qtr. mean ± s.d.		0.023±0.006

[a] Iodine-131 concentrations are <0.07 pCi/m^3 unless noted otherwise in Appendix C.

Table 7. Airborne particulates and iodine collected at Location T-9, analyses for gross beta and iodine-131.[a]

Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)	Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)
01-07-91	292	0.028±0.004	07-08-91	294	0.024±0.003
01-14-91	294	0.024±0.003	07-15-91	297	0.017±0.003
01-21-91	292	0.034±0.004	07-22-91	234	0.023±0.004
01-28-91	295	0.022±0.003	07-29-91	294	0.015±0.003
02-04-91	289	0.026±0.003	08-05-91	299	0.019±0.003
02-11-91	299	0.031±0.004	08-12-91	296	0.019±0.003
02-18-91	292	0.014±0.003	08-19-91	290	0.026±0.004
02-25-91	294	0.019±0.003	08-26-91	295	0.020±0.003
03-04-91	288	0.022±0.003	09-02-91	295	0.025±0.003
03-11-91	291	0.023±0.003	09-09-91	292	0.028±0.004
03-18-91	287	0.015±0.003	09-16-91	292	0.027±0.004
03-25-91	299	0.018±0.004	09-23-91	294	0.021±0.002
04-01-91	286	0.020±0.003	09-30-91	299	0.012±0.002
1st Qtr. mean ± s.d.		0.023±0.006	3rd Qtr. mean ± s.d.		0.021±0.005
04-08-91	294	0.024±0.004	10-07-91	301	0.026±0.003
04-15-91	275	0.020±0.003	10-14-91	299	0.023±0.003
04-22-91	286	0.004±0.003	10-21-91	280	0.021±0.003
04-29-91	290	0.020±0.002	10-28-91	276[b]	0.028±0.003
05-06-91	290	0.011±0.003	11-04-91	285	0.027±0.004
05-13-91	295	0.017±0.003	11-11-91	284	0.023±0.003
05-20-91	323	0.020±0.003	11-18-91	289	0.039±0.003
05-27-91	297	0.017±0.002	11-25-91	282	0.030±0.004
06-03-91	297	0.017±0.003	12-02-91	271	0.033±0.004
06-10-91	304	0.011±0.003	12-09-91	275	0.024±0.004
06-17-91	296	0.019±0.003	12-16-91	286	0.036±0.004
06-24-91	301	0.018±0.003	12-23-91	288	0.021±0.004
07-01-91	295	0.022±0.003	12-30-91	284	0.027±0.004
2nd Qtr. mean ± s.d.		0.017±0.005	4th Qtr. mean ± s.d.		0.023±0.006

[a] Iodine-131 concentrations are <0.07 pCi/m^3 unless noted otherwise in Appendix C.

[b] Corrected calibration curve.

Table 8. Airborne particulates and iodine collected at Location T-11, analyses for gross beta and iodine-131.[a]

Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)	Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)
01-07-91	372	0.023±0.003	07-08-91	283	0.023±0.004
01-14-91	346	0.018±0.003	07-15-91	282	0.015±0.003
01-21-91	304	0.030±0.004	07-22-91	277	0.030±0.004
01-28-91	295	0.021±0.003	07-29-91	285	0.014±0.003
02-04-91	300	0.031±0.004	08-05-91	282	0.017±0.003
02-11-91	305	0.032±0.004	08-12-91	280	0.015±0.003
02-18-91	273	0.014±0.003	08-19-91	272	0.026±0.004
02-25-91	283	0.018±0.003	08-26-91	305	0.019±0.003
03-04-91	278	0.018±0.003	09-02-91	273	0.023±0.003
03-11-91	285	0.025±0.004	09-09-91	294	0.025±0.004
03-18-91	279	0.013±0.003	09-16-91	271	0.026±0.004
03-25-91	287	0.018±0.004	09-23-91	276	0.026±0.003
04-01-91	282	0.018±0.003	09-30-91	278	0.012±0.002
1st Qtr. mean ± s.d.		0.021±0.006	3rd Qtr. mean ± s.d.		0.021±0.006
04-08-91	285	0.022±0.004	10-07-91	285	0.026±0.004
04-15-91	285	0.019±0.003	10-14-91	272	0.024±0.004
04-22-91	277	0.010±0.003	10-21-91	277	0.020±0.003
04-29-91	280	0.021±0.002	10-28-91	275	0.028±0.003
05-06-91	283	0.009±0.003	11-04-91	269	0.027±0.004
05-13-91	283	0.018±0.003	11-11-91	294	0.026±0.003
05-20-91	279	0.016±0.003	11-18-91	273	0.044±0.003
05-27-91	283	0.017±0.002	11-25-91	316	0.018±0.003
06-03-91	285	0.017±0.003	12-03-91	304	0.024±0.003
06-10-91	287	0.010±0.003	12-09-91	237	0.026±0.004
06-17-91	280	0.018±0.003	12-16-91	279	0.037±0.004
06-24-91	277	0.023±0.004	12-23-91	273	0.021±0.004
07-01-91	277	0.019±0.003	12-30-91	278	0.026±0.004
2nd Qtr. mean ± s.d.		0.017±0.005	4th Qtr. mean ± s.d.		0.027±0.007

[a] Iodine-131 concentrations are <0.07 pCi/m^3 unless noted otherwise in Appendix C.

Table 9. Airborne particulates and iodine collected at Location T-12, analyses for gross beta and iodine-131.[a]

Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)	Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)
01-07-91	296	0.031±0.004	07-08-91	280	0.022±0.004
01-14-91	289	0.025±0.003	07-15-91	283	0.016±0.003
01-21-91	295	0.034±0.004	07-22-91	275	0.032±0.004
01-28-91	309	0.022±0.003	07-29-91	288	0.018±0.003
02-04-91	295	0.030±0.004	08-05-91	284	0.016±0.003
02-11-91	303	0.028±0.003	08-12-91	281	0.018±0.003
02-18-91	300	0.017±0.003	08-19-19	278	0.024±0.004
02-25-91	313	0.022±0.003	08-26-91	276	0.022±0.003
03-04-91	322	0.021±0.003	09-02-91	282	0.025±0.003
03-11-91	311	0.026±0.003	09-09-91	280	0.028±0.004
03-18-91	312	0.013±0.003	09-16-91	278	0.026±0.004
03-25-91	312	0.020±0.004	09-23-91	278	0.021±0.002
04-01-91	294	0.017±0.003	09-30-91	282	0.012±0.002
1st Qtr. mean ± s.d.		0.024±0.006	3rd Qtr. mean ± s.d.		0.022±0.006
04-08-91	306	0.025±0.004	10-07-91	273	0.027±0.004
04-15-91	302	0.021±0.003	10-14-91	273	0.034±0.004
04-22-91	300	0.009±0.003	10-21-91	267	0.022±0.004
04-29-91	299	0.020±0.002	10-28-91	285	0.023±0.002
05-06-91	302	0.011±0.003	11-04-91	282	0.028±0.004
05-13-91	295	0.017±0.003	11-11-91	276	0.024±0.004
05-20-91	295	0.016±0.003	11-18-91	283	0.042±0.003
05-27-91	282	0.017±0.002	11-25-91	286	0.027±0.004
06-03-91	284	0.023±0.003	12-02-91	280	0.022±0.003
06-10-91	286	0.013±0.003	12-09-91	274	0.021±0.004
06-17-91	282	0.018±0.003	12-16-91	279	0.034±0.004
06-24-91	279	0.019±0.003	12-23-91	279	0.021±0.004
07-01-91	280	0.020±0.003	12-30-91	280	0.023±0.004
2nd Qtr. mean ± s.d.		0.018±0.005	4th Qtr. mean ± s.d.		0.027±0.006

[a] Iodine-131 concentrations are <0.07 pCi/m^3 unless noted otherwise in Appendix C.

Table 10. Airborne particulates and iodine collected at Location T-27, analyses for gross beta and iodine-131.[a]

Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)	Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)
01-07-91	299	0.032±0.004	07-08-91	287	0.020±0.003
01-14-91	291	0.025±0.003	07-15-91	288	0.016±0.003
01-21-91	293	0.033±0.004	07-22-91	294	0.032±0.004
01-28-91	296	0.024±0.003	07-29-91	287	0.016±0.003
02-04-91	294	0.028±0.004	08-05-91	289	0.016±0.003
02-11-91	283	0.030±0.004	08-12-91	286	0.015±0.003
02-18-91	289	0.016±0.003	08-19-91	289	0.022±0.003
02-25-91	296	0.019±0.003	08-26-91	278	0.020±0.003
03-04-91	285	0.022±0.003	09-02-91	292	0.026±0.003
03-11-91	290	0.025±0.004	09-09-91	291	0.030±0.004
03-18-91	277	0.011±0.003	09-16-91	288	0.026±0.004
03-25-91	294	0.018±0.004	09-23-91	290	0.016±0.002
04-01-91	286	0.018±0.003	09-30-91	289	0.015±0.002
1st Qtr. mean ± s.d.		0.023±0.007	3rd Qtr. mean ± s.d.		0.021±0.006
04-08-91	285	0.016±0.003	10-07-91	293	0.025±0.003
04-15-91	289	0.019±0.003	10-14-91	289	0.022±0.003
04-22-91	285	0.007±0.003	10-21-91	289	0.020±0.003
04-29-91	289	0.021±0.002	10-28-91	290	0.026±0.002
05-06-91	291	0.012±0.003	11-04-91	291	0.030±0.004
05-13-91	286	0.019±0.003	11-11-91	286	0.024±0.003
05-20-91	288	0.019±0.003	11-18-91	287	0.041±0.003
05-27-91	288	0.015±0.002	11-25-91	291	0.030±0.004
06-03-91	288	0.014±0.003	12-03-91	326	0.022±0.003
06-10-91	288	0.010±0.003	12-09-91	254	0.029±0.004
06-17-91	286	0.019±0.003	12-16-91	292	0.037±0.004
06-24-91	287	0.018±0.003	12-23-91	288	0.023±0.004
07-01-91	287	0.019±0.003	12-30-91	287	0.025±0.004
2nd Qtr. mean ± s.d.		0.016±0.004	4th Qtr. mean ± s.d.		0.027±0.006

[a] Iodine-131 concentrations are <0.07 pCi/m^3 unless noted otherwise in Appendix C.

Table 11. Airborne particulates, gross beta analyses, monthly averages, minima, and maxima, 1991.[a]

Month	Location	Number of Samples	Gross Beta Activity (pCi/m^3) Average	Minimum	Maximum
January	T-1	4	0.026	0.021	0.032
	T-2	4	0.026	0.022	0.032
	T-3	4	0.028	0.022	0.032
	T-4	4	0.029	0.024	0.036
	T-7	4	0.027	0.024	0.031
	T-8	4	0.029	0.022	0.034
	All Indicators	24	0.028	0.021	0.036
	T-9	4	0.027	0.022	0.034
	T-11	4	0.023	0.018	0.030
	T-12	4	0.028	0.022	0.034
	T-27	4	0.028	0.024	0.033
	All Controls	16	0.026	0.018	0.034
February	T-1	4	0.023	0.015	0.029
	T-2	4	0.024	0.018	0.032
	T-3	4	0.026	0.018	0.032
	T-4	4	0.024	0.016	0.029
	T-7	4	0.022	0.014	0.026
	T-8	4	0.024	0.018	0.028
	All Indicators	24	0.024	0.014	0.032
	T-9	4	0.022	0.014	0.031
	T-11	4	0.024	0.014	0.032
	T-12	4	0.024	0.017	0.030
	T-27	4	0.023	0.016	0.030
	All Controls	16	0.023	0.014	0.032

[a] Unless specified otherwise, data for samples collected on the first, second, or third day of a month are grouped with data of the previous month. Numbers in parentheses indicate the number of samples with unreliable and less than value results which are excluded from the average.

Table 11. Airborne particulates, gross beta analyses, monthly averages, minima, and maxima, 1991[a] (continued)

Month	Location	Number of Samples[a]	Gross beta activity (pCi/m^3) Average	Minimum	Maximum
March	T-1	5	0.018	0.015	0.025
	T-2	5	0.018	0.012	0.022
	T-3	5	0.020	0.013	0.025
	T-4	5	0.020	0.017	0.024
	T-7	5	0.019	0.018	0.021
	T-8	5	0.020	0.012	0.026
	All Indicators	30	0.019	0.012	0.026
	T-9	5	0.020	0.015	0.023
	T-11	5	0.018	0.013	0.025
	T-12	5	0.019	0.013	0.026
	T-27	5	0.019	0.011	0.025
	All Controls	20	0.019	0.011	0.026
April	T-1	4	0.020	0.008	0.028
	T-2	4	0.019	0.011	0.022
	T-3	4	0.018	0.010	0.025
	T-4	4	0.018	0.006	0.023
	T-7	4	0.017	0.008	0.021
	T-8	4	0.020	0.005	0.034
	All Indicators	24	0.019	0.005	0.034
	T-9	4	0.017	0.004	0.024
	T-11	4	0.018	0.010	0.022
	T-12	4	0.019	0.009	0.025
	T-27	4	0.016	0.007	0.021
	All Controls	16	0.018	0.004	0.025

[a] Unless specified otherwise, data for samples collected on the first, second, or third day of a month are grouped with data of the previous month. Numbers in parentheses indicate the number of samples with unreliable and less than value results which are excluded from the average.

Table 11. Airborne particulates, gross beta analyses, monthly averages, minima, and maxima, 1991[a] (continued)

Month	Location	Number of Samples[a]	Gross beta activity (pCi/m^3) Average	Minimum	Maximum
May	T-1	5	0.017	0.014	0.021
	T-2	5	0.014	0.007	0.020
	T-3	5	0.013	0.006	0.019
	T-4	5	0.017	0.012	0.020
	T-7	5	0.015	0.008	0.018
	T-8	5	0.016	0.011	0.020
	All Indicators	30	0.015	0.006	0.021
	T-9	5	0.016	0.011	0.020
	T-11	5	0.017	0.009	0.018
	T-12	5	0.017	0.011	0.023
	T-27	5	0.016	0.012	0.019
	All Controls	20	0.016	0.009	0.023
June	T-1	4	0.017	0.009	0.021
	T-2	4	0.016	0.010	0.021
	T-3	4	0.015	0.009	0.021
	T-4	4	0.017	0.012	0.020
	T-7	4	0.016	0.009	0.020
	T-8	4	0.016	0.010	0.018
	All Indicators	24	0.016	0.009	0.021
	T-9	4	0.018	0.011	0.022
	T-11	4	0.018	0.010	0.023
	T-12	4	0.018	0.013	0.020
	T-27	4	0.016	0.010	0.019
	All Controls	16	0.018	0.010	0.023

[a] Unless specified otherwise, data for samples collected on the first, second, or third day of a month are grouped with data of the previous month. Numbers in parentheses indicate the number of samples with unreliable and less than value results which are excluded from the average.

Table 11. Airborne particulates, gross beta analyses, monthly averages, minima, and maxima, 1991[a] (continued)

Month	Location	Number of Samples[a]	Gross beta activity (pCi/m^3) Average	Minimum	Maximum
July	T-1	4	0.020	0.014	0.034
	T-2	4	0.019	0.012	0.030
	T-3	4	0.021	0.014	0.032
	T-4	4	0.021	0.014	0.034
	T-7	4	0.020	0.016	0.033
	T-8	4	0.019	0.010	0.030
	All Indicators	24	0.020	0.010	0.034
	T-9	4	0.020	0.015	0.024
	T-11	4	0.020	0.014	0.030
	T-12	4	0.022	0.016	0.032
	T-27	4	0.021	0.016	0.032
	All Controls	16	0.021	0.014	0.032
August	T-1	5	0.016	0.013	0.022
	T-2	5	0.021	0.015	0.026
	T-3	5	0.020	0.017	0.025
	T-4	5	0.018	0.016	0.031
	T-7	5	0.021	0.016	0.027
	T-8	5	0.019	0.014	0.024
	All Indicators	30	0.019	0.013	0.031
	T-9	5	0.022	0.019	0.026
	T-11	5	0.020	0.015	0.026
	T-12	5	0.021	0.016	0.0
	T-27	5	0.020	0.016	0.0
	All Controls	20	0.021	0.015	0.026

[a] Unless specified otherwise, data for samples collected on the first, second, or third day of a month are grouped with data of the previous month. Numbers in parentheses indicate the number of samples with unreliable and less than value results which are excluded from the average.

Table 11. Airborne particulates, gross beta analyses, monthly averages, minima, and maxima, 1991[a] (continued)

Month	Location	Number of Samples[a]	Gross beta activity (pCi/m^3) Average	Minimum	Maximum
September	T-1	4	0.020	0.012	0.027
	T-2	4	0.018	0.012	0.023
	T-3	4	0.018	0.010	0.025
	T-4	4	0.019	0.008	0.026
	T-7	4	0.022	0.012	0.031
	T-8	4	0.020	0.013	0.024
All Indicators		24	0.020	0.008	0.031
	T-9	4	0.022	0.012	0.028
	T-11	4	0.022	0.012	0.026
	T-12	4	0.022	0.012	0.028
	T-27	4	0.022	0.015	0.030
All Controls		16	0.022	0.012	0.030
October	T-1	4	0.022	0.019	0.029
	T-2	4	0.022	0.020	0.025
	T-3	4	0.020	0.016	0.024
	T-4	4	0.022	0.018	0.025
	T-7	4	0.026	0.019	0.030
	T-8	4	0.020	0.013	0.025
All Indicators		24	0.022	0.013	0.030
	T-9	4	0.024	0.021	0.028
	T-11	4	0.024	0.020	0.028
	T-12	4	0.026	0.022	0.034
	T-27	4	0.023	0.020	0.026
All Controls		16	0.024	0.020	0.034

[a] Unless specified otherwise, data for samples collected on the first, second, or third day of a month are grouped with data of the previous month. Numbers in parentheses indicate the number of samples with unreliable and less than value results which are excluded from the average.

Table 11. Airborne particulates, gross beta analyses, monthly averages, minima, and maxima, 1991[a] (continued)

Month	Location	Number of Samples[a]	Gross beta activity (pCi/m^3) Average	Minimum	Maximum
November	T-1	5	0.028	0.024	0.035
	T-2	5	0.030	0.026	0.040
	T-3	5	0.027	0.022	0.037
	T-4	5	0.029	0.026	0.038
	T-7	5	0.031	0.023	0.041
	T-8	5	0.027	0.022	0.040
All Indicators		30	0.029	0.022	0.041
	T-9	5	0.030	0.023	0.039
	T-11	5	0.028	0.018	0.044
	T-12	5	0.029	0.022	0.042
	T-27	5	0.029	0.022	0.041
All Controls		20	0.029	0.018	0.044
December	T-1	4	0.024	0.021	0.030
	T-2	4	0.024	0.016	0.031
	T-3	4	0.021	0.016	0.028
	T-4	4	0.024	0.021	0.031
	T-7	4	0.026	0.022	0.032
	T-8	4	0.022	0.016	0.027
All Indicators		24	0.024	0.016	0.032
	T-9	4	0.027	0.021	0.036
	T-11	4	0.028	0.021	0.037
	T-12	4	0.025	0.021	0.034
	T-27	4	0.028	0.023	0.037
All Controls		16	0.027	0.021	0.037

[a] Unless specified otherwise, data for samples collected on the first, second, or third day of a month are grouped with data of the previous month. Numbers in parentheses indicate the number of samples with unreliable and less than value results which are excluded from the average.

Table 12. Airborne particulates, quarterly composites of all indicator and all control locations, analyses for strontium and gamma-emitting isotopes, 1991.

	Sample Description and Activity (pCi/m^3)				
	January - Mar				
Lab Code	TAP-2525	TAP-2526	TAP-2528	TAP-2530	TAP-2532
Location	T-1	T-2	T-3	T-4	T-7
Volume (m^3)	3830	3756	3656	3714	3564
Sr-89	<0.0004	<0.0005	<0.0004	<0.0004	<0.0004
Sr-90	<0.0004	<0.0004	<0.0004	<0.0004	<0.0003
Be-7	0.058±0.013	0.066±0.011	0.046±0.011	0.058±0.012	0.050±0.015
K-40	<0.026	<0.021	<0.019	<0.021	<0.0024
Nb-95	<0.0015	<0.0012	<0.0014	<0.0015	<0.0012
Zr-95	<0.0023	<0.0026	<0.0025	<0.0025	<0.0028
Ru-103	<0.0009	<0.0009	<0.0013	<0.0010	<0.0010
Ru-106	<0.010	<0.0056	<0.0096	<0.0091	<0.011
Cs-134	<0.0010	<0.0008	<0.0010	<0.0009	<0.0009
Cs-137	<0.0012	<0.0010	<0.0011	<0.0010	<0.0012
Ce-141	<0.0016	<0.0013	<0.0016	<0.0014	<0.0018
Ce-144	<0.0061	<0.0055	<0.0066	<0.0055	<0.0052

Lab Code	TAP-2533	TAP-2534	TAP-2535	TAP-2536	TAP-2537
Location	T-8	T-9 (C)	T-11 (C)	T-12 (C)	T-27 (C)
Volume (m^3)	3651	3798	3889	3951	3773
Sr-89	<0.0003	<0.0003	<0.0003	<0.0004	<0.0003
Sr-90	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003
Be-7	0.063±0.010	0.059±0.012	0.060±0.010	0.054±0.013	0.066±0.011
K-40	<0.020	<0.023	<0.017	<0.022	<0.019
Nb-95	<0.0010	<0.0014	<0.0010	<0.0012	<0.0008
Zr-95	<0.0022	<0.0025	<0.0017	<0.0026	<0.0014
Ru-103	<0.0009	<0.0008	<0.0007	<0.0008	<0.0008
Ru-106	<0.0052	<0.008	<0.0049	<0.0076	<0.0060
Cs-134	<0.0008	<0.0009	<0.0006	<0.0010	<0.0008
Cs-137	<0.0008	<0.0012	<0.0007	<0.0012	<0.0008
Ce-141	<0.0008	<0.0016	<0.0007	<0.0014	<0.0009
Ce-144	<0.0026	<0.0054	<0.0024	<0.0058	<0.0025

Table 12. Airborne particulates, quarterly composites of all indicator and all control locations, analyses for strontium and gamma-emitting isotopes, 1991 (continued)

	Sample Description and Activity (pCi/m^3)				
	April - June				
Lab Code	TAP-2645	TAP-2646	TAP-2647	TAP-2648	TAP-2649
Location	T-1	T-2	T-3	T-4	T-7
Volume (m^3)	3585	3803	3670	3544	3539
Sr-89	<0.0004	<0.0004	<0.0003	<0.0005	<0.0005
Sr-90	<0.0003	<0.0003	<0.0002	<0.0004	<0.0004
Be-7	0.056±0.016	0.056±0.013	0.054±0.014	0.059±0.010	0.061±0.011
K-40	<0.029	<0.019	<0.022	<0.017	<0.022
Nb-95	<0.0017	<0.0013	<0.0017	<0.0016	<0.0022
Zr-95	<0.0029	<0.0022	<0.0021	<0.0018	<0.0028
Ru-103	<0.0013	<0.0007	<0.0013	<0.0007	<0.0013
Ru-106	<0.011	<0.0079	<0.0071	<0.0075	<0.0080
Cs-134	<0.0010	<0.0004	<0.0010	<0.0006	<0.0009
Cs-137	<0.0012	<0.0007	<0.0009	<0.0007	<0.0011
Ce-141	<0.0023	<0.0011	<0.0017	<0.0008	<0.0018
Ce-144	<0.0067	<0.0022	<0.0061	<0.0024	<0.005
Lab Code	TAP-2650	TAP-2651	TAP-2652	TAP-2653	TAP-2654
Location	T-8	T-9 (C)	T-11 (C)	T-12 (C)	T-27 (C)
Volume (m^3)	3617	3617	3661	3792	3737
Sr-89	<0.0004	<0.0004	<0.0003	<0.0004	<0.0004
Sr-90	<0.0003	<0.0003	<0.0002	<0.0003	<0.0003
Be-7	0.061±0.011	0.061±0.008	0.055±0.009	0.066±0.016	0.060±0.019
K-40	<0.019	<0.012	<0.011	<0.027	<0.027
Nb-95	<0.0012	<0.0016	<0.0012	<0.0018	<0.0033
Zr-95	<0.0015	<0.0023	<0.0016	<0.0031	<0.0027
Ru-103	<0.0008	<0.0014	<0.0009	<0.0014	<0.0015
Ru-106	<0.0069	<0.010	<0.0066	<0.0095	<0.0096
Cs-134	<0.0006	<0.0009	<0.0008	<0.0008	<0.0010
Cs-137	<0.0009	<0.0011	<0.0009	<0.0013	<0.0011
Ce-141	<0.0010	<0.0024	<0.0011	<0.0022	<0.0027
Ce-144	<0.0023	<0.0065	<0.0032	<0.0065	<0.0066

Table 12. Airborne particulates, quarterly composites of all indicator and all control locations, analyses for strontium and gamma-emitting isotopes, 1991 (continued)

	Sample Description and Activity (pCi/m^3) July - September				
Lab Code	TAP-2763	TAP-2764	TAP-2765	TAP-2766	TAP-2767
Location	T-1	T-2	T-3	T-4	T-7
Volume (m^3)	3635	3869	3743	3468	3885
Sr-89	<0.0006	<0.0006	<0.0005	<0.0006	<0.0009
Sr-90	<0.0002	<0.0003	<0.0002	<0.0003	<0.0004
Be-7	0.057±0.013	0.060±0.010	0.051±0.014	0.055±0.010	0.050±0.012
K-40	<0.024	<0.016	<0.024	<0.016	<0.022
Nb-95	<0.0015	<0.0013	<0.0017	<0.0013	<0.0016
Zr-95	<0.0023	<0.0022	<0.0032	<0.0020	<0.0021
Ru-103	<0.0012	<0.0007	<0.0011	<0.0008	<0.0011
Ru-106	<0.0097	<0.0066	<0.010	<0.0072	<0.0093
Cs-134	<0.0008	<0.0008	<0.0011	<0.0006	<0.0009
Cs-137	<0.0013	<0.0008	<0.0012	<0.0008	<0.0010
Ce-141	<0.0016	<0.0008	<0.0014	<0.0009	<0.0014
Ce-144	<0.0060	<0.0027	<0.0052	<0.0031	<0.0048
Lab Code	TAP-2768	TAP-2769	TAP-2770	TAP-2771	TAP-2772
Location	T-8	T-9 (C)	T-11 (C)	T-12 (C)	T-27 (C)
Volume (m^3)	3745	3771	3658	3645	3748
Sr-89	<0.0010	<0.0008	<0.0009	<0.0008	<0.0013
Sr-90	<0.0004	<0.0004	<0.0004	<0.0004	<0.0006
Be-7	0.057±0.010	0.061±0.012	0.056±0.011	0.056±0.014	0.054±0.012
K-40	<0.015	<0.023	<0.015	<0.018	<0.021
Nb-95	<0.0012	<0.0015	<0.0013	<0.0017	<0.0015
Zr-95	<0.0016	<0.0025	<0.0023	<0.0026	<0.0022
Ru-103	<0.0008	<0.0012	<0.0009	<0.0010	<0.0009
Ru-106	<0.0063	<0.011	<0.0095	<0.012	<0.0064
Cs-134	<0.0005	<0.0011	<0.0007	<0.0009	<0.0008
Cs-137	<0.0006	<0.0010	<0.0009	<0.0014	<0.0009
Ce-141	<0.0008	<0.0017	<0.0010	<0.0017	<0.0015
Ce-144	<0.0023	<0.0053	<0.0028	<0.0048	<0.0050

Table 12. Airborne particulates, quarterly composites of all indicator and all control locations, analyses for strontium and gamma-emitting isotopes, 1991 (continued)

	Sample Description and Activity (pCi/m^3)				
	October - December				
Lab Code	TAP-2890	TAP-2891	TAP-2892	TAP-2893	TAP-2894
Location	T-1	T-2	T-3	T-4	T-7
Volume (m^3)	3699	3800	3819	3693	3834
Sr-89	<0.0004	<0.0004	<0.0005	<0.0004	<0.0004
Sr-90	<0.0004	<0.0004	<0.0005	<0.0003	<0.0004
Be-7	0.047±0.008	0.050±0.012	0.041±0.008	0.047±0.015	0.054±0.015
K-40	<0.015	<0.029	<0.024	<0.028	<0.029
Nb-95	<0.0013	<0.0021	<0.0018	<0.0017	<0.0017
Zr-95	<0.0017	<0.0032	<0.0029	<0.0023	<0.0019
Ru-103	<0.0007	<0.0015	<0.0014	<0.0012	<0.0012
Ru-106	<0.0060	<0.013	<0.013	<0.0099	<0.011
Cs-134	<0.0006	<0.0013	<0.0010	<0.0011	<0.0011
Cs-137	<0.0007	<0.0013	<0.0014	<0.0011	<0.0014
Ce-141	<0.0008	<0.0022	<0.0024	<0.0025	<0.0027
Ce-144	<0.0023	<0.0087	<0.0082	<0.0085	<0.0079
Lab Code	TAP-2895	TAP-2896	TAP-2897	TAP-2898	TAP-2899
Location	T-8	T-9 (C)	T-11 (C)	T-12 (C)	T-27 (C)
Volume (m^3)	3840	3701	3632	3617	3763
Sr-89	<0.0004	<0.0004	<0.0005	<0.0004	<0.0004
Sr-90	<0.0004	<0.0003	<0.0004	<0.0004	<0.0004
Be-7	0.050±0.015	0.051±0.016	0.044±0.009	0.048±0.008	0.043±0.008
K-40	<0.027	<0.029	<0.011	<0.011	<0.013
Nb-95	<0.0020	<0.0016	<0.0014	<0.0012	<0.0012
Zr-95	<0.0026	<0.0030	<0.0021	<0.0018	<0.0019
Ru-103	<0.0016	<0.0013	<0.0011	<0.0009	<0.0010
Ru-106	<0.014	<0.013	<0.0083	<0.0067	<0.0069
Cs-134	<0.0012	<0.0011	<0.0009	<0.0007	<0.0008
Cs-137	<0.0016	<0.0014	<0.0010	<0.0009	<0.0008
Ce-141	<0.0026	<0.0024	<0.0020	<0.0012	<0.0015
Ce-144	<0.0081	<0.0080	<0.0058	<0.0034	<0.0046

Table 13. Area monitors (TLD), quarterly, 1991.

Location	mR/91 days			
	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
Indicator				
T-1	10.5±0.3	11.1±0.4	11.2±0.7	11.9±0.6
T-2	11.9±0.4	10.9±0.2	12.3±0.6	11.9±0.5
T-3	11.9±0.5	11.4±0.8	12.7±0.6	12.2±0.9
T-4	15.0±0.6	12.6±0.4	15.0±0.7	13.9±0.4
T-5	13.1±0.8	11.5±0.3	12.7±0.7	12.2±0.3
T-6	10.4±0.6	11.0±0.5	11.6±0.6	11.6±0.7
T-7	16.4±0.8	16.1±0.7	15.9±0.7	16.8±0.6
T-8	21.0±0.8	17.7±0.9	21.4±1.1	18.1±0.5
T-10	13.8±0.6	13.1±0.5	13.9±0.8	13.4±0.7
T-38	11.8±0.3	13.1±0.5	11.7±0.5	13.3±0.7
T-39	14.0±0.7	13.8±0.3	13.4±0.7	13.7±0.6
T-40	12.6±0.7	13.2±0.6	13.7±0.6	14.2±0.6
T-41	10.1±0.6	12.3±0.4	10.9±0.8	13.1±0.7
T-42	9.9±0.6	10.4±0.6	9.9±0.5	11.3±0.4
T-43	14.2±0.9	16.0±0.7	16.2±0.8	16.6±0.7
T-44	14.5±0.7	15.2±1.0	16.1±0.9	16.8±0.6
T-45	18.9±0.9	17.5±0.6	20.7±0.8	18.1±0.9
T-46	12.3±0.5	12.1±0.5	13.3±0.5	12.6±0.9
T-47	8.2±0.5	9.3±0.4	9.2±0.5	10.2±0.7
T-48	14.9±0.8	15.7±0.5	17.2±0.5	16.8±0.8
T-49	11.8±0.6	11.5±0.4	12.0±0.5	10.8±0.
T-50	17.4±0.4	21.2±0.7	20.0±0.6	20.9±0.4
T-51	14.4±0.7	15.0±0.5	16.7±0.8	16.3±0.9
T-52	18.2±0.4	21.0±0.5	21.5±0.5	20.2±0.5
T-53	16.6±0.6	22.7±1.1	19.4±0.5	22.5±0.5
T-54	16.3±0.4	19.8±0.8	19.4±0.6	21.6±0.3
T-55	14.5±0.5	14.6±0.6	17.0±0.5	15.6±0.6
Mean ± s.d.	13.9±3.0	14.4±3.6	15.0±3.6	15.1±3.5
Control				
T-9	11.7±0.4	12.1±0.5	12.1±0.5	11.5±1.1
T-11	13.4±0.4	12.8±0.6	14.9±0.6	12.7±1.0
T-12	19.4±1.1	17.6±0.9	19.7±0.5	17.5±0.8
T-23	13.3±0.4	14.0±0.7	13.6±0.6	11.9±1.0
T-24	17.4±0.6	15.8±0.5	18.2±0.5	16.8±0.5
T-27	15.7±0.4	16.8±0.7	17.2±0.7	17.8±1.0
Mean ± s.d.	15.2±2.9	14.8±2.2	16.0±2.9	14.7±3.0

Table 13. Area monitors (TLD), quarterly, 1991 (continued)

Location	mR/91 days 1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
Indicator				
T-60	12.0±0.6	10.9±0.6	11.1±0.7	12.0±0.4
T-61	11.8±0.5	10.5±0.7	10.9±0.6	10.9±0.7
T-62	11.3±0.5	10.7±0.4	11.3±0.3	11.4±0.6
T-63	14.0±0.7	12.2±0.5	13.1±0.3	13.0±0.6
T-64	9.5±0.8	9.3±0.7	8.5±0.3	10.6±0.4
T-65	16.5±0.8	15.2±0.7	16.0±0.6	15.9±0.9
T-66	22.1±0.8	21.8±0.7	22.0±0.9	20.2±0.7
T-67	20.8±1.0	18.9±1.3	21.5±0.5	19.2±1.2
T-68	16.3±0.8	17.5±1.3	18.6±0.8	18.6±1.0
T-69	19.6±1.6	14.3±0.6	20.3±0.7	13.3±0.7
T-70	11.9±0.8	9.7±0.6	11.2±0.6	11.0±0.6
T-71	17.9±0.7	18.3±0.6	15.1±0.4	16.8±0.9
T-73	14.4±1.0	12.5±0.6	13.7±0.4	13.3±0.4
T-74	13.7±0.9	11.3±0.5	12.4±0.6	11.3±0.5
T-75	16.3±0.9	14.8±0.8	16.5±0.7	15.2±0.7
T-76	12.3±0.7	11.0±0.8	12.2±0.6	11.2±0.6
T-77	11.5±0.5	9.5±0.4	10.6±0.6	10.7±0.5
T-90	17.5±0.7	17.6±0.8	18.1±0.4	18.1±1.2
T-91	ND[a]	16.2±0.9	17.7±0.7	17.5±0.4
T-92	12.2±0.5	9.9±0.7	13.2±0.3	9.6±0.9
T-93	12.4±0.6	15.1±0.2[b]	ND[a]	11.7±0.9
T-94	17.1±0.6	11.5+0.4	18.0±0.4	12.3±0.6
T-97	18.2±0.5	17.5±0.9	20.5±0.4	17.0±0.5
T-99	18.8±0.7	18.9±0.6	20.0±0.6	19.5±0.5
T-112	15.3±1.0	15.4±0.6	15.3±0.3	15.0±0.5
T-121	17.8±0.7	19.5±0.9	19.3±0.8	19.5±0.5
T-122	15.0±0.9	13.4±0.4	16.9±0.8	14.7±0.3
T-123	14.5±1.0	15.7±0.9	16.6±0.8	16.0±0.4
T-125	16.1±0.7	17.3±0.5	18.2±0.6	18.5±0.9
T-126	15.9±0.7	16.7±1.0	18.3±0.6	17.0±0.6
T-127	20.2±0.9	20.5±0.8	22.5±0.5	20.4±0.7
T-128	18.0±0.5	19.0±0.9	19.6±0.6	18.9±0.8
T-150	12.5±0.8	9.2±0.6	12.8±0.2	9.8±0.3
T-151	18.1±0.5	19.0±1.2	20.0±0.4	19.0±1.0
T-153	19.5±1.1	21.9±1.6	21.8±0.9	21.0±0.8
T-154	16.2±0.7	16.6±1.1	18.0±0.6	15.9±0.6
T-201	14.1±0.3	15.6±0.8	14.1±0.4	13.2±0.6
T-202	14.0±0.8	17.3±0.5[b]	13.9±0.3	ND[a]
T-203	ND[a]	15.3±0.6	ND[a]	13.7±0.5
T-204	ND[a]	16.1±0.8	ND[a]	13.7±0.4
T-205	16.3±0.6	18.9±1.0	15.5±0.3	16.4±0.9
T-206	11.9±0.4	11.9±0.5	12.6±1.1	10.7±0.7
T-207	11.4±0.4	11.2±0.5	11.2±0.7	10.0±0.6
T-208	12.1±0.3	10.8±0.8	11.7±0.4	10.0±0.6
Mean±s.d.	15.3±3.1	14.9±3.7	15.9±3.8	14.7±3.5

[a] ND = No data; TLD missing.

[b] Placed 04-11-91; removed 10-09-91.

Table 13. Area monitors (TLD), quarterly, 1991 (continued)

Location	mR/91 days 1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
Control				
T-78	ND[b]	ND[b]	ND[b]	ND[b]
T-95	19.2±1.0	18.9±1.4	20.2±1.0	18.6±0.9
T-96	10.0±0.5	10.8±0.7	10.1±0.3	11.1±1.0
T-98	19.2±0.8	19.5±1.0	19.0±0.3	19.3±0.7
T-100	17.3±0.8	16.5±1.2	19.1±0.5	17.0±0.8
T-101	16.3±0.7	16.2±1.0	17.0±0.7	16.4±0.7
T-102	13.5±0.9	12.1±0.6	13.8±0.5	8.2±0.9
T-103	17.4±0.6	16.7±0.7	18.2±0.8	16.5±0.9
T-104	15.2±1.0	15.8±0.8	16.1±0.9	15.3±0.9
T-105	18.7±1.4	18.5±1.2	19.8±1.2	17.0±0.9
T-106	14.2±0.6	16.1±0.7	14.7±0.6	15.0±0.8
T-107	15.2±1.1	18.2±1.4	16.5±1.0	16.0±0.6
T-108	17.3±0.7	19.9±0.5	19.1±0.5	18.8±0.4
T-109	20.6±0.5	20.3±0.5	18.8±0.6	18.7±0.5
T-110	17.2±0.9	17.9±0.9	18.0±0.6	16.6±0.9
T-111	16.6±0.6	19.9±1.2	17.3±0.7	17.2±0.9
T-124	13.8±1.0	13.7±1.0	15.0±0.8	14.5±0.4
T-155	16.0±0.6	14.0±0.7	17.6±0.6	15.3±0.6
Mean±s.d.	16.3±2.6	16.8±2.8	17.1±2.6	16.0±2.8
QC				
T-79	ND[b]	ND[b]	ND[b]	ND[b]
T-80	13.6±0.8	11.9±0.7	13.1±0.8	12.8±0.8
T-81	13.0±0.7	11.4±0.6	12.7±0.9	12.1±0.6
T-82	9.2±0.9	9.1±0.6	8.8±0.3	9.6±0.5
T-83	10.5±0.6	9.1±0.5	10.7±0.4	9.8±0.4
T-84	14.5±0.6	13.1±0.7	13.9±0.3	13.4±0.6
T-85	14.2±0.5	12.9±0.7	13.2±0.5	13.1±0.7
T-86	10.5±0.9	9.9±0.5	10.1±0.6	10.9±0.8
T-88	20.7±0.6	18.3±0.9	21.9±0.7	18.3±0.6
T-89	15.5±0.8	13.9±0.6	14.7±0.4	14.5±0.3
T-113	13.7±0.8	15.3±0.8	14.5±0.4	14.5±0.4
T-114	ND[a]	17.2±0.5[c]	12.9±0.6	11.4±0.3
T-115	20.2±1.1	21.8±0.8	21.5±1.3	18.6±1.0
T-116	19.8±1.1	ND[a]	21.4±0.8	16.5±0.6
T-117	16.7±0.8	18.9±0.8	18.5±0.9	17.7±0.6
T-118	13.8±0.8	17.0±1.1	15.6±0.8	15.4±0.6
T-119	19.3±1.0	21.3±0.8	22.7±0.6	22.0±0.9
T-120	15.7±0.7	18.8±1.1	17.8±0.5	19.4±0.5
T-200	15.2±1.1	18.7±0.8	15.8±0.9	17.0±0.8
Mean±s.d.	15.1±3.4	15.2±4.2	15.5±4.2	14.8±3.5

[a] ND = No data. TLD missing.
[b] ND = No data; site deleted from project.
[c] Placed 04-11-91; removed 10-03-91.

Table 13 Area monitors (TLD), quarterly, 1991 (continued)

Location	mR/91 drys			
	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
Shield				
T-87	5.0±0.6	4.3±0.5	5.6±0.3	4.8±0.3

Table 14. Area monitors (TLD), annually, 1991.

Location	mR/365 days
Indicator	
T-1	50.0±2.2
T-2	51.2±1.2
T-3	48.8±1.1
T-4	58.0±1.1
T-5	52.7±1.8
T-6	ND[a]
T-7	61.3±0.7
T-8	82.3±1.2
T-10	62.0±2.5
T-38	45.6±1.0
T-39	51.0±1.2
T-40	57.5±1.2
T-41	48.7±1.1
T-42	42.9±1.9
T-43	69.5±0.9
T-44	72.1±1.1
T-45	71.8±0.8
T-46	51.0±1.0
T-47	35.6±0.7
T-48	65.6±1.1
T-49	47.8±0.9
T-50	78.3±0.7
T-51	59.3±0.8
T-52	80.7±1.9
T-53	74.7±1.7
T-54	70.7±1.7
T-55	58.2±1.0
Mean ± s.d.	59.5±12.5
Control	
T-9	52.8±2.4
T-11	63.1±0.8
T-12	80.7±1.7
T-23	57.7±1.2
T-24	74.0±1.4
T-27	74.0±1.2
Mean ± s.d.	67.0±10.8

[a] ND = no data; TLD missing.

Table 14. Area monitors (TLD), annually, 1991 (continued)

Location	mR/365 days
Indicator	
T-60	48.7±1.6
T-61	47.1±1.6
T-62	46.4±0.6
T-63	52.9±0.7
T-64	39.2±0.6
T-65	65.8±1.4
T-66	83.4±2.4
T-67	79.0±1.7
T-68	72.2±1.6
T-69	77.0±1.9
T-70	43.5±1.1
T-71	68.8±1.0
T-73	55.7±1.1
T-74	54.0±1.7
T-75	61.1±1.4
T-76	17.1±2.3
T-77	44.7±0.8
T-90	79.7±2.1
T-91	ND[a]
T-92	53.7±2.0
T-93	ND[a]
T-94	72.2±1.7
T-97	77.6±1.8
T-99	78.8±1.0
T-112	61.0±1.3
T-121	76.4±2.4
T-122	63.6±1.6
T-123	65.2±1.1
T-125	72.3±1.4
T-126	62.6±2.0
T-127	73.4±0.7
T-128	76.1±2.0
T-150	56.2±1.1
T-151	73.7±1.4
T-153	81.5±2.0
T-154	66.5±1.1
T-201	53.8±1.5
T-202	ND[a]
T-203	ND[a]
T-204	ND[a]
T-205	56.8±1.7
T-206	20.2±1.5[b]
T-207	37.7±1.5
T-208	41.9±2.0
Mean ± s.d.	61.2±14.9

[a] ND = No data; TLD missing.

[b] TLD wet; may account for low reading.

Table 14. Area monitors (TLD), annually, 1991 (continued)

Location	mR/365 days
Control	
T-78	ND[a]
T-95	77.6±1.8
T-96	50.9±1.3
T-98	75.4±0.8
T-100	69.1±0.9
T-101	72.3±0.6
T-102	56.5±1.5
T-103	73.6±0.6
T-104	66.7±1.2
T-105	80.4±1.1
T-106	61.0±1.1
T-107	70.9±0.8
T-108	78.4±1.1
T-109	76.5±2.6
T-110	68.4±1.9
T-111	70.2±1.7
T-124	59.4±2.0
T-155	67.9±1.3
Mean ± s.d.	69.1±8.2
QC	
T-79	ND[a]
T-80	48.2±1.6
T-81	46.0±0.5
T-82	36.9±0.7
T-83	38.5±0.5
T-84	53.6±0.7
T-85	50.5±0.8
T-86	42.8±1.3
T-88	80.9±1.1
T-89	57.5±1.3
T-113	55.0±1.0
T-114	ND[b]
T-115	77.8±0.9
T-116	80.6±1.9
T-117	70.7±2.8
T-118	59.3±1.8
T-119	85.4±1.0
T-120	69.7±0.6
T-200	65.7±2.3
Mean ± s.d.	59.9±15.5
Shield	
T 87	24.9±1.5

[a] ND = No data; site deleted from project.

[b] ND = No data; TLD missing.

Table 15. Milk samples, analyses for Sr-89, Sr-90, I-131, and gamma-emitting isotopes. Collection: Semimonthly May through October, monthly otherwise.

Date Collected	Lab Code	Activity (pCi/L) Sr-89	Sr-90	I-131	Ba-La-140	Cs-137	K-40
		T-8 Farm, 2.7 mi WSW of Station					
01-14-91	TMI-5811,2	<0.4	1.1±0.2	<0.4	<10	<10	1220±100
02-11-91	5892	<0.6	1.1±0.4	<0.3	<10	<10	1170±110
03-11-91	5970	<0.4	0.8±0.3	<0.2	<10	<10	1150±150
04-08-91	6031	<0.5	0.5±0.3	<0.2	<10	<10	1180±150
05-13-91	6163	<0.8	0.7±0.4	<0.4	<10	<10	1240±100
05-27-91	6241	<0.9	1.4±0.6	<0.3	<10	<10	1260±150
06-10-91	6324	<0.7	0.7±0.3	<0.4	<10	<10	1230±90
06-24-91	6406	<0.5	0.7±0.3	<0.3	<10	<10	1200±150
07-08-91	6486	<0.6	0.7±0.3	<0.3	<10	<10	1370±140
07-22-91	6576	<0.9	1.0±0.5	<0.2	<10	<10	1280±100
08-12-91	6725	<0.6	0.8±0.3	<0.3	<10	<10	1100±130
08-26-91	6781	<0.5	0.8±0.3	<0.3	<10	<10	1250±120
09-09-91	6848	<0.9	1.9±0.7	<0.2	<10	<10	1170±150
09-23-91	6949	<0.6	1.1±0.4	<0.3	<10	<10	1500±170
10-15-91	7066	<1.1	<0.7	<0.3	<10	<10	1280±140
10-28-91	7136	<0.5	0.9±0.4	<0.2	<10	<10	1290±140
11-12-91	7205	<0.7	0.8±0.4	<0.2	<10	<10	1130±110
12-09-91	7274	<0.7	1.8±0.6	<0.2	<10	<10	1230±130
		T-199 (C) Farm, 8.5 mi SW of Station					
01-14-91	TMI-5815	<0.4	2.4±0.5	<0.3	<10	<10	1240±150
02-12-91	NS[a]	--	--	--	--	--	--

[a] NS = No sample; location dropped from program.

Table 15. Milk samples, analyses for Sr-89, Sr-90, I-131, and gamma-emitting isotopes (continued)

Date Collected	Lab Code	Activity (pCi/L) Sr-89	Sr-90	I-131	Ba-La-140	Cs-137	K-40
		T-24 (C) Sandusky, 21.0 mi SE of Station					
01-15-91	TMI-5813	<0.4	0.9±0.3	<0.2	<10	<10	1410±160
02-12-91	5893	<0.7	1.2±0.5	<0.3	<10	<10	1230±150
03-12-91	5971	<0.4	1.4±0.4	<0.2	<10	<10	1200±100
04-09-91	6035	<0.5	1.2±0.4	<0.2	<10	<10	1260±140
05-14-91	6164	<0.7	1.8±0.5	<0.3	<10	<10	1310±110
05-28-91	6242	<0.7	2.1±0.5	<0.3	<10	<10	1200±130
06-11-91	6325,6	<0.7	1.4±0.3	<0.4	<10	<10	1260±80
06-25-91	6407	<0.5	1.4±0.4	<0.2	<10	<10	1[illegible]150
07-09-91	6487	<0.5	2.1±0.5	<0.3	<10	<10	1[illegible]±140
07-23-91	6577	<1.1	1.7±0.4	<0.3	<10	<10	1230±110
08-13-91	6726	<0.5	1.3±0.4	<0.3	<10	<10	1110±110
08-27-91	6782	<0.6	0.9±0.4	<0.2	<10	<10	1200±130
09-10-91	6849	<0.7	1.5±0.5	<0.2	<10	<10	1330±140
09-24-91	6950	<0.6	1.1±0.4	<0.4	<10	<10	1160±130
10-15-91	7067	<0.7	1.4±0.4	<0.3	<10	<10	1180±160
10-29-91	7137	<0.5	1.5±0.4	<0.4	<10	<10	1290±140
11-12-91	7206,7	<0.9	1.1±0.3	<0.2	<10	<10	1320±90
12-10-91	7275	<0.6	1.2±0.4	<0.3	<10	<10	1270±80
		T-57 (C) Farm, 22 miles SSE of Station					
01-15-91	TMI-5814	<0.4	0.8±0.3	<0.2	<10	<10	1200±120
02-12-91	5894	<0.5	0.9±0.3	<0.2	<10	<10	1340±120
03-12-91	5972	<0.4	0.9±0.4	<0.2	<10	<10	1170±120
04-09-91	6036	<0.4	0.6±0.3	<0.2	<10	<10	1310±130
05-14-91	6165	<0.6	0.8±0.3	<0.2	<10	<10	1220±110
05-28-91	6243	<0.6	1.3±0.4	<0.3	<10	<10	1050±130
06-11-91	6327	<0.6	1.1±0.4	<0.3	<10	<10	1170±120
06-25-91	6408	<0.5	0.8±0.3	<0.3	<10	<10	1290±150
07-09-91	6488	<0.6	1.2±0.4	<0.3	<10	<10	1290±150
07-23-91	6578	<0.7	1.3±0.4	<0.2	<10	<10	1460±100
08-13-91	6727	<0.6	1.8±0.4	<0.3	<10	<10	1250±140
08-27-91	6783	<0.7	2.1±0.7	<0.3	<10	<10	1160±120
09-10-91	6850	<0.6	0.6±0.3	<0.2	<10	<10	1290±140
09-24-91	6951	<0.6	1.0±0.4	<0.3	<10	<10	1300±120
10-15-91	7068	<0.7	0.6±0.4	<0.4	<10	<10	1340±130
10-29-91	7138	<0.6	0.6±0.3	<0.3	<10	<10	1280±170
11-12-91	7208	<0.7	1.2±0.4	<0.2	<10	<10	1310±140
12-10-91	7276	<0.6	0.8±0.4	<0.3	<10	<10	1300±90

Table 16. Milk samples, analyses for calcium, stable potassium, and ratios of Sr-90 (pCi) per gram of calcium and Cs-137 (pCi) per gram of potassium. Collection: Semimonthly May through October; monthly otherwise.

Date Collected	Lab Code	Calcium (g/L)	Potassium (g/L)	Sr-90 (pCi) per gram of Calcium	Cs-137 (pCi) per gram of Potassium
	T-8 Farm, 2.7 mi WSW of Station				
01-14-91	TMI-5811,2	0.92	1.41±0.12	1.20	<7.09
02-12-91	5892	0.70	1.35±0.13	1.57	<7.41
03-12-91	5970	0.85	1.33±0.17	0.94	<7.52
04-08-91	6034	0.85	1.36±0.17	0.59	<7.35
05-13-91	6163	0.86	1.44±0.12	0.81	<6.94
05-27-91	6241	0.85	1.46±0.17	1.65	<6.85
06-10-91	6324	0.87	1.42±0.10	0.80	<7.04
06-24-91	6406	0.78	1.39±0.17	0.90	<7.19
07-08-91	6486	0.79	1.58±0.16	0.89	<6.33
07-22-91	6576	0.84	1.48±0.17	1.19	<6.76
08-12-91	6725	0.85	1.27±0.15	0.94	<7.87
08-26-91	6781	1.01	1.44±0.14	0.79	<6.94
09-09-91	6848	0.84	1.35±0.17	2.26	<7.41
09-23-91	6949	0.97	1.73±0.20	1.13	<5.78
10-15-91	7066	0.50[b]	1.48±0.16	<1.40	<6.76
10-28-91	7136	0.95	1.49±0.16	0.95	<6.71
11-12-91	7205	0.92	1.31±0.13	0.87	<7.63
12-09-91	7274	0.85	1.42±0.15	2.12	<7.03
	T-199 (C) Farm 8.5 mi SW of Station				
01-14-91	TMI-5815	0.96	1.43±0.17	2.50	<6.99
02-12-91	NS[a]	--	--	--	--

[a] NS = No sample; location dropped from program.

[b] Analysis was repeated; result of reanalysis 0.50 g/L.

Table 16. Milk samples, analyses for calcium, stable potassium, and ratios of Sr-90 (pCi) per gram of calcium and Cs-137 (pCi) per gram of potassium (continued)

Date Collected	Lab Code	Calcium (g/L)	Potassium (g/L)	Sr-90 (pCi) per gram of Calcium	Cs-137 (pCi) per gram of Potassium
	T-24 (C) Sandusky, 21.0 mi SE of Station				
01-15-91	TMI-5813	0.90	1.63±0.18	1.00	<6.13
02-12-91	5893	0.93	1.42±0.17	1.29	<7.04
03-12-91	5971	0.81	1.39±0.12	1.73	<7.19
04-09-91	6035	1.18	1.46±0.16	1.02	<6.85
05-13-91	6164	0.82	1.51±0.13	2.20	<6.62
05-27-91	6242	0.93	1.39±0.15	2.26	<7.19
06-10-91	6325,6	0.82	1.45±0.09	1.71	<6.85
06-24-91	6407	1.06	1.39±0.17	1.32	<7.19
07-09-91	6487	0.81	1.47±0.16	2.59	<6.80
07-23-91	6577	0.96	1.42±0.13	1.77	<7.04
08-13-91	6726	0.89	1.28±0.13	1.46	<7.81
08-27-91	6782	0.87	1.39±0.15	1.03	<7.19
09-10-91	6849	0.84	1.54±0.16	1.79	<6.49
09-24-91	6950	0.93	1.34±0.15	1.18	<7.46
10-15-91	7067	0.88	1.36±0.18	1.59	<7.35
10-29-91	7137	0.88	1.49±0.16	1.70	<6.71
11-12-91	7206,7	0.88	1.53±0.10	1.25	<6.54
12-10-91	7275	0.61	1.47±0.09	1.97	<6.80
	T-57 (C) Farm, 22 miles SSE of Station				
01-15-91	TMI-5814	0.89	1.39±0.14	0.90	<7.19
02-12-91	5894	0.87	1.55±0.14	1.03	<6.45
03-12-91	5972	0.88	1.35±0.14	1.02	<7.41
04-09-91	6036	1.01	1.51±0.15	0.59	<6.62
05-13-91	6165	0.83	1.41±0.13	0.96	<7.09
05-27-91	6243	0.84	1.21±0.15	1.55	<8.26
06-10-91	6327	0.92	1.35±0.14	1.20	<7.41
06-24-91	6408	0.88	1.49±0.17	0.91	<6.71
07-09-91	6488	0.91	1.49±0.17	1.32	<6.71
07-23-91	6578	0.97	1.69±0.12	1.34	<5.92
08-13-91	6727	0.97	1.44±0.16	1.86	<6.94
08-27-91	6783	0.94	1.34±0.14	2.23	<7.46
09-10-91	6850	0.92	1.49±0.16	0.65	<6.71
09-24-91	6951	0.98	1.50±0.14	1.02	<6.67
10-15-91	7068	0.94	1.55±0.15	0.64	<6.45
10-29-91	7138	1.03	1.48±0.20	0.58	<6.76
11-12-91	7208	0.87	1.51±0.16	1.38	<6.62
12-10-91	7276	0.90	1.50±0.10	0.89	<6.67

Table 17. Ground water samples, analyses for gross beta, Sr-89, Sr-90, and gamma-emitting isotopes. Collection: Quarterly.

Sample Description and Activity (pCi/L)					Annual Mean ± s.d.
T-7					
Lab Code	TWW-9260	TWW-321	TWW-1523	TWW-2839	
Collection Period	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	
Gross Beta					
Suspended Solids	<0.4	<0.2	<0.2	<0.8	<0.8
Dissolved Solids	2.9±0.5	2.9±0.4	3.0±0.7	3.0±0.3	3.0±0.1
Total Residue	2.9±0.5	2.9±0.4	3.0±0.7	3.0±0.3	3.0±0.1
H-3	<330	<330	<330	<330	<330
Sr-89	<0.9	<0.6	<0.8	<0.8	<0.9
Sr-90	<0.9	<0.5	0.6±0.3	0.9±0.3	0.8±0.2
Cs-137	<10	<10	<10	<10	<10
T-54					
Lab Code	TWW-9262	TWW-323,4	TWW-1525	TWW-2841	
Collection Period	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	
Gross Beta					
Suspended Solids	<0.4	<0.3	<0.2	<0.8	<0.8
Dissolved Solids	2.4±1.1	3.3±0.9	3.3±2.3	3.3±0.4	3.1±0.4
Total Residue	2.4±1.1	3.3±0.9	3.3±2.3	3.3±0.4	3.1±0.4
H-3	<330	<330	<330	<330	<330
-89	<0.5	<0.5	<0.8	<1.2	<1.2
Sr-90	<0.4	<0.4	<0.4	<0.5	<0.5
Cs-137	<10	<10	<10	<10	<10

Table 17. Ground water samples, analyses for gross beta, Sr-89, Sr-90, and gamma-emitting isotopes (continued)

Sample Description and Activity (pCi/L)					Annual Mean ± s.d.
T-23 (C)					
Lab Code	ND[a]	TWW-1408	TWW-3464	TWW-3716	
Collection Period	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	
Gross Beta					
Suspended Solids	--	<0.2	<0.2	<0.7	<0.7
Dissolved Solids	--	2.3±1.7	<2.3	<1.9	2.3±1.7
Total Residue	--	2.3±1.7	<2.3	<1.9	2.3±1.7
H-3	--	<330	<330	<330	<330
Sr-89	--	<0.7	<1.3	<1.1	<1.3
Sr-90	--	<0.4	<0.5	<0.4	<0.5
Cs-137	--	<10	<10	<10	<10
T-27 (C)					
Lab Code	TWW-9261	TWW-322	TWW-1524	TWW-2840	
Collection Period	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	
Gross Beta					
Suspended Solids	<0.4	<0.2	<0.2	<0.8	<0.8
Dissolved Solids	1.8±0.8	2.3±1.3	1.8±1.3	1.6±1.2	1.9±0.3
Total Residue	1.8±0.8	2.3±1.3	1.8±1.3	1.6±1.2	1.9±0.3
H-3	<330	<330	<330	<300	<330
Sr-89	<0.9	<0.7	<1.1	<1.5	<1.5
Sr-90	<0.6	<0.6	<0.5	<0.7	<0.7
Cs-137	<10	<10	<10	<10	<10

[a] ND = No data; samples not available.

Table 17. Ground water samples, analyses for gross beta, Sr-89, Sr-90, and gamma-emitting isotopes (continued)

Sample Description and Activity (pCi/L)					Annual Mean ± s.d.
T-141 (QC)					
Lab Code	TWW-9263	TWW-325	NS[a]	TWW-2842	
Collection Period	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	
Gross Beta					
Suspended Solids	<0.3	<0.2	--	<0.8	<0.8
Dissolved Solids	<1.0	3.3±0.7	--	3.3±0.4	3.3±0.0
Total Residue	<1.0	3.3±0.7	--	3.3±0.4	3.3±0.0
H-3	<330	<330	--	<330	<330
Sr-89	<0.8	<0.5	--	<1.1	<1.1
Sr-90	<0.6	<0.5	--	<0.4	<0.6
Cs-137	<10	<10	--	<10	<10

[a] NS = no sample; sample not received.

Table 18. Domestic meat samples, analysis for gamma-emitting isotopes.

Location	Date Collected	Lab Code	Sample Type	Activity (pCi/g wet) K-40	Cs-137
T-197	07-29-91	TME-149	Chicken	2.71±0.48	<0.029
T-34	09-13-91	TME-156	Chicken	1.94±0.40	<0.017

Table 19. Wildlife meat samples, analysis for gamma-emitting isotopes.

Location	Collection Date	Lab Code	Sample Type	Activity (pCi/g wet) K-40	Cs-137
T-31	09-10-91	TME-155	Goose	1.90±0.46	<0.020
	12-24-91	-157	Muskrat	1.47±0.32	<0.021

Table 20. Green leafy vegetables, analyses for strontium-89, strontium-90, I-131 and other gamma-emitting isotopes. Collection: Monthly in season.

Sample Description and Activity (pCi/g wet)						
Location	T-8	T-8	T-8	T-8	T-8	T-25
Lab Code	TVE-1116	TVE-1117	TVE-1177	TVE-1178	TVE-1179	TVE-1118
Collection Date	07-16-91	07-16-91	08-21-91	08-21-91	08-21-91	07-16-91
Type	Horseradish	Rhubarb	Horseradish	Cabbage	Broccoli	Spinach
Sr-89	<0.009	<0.007	<0.003	<0.007	<0.004	<0.010
Sr-90	0.004±0.002	0.003±0.002	<0.002	0.005±0.002	0.003±0.001	<0.004
I-131	<0.009[a]	<0.022	<0.047	<0.020	<0.024	<0.004[a]
K-40	6.91±0.17	3.13±0.48	4.91±0.63	2.55±0.29	3.64±0.51	8.01±0.19
Nb-95	<0.023	<0.011	<0.036	<0.014	<0.021	<0.016
Zr-95	<0.022	<0.017	<0.051	<0.023	<0.038	<0.015
Cs-137	<0.008	<0.010	<0.030	<0.013	<0.018	<0.004
Ce-141	<0.049	<0.004	<0.038	<0.016	<0.020	<0.026
Ce-144	<0.057	<0.019	<0.14	<0.066	<0.082	<0.029
Location	T-25	T-25	T-25	T-37	T-37	
Lab Code	TVE-1180	TVE-1181	TVE-1182	TVE-1119	TVE-1183	
Collection Date	08-21-91	08-21-91	08-21-91	07-16-91	08-21-91	
Type	Parsley	Kale	Cauliflower	Cabbage	Cabbage	
Sr-89	<0.007	<0.004	<0.006	<0.001	<0.002	
Sr-90	<0.004	<0.002	0.004±0.002	<0.001	<0.001	
I-131	<0.039	<0.036	<0.035	<0.005[a]	<0.017	
K-40	7.69±0.68	4.09±0.50	4.45±0.62	1.74±0.11	2.06±0.28	
Nb-95	<0.028	<0.026	<0.030	<0.017	<0.010	
Zr-95	<0.048	<0.040	<0.045	<0.015	<0.017	
Cs-137	<0.026	<0.026	<0.030	<0.004	<0.009	
Ce-141	<0.031	<0.030	<0.031	<0.027	<0.029	
Ce-144	<0.12	<0.13	<0.14	<0.032	<0.076	

[a] LLD for I-131 not reached due to delay in counting. Reported result is LLD at time of measurement.

Table 20. Green leafy vegetables, analyses for strontium-89, strontium-90, I-131 and other gamma-emitting isotopes (continued)

Sample Description and Activity (pCi/g wet)						
Location	T-8	T-8	T-8	T-37	T-25	T-25
Lab Code	TVE-1246	TVE-1247	TVE-1248	TVE-1243	TVE-1245	TVE-1250
Collection Date	09-17-91	09-17-91	09-17-91	09-17-91	09-17-91	09-17-91
Type	Broccoli	Tomatoes	Horseradish	Cabbage	Pepper Leaves	Parsley
Sr-89	<0.007	<0.006	<0.006	<0.002	<0.004	<0.006
Sr-90	0.005±0.002	0.004±0.002	0.005±0.002	<0.001	<0.001	0.003±0.002
I-131	<0.047	<0.033	<0.030	<0.014	<0.033	<0.029
K-40	4.25±0.58	4.27±0.46	4.43±0.47	1.57±0.21	5.89±0.52	8.91±0.66
Nb-95	<0.035	<0.022	<0.024	<0.014	<0.020	<0.025
Zr-95	<0.052	<0.032	<0.042	<0.022	<0.031	<0.042
Cs-137	<0.029	<0.018	<0.024	<0.012	<0.020	<0.022
Ce-141	<0.038	<0.026	<0.028	<0.014	<0.026	<0.028
Ce-144	<0.14	<0.11	<0.11	<0.057	<0.10	<0.12

Table 21. Fruit Samples, analyses for strontium-89, strontium-90, I-131 and other gamma-emitting isotopes. Collection: Monthly in season.

Sample Description and Activity (pCi/g wet)					
Location	T-8	T-23	T-37	T-25	T-173
Lab Code	TVE-1249	TVE-1280	TVE-1241,2	TVE-1244	TVE-1240
Collection Date	09-17-91	10-11-91	09-17-91	09-17-91	09-09-91
Type	Apples	Grapes	Apples	Apples	Grapes
Sr-89	<0.001	<0.003	<0.001[a]	<0.002	<0.005
Sr-90	<0.001	<0.001	<0.001[a]	<0.001	0.005±0.002
I-131	<0.015	<0.01	<0.019	<0.020	<0.041
K-40	0.91±0.17	2.20±0.18	1.06±0.13	1.10±0.18	1.77±0.26
Nb-95	<0.013	<0.007	<0.010	<0.012	<0.016
Zr-95	<0.018	<0.012	<0.018	<0.018	<0.026
Cs-137	<0.009	<0.006	<0.011	<0.009	<0.012
Ce-141	<0.016	<0.010	<0.016	<0.016	<0.020
Ce-144	<0.064	<0.040	<0.062	<0.061	<0.072

Location
Lab Code
Collection Date
Type
Sr-89
Sr-90
I-131
K-40
Nb-95
Zr-95
Cs-137
Ce-141
Ce-144

[a] Result of single analysis; not enough sample to duplicate.

Table 22. Animal - wildlife feed samples, analysis for gamma-emitting isotopes. Collection: Annually.

Sample Description and Activity (pCi/g wet)			
Location	T-8	T-57	T-[illegible]7
Collection Date	01-14-91	01-15-91	07-29-91
Lab Code	TCF-447	TCF-448	TCF-450
Type	Mixed Feed	Mixed Feed	Mixed Feed
Be-7	<0.18	<0.098	<0.076
K-40	12.50±0.62	2.59±0.30	3.81±0.31
Nb-95	<0.020	<0.014	<0.014
Zr-95	<0.034	<0.023	<0.025
Ru-103	<0.020	<0.012	<0.010
Ru-106	<0.17	<0.11	<0.088
Cs-137	<0.022	<0.011	<0.010
Ce-141	<0.047	<0.020	<0.006
Ce-144	<0.23	<0.090	<0.022

Location	T-8	T-8	T-57
Collection Date	08-13-91	08-13-91	08-13-91
Lab Code	TCF-452	TCF-453	TCF-454
Type	Haylage	Corn	Hay
Be-7	<0.14	<0.14	0.70±0.14
K-40	12.70±0.37	2.03±0.20	16.40±0.70
Nb-95	<0.020	<0.020	<0.029
Zr-95	<0.030	<0.029	<0.042
Ru-103	<0.018	<0.020	<0.024
Ru-106	<0.12	<0.12	<0.19
Cs-137	<0.014	<0.013	<0.023
Ce-141	<0.040	<0.041	<0.037
Ce-144	<0.11	<0.11	<0.13

Table 22. Animal - wildlife feed samples, analysis for gamma-emitting isotopes. Collection: Annually.

Sample Description and Activity (pCi/g wet)			
Location	T-31	T-31	T-34
Collection Date	09-11-91	09-11-91	09-13-91
Lab Code	TCF-463	TCF-464	TCF-462
Type	Smartweed	Cattail	Chicken Feed
Be-7	0.84±0.05	<0.36	<0.089
K-40	3.06±0.12	2.35±0.52	3.93±0.30
Nb-95	<0.007	<0.050	<0.016
Zr-95	<0.011	<0.082	<0.024
Ru-103	<0.006	<0.043	<0.012
Ru-106	<0.043	<0.26	<0.087
Cs-137	<0.005	<0.036	<0.010
Ce-141	<0.014	<0.060	<0.020
Ce-144	<0.037	<0.18	<0.059

Location	T-198
Collection Date	09-11-91
Lab Code	TCF-465
Type	Smartweed
Be-7	1.20±0.23
K-40	2.05±0.38
Nb-95	<0.032
Zr-95	<0.048
Ru-103	<0.025
Ru-106	<0.17
Cs-137	<0.020
Ce-141	<0.039
Ce-144	<0.13

Table 23. Soil samples, analysis for gamma-emitting isotopes.

Sample Description and Activity (pCi/g dry)				
Location	T-1	T-2	T-3	T-4
Date	04-15-91	04-15-91	04-15-91	04-15-91
Lab Code	TSO-522	TSO-523	TSO-524	TSO-525
Be-7	<0.33	<0.23	<0.48	<0.48
K-40	11.96±0.90	8.76±0.55	15.20±1.14	18.80±1.00
Nb-95	<0.046	<0.028	<0.063	<0.077
Zr-95	<0.073	<0.043	<0.096	<0.13
Ru-103	<0.034	<0.029	<0.050	<0.060
Ru-106	<0.35	<0.20	<0.40	<0.98
Cs-137	0.23±0.063	0.36±0.033	0.084±0.055	0.24±0.045
Ce-141	<0.067	<0.078	<0.081	<0.12
Ce-144	<0.20	<0.30	<0.28	<0.41
Location	T-7	T-8	T-9 (C)	T-11 (C)
Date	04-15-91	04-15-91	04-15-91	04-15-91
Lab Code	TSO-526	TSO-527,8	TSO-529	TSO-530
Be-7	<0.26	<0.30	<0.46	<0.31
K-40	8.56±0.50	22.15±0.79	14.10±0.85	12.40±0.63
Nb-95	<0.045	<0.054	<0.070	<0.048
Zr-95	<0.072	<0.084	<0.12	<0.080
Ru-103	<0.032	<0.037	<0.058	<0.038
Ru-106	<0.58	<0.34	<0.85	<0.58
Cs-137	0.030±0.021	0.15±0.024	0.39±0.048	0.12±0.027
Ce-141	<0.069	<0.054	<0.11	<0.076
Ce-144	<0.25	<0.20	<0.37	<0.26
Location	T-12 (C)	T-23 (C)	T-27 (C)	
Date	04-15-91	05-29-91	04-15-91	
Lab Code	TSO-531	TSO-557	TSO-532	
Be-7	<0.54	<0.43	<0.45	
K-40	20.18±1.38	15.40±0.81	18.00±0.94	
Nb-95	<0.070	<0.058	<0.075	
Zr-95	<0.11	<0.11	<0.12	
Ru-103	<0.059	<0.055	<0.058	
Ru-106	<0.49	<0.82	<0.88	
Cs-137	0.53±0.089	0.48±0.050	0.34±0.046	
Ce-141	<0.096	<0.10	<0.11	
Ce-144	<0.33	<0.35	<0.38	

Table 23. Soil samples, analysis for gamma-emitting isotopes (continued)

Sample Description and Activity (pCi/g dry)				
Location	T-1	T-2	T-3	T-4
Date	10-14-91	10-14-91	10-14-91	10-14-91
Lab Code	TSO-588	TSO-589	TSO-590	TSO-591
Be-7	<0.24	<0.56	0.47±0.36	<0.40
K-40	9.14±0.55	9.41±1.06	7.33±0.75	18.30±1.00
Nb-95	<0.036	<0.073	<0.080	<0.066
Zr-95	<0.054	<0.11	<0.085	<0.11
Ru-103	<0.031	<0.059	<0.054	<0.053
Ru-106	<0.29	<0.45	<0.29	<0.58
Cs-137	0.21±0.027	0.26±0.070	<0.041	0.23±0.040
Ce-141	<0.064	<0.10	<0.11	<0.12
Ce-144	<0.21	<0.29	<0.21	<0.38
Location	T-7	T-8	T-9(C)	T-11(C)
Date	10-14-91	10-14-91	10-14-91	10-14-91
Lab Code	TSO-592	TSO-593,4	TSO-595	TSO-596
Be-7	<0.35	0.98±0.33	0.55±0.28	<0.32
K-40	12.13±0.81	23.68±0.83	16.04±0.87	11.20±0.61
Nb-95	<0.054	<0.086	<0.069	<0.066
Zr-95	<0.072	<0.10	<0.071	<0.074
Ru-103	<0.038	<0.063	<0.051	<0.048
Ru-106	<0.32	<0.39	<0.32	<0.24
Cs-137	<0.043	0.29±0.037	0.73±0.064	0.22±0.027
Ce-141	<0.070	<0.12	<0.062	<0.10
Ce-144	<0.19	<0.27	<0.16	<0.18
Location	T-12(C)	T-23(C)	T-27(C)	
Date	10-14-91	10-11-91	10-14-91	
Lab Code	TSO-597	TSO-587	TSO-598	
Be-7	<0.38	0.24±0.10	<0.41	
K-40	18.15±0.89	9.92±0.28	17.87±0.93	
Nb-95	<0.065	<0.019	<0.086	
Zr-95	<0.092	<0.024	<0.11	
Ru-103	<0.051	<0.014	<0.055	
Ru-106	<0.48	<0.11	<0.32	
Cs-137	0.46±0.041	0.59±0.022	0.15±0.045	
Ce-141	<0.11	<0.017	<0.11	
Ce-144	<0.32	<0.058	<0.22	

Table 24. Treated surface water samples, monthly composites of weekly grab samples, analysis for gross beta, 1991.

Collection Period	Lab Code	Gross Beta Activity (pCi/L) Suspended Solids	Dissolved Solids	Total Residue
T-11 (C)				
January	TSWT-9394,5	<0.4	3.2±0.4	3.2±0.4
February	9694	<0.2	2.0±0.4	2.0±0.4
March	31	<0.2	2.5±0.3	2.5±0.3
1st Qtr. mean±s.d.		<0.4	2.6±0.6	2.6±0.6
April	TSWT-515	<0.2	2.7±0.3	2.7±0.3
May	833	<0.2	2.2±0.6	2.2±0.6
June	1238	<0.2	2.6±0.4	2.6±0.6
2nd Qtr. mean±s.d.		<0.2	2.5±0.3	2.5±0.3
July	TSWT-1787	<0.2	2.4±0.6	2.4±0.6
August	2162,3	<0.8	2.4±0.4	2.4±0.4
September	2662	<0.9	1.8±0.5	1.8±0.5
3rd Qtr. mean±s.d.		<0.9	2.2±0.3	2.2±0.3
October	TSWT-3105	<0.5	2.8±0.7	2.8±0.7
November	3496	<0.2	2.2±0.5	2.2±0.5
December	4042	<0.2	2.2±0.6	2.2±0.6
4th Qtr. mean±s.d.		<0.5	2.4±0.3	2.4±0.3

Table 24. Treated surface water samples, monthly composites of weekly grab samples, analysis for gross beta, 1991 (continued)

Collection Period	Lab Code	Gross Beta Activity (pCi/L) Suspended Solids	Dissolved Solids	Total Residue
T-12 (C)				
January	TSWT-9396	<0.4	2.9±0.5	2.9±0.5
February	9695	<0.2	1.6±0.4	1.6±0.4
March	32	<0.2	1.7±0.3	1.7±0.3
1st Qtr. mean±s.d.		<0.4	2.1±0.7	2.1±0.7
April	TSWT-516	<0.2	2.4±0.3	2.4±0.3
May	834	<0.2	1.6±0.5	1.6±0.5
June	1239	<0.2	1.8±0.4	1.8±0.4
2nd Qtr. mean±s.d.		<0.2	1.9±0.4	1.9±0.4
July	TSWT-1788	<0.2	1.8±0.6	1.8±0.6
August	2164	<0.4	1.5±0.4	1.5±0.4
September	2663	<0.2	2.0±0.5	2.0±0.5
3rd Qtr. mean±s.d.		<0.4	1.8±0.2	1.8±0.2
October	TSWT-3106	<0.3	2.0±0.6	2.0±0.6
November	3497,8	<0.2	1.9±0.3	1.9±0.3
December	4043	<0.2	1.6±0.5	1.6±0.5
4th Qtr. mean±s.d.		<0.3	1.8±0.2	1.8±0.2

Table 24. Treated surface water samples, monthly composites of weekly grab samples, analysis for gross beta, 1991 (continued)

Collection Period	Lab Code	Gross Beta Activity (pCi/L) Suspended Solids	Dissolved Solids	Total Residue
T-23 (C)				
January	TSWT-9525,6	<0.2	2.0±0.2	2.0±0.2
February	9815	<0.4	2.2±0.5	2.2±0.5
March	192,3	<0.4	2.1±0.4	2.1±0.4
1st Qtr. mean±s.d.		<0.4	2.1±0.1	2.1±0.1
April	TSWT-600	<0.3	2.2±0.3	2.2±0.3
May	985	<0.2	2.1±0.6	2.1±0.6
June	1410	<0.2	1.9±0.5	1.9±2.5
2nd Qtr. mean±s.d.		<0.3	2.1±0.2	2.1±0.2
July	TSWT-1822,3	<0.4	1.7±0.5	1.7±0.5
August	2342	<0.4	2.1±0.5	2.1±0.5
September	2723	<0.2	2.1±0.5	2.1±0.5
3rd Qtr. mean±s.d.		<0.4	2.0±0.2	2.0±0.2
October	TSWT-3229	<0.4	2.3±0.5	2.3±0.5
November	3715	<0.4	2.0±0.5	2.0±0.5
December	4206	<0.3	3.0±0.5	3.0±2.5
4th Qtr. mean±s.d.		<0.4	2.4±0.5	2.4±0.5

Table 24. Treated surface water samples, monthly composites of weekly grab sample. Analysis for gross beta, 1991 (continued)

Collection Period	Lab Code	Gross Beta Activity (pCi/L) Suspended Solids	Dissolved Solids	Total Residue
T-28				
January	TSWT-9397	<0.4	3.2±0.5	3.2±0.5
February	9696,7	<0.4	2.3±0.3	2.3±0.3
March	33	<0.2	1.9±0.3	1.9±0.3
1st Qtr. mean±s.d.		<0.4	2.5±0.7	2.5±0.7
April	TSWT-517,8	<0.7	1.8±0.2	1.8±0.2
May	835	<0.2	2.2±0.6	2.2±0.6
June	1240	<0.2	1.6±0.4	1.6±0.4
2nd Qtr. mean±s.d.		<0.7	1.9±0.3	1.9±0.3
July	TSWT-1789,90	<0.2	1.4±0.4	1.4±0.4
August	2165	<0.4	1.6±0.4	1.6±0.4
September	2664	<0.2	1.7±0.5	1.7±0.5
3rd Qtr. mean±s.d.		<0.4	1.6±0.2	1.6±0.2
October	TSWT-3107	<0.4	1.6±0.6	1.6±0.6
November	3499	<0.4	1.4±0.4	1.4±0.4
December	4044	<0.2	2.0±0.5	2.0±0.5
4th Qtr. mean±s.d.		<0.4	1.7±0.3	1.7±0.3

Table 24. Treated surface water samples, monthly composites of weekly grab samples, analysis for gross beta, 1991 (continued)

Collection Period	Lab Code	Gross Beta Activity (pCi/L) Suspended Solids	Dissolved Solids	Total Residue
T-50				
January	TSWT-9398	<0.4	3.1±0.5	3.1±0.5
February	9698	<0.4	2.2±0.5	2.2±0.5
March	34	<0.2	2.3±0.3	2.3±0.3
1st Qtr. mean±s.d.		<0.4	2.5±0.5	2.5±0.5
April	TSWT-519	<0.4	2.6±0.3	2.6±0.3
May	836	<0.2	2.3±0.6	2.3±0.6
June	1241	<0.2	2.0±0.4	2.0±0.4
2nd Qtr. mean±s.d.		<0.4	2.3±0.3	2.3±0.3
July	TSWT-1791	<0.2	2.4±0.6	2.4±0.6
August	2166	<0.4	2.2±0.5	2.2±0.5
September	2665,6	<0.2	2.3±0.4	2.3±0.4
3rd Qtr. mean±s.d.		<0.4	2.3±0.1	2.3±0.1
October	TSWT-3108	<0.4	2.4±0.7	2.4±0.7
November	3500	<0.3	2.6±0.5	2.6±0.5
December	[illegible]45	<0.2	2.1±0.6	2.1±0.6
4th Qtr. mean±s.d.		<0.4	2.4±0.2	2.4±0.2

Table 24. Treated surface water samples, monthly composites of weekly grab samples, analysis for gross beta, 1991 (continued)

Collection Period	Lab Code	Gross Beta Activity (pCi/L) Suspended Solids	Dissolved Solids	Total Residue
T-144				
January	TSWT-9400	<0.4	2.8±0.5	2.8±0.5
February	9700	<0.2	3.7±0.6	3.7±0.6
March	37	<0.2	3.4±0.3	3.4±0.3
1st Qtr. mean±s.d.		<0.4	3.3±0.5	3.3±0.5
April	TSWT-521	<0.7	2.0±0.5	2.0±0.5
May	838	<0.2	3.4±0.6	3.4±0.6
June	1243	<0.2	2.0±0.5	2.0±0.5
2nd Qtr. mean±s.d.		<0.7	2.5±0.8	2.5±0.8
July	TSWT-1793	<0.2	1.8±0.6	1.8±0.6
August	2168	<0.4	2.1±0.5	2.1±0.5
September	2668	<0.3	1.3±0.4	1.3±0.4
3rd Qtr. mean±s.d.		<0.4	1.7±0.4	1.7±0.4
October	TSWT-3110	<0.8	2.6±0.5	2.6±0.5
November	3502	<0.2	2.7±0.5	2.7±0.5
December	4047	<0.2	2.4±0.6	2.4±0.6
4th Qtr. mean±s.d.		<0.8	2.6±0.2	2.6±0.2

Table 25. Treated surface water samples, monthly composite of weekly samples, analysis for gross beta, tritium, gamma-emitting isotopes, Sr-89, and Sr-90, 1991.

Sample Description and Activity (pCi/L)				Quarterly Mean±s.d.
T-143 (QC)				
Lab Code	TSWT-9399	TSWT-9699	TSWT-35,6	
Collection Period	January	February	March	1st Qtr.
Gross Beta				
Suspended Solids	<0.3	<0.4	<0.9	<0.9
Dissolved Solids	2.8±0.3	2.0±0.5	2.5±0.4	2.4±0.4
Total Residue	2.8±0.3	2.0±0.5	2.5±0.4	2.4±0.4
H-3	<330	<330	<330	<330
Sr-89	<0.9	<1.2	<0.4	<1.2
Sr-90	<0.8	<1.1	<0.4	<1.1
Cs-137	<10	<10	<10	<10
Lab Code	TSWT-520	TSWT-837	TSWT-1242	
Collection Period	April	May	June	2nd Qtr.
Gross Beta				
Suspended Solids	<0.4	<0.2	<0.4	<0.4
Dissolved Solids	3.0±0.5	2.4±0.6	1.7±0.6	2.4±0.6
Total Residue	3.0±0.5	2.4±0.6	1.7±0.6	2.4±0.6
H-3	<330	<330	<330	<330
Sr-89	<0.6	<0.8	<0.6	<0.8
Sr-90	<0.4	<0.5	0.6±0.3	0.6±0.3
Cs-137	<10	<10	<10	<10

Table 25. Treated surface water samples, monthly composite of weekly samples, analysis for gross beta, tritium, gamma-emitting isotopes, Sr-89 and Sr-90, 1991 (continued)

Sample Description and Activity (pCi/L)				Quarterly Mean±s.d.
T-143 (QC)				
Lab Code	TSWT-1792	TSWT-2167	TSWT-2667	
Collection Period	July	August	September	3rd Qtr.
Gross Beta				
Suspended Solids	<0.2	<0.6	<0.4	<0.6
Dissolved Solids	2.2±0.5	2.5±0.6	1.8±0.4	2.2±0.4
Total Residue	2.2±0.5	2.5±0.6	1.8±0.4	2.2±0.4
H-3	<330	393±108[a]	<330	393±108
Sr-89	<0.7	<0.8	<1.4	<1.4
Sr-90	<0.4	0.8±0.4	<0.6	0.8±0.4
Cs-137	<10	<10	<10	<10
Lab Code	TSWT-3109	TSWT-3501	TSWT-4046	
Collection Period	October	November	December	4th Qtr.
Gross Beta				
Suspended Solids	<0.3	<0.2	<0.3	<0.3
Dissolved Solids	1.4±0.4	2.8±0.5	1.8±0.4	2.0±0.7
Total Residue	1.4±0.4	2.8±0.5	1.8±0.4	2.0±0.7
H-3	<330	<330	<330	<330
Sr-89	<1.2	<0.8	<0.8	<1.2
Sr-90	<0.6	0.6±0.3	<0.7	0.6±0.3
Cs-137	<10	<10	<10	<10

[a] Analysis was repeated, result of reanalysis 335±94 pCi/L.

Table 26. Treated surface water samples, quarterly composites of weekly grab samples, analysis for tritium, strontium and gamma-emitting isotopes.

Location	1991 Collection Period	Lab Code	Activity (pCi/L) H-3	Sr-89	Sr-90	Cs-137
Control						
T-11	1st Quarter	TSWT-360	<330	<0.7	<0.6	<10
	2nd Quarter	1549	<330	<1.2	<0.6	<10
	3rd Quarter	3115	<330	<1.2	0.6±0.3	<10
	4th Quarter	4133	<330	<0.6	0.6±0.3	<10
	Annual mean ± s.d.		<330	<1.2	0.6±0.0	<10
T-12	1st Quarter	TSWT-361	<330	<0.8	<0.6	<10
	2nd Quarter	1550	<330	<1.0	<0.5	<10
	3rd Quarter	3116	<330	<1.6	<0.6	<10
	4th Quarter	4134	<330	<0.8	<0.6	<10
	Annual mean ± s.d.		<330	<1.6	<0.6	<10
T-23	1st Quarter	TSWT-362	<330	<0.8	<0.5	<10
	2nd Quarter	1702	<330	<0.9	<0.5	<10
	3rd Quarter	3120	<330	<0.8	<0.4	<10
	4th Quarter	4207	<330	<0.6	<0.5	<10
	Annual mean ± s.d.		<330	<0.9	<0.5	<10

Table 26. Treated surface water samples, quarterly composites of weekly grab samples, analysis for tritium, strontium and gamma-emitting isotopes, 1991 (continued)

Location	Collected Date	Lab Code	Activity (pCi/L) H-3	Sr-89	Sr-90	Cs-137
Indicator						
T-28	1st Quarter	TSWT-363	<330	<0.8	<0.6	<10
	2nd Quarter	1561	<330	<1.0	<0.5	<10
	3rd Quarter	[illegible]	<330	<1.1	<0.5	<10
	4th Quarter	4135	<330	<0.8	<0.6	<10
	Annual mean ± s.d.		<330	<1.1	<0.6	<10
T-50	1st Quarter	TSWT-364	<330	<0.7	<0.5	<10
	2nd Quarter	1553	<330	<0.8	0.5±0.3	<10
	3rd Quarter	3118	<330	<1.2	0.6±0.3	<10
	4th Quarter	4136	<330	<0.7	<0.5	<10
	Annual mean ± s.d.		<330	<1.2	0.6±0.1	<10
T-144	1st Quarter	TSWT-365	<330	<0.7	<0.5	<10
	2nd Quarter	1554	<330	<0.9	<0.5	<10
	3rd Quarter	3119	<330	<1.5	<0.6	<10
	4th Quarter	4137	<330	<0.6	0.8±0.3	<10
	Annual mean ± s.d.		<330	<1.5	0.8±0.3	<10

Table 27. Untreated surface water samples, monthly composites of weekly samples, analysis for gross beta, tritium, and gamma-emitting isotopes, 1991.

Collection Period	Lab Code	Gross Beta Activity (pCi/L) Suspended Solids	Dissolved Solids	Total Residue	Activity (pCi/L) H-3	Cs-137
Control						
T-11 (C)						
January	TSWU-9388	<0.3	2.8±0.3	2.8±0.3	<330	<10
February	9685,b	<0.4	2.7±0.4	2.7±0.4	<330	<10
March	24,5	<0.9	2.7±0.3	2.7±0.3	<330	<10
1st Qtr. mean ± s.d.		<0.9	2.7±0.1	2.7±0.1	<330	<10
April	TSWU-509	<0.2	2.5±0.5	2.5±0.5	<330	<10
May	826	<0.2	2.5±0.3	2.5±0.3	<330	<10
June	1231	<0.5	2.2±0.5	2.2±0.5	<330	<10
2nd Qtr. mean ± s.d.		<0.5	2.4±0.2	2.4±0.2	<330	<10
July	TSWU-1781	<0.2	2.8±0.4	2.8±0.4	<330	<10
August	2196,7	<0.3	2.0±0.3	2.0±0.3	<330	<10
September	2657	<0.2	2.0±0.5	2.0±0.5	<330	<10
3rd Qtr. mean ± s.d.		<0.3	2.3±0.5	2.3±0.5	<330	<10
October	TSWU-3098	<0.4	2.5±0.3	2.5±0.3	<330	<10
November	3490	<0.2	2.0±0.5	2.0±0.5	<330	<10
December	4036	<0.2	2.1±0.5	2.1±0.5	<330	<10
4th Qtr. mean ± s.d.		<0.4	2.2±0.3	2.2±0.3	<330	<10

Table 27. Untreated surface water samples, monthly composites of weekly samples, analysis for gross beta, tritium, and gamma-emitting isotopes, 1991 (continued)

Collection Period	Lab Code	Gross Beta Activity (pCi/L) Suspended Solids	Dissolved Solids	Total Residue	Activity (pCi/L) H-3	Cs-137
Control						
T-12 (C)						
January	TSWU-9389	4.2±0.5[a]	4.1±0.3	8.3±0.6	<330	<10
February	9687	<0.2	2.4±0.3	2.4±0.3	<330	<10
March	26	<0.5	2.4±0.4	2.4±0.4	<330	<10
1st Qtr. mean ± s.d.		4.2±0.5	3.0±1.[illegible]	4.4±3.4	<330	<10
April	TSWU-510	<0.2	2.2±0.5	2.2±0.5	<330	<10
May	827	1.2±0.2	3.0±0.3	4.2±0.4	<330	<10
June	1232	<0.4	2.4±0.3	2.4±0.3	<330	<10
2nd Qtr. mean ± s.d.		1.2±0.2	2.5±0.4	2.9±1.1	<330	<10
July	TSWU-1782	<0.4	2.8±0.3	2.8±0.3	<330	<10
August	2157	<0.2	2.6±0.3	2.6±0.3	<330	<10
September	2658	<0.2	2.9±0.5	2.9±0.5	<330	<10
3rd Qtr. mean ± s.d.		<0.4	2.8±0.2	2.8±0.2	<330	<10
October	TSWU-3099	<0.4	2.1±0.2	2.1±0.2	<330	<10
November	3491	<0.2	2.3±0.5	2.3±0.5	<330	<10
December	4037	<0.2	2.3±0.5	2.3±0.5	<330	<10
4th Qtr. mean ± s.d.		<0.4	2.2±0.1	2.2±0.1	<330	<10

[a] Analysis was repeated; result of reanalysis, 6.8±0.4 pCi/L; sample very cloudy and very high in sediment content.

Table 27. Untreated surface water samples, monthly composites of weekly samples, analysis for gross beta, tritium, and gamma-emitting isotopes, 1991 (continued)

Collection Period	Lab Code	Gross Beta Activity (pCi/L) Suspended Solids	Dissolved Solids	Total Residue	Activity (pCi/L) H-3	Cs-137
Control						
T-23 (C)						
January	TSWU-9527	<0.2	2.3±0.3	2.3±0.3	<330	<10
February	9814	<0.5	2.7±0.5	2.7±0.5	<330	<10
March	194	0.5±0.1	2.7±0.3	3.2±0.3	<330	<10
1st Qtr. mean ± s.d.		0.5±0.1	2.6±0.2	2.7±0.4	<330	<10
April	TSWU-601	<0.2	1.9±0.5	1.9±0.5	<330	<10
May	986	<0.2	2.2±0.3	2.2±0.3	<330	<10
June	1409	<0.4	2.8±0.5	2.8±0.5	<330	<10
2nd Qtr. mean ± s.d.		<0.4	2.3±0.5	2.3±0.5	<330	<10
July	TSWU-1821	<0.2	1.9±0.3	1.9±0.3	<330	<10
August	2341	<0.3	1.6±0.4	1.6±0.4	<330	<10
September	2722	<0.2	2.4±0.5	2.4±0.5	<330	<10
3rd Qtr. mean ± s.d.		<0.3	2.0±0.4	2.0±0.4	<330	<10
October	TSWU-3228	<0.4	2.1±0.5	2.1±0.5	<330	<10
November	3714	<0.2	3.0±1.0	3.0±1.0	<330	<10
December	4205	<0.2	1.9±0.5	1.9±0.5	<330	<10
4th Qtr. mean ± s.d.		<0.4	2.3±0.6	2.3±0.6	<330	<10

Table 27. Untreated surface water samples, monthly composites of weekly samples, analysis for gross beta, tritium, and gamma-emitting isotopes, 1991 (continued)

Collection Period	Lab Code	Gross Beta Activity (pCi/L) Suspended Solids	Dissolved Solids	Total Residue	Activity (pCi/L) H-3	Cs-137
Indicator						
T-3						
January	TSWU-9387	<0.3	3.3±0.3	3.3±0.3	<330	<10
February	9684	<0.2	3.7±0.3	3.7±0.3	<330	<10
March	22	<0.5	2.9±0.5	2.9±0.5	<330	<10
1st Qtr. mean ± s.d.		<0.5	3.3±0.4	3.3±0.4	<330	<10
April	TSWU-506,7	<0.2	3.6±0.2	3.6±0.2	<330	<10
May	824	<0.3	3.3±0.4	3.3±0.4	<330	<10
June	1229	<0.2	3.0±0.3	3.0±0.3	<330	<10
2nd Qtr. mean ± s.d.		<0.3	3.3±0.3	3.3±0.3	<330	<10
July	TSWU-1778,9	<0.2	2.8±0.2	2.8±0.2	<330	<10
August	2155	0.3±0.1	1.9±0.5	2.2±0.5	424±107[a]	<10
September	2654,5	<0.3	3.0±0.4	3.0±0.4	<330	<10
3rd Qtr. mean ± s.d.		0.3±0.1	2.6±0.6	2.7±0.4	424±107	<10
October	TSWU-3096	<0.4	3.2±0.3	3.2±0.3	<330	<10
November	3488	<0.2	2.7±0.5	2.7±0.5	<330	<10
December	4034	0.6±0.1	2.2±0.6	2.8±0.6	<330	<10
4th Qtr. mean ± s.d.		0.6±0.1	2.7±0.5	2.9±0	<330	<10

[a] Analysis was repeated; result of reanalysis 458±99 pCi/L.

Table 27. Untreated surface water samples, monthly composites of weekly samples, analysis for gross beta, tritium, and gamma-emitting isotopes, 1991 (continued)

Collection Period	Lab Code	Gross Beta Activity (pCi/L) Suspended Solids	Dissolved Solids	Total Residue	Activity (pCi/L) H-3	Cs-137
Indicator						
T-28						
January	TSWU-9391	<0.4	3.4±0.3	3.4±0.3	<330	<10
February	9689	<0.2	3.2±0.5	3.2±0.5	<330	<10
March	28	<0.5	2.4±0.6	2.4±0.6	<330	<10
1st Qtr. mean ± s.d.		<0.5	3.0±0.5	3.0±0.5	<330	<10
April	TSWU-512	<0.2	3.0±0.5	3.0±0.5	<330	<10
May	829	<0.2	3.2±0.3	3.2±0.3	<330	<10
June	1234	<0.2	2.3±0.3	2.3±0.3	<330	<10
2nd Qtr. mean ± s.d.		<0.2	2.8±0.5	2.8±0.5	<330	<10
July	TSWU-1784	<0.2	2.3±0.3	2.3±0.3	353±100	<10
August	2159	<0.3	2.0±0.5	2.0±0.5	<330	<10
September	2659	<0.2	2.6±0.5	2.6±0.5	<330	<10
3rd Qtr. mean ± s.d.		<0.3	2.3±0.3	2.3±0.3	353±100	<10
October	TSWU-3100	<0.4	3.0±0.8	3.0±0.8	<330	<10
November	3493	<0.2	2.7±0.5	2.7±0.5	<330	<10
December	4038	<0.2	2.5±0.5	2.5±0.5	<330	<10
4th Qtr. mean ± s.d.		<0.4	2.7±0.2	2.7±0.2	<330	<10

Table 27. Untreated surface water samples, monthly composites of weekly samples, analysis for gross beta, tritium, and gamma-emitting isotopes, 1991 (continued)

Collection Period	Lab Code	Gross Beta Activity (pCi/L) Suspended Solids	Dissolved Solids	Total Residue	Activity (pCi/L) H-3	Cs-137
Indicator						
T-50						
January	TSWU-9392	<0.3	3.2±0.3	3.2±0.3	<330	<10
February	2590	<0.2	2.8±0.5	2.8±0.5	<330	<10
March	29	<0.5	2.1±0.6	2.1±0.6	<330	<10
1st Qtr. mean ± s.d.		<0.5	2.7±0.6	2.7±0.6	<330	<10
April	TSWU-513	<0.2	3.2±0.5	3.2±0.5	<330	<10
May	830	<0.2	4.4±0.4	4.4±0.4	<330	<10
June	1235	<0.3	2.1±0.3	2.1±0.3	<330	<10
2nd Qtr. mean ± s.d.		<0.3	3.2±1.2	3.2±1.2	<330	<10
July	TSWU-1785	<0.2	2.0±0.3	2.0±0.3	<330	<10
August	2160	<0.2	2.3±0.6	2.3±0.6	657±115[a]	<10
September	2660	<0.2	2.5±0.5	2.5±0.5	<330	<10
3rd Qtr. mean ± s.d.		<0.2	2.3±0.2	2.3±0.2	657±115	<10
October	TSWU-3101	<0.3	2.4±0.5	2.4±0.5	337±96	<10
November	3494	<0.2	2.9±0.5	2.9±0.5	<330	<10
December	4039,40	<0.2	2.6±0.4	2.6±0.4	<330	<10
4th Qtr. mean ± s.d.		<0.3	2.6±0.2	2.6±0.2	337±96	<10

[a] Analysis was repeated; result of reanalysis 578±103 pCi/L.

Table 28. Untreated surface water samples, monthly composite of weekly samples, analysis for gross beta, tritium, strontium, and gamma-emitting isotopes, 1991.

Sample Description and Activity (pCi/L)				Quarterly Mean±s.d.
T-145 (QC)				
Lab Code	TSWU-9393	TSWU-9691	TSWU-30	
Collection Period	January	February	March	1st Qtr.
Gross Beta				
Suspended Solids	<0.3	<0.2	<0.5	<0.5
Dissolved Solids	4.9±0.4	3.4±0.5	3.0±0.6	3.8±1.0
Total Residue	4.9±0.4	3.4±0.5	3.0±0.6	3.8±1.0
H-3	<330	<330	<330	<330
Sr-89	<0.8	< .4	<0.6	<0.8
Sr-90	<0.6	<0.4	<0.6	<0.6
Cs-137	<10	<10	<10	<10
Lab Code	TSWU-514	TSWU-831,2	TSWU-1236,7	
Collection Period	April	May	June	2nd Qtr.
Gross Beta				
Suspended Solids	<0.4	0.8±0.2	<0.4	0.8±0.2
Dissolved Solids	2.8±0.5	3.0±0.2	2.2±0.2	2.7±0.4
Total Residue	2.8±0.5	3.8±0.3	2.2±0.2	2.9±0.8
H-3	<330	<330	<330	<330
Sr-89	<0.6	<0.4	<0.5	<0.6
Sr-90	<0.5	<0.5	<0.7	<0.7
Cs-137	<10	<10	<10	<10

Table 28. Untreated surface water samples, monthly composite of weekly samples, analysis for gross beta, tritium, strontium, and gamma-emitting isotopes, 1991 (continued).

Sample Description and Activity (pCi/L)				Quarterly Mean±s.d.
T-145 (QC)				
Lab Code	TSWU-1786	TSWU-2161	TSWU-2661	
Collection Period	July	August	September	3rd Qtr.
Gross Beta				
Suspended Solids	<0.3	<0.2	<0.4	<0.4
Dissolved Solids	2.4±0.3	1.9±0.5	2.0±0.5	2.1±0.3
Total Residue	2.4±0.3	1.9±0.5	2.0±0.5	2.1±0.3
H-3	<330	<330	<330	<330
Sr-89	<0.7	<0.7	<1.0	<1.0
Sr-90	0.8±0.3	<0.4	<0.5	0.8±0.3
Cs-137	<10	<10	<10	<10
Lab Code	TSWU-3104	TSWU-3495	TSWU-4041	
Collection Period	October	November	December	4th Qtr.
Gross Beta				
Suspended Solids	<0.4	<0.2	<0.2	<0.4
Dissolved Solids	3.1±0.3	2.9±0.5	2.0±0.5	2.7±0.6
Total Residue	3.1±0.3	2.9±0.5	2.0±0.5	2.7±0.6
H-3	<330	<330	<330	<330
Sr-89	<1.0	<0.7	<0.7	<1.0
Sr-90	<0.6	0.5±0.3	<0.6	0.5±0.3
Cs-137	<10	<10	<10	<10

Table 29. Untreated surface water samples, quarterly composites of weekly grab samples, analysis for strontium, 1991.

Location	Collection Date	Lab Code	Activity (pCi/L) Sr-89	Sr-90
Control				
T-11	1st Quarter	TSWU-312,3	<0.7	<0.6
	2nd Quarter	1696	<0.8	0.6±0.3
	3rd Quarter	3085	<1.3	<0.5
	4th Quarter	4176	<0.6	0.6±0.3
	Annual mean±s.d.		<1.3	0.6±0.0
T-12	1st Quarter	TSWU-314	<0.8	<0.7
	2nd Quarter	1697	<0.7	<0.4
	3rd Quarter	3086	<1.5	<0.6
	4th Quarter	4177	<0.6	0.9±0.5
	Annual mean±s.d.		<1.5	0.9±0.5
T-23	1st Quarter	TSWU-366	<0.9	<0.7
	2nd Quarter	1756	<1.3	<0.7
	3rd Quarter	3121	<1.9	<0.8
	4th Quarter	4268	<0.6	0.7±0.3
	Annual mean±s.d.		<1.9	0.7±0.3

Table 29. Untreated surface water samples, quarterly composites of weekly grab samples, analysis for strontium, 1991 (continued)

Location	Collection Date	Lab Code	Activity (pCi/L) Sr-89	Sr-90
Indicator				
T-3	1st Quarter	TSWU-311	<0.8	<0.6
	2nd Quarter	1694	<0.9	0.6±0.3
	3rd Quarter	3004	<1.2	0.6±0.3
	4th Quarter	4175	<0.7	<0.6
	Annual mean±s.d.		<1.2	0.6±0.0
T-28	1st Quarter	TSWU-316	<0.7	<0.8
	2nd Quarter	1699	<1.1	<0.6
	3rd Quarter	3087	<1.2	<0.5
	4th Quarter	4178	<0.6	<0.5
	Annual mean±s.d.		<1.2	<0.8
T-50	1st Quarter	TSWU-317	<0.7	<0.7
	2nd Quarter	1700,1	<1.2	<0.7
	3rd Quarter	3088	<1.6	1.2±0.5
	4th Quarter	4179,80	<0.8	<0.7
	Annual mean±s.d.		<1.6	1.2±0.5

Table 30. Untreated surface lake water samples, monthly composites of weekly grab samples, analysis for gross beta, tritium, strontium-89, strontium-90 and gamma-emitting isotopes, collected May through October, 1991.

Location	Period	Lab Code	Gross Beta Activity (pCi/L)			Activity (pCi/L)			
			Suspended Solids	Dissolved Solids	Total Residue	H-3	Sr-89	Sr-90	Cs-137
T-130	(MAY)	TSWU-855	<0.4	2.4±0.6	2.4±0.6	<330	<0.5	<0.4	<10
	(JUN)	1310	0.5±0.2	2.5±0.5	3.0±0.5	<330	<0.7	<0.5	<10
	(JUL)	1884	<0.2	2.4±0.4	2.4±0.4	<330	<0.9	<0.4	<10
	(AUG)	2198	<0.2	2.0±0.6	2.0±0.6	884±113[a]	<0.7	<0.5	<10
	(SEP)	2669	0.4±0.2	2.1±0.5	2.5±0.5	<330	<1.1	<0.6	<10
	(OCT)	3138	<0.8	2.5±0.3	2.5±0.3	<330	<1.4	<0.6	<10
T-131	(MAY)	TSWU-856	<0.4	1.6±0.9	1.6±0.9	<330	<0.9	1.2±0.5	<10
	(JUN)	1311	<0.4	2.5±0.3	2.5±0.3	<330	<1.2	<0.7	<10
	(JUL)	1885	<0.4	2.2±0.5	2.2±0.5	<330	<1.1	<0.5	<10
	(AUG)	2199	<0.2	2.3±0.3	2.3±0.3	<330	<1.0	<0.6	<10
	(SEP)	2670	<0.4	2.6±0.6	2.6±0.6	<330	<1.6	<0.8	<10
	(OCT)	3139	<0.3	2.7±0.5	2.7±0.5	<330	<1.6	<0.6	<10
T-132	(MAY)	TSWU-857	<0.4	2.5±0.6	2.5±0.6	<330	<0.7	<0.4	<10
	(JUN)	1312	<0.2	2.1±0.5	2.1±0.5	<330	<0.6	<0.4	<10
	(JUL)	1886	<0.3	1.7±0.4	1.7±0.4	<330	<0.9	0.6±0.3	<10
	(AUG)	2200	<0.2	2.6±0.6	2.6±0.6	<330	<0.7	<0.4	<10
	(SEP)	2671	<0.4	1.7±0.5	1.7±0.5	<330	<0.9	0.9±0.3	<10
	(OCT)	3140	<0.4	2.2±0.5	2.2±0.5	<330	<1.3	0.6±0.3	<10
T-133	(MAY)	TSWU-858	<0.3	2.0±1.0	2.0±1.0	<330	<0.8	0.6±0.4	<10
	(JUN)	1313,4	<0.7	2.4±0.2	2.4±0.2	<330	<1.0	<0.6	<10
	(JUL)	1887	<0.2	2.0±0.5	2.0±0.5	<330	<1.0	0.7±0.3	<10
	(AUG)	2201	<0.2	2.2±0.3	2.2±0.3	<330	<1.0	<0.7	<10
	(SEP)	2672	<0.3	2.0±0.5	2.0±0.5	<330	<1.1	0.8±0.4	<10
	(OCT)	3141	0.7±0.2	2.4±0.3	3.1±0.4	<330	<1.2	0.6±0.4	<10

[a] Analysis was repeated; result of reanalysis 886±112 pCi/L.

Table 30. Untreated surface lake water samples, monthly composites of weekly grab samples, analysis for gross beta, tritium, strontium-89, strontium-90 and gamma-emitting isotopes, collected May through October, 1991 (continued)

Location	Period	Lab Code	Gross Beta Activity (pCi/L)			Activity (pCi/L)			
			Suspended Solids	Dissolved Solids	Total Residue	H-3	Sr-89	Sr-90	Cs-137
T-134	(MAY)	TSWU-859	<0.4	2.5±0.8	2.5±0.8	<330	<0.8	0.8±0.4	<10
	(JUN)	1315	<0.2	2.3±0.5	2.3±0.5	<330	<0.6	<0.4	<10
	(JUL)	1888	<0.2	2.2±0.4	2.2±0.4	<330	<1.0	0.6±0.3	<10
	(AUG)	2202	<0.2	1.5±0.5	1.5±0.5	<330	<0.8	<0.5	<10
	(SEP)	2673	<0.4	2.6±0.6	2.6±0.6	<330	<1.1	0.6±0.3	<10
	(OCT)	3142	0.6±0.2	2.9±0.5	3.5±0.5	<330	<1.5	<0.6	<10
T-135	(MAY)	TSWU-860	<0.4	2.3±1.0	2.3±1.0	<330	<0.7	0.6±0.3	<10
	(JUN)	1316	<0.2	2.0±0.5	2.0±0.5	<330	<0.5	<0.4	<10
	(JUL)	1889,90	<0.7	2.3±0.2	2.3±0.2	<330	<0.8	0.6±0.2	<10
	(AUG)	2203	<0.2	2.2±0.3	2.2±0.3	<330	<1.0	<0.6	<10
	(SEP)	2674	<0.4	2.2±0.5	2.2±0.5	<330	<1.4	<0.5	<10
	(OCT)	3143	<0.7	2.6±0.5	2.6±0.5	<330	<1.6	<0.7	<10
T-137 (C)	(MAY)	TSWU-861	<0.2	2.6±0.7	2.6±0.7	<330	<0.9	0.6±0.3	<10
	(JUN)	1317	<0.2	2.2±0.5	2.2±0.5	<330	<0.5	0.5±0.3	<10
	(JUL)	1891	<0.2	2.5±0.4	2.5±0.4	<330	<0.9	0.8±0.3	<10
	(AUG)	2204	<0.2	1.8±0.5	1.8±0.5	<330	<0.8	0.6±0.4	<10
	(SEP)	2675	0.4±0.2	2.6±0.5	3.0±0.5	<330	<1.2	0.6±0.4	<10
	(OCT)	3144	<0.7	2.3±0.5	2.3±0.5	<330	<2.3	<0.6	<10
T-138 (C)	(MAY)	TSWU-862	<0.5	1.7±0.7	1.7±0.7	<330	<0.6	1.0±0.4	<10
	(JUN)	1318	<0.2	1.8±0.5	1.8±0.5	<330	<1.3	1.2±0.6	<10
	(JUL)	1892	<0.3	2.1±0.5	2.1±0.5	<330	<0.8	0.7±0.3	<10
	(AUG)	2205	<0.2	2.0±0.5	2.0±0.5	<330	<0.6	0.8±0.4	<10
	(SEP)	2676,7	<0.4	2.4±0.3	2.4±0.3	<330	<1.1	0.6±0.3	<10
	(OCT)	3145	<0.7	2.0±0.5	2.0±0.5	<330	<1.3	1.0±0.4	<10

Table 30. Untreated surface lake water samples, monthly composites of weekly grab samples, analysis for gross beta, tritium, strontium-89, strontium-90 and gamma-emitting isotopes, collected May through October, 1991 (continued)

Location	Period	Lab Code	Gross Beta Activity (pCi/L)			Activity (pCi/L)			
			Suspended Solids	Dissolved Solids	Total Residue	H-3	Sr-89	Sr-90	Cs-137
T-152	(MAY)	TSWU-863	<0.5	3.3±0.7	3.3±0.7	<330	<0.8	<0.4	<10
	(JUN)	1319	0.3±0.1	3.5±0.5	3.8±0.5	<330	<1.0	<0.6	<10
	(JUL)	1893	<0.2	3.3±0.4	3.3±0.4	<330	<1.0	<0.5	<10
	(AUG)	2206	<0.2	2.3±0.6	2.3±0.6	<330	<0.8	0.6±0.3	<10
	(SEP)	2678	<0.3	2.5±0.7	2.5±0.7	<330	<1.2	<0.6	<10
	(OCT)	3146,7	<0.4	3.4±0.4	3.4±0.4	<330	<1.2	0.7±0.4	<10
T-158 (C)	(MAY)	TSWU-864,5	<0.3	2.1±0.7	2.1±0.7	<330	<0.9	<0.9	<10
	(JUN)	1320	<0.3	2.3±0.3	2.3±0.3	<330	<1.4	<0.8	<10
	(JUL)	1894	<0.4	2.6±0.5	2.6±0.5	<330	<0.9	<0.4	<10
	(AUG)	2207	<0.2	2.4±0.6	2.4±0.6	<330	<0.7	<0.5	<10
	(SEP)	2679	<0.3	2.1±0.5	2.1±0.5	<330	<1.3	<0.6	<10
	(OCT)	3148	<0.8	2.7±0.5	2.7±0.5	<330	<1.4	1.4±0.5	<10
T-162 (C)	(MAY)	TSWU-866	<0.4	2.4±1.0	2.4±1.0	<330	<0.9	<0.6	<10
	(JUN)	1321	<0.4	2.1±0.3	2.1±0.3	<330	<1.0	<0.6	<10
	(JUL)	1895	<0.2	2.2±0.4	2.2±0.4	<330	<0.8	<0.4	<10
	(AUG)	2208,9	<0.4	2.2±0.4	2.2±0.4	<330	<0.7	1.0±0.3	<10
	(SEP)	2680	<0.4	2.1±0.5	2.1±0.5	<330	<1.3	<0.7	<10
	(OCT)	3149	<0.7	2.0±0.5	2.0±0.5	<330	<1.4	<0.6	<10
T-164 (C)	(MAY)	TSWU-867	<0.3	1.6±0.9	1.6±0.9	<330	<0.8	0.7±0.4	<10
	(JUN)	1322	<0.4	2.6±0.5	2.6±0.5	<330	<1.5	<0.9	<10
	(JUL)	1896	<0.4	2.0±0.3	2.0±0.3	<330	<1.9	<0.9	<10
	(AUG)	2210	<0.3	1.8±0.5	1.8±0.5	<330	<0.9	<0.5	<10
	(SEP)	2681	<0.4	2.2±0.5	2.2±0.5	<330	<1.2	<0.5	<10
	(OCT)	3150	<0.7	2.2±0.7	2.2±0.7	333±91	<1.2	<0.5	<10

Table 30. Untreated surface lake water samples, monthly composites of weekly grab samples, analysis for gross beta, tritium, strontium-89, strontium-90 and gamma-emitting isotopes, collected May through October, 1991 (continued)

Location	Period	Lab Code	Gross Beta Activity (pCi/L)			Activity (pCi/L)			
			Suspended Solids	Dissolved Solids	Total Residue	H-3	Sr-89	Sr-90	Cs-137
T-167 (C)	(MAY)	TSWU-868	<0.4	2.5±0.7	2.5±0.7	<330	<0.8	<0.5	<10
	(JUN)	1323	<0.3	2.5±0.5	2.5±0.5	<330	<0.9	0.7±0.4	<10
	(JUL)	1897	<0.3	2.0±0.8	2.0±0.8	<330	<0.9	0.7±0.3	<10
	(AUG)	2211	<0.3	2.1±0.5	2.1±0.5	<330	<1.7	0.7±0.4	<10
	(SEP)	2682	<0.3	2.4±0.5	2.4±0.5	<330	<1.2	0.6±0.4	<10
	(OCT)	3151	<0.8	2.2±0.5	2.2±0.5	<330	<1.1	0.8±0.4	<10
T-168 (C)	(MAY)	TSWU-869	<0.5	1.7±0.6	1.7±0.6	<330	<1.2	<0.8	<10
	(JUN)	1324,5	<0.7	2.2±0.2	2.2±0.2	<330	<0.7	<0.5	<10
	(JUL)	1898	<0.4	2.3±0.3	2.3±0.3	<330	<0.9	0.6±0.3	<10
	(AUG)	2212	<0.2	1.7±0.5	1.7±0.5	<330	<0.9	1.0±0.4	<10
	(SEP)	2683	<0.4	2.3±0.5	2.3±0.5	<330	<1.2	<0.6	<10
	(OCT)	3152	<0.7	2.0±0.4	2.0±0.4	<330	<1.2	<0.6	<10

NOTE: Pages 72 through 74 are intentionally left out.

Table 31. Fish samples, analyses for gross beta and gamma-emitting isotopes.
Collection: Semiannually.

Sample Description and Activity (pCi/g wet)						
	Indicator			Control		
Location	T-33 (Lake Erie 1.5 mi NE of Station)			T-35		
Collection Date	05-23-91	05-23-91	05-23-91	05-23-91	05-23-91	05-23-91
Lab Code	TF-1462	TF-1463,4	TF-1465	TF-1466	TF-1467	TF-1468,9
Sample Type	Walleye	White Bass	Carp	Walleye	White Bass	Carp
Gross Beta	2.20±0.07	2.43±0.06	2.66±0.08	3.31±0.10	2.27±0.08	2.69±0.05
K-40	1.90±0.37	2.18±0.22	3.17±0.41	1.93±0.64	1.87±0.34	2.56±0.26
Cs-137	<0.023	0.026±0.018	<0.013	<0.035	<0.020	<0.019[a]

Location	T-33 (Lake Erie 1.5 mi NE of Station)	T-35
Collection Date		
Lab Code		
Sample Type		
Gross Beta		
K-40		
Cs-137		

[a] Corrected result.

Table 32. Shoreline sediment samples, analyses for gamma-emitting isotopes. Collection: Semiannually.

Sample Description and Activity (pCi/g dry)				
Location	T-3	T-4	T-4	T-27 (C)
Date	05-02-91	05-02-91	05-29-91	05-02-91
Lab Code	TBS-938	TBS-939	TBS-961	TBS-941
K-40	14.54±0.89	16.77±1.02	17.80±0.98	11.78±0.[illegible]
Mn-54	<0.038	<0.047	<0.061	<0.02[illegible]
Co-58	<0.035	<0.035	<0.075	<0.[illegible]
Co-60	<0.052	<0.056	<0.079	<0.[illegible]
Cs-134	<0.031	<0.035	<0.080	<0.026
Cs-137	0.11±0.038	<0.046	<0.062	<0.037

Location	T-132	T-138(C)	T-164(C)
Date	05-29-91	05-29-91	05-29-91
Lab Code	TBS-962	TBS-963	TBS-964
K-40	10.50±0.58	17.82±1.14	9.92±0.54
Mn-54	<0.035	<0.050	<0.[illegible]5
Co-58	<0.036	<0.053	<0.039
Co-60	<0.043	<0.061	<0.045
Cs-134	<0.034	<0.039	<0.042
Cs-137	<0.030	0.57±0.063	<0.035

Location
Date
Lab Code
K-40
Mn-54
Co-58
Co-60
Cs-134
Cs-137

Table 32. Shoreline sediment samples (continued)

Sample Description and Activity (pCi/g dry)					
Location	T-3	T-4	T-4	T-23	T-27 (C)
Date	10-31-91	10-03-91	10-31-91	10-11-91	10-31-91
Lab Code	TBS-1054	TBS-1014	TBS-1055	TBS-1022	TBS-1057
K-40	10.73±0.37	13.75±0.70	11.80±0.66	11.30±0.51	9.70±0.53
Mn-54	<0.014	<0.034	<0.038	<0.025	<0.028
Co-58	<0.016	<0.042	<0.046	<0.025	<0.035
Co-60	<0.017	<0.039	<0.048	<0.030	<0.037
Cs-134	<0.012	<0.024	<0.047	<0.030	<0.034
Cs-137	<0.016	0.12±0.028	<0.035	0.20±0.020	<0.026

Location	T-132	T-138(C)	T-164(C)
Date	10-03-91	10-03-91	09-27-91
Lab Code	TBS-1018	TBS-1015	TBS-1002
K-40	9.57±0.50	13.10±0.94	10.10±0.45
Mn-54	<0.027	<0.046	<0.013
Co-58	<0.039	<0.050	<0.016
Co-60	<0.034	<0.055	<0.017
Cs-134	<0.029	<0.057	<0.020
Cs-137	<0.022	0.47±0.049	<0.013

Location	
Date	
Lab Code	
K-40	
Mn-54	
Co-58	
Co-60	
Cs-134	
Cs-137	

Table 33. Egg samples, analysis for gamma-emitting isotopes.
Collection: Annually.

Sample Description and Activity (pCi/g wet)		
Location	T-34	T-197
Date	09-13-91	07-29-91
Lab Code	TE-60	TE-59
K-40	1.33±0.411	1.01±0.17
Nb-95	<0.035	<0.014
Zr-95	<0.047	<0.020
Ru-103	<0.023	<0.012
Ru-106	<0.16	<0.091
Cs-137	<0.018	<0.011
Ce-141	<0.039	<0.016
Ce 144	<0.11	<0.055

ANNUAL ENVIRONMENTAL OPERATING REPORT:

for

Davis-Besse Nuclear Power Station
January 1, 1991 to December 31, 1991

Prepared by:
Radiological Environmental
Davis-Besse Nuclear Power Station
Toledo Edison Company
Toledo, Ohio

April 1992

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Summary

The Annual Environmental Operating Report is a detailed report of the Environmental Monitoring Programs conducted at the Davis-Besse Nuclear Power Station from January 1 through December 31, 1991. Reports included are the Radiological Environmental Monitoring, Land Use Census, Meteorological Monitoring, Marsh Management, Zebra Mussel Control, Water Treatment, and Chemical Waste Management Programs.

Radiological Environmental Monitoring Program

The operation of a nuclear power station results in the release of small amounts of radioactivity to the surrounding environment. These releases must comply with stringent regulations imposed by the Nuclear Regulatory Commission (NRC). The Radiological Environmental Monitoring Program (REMP) has been established to monitor the radiological condition of the environment around Davis-Besse. This program includes the sampling and analysis of environmental samples, and the evaluation of the effects of releases of radioactivity on the environment.

Radiation levels and radioactivity are monitored within a 25 mile radius around Davis-Besse. The environment around Davis-Besse has been monitored for approximately 20 years. The REMP was established about five years before Davis-Besse became operational. This program provided data on background radiation and radioactivity which is normally present in the area. Davis-Besse has continued to monitor the environment by sampling air, groundwater, milk, edible meat, fruits and vegetables, animal feed, soil, drinking water, surface water, fish, and shoreline sediments, as well as by measuring radiation directly.

Samples are collected from both indicator and control locations. Indicator locations are within approximately five miles of Davis-Besse and are expected to show naturally occuring radioactivity plus any increases of radioactivity that might occur due to the operation of Davis-Besse. Control location are greater than five miles away from Davis-Besse, and are expected to indicate the presence of only naturally occurring radioactivity. The results obtained at the samples collected from indicator locations are compared with

the results from those collected at control locations and with the concentrations present in the environment before Davis-Besse became operational. This allows for the assessment of any impact the operation of Davis-Besse might have had on the surrounding environment.

In 1991, over 2600 radiological environmental samples were collected, and over 3600 analyses for radioactivity were performed. Radionuclide concentrations measured at indicator locations were compared with concentrations measured at control locations, as well as those measured in previous studies.

The results of the REMP indicate the adequacy of the control of the release of radioactivity in effluents at Davis-Besse. These results also indicate that Davis-Besse complies with all applicable federal regulations. These results are divided into four sections: atmospheric monitoring, terrestrial monitoring, aquatic monitoring and direct radiation monitoring.

- Atmospheric Monitoring

Samples of air are collected to monitor the atmosphere. The 1991 results are similar to those observed in preoperational and previous operational programs. Only background radioactivity normally present in the environment was detected.

- Terrestrial monitoring

This includes analysis of milk, groundwater, meat, fruits, vegetables, animal feed and soil samples. The results of the sample analyses compare favorably with those of previous years. For example, cesium-137 radioactivity in soil was at an average concentration of 0.30 picocurie per gram dry weight (pCi/g) in 1991, which is at the low end of the range of 0.014 to 3.44 pCi/g dry weight observed over the past 12 years of station operation. The results of the analyses of the other terrestrial samples also indicate concentrations of radioactivity similar to previous years, and indicate no buildup of radioactivity attributable to the operation of Davis-Besse.

- Aquatic monitoring

This includes the collection and analysis of drinking water, untreated surface water, fish and shoreline sediments. The 1991 results of analyses for fish, drinking water, and shoreline sediment indicate normal background concentrations of radionuclides and show no increase or buildup of radioactivity due to station operation. In untreated water, a trace amount of tritium (884 pCi/l) that could be attributed to station operation was detected in only one

sample. This had no impact on the nearby residents or the surrounding environment.

- Direct Radiation

Direct radiation measurements averaged 15.0 mrem/91 days at indicator locations and 16.2 mrem/91 days at control locations, showing that, in 1991, radiation in the area of Davis-Besse was similar to radiation at locations greater than 5 miles away from the Station

The 1991 operation of Davis-Besse caused no significant increase in the concentrations of radionuclides in the environment and no significant change in the quality of the environment. All radioactivity released in the Station's effluents was well below the applicable federal regulatory limits. The estimated radiation dose to the general public due to the operation of Davis-Besse in 1991 was also well below all applicable regulatory limits.

In order to estimate this radiation dose, the pathways through which public exposure can occur must be known. To identify these exposure pathways, an Annual Land Use Census is performed as part of the REMP. During the census, Davis-Besse personnel travel every public road within a five mile radius of the Station vent to locate the radiological exposure pathways. The one pathway of particular concern is the pathway that, for a specific radionuclide, provides the greatest dose to a sector of the population, and is called the critical pathway. The critical pathway for 1991 remained unchanged from the 1990 Land Use Census, which is an infant/milk pathway at 4270 meters in the west-southwest sector.

Meteorological Monitoring

The Meteorological Monitoring Program at Davis-Besse is part of a program for evaluating the effects of the routine operation of the station on the surrounding environment. Meteorological Monitoring began in October 1968. Meteorological instruments measure continuously and are monitored daily by meteorological monitoring personnel.

Meteorological data recorded at Davis-Besse include wind speed, wind direction, sigma theta (standard deviation of wind direction), ambient temperature, differential temperature, dew point and precipitation. Two instrument equipped meteorological towers are used to collect data. Data recovery for 1991 was 90% or greater for all measured parameters. In 1991, the data

recovery for the six instruments required to be operational by Davis-Besse Technical Specifications was greater than 90%.

Marsh Management

Toledo Edison and the Cleveland Electric Illuminating Company co-own the Navarre Marsh which they lease to the U.S. Fish and Wildlife Service, who manage it as part of the Ottawa National Wildlife Refuge. Davis-Besse Environmental Compliance personnel are responsible for inspecting the marsh and reporting its status monthly.

Special projects conducted in 1991 included song bird and Canada goose banding. In 1991, 6432 birds were banded. In addition, unwanted and disruptive plant species, such as purple loosestrife (*Lythrum salicaria*) and the giant reed (*Phragmities australisi),* were controlled in order to enhance the ability of the marsh to support the resident wildlife.

Zebra Mussel Control

The Zebra Mussel Control Program was implemented in 1990 to study the extent of mussel infestation at Davis-Besse. Routine sampling and analyses of water from various locations at the station provide estimates of the number of zebra mussels which might enter the plant.

In addition to the sampling, Davis-Besse and the Electric Power Research Institute are conducting experiments to determine alternate methods for controlling the zebra mussel.

Water Treatment

Davis-Besse uses Lake Erie as a source of water for the site Water Treatment Plant. The water is treated onsite to provide domestic water and to produce high purity water for use in the Station's cooling systems. Principal activities in 1991 included the removal of precipitator number one from service for cleaning and maintenance and the implementation of the new Ohio Environmental Protection Agency' Drinking Water Standards which placed more stringant restrictions on turbity and additional bacteriological requirement.

Wastewater generated onsite is treated at the Davis-Besse Wastewater Treatment Plant. The wastewater is processed and then pumped to holding basins where further reduction in solid content takes place. Following many days in the basin, the wastewater is discharged, along with other Station waste waters, back into Lake Erie. During 1991, Waste Water Treatment Plant Number 1 was out of service due to damage to an interior tank. The installation of supports has corrected the problem and the plant should be back in operation early in 1992. Current plans are to remove Wastewater Treatment Plant Number 2 from service for cleaning and maintenance in 1992.

Chemical Waste Management

The Chemical Waste Management Program at Davis-Besse was developed to ensure that the offsite disposal of nonradioactive hazardous and non-hazardous chemical wastes is performed in accordance with all applicable state and federal regulations. Davis-Besse uses the best available technology, such as incineration or treatment to reduce toxicity, for offsite disposal of its chemical wastes in order to protect human health and the environment.

In 1991, as a result of waste minimization efforts, 648 pounds of hazardous waste (used solvents), 7,355 gallons of waste oil and 24 nickel cadmium battery cells were sent to recycling firms or a fuel blenders for thermal energy purposes.

As required by Superfund Amendment and Reauthorization Act (SARA), Davis-Besse reported eight hazardous products and chemicals to local and state agencies. Two of the chemicals, hydrazine and sulfuric acid, are classified as "extremely hazardous" substances.

As part of the program to remove polychorinated biphenyls (PCB) fluid from Davis-Besse, ten previously filled PCB transformers were retrofilled for the final time in 1990. These were sampled and analyzed in 1991 and re-classified to non-PCB. The last identified PCB transformer at Davis-Besse received the final retrofill in 1991. This transformer will be analyzed in 1992 and is expected to be re-classified as non-PCB .

Appendices

Appendix A contains a Glossary of terms used throughout this report. It is not meant to be a comprehensive reference source for interpreting any documents other than this 1992 Annual Environmental Operating Report.

Appendix B contains results from the Interlaboratory Comparison Program required by Davis-Besse Technical Specifications. Samples with known concentrations of radioisotopes are prepared by the Environmental Protection Agency (EPA), and then sent (with information on sample type and date of collection only) to the laboratory contracted by the Centerior Energy Corporation to analyze the REMP samples. The results are then checked by the EPA to ensure consistency with the know values. The results from both the contracted laboratory and the EPA are provided in Appendix B.

Appendix C contains data reporting conventions used in the REMP at Davis-Besse. The appendix provides an explanation of the format and computational methods used in reporting REMP data. Information on counting uncertainties, and computation of averages and standard deviations is also provided.

Appendix D lists the maximum permissible concentrations of alpha and beta emitting radioisotopes and of certain other radioisotopes in air and water samples. These concentrations are taken directly from the Code of Federal Regulations, and provide comparison values for actual REMP sampling results for 1991.

Appendix E provides a REMP sampling summary from 1991. The appendix provides a listing of the following for each sample type:

- the number and types of analyses performed
- the lower limit of detection for each analysis
- the mean and range of results for control and indicator locations
- the mean, range, and location description for the location with the highest annual mean
- the number of non-routine results

For detailed studies, Appendix E will provide more specific information than that listed in Chapter 2 of this report. Additionally, more specific information is submitted to the NRC in Annual Environmental Monitoring Report Attachment 1. This document is not distributed with the rest of the Annual Environmental Operating Report due to its large size and technical nature. The information presented in Appendices B through E were provided by Teledyne Isotopes Midwest Laboratories in their Annual Report to Toledo Edison (Part 1, Feb. 1992).

Introduction

Coal, oil, natural gas, and hydropower have been used to run this nation's electric generating stations; however, each method has its drawbacks. Coal-fired power can affect the environment through mining, acid rain, and airborne discharges. Oil and natural gas are in limited supply and are therefore costly, and hydropower is limited due to the environmental impact of damming our waterways and the scarcity of suitable sites in our country.

Nuclear energy provides an alternate source of energy which is readily available. The operation of nuclear power stations has a very small impact on the environment. In fact, the Davis-Besse Nuclear Power Station is surrounded by hundreds of acres of marshland which makes up part of the Ottawa National Wildlife Refuge, the only national refuge in Ohio.

In order to more fully understand this unique source of energy, background information on basic radiation characteristics, risk assessment, reactor operation, and effluent control, is provided in this chapter.

Fundamentals

The Atom

All matter consist of **atoms**. Simply described, atoms are made up of positively and negatively charged particles, and particles which are neutral. These particles are called **protons, electrons,** and **neutrons,** respectively (Figure 1-1). The relatively large protons and neutrons are packed tightly together in a cluster at the center of the atom, called the **nucleus**. Orbiting around this nucleus are one or more smaller electrons. In an electrically neutral atom, the negative charges of the electrons are balanced by the positive charges of the protons. Due to their dissimilar charges, the protons and electrons have a strong attraction for each other, which helps hold the atom together.

Other attractive forces between the protons and neutrons keep the densely packed protons from repelling each other, preventing the nucleus from breaking apart.

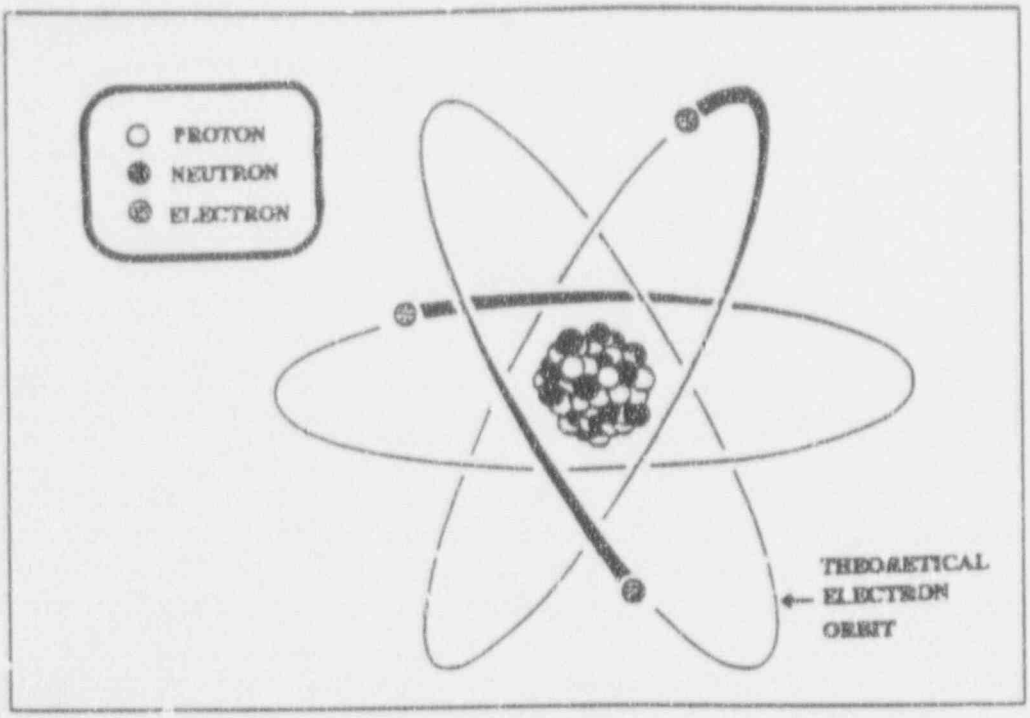


Figure 1-1: An atom consists of two parts: a nucleus containing positively charged protons and electrically neutral neutrons and one or more negatively charged electrons orbiting the nucleus. Protons and neutrons are nearly identical in size and weight, while each is about 2000 times heavier than an electron.

Isotopes

A group of identical atoms, containing the same number of protons, make up an **element.** In fact, the number of protons an atoms contains determines its chemical identity. For instance, all atoms with one proton are hydrogen atoms and all the atoms with eight protons are oxygen atoms. However, the number of neutrons in the nucleus of an element may vary. Atoms with the same number of protons, but different number of neutrons, are called **isotopes.** As an example, Table 1-1 list some of the isotopes of uranium. Different isotopes of the same element have the same chemical properties, and many are stable, or nonradioactive. An unstable or radioactive isotope of an element is called a **radioisotope.**

Radiation and Radioactivity

Radionuclides

The parts of an atom are normally in a balanced, **stable** state. If the nucleus of an atom contains an excess of energy, it is called a **radioisotope**, **radioactive atom**, or **radionuclide**. The excess energy is usually due to excess number of neutrons in the nucleus of the atom.

Radionuclides can be naturally occurring such as uranium-238, beryllium-7 and potassium-40, or man-made, such as iodine-131, cesium-137, and cobalt-60.

Table 1-1: Isotopes of Uranium

Isotope	Symbol	# of Protons	# of Neutrons
Uranium-235	U-235	92	143
Uranium-236	U-236	92	144
Uranium-237	U-237	92	145
Uranium-238	U-238	92	146
Uranium-239	U-239	92	147
Uranium-240	U-240	92	148

Radiation

Radiation is simply the conveyance of energy through space. For instance, heat emanating from a stove is a form of radiation, as are light rays, microwaves, and radio waves. **Ionizing radiation** is another type of radiation and has similar properties to those of the examples listed above.

Ionizing radiation consists of both **electromagnetic radiation** and **particulate radiation**. Electromagnetic radiation consists of rays of energy with no measurable mass that travel with a wave-like motion through space. Included in this category are **gamma rays** and **X-rays**. Particulate radiation

consists of tiny, fast moving particles which, if uninhibited, travel in a straight line through space. The three types of particulate radiation of concern to us are **alpha particles**, made up of 2 protons and 2 neutrons; **beta particles**, which are essentially free electrons (electrons not attached to an atom); and **neutrons**. The properties of these types of radiation will be described more fully in the Range and Shielding section on page 1-5 .

Radioactive Decay

Radioactive atoms attempt to reach a stable, non-radioactive state through a process known as **radioactive decay**. Radioactive decay is the release of energy from an atom through the emission of ionizing radiation. Radioactive atoms may decay directly to a stable state or may go through a series of decay stages, called a **radioactive decay series**, and produce several **daughter products** which eventually result in a stable atom. The loss of energy and/or matter through radioactive decay may transform the atom into a chemically different element. For example, when uranium-238 decays, it emits an alpha particle and, as a result, the atom loses 2 protons and 2 neutrons. As discussed previously, the number of protons in the nucleus of an atom determines its chemical identity. Therefore, when the uranium-238 atom loses the 2 protons and 2 neutrons, it is transformed into an atom of thorium-234. Thorium-234 is one of the 14 successive daughter products of uranium-238. Radon is another daughter product, and the series ends with stable lead-206. This example is part of a known radioactive decay series, called the uranium series, which begins with uranium-238 and ends with lead-206.

Half-life

Most radionuclides vary greatly in the frequency with which their atoms release radiation. Some radioactive materials, in which there are only infrequent emissions, tend to have a very long half-lives. Those radioactive materials that are very active, emitting radiation more frequently, tend to have a comparably short half-lives. The length of time an atoms remains radioactive is defined in terms of **half-lives**. Half-life is the amount of time required for a radioactive substance to lose half its activity through the process of radioactive decay. Half-lives vary from millionths of a second to millions of years.

Interaction With Matter

Ionization

Through interactions with atoms, alpha, beta, and gamma radiation lose their energy. When these forms of radiation interact with any form of material, the energy they impart may cause atoms in that material to become **ions**, or charged particles. Normally, an atom has the same number of protons as electrons. Thus, the number of positive and negative charges cancel, and the atom is electrically neutral. When one or more electrons are removed an ion is formed. Ionization is one of the processes which may result in damage to biological systems.

Range and Shielding

Particulate and electromagnetic radiation each travel through matter differently because of their different properties. Alpha particles contain 2 protons and 2 neutrons, are relatively large, and carry an electrical charge of +2. Alpha particles are ejected from the nucleus of a radioactive atom at speeds ranging from 2,000 to 20,000 miles per second. However, due to its comparatively large size, an alpha particle usually does not travel very far before it loses most of its energy through collisions and other interactions with atoms. As a result, alpha particles can easily be stopped by a sheet of paper or a few centimeters of air (Figure 1-2).

Beta particles are very small, and comparatively fast particles, traveling at speeds near the speed of light (186,000 miles per second). Beta particles have an electrical charge of either +1 or -1. Because they are so small and have a low charge, they do not collide and interact as often as alpha particles, so they can travel farther. Beta particles can usually travel through several meters of air, but may be stopped by a thin piece of metal or wood.

Gamma rays are pure energy that travel at the speed of light. They have no measurable charge or mass, and generally travel much farther than alpha or beta particles before being absorbed. After repeated interactions, the gamma ray finally loses all of its energy it and vanishes. The range of a gamma ray in air varies, depending on the ray's energy and interactions. Very high energy gamma radiation can travel a considerable distance, whereas low energy gamma radiation may travel only a few feet in air. Lead is used as shielding material for gamma radiation because of its density. Several inches of lead or concrete may be needed to effectively shield gamma rays.

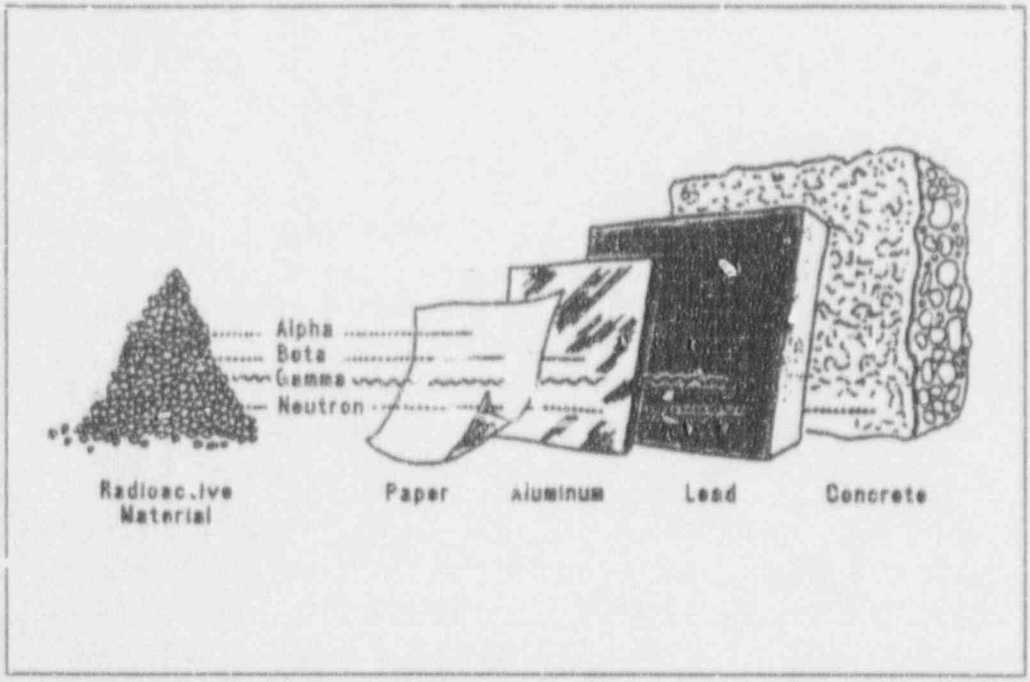


Figure 1-2: As radiation travels, it collides and interacts with other atoms and loses energy. Alpha particles can be stopped by a sheet of paper, and beta particles by a thin sheet of aluminum. Gamma radiation is shielded by highly dense materials such as lead, while hydrogenous materials (those containing hydrogen atoms), such as water and concrete, are used to stop neutrons.

Neutrons come from several sources, including the interactions of cosmic radiation with the earth's atmosphere and nuclear reactions within nuclear power reactors. However, neutrons are generally not of environmental concern since nuclear power stations are designed to keep neutrons within the containment building.

Because neutrons have no charge, they are able to pass very close to the nuclei of the material through which they are traveling. As a result, neutrons may be captured by one of these nuclei or they may be deflected, much in the way that a rolling billiard ball is deflected when it strikes another. When deflected, the neutron loses some if its energy. After a series of these deflections, the neutron has lost most of its energy. At this point, the neutron moves about as slowly as the atoms of the material through which it is traveling, and is called a **thermal neutron.** In comparison, fast neutrons are much more energetic than thermal neutrons and have greater potential for causing damage to the material through which they travel. Fast neutrons can have from 200 thousand to 200 million times the energy of thermal neutrons.

Neutron shielding is designed to slow down fast neutrons and absorb thermal neutrons. Often neutron shielding material consists of several components, including a highly dense material such as water or polyethylene, to further slow the neutrons. The shield is then completed with a material such as cadmium, to absorb the now thermal neutrons. At Davis-Besse, concrete is used to form an effective neutron shield. Concrete is used because it contains water molecules and can be easily molded around odd shapes.

Quantities and Units of Measurement

There are several quantities and units of measurement used to describe radioactivity and its effects. Four terms of particular usefulness are **activity, exposure, absorbed dose,** and **dose equivalent.**

Activity: Curie

Activity is the number of nuclei in a sample that disintegrate (decay) per unit of time. Each time a nucleus disintegrates, radiation is emitted. The **curie** (Ci) is the unit used to describe the activity of a material and indicates the rate at which the atoms of a radioactive substance are decaying. One curie indicates the disintegration of 37 billion atoms per second.

A curie is a unit of activity, not a quantity of material. Thus, the amount of material required to produce one curie varies. For example, one gram of radium-226 is the equivalent of one curie of activity, but it would take 9,170,000 grams (about 10 tons) of thorium-232 to equal one curie.

Smaller units of the curie are often used, especially when discussing the low concentrations of radioactivity detected in environmental samples. For instance, the microcurie (uCi) is equal to one millionth of a curie, while the picocurie (pCi) represents one trillionth of a curie.

Exposure: Roentgen

Exposure is a term used to describe the ability of ionizing radiation from gamma or x-rays to produce ion pairs in a certain volume of air. Exposure measures the energy of the radiation and is expressed in units called **roentgens (R).** One roentgen is the quantity of exposure that causes approximately two billion ionizing events (i.e., creation of ion pairs) per cubic centimeter of air.

A common way to describe the rate of exposure to gamma radiation is in **roentgens per hour (R/hr)**. Often a smaller unit used is **milliroentgens per hour (mR/hr),** which is 1000 times less.

The roentgen applies only to radiation associated with gamma or X rays, and is not used to describe exposure to alpha, beta or neutron radiation. In addition, the roentgen applies only to the energy of the radiation in air, and does not account for the fact that different substances absorb different amounts of energy. Thus, another unit is necessary to describe the amount of energy absorbed by any material.

Absorbed Dose: Rad

Absorbed dose is a term used to describe the radiation energy absorbed by any material exposed to ionizing radiation, and can be used for both particulate and electromagnetic radiation. The **rad (radiation absorbed dose)** is the unit used to measure the absorbed dose. It is defined as the energy of ionizing radiation deposited per gram of absorbing material (1 rad = 100 erg/gm). The rate of absorbed dose is usually given in rad/hr.

If the biological effect of radiation was directly proportional to the energy deposited by radiation in an organism, the rad would be a suitable measurement of the biological effect. However, biological effects depend not only on the total energy deposited per gram of tissue, but on how this energy is distributed along its path. Experiments have shown that some types of radiation are more damaging per unit path of travel than others. Thus, another unit is needed to quantify the biological damage caused by ionizing radiation.

Dose Equivalent: Rem

Biological damage due to alpha, beta, gamma and neutron radiation may result from the ionization caused by these radiations. Some types of radiation, especially alpha particles which cause dense local ionization, can result in up to 20 times the amount of biological damage for the same energy imparted as do gamma or X rays. Therefore, a **quality** factor must be applied to account for the different ionizing capabilities of various types of ionizing radiation. When the quality factor is multiplied by the absorbed dose, the result is the **dose equivalent,** which is an estimate of the possible biological damage resulting from exposure to a particular type of ionizing radiation. The dose equivalent is measured in **rem (radiation equivalent man).**

As an example of this conversion from absorbed dose to dose equivalent, the quality factor for alpha radiation is 20. Hence, 1 rad of alpha radiation is approximately equal to 20 rem. Beta and gamma radiation each have a quality factor of 1, therefore one rad of either beta or gamma radiation is approximately equal to one rem. Thermal neutrons have a quality factor of 3, and fast neutrons have a quality factor of 10. One rem produces the same amount of biological damage, regardless of the source.

In terms of environmental radiation, the rem is a large unit. Therefore, a smaller unit, the **millirem,** is often used. One millirem (mrem) is equal to 1/1000 of a rem.

Sources of Radiation

Background Radiation

Radiation is not a new creation of the nuclear power industry; it is a natural occurrence on the earth. Mankind has always lived with radiation and always will. In fact, during every second of life, over 7,000 atoms undergo radioactive decay in the body of the average adult. In addition to that which normally occurs in our bodies, it also occurs naturally in the soil, water, air, and space. All these common sources of radiation contribute to the natural background radiation to which everyone is exposed (Figure 1-3).

The earth is constantly showered by a steady stream of high energy gamma rays and particulate radiation that come from space, known as cosmic radiation. The atmosphere shields out most of this radiation, but everyone still receives about 20 to 50 mrem each year from this source. The thinner air at higher altitudes provides less protection against cosmic radiation. Therefore, people living at higher altitudes or even flying in an airplane are exposed to more cosmic radiation. For example, the dose due to cosmic radiation in Denver, Colorado (elevation 5280 feet above sea level) is approximately 47 mrem per year, whereas, in Toledo, Ohio (maximum elevation 630 feet above sea level), the dose attributed to cosmic radiation is approximately 26 mrem per year. Radionuclides commonly found in the atmosphere as a result of cosmic ray interactions include beryllium-7, carbon-14, tritium, and sodium-22.

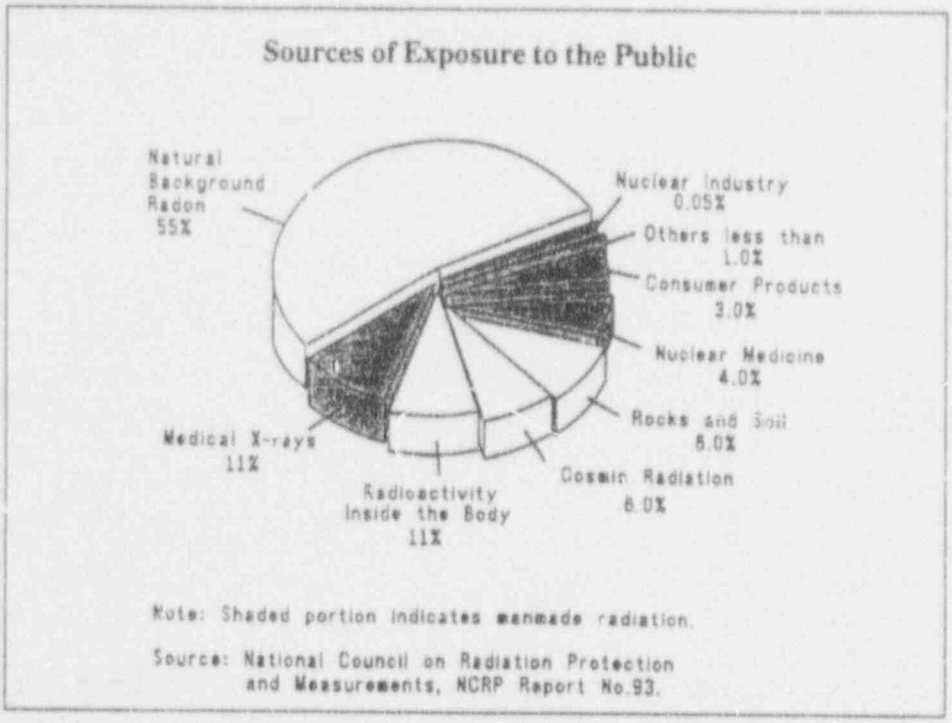


Figure 1-3: A very small annual dose to the public results from the nuclear power industry. Actually, the most significant annual dose the average individual receives is that from naturally occurring radon.

Other natural sources of radiation include the radionuclides naturally found in soil, water, food, building materials and even people. People have always been radioactive, in part because the carbon found in their bodies is a mixture of all carbon isotopes, both non-radioactive and radioactive.

In fact, because radioactive carbon-14 has a known half-life of 5730 years and exists in all living things, archaeologists can use carbon dating to determine the age of a fossil or other artifact. After an organism dies, it no longer takes up carbon, and the radioactive carbon-14 present in its body continues to decay. Thus, archaeologists can estimate the point at which it no longer assimilated radioactive carbon in its tissues (i.e., the point of death).

Another common naturally occurring radionuclide is potassium-40. About one-third of the external terrestrial and internal whole body dose from natural sources is attributable to this natural radioactive isotope of potassium. Recently, concern has been expressed over another source of background radiation-radon. According to the National Council on Radiation Protection (NCRP), over half of the radiation dose the average American receives is

attributed to radon. Radon is a colorless, odorless, radioactive gas that results from the decay of radium-226, a member of the uranium-238 decay series.

Radon atoms are produced in the soil and migrate through air-filled pores in the soil to reach the atmosphere. Radon occurs in all soils, but because it is a daughter product of uranium, it occurs in higher concentrations in rocks (and soils derived from rocks) with high concentrations of uranium, such as black shales, granites, phosphate rocks and carbonate rocks.

Radon occurs indoors as a result of radon in the soil or rock under the building or radon in building materials, water supplies, natural gas or outdoor air. Groundwater supplies can become contaminated with radon migrating through the soil. In addition, the unvented combustion of natural gas can also contribute to indoor radon concentrations. However, the primary source of indoor radon is that which diffuses into the building from the underlying soil or rock.

Radon may enter buildings through the walls, floors, vents and other openings. Although radon can migrate through uncracked slabs, slabs with cracks or openings for piping, sumps, etc. may considerably increase the transmission of radon into a building. Although there is no reliable method of predicting which buildings will have greater indoor concentrations of radon, the following factors directly impact radon uptake and accumulation of uranium content of the soil:

- weather conditions
- constructions methods
- presence/absence of any cracks or openings in the foundations

Some weather conditions, such as low pressure systems or increased rain fall, act to force radon out of the soil at an increased rate. In addition, construction methods affect indoor radon concentrations. Buildings built on a slab with no crawl space, sealed to prevent energy loss, those with basements, and those without fully ventilated crawl spaces tend to be linked to higher radon concentrations.

Because uranium naturally occurs in all soils and rocks, everyone is continuously exposed to radon and its daughter products. However, radon does not typically pose a health hazard unless it is allowed to concentrate in a confined area, such as a building.

Radon-related health concerns stem from the exposure of the lungs to this radioactive gas. Radon emits alpha radiation when it decays. Alpha radiation can easily be stopped by a person's dead skin layer. However, alpha radiation can cause damage to internal tissues when ingested or inhaled. As a result, exposure to the lungs is of greatest concern, especially as the only recognized health effect associated with exposure to radon is an increased risk of lung cancer.

Radon can be detected in one of several ways. Three common methods used presently to detect radon in homes and other buildings are as follows:

- **Charcoal canister method:**
  Charcoal canisters, which absorb radon, are placed in a building, and after approximately 1 to 5 days are removed and sent to a laboratory where the radon decay products are analyzed. From this information, the laboratory can determine the approximate concentration of radon gas required to produce the decay products measured.

- **Alpha track method:**
  Alpha track detectors utilize a radiation-sensitive film. When the alpha emissions from radon strike the film, they make a track. The alpha track detector is usually placed in a building for 2 weeks to several months, and, like the charcoal canister, is sent to a laboratory for analysis. At the laboratory the number of tracks on the film are counted. This information is used to estimate the average concentration of radon in the building during the period that the film was exposed.

- **Electronic monitoring method:**
  Electronic monitors are available which continuously detect the number of negative ions produced by decaying radon and provide instantaneous information on the concentration of radon in the air.

The United States Environmental Protection Agency has provided guidelines for radon monitoring in homes and other buildings, and has developed recommendations for concentrations at which to take corrective actions. Further information on radon, its detection , and actions to reduce the radon concentration in buildings can be obtained by contacting the state radon program office at the following address:

Ohio Department of Health
P.O. BOX 118
Columbus, Ohio 43266-0118
(614) 481-5800
(800) 523-4439 (in Ohio Only)

Man-Made Radiation

In addition to naturally occurring radiation and radioactivity, people are also exposed to man-made radiation. The largest sources of exposure include medical x-rays and radioactive pharmaceuticals. Small doses are also received from consumer products such as televisions, smoke detectors, and fertilizers. Fallout from nuclear weapons tests is another source of man-made exposure. Fallout radionuclides include strontium-90, cesium-137, carbon-14, and tritium. As shown in Figure 1-3, a very small percent of the annual dose a member of the public receives is due to the production of nuclear power. In fact, the maximum whole body doses to the public due to radioactivity released in liquid and gaseous effluents from Davis-Besse in 1991 were only 0.07 and 0.04 mrem, respectively. Each of these doses is less than the dose an individual would receive from one coast-to-coast jet flight (3 mrem).

Health Effects of Radiation

Studies

The effects of ionizing radiation on human health have been under study for more than eighty years. Scientists have obtained valuable knowledge through the study of laboratory animals that were exposed to radiation under extremely controlled conditions. However, it has proven difficult to relate the biological effects of irradiated laboratory animals to the potential health effects on humans. Hence, much study has been done with human populations that were radiated under various circumstances. These groups include the survivors of the atomic bomb; persons undergoing medical radiation treatment; radium dial painters, who ingested large amounts of radioactivity by "tipping" the paint brushes with their lips; uranium miners, who inhaled large amounts of radioactive dust while mining pitchblende (uranium ore); and early radiologists, who accumulated large doses of radiation while unaware of the potential hazards.

The studies performed on these groups have increased our knowledge of the health effects from large doses of radiation. However, less is known about the effects of low doses of radiation. To be on the conservative side, we assume that health effects resulting from low doses of radiation occur proportionally to those observed following large doses of radiation. Some radiation scientists agree that this assumption overestimates the risks associated with a low level radiation exposure. The effects predicted in this manner have never been actually observed in individuals exposed to low level radiation. However, this assumption provides a highly conservative model of radiation-induced health effects, because it most probably overestimates the risks associated with receiving low doses of radiation.

Health Risks

Since the actual effects of exposure to low radiation are difficult to assess, scientists often refer to the risk involved. The problem is one of evaluating alternatives, of comparing risks and weighing them against benefits. People make decisions involving risks every day, such as whether to(not to) wear seat belts; or whether to (not to) smoke cigarettes. Risks are a part of everyday life. The question is one of determining how great the risks are. We accept the inevitability of automobile accidents. Chances are that several people reading this report will be seriously injured this year as a result of automobile accidents. By building safer cars or wearing seat belts, this risk can be reduced, however, even a parked car is not risk-free. You could choose not to drive, but even as a pedestrian or a bicyclist you may be injured by cars. Reducing the risk of injury from automobiles to zero requires moving to a place where there are no automobiles.

While most people accept the risks inherent in such activities as smoking and driving to work each day, some people seem to feel that their energy needs should be met on a risk-free basis. However, this is impossible , no matter what the energy source. The burning of fossil fuels can have a negative impact on the environment, and even the use of hydropower entails risks, including that of a ruptured dam and habitat destruction that can result from damming waterways. Thus, attention should be focused on taking steps to safeguard the public, on developing a realistic assessment of the risks, and on placing these risks in perspective. One of the most widely distorted perceptions of risk is that associated with radiation exposure.

Because some people do not understand ionizing radiation and its associated risks, they may fear it. This fear is compounded by the fact that we cannot hear, smell, taste or feel ionizing radiation. Sometimes, if we have another source of information, we may believe the widespread myths about ionizing

radiation and its health effects. But this is not true of other potentially hazardous things for which we have the same lack of sensory perception such as radio waves, carbon monoxide, and small concentrations of numerous cancer causing substances. Although these risks are just as real as the risks concerning in radiation. Most risks are with us throughout our lives, and their effects can be added up over a lifetime to obtain a total effect on our lives. Table 1-2 shows a number of different factors that decrease the average life expectancy of individuals in the United States.

Table 1-2: Risk Factors
Factors Estimated Decrease in Average Life Expectancy*

Male rather than female		5.0 years
Overweight by 30%		3.6 years
Cigarette smoking:	1 pack/day	7.0 years
	2 packs/day	10.0 years
Heart diseases		5.8 years
Cancer		2.7 years
City Living (not rural)		5.0 years
125 operating nuclear power stations		less than 12 minutes

* The typical life span in the United States is now 76 years for women and 71 years for men.

The American Cancer Society estimates that about 30 percent of all Americans will develop cancer at some time in their lives from all possible causes. Thus, in a group of 10,000 people, it is expected that 3,000 of them will develop cancer. If each person in that group of 10,000 people were to receive 100 millirem in addition to the natural and man-made sources of radiation they are normally exposed to then there is an increased probability that would indicate one additional person from that group may develop cancer during his/her lifetime. This increases the risk from 30 percent to 30.01 percent. For comparison, the average offsite dose to individuals in the population due to the operation of the Davis-Besse Nuclear Power Station is significantly less than one millirem (0.001 millirem in 1991). If it is

considered that the Davis-Besse Nuclear Power Station will operate for the remainder of its license at this rate, the probability of even one person in the population developing a cancer due to the presence of the Davis-Besse Nuclear Power Station is extremely small.

The preceding table should provide you with an idea of the risks associated with nuclear power with respect to other, more significant risks that we accept as a part of our daily lives. Only when one is presented with a basis for comparison, can he or she make the decisions that he benefits derived from a particular activity (e.g., driving an automobile) outweigh the costs associated with that activity (e.g., possibility of an automobile accident). By comparing the risks associated with familiar activities, this provides people with a means to put the risks associated with nuclear power in perspective.

Benefits of Nuclear Power

Nuclear power plays an important part in meeting today's electricity needs, and will continue to serve as an important source of electric energy well into the future. In 1980, nuclear power accounted for only eleven percent of the electricity produced in the United States (Figure 1-4). By the end of 1991, however, this number was greater than twenty percent. At the same time, dependence on oil as an energy source decreased by more than half. By decreasing the nations' dependence on oil, dependence on foreign oil supplies also decreases, thereby ensuring the nation can continue to be self-sufficient in meeting the energy needs of it's private and business sectors.

Nuclear power offers several advantages over alternative sources of electric energy:

- nuclear power has an excellent safety record dating back to 1957 when the first commercial nuclear power station began operating,
- uranium, the fuel for nuclear power stations, is a relatively inexpensive fuel that is readily available in the United States,
- nuclear power is the cleanest energy source for power stations that use steam to produce electricity.

The following sections provide information on the fundamentals of and how Davis-Besse uses nuclear fuel and the fission process to produce electricity.

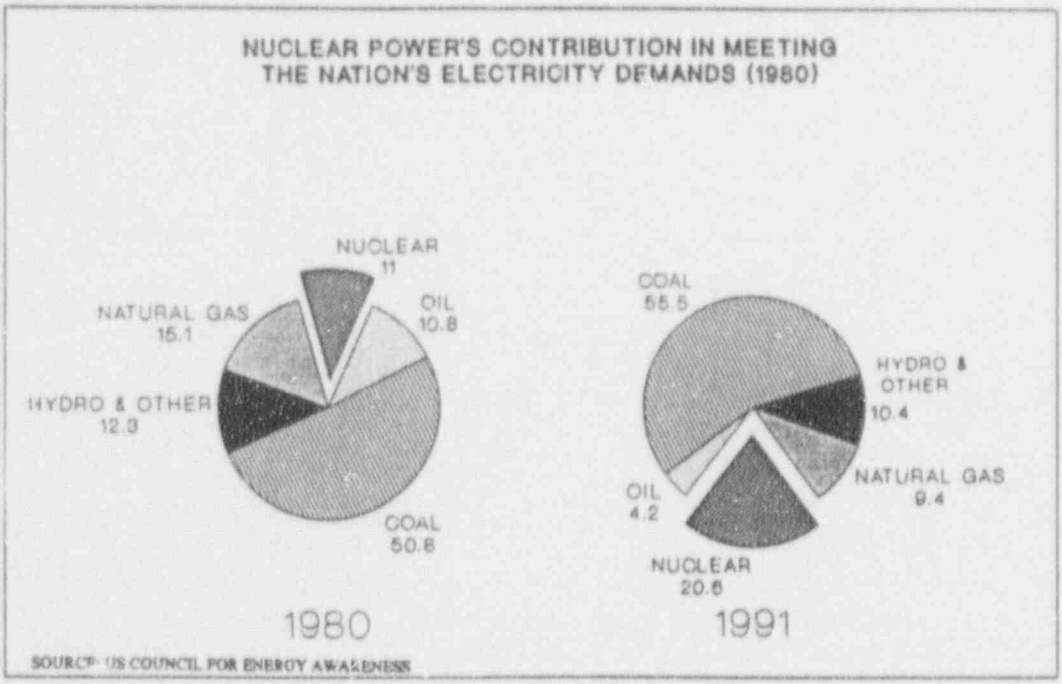


Figure 1-4: Since 1980, the nation's dependence on nuclear power for supplying electricity has almost doubled. This has led to the decreased dependence on the amount of oil and natural gas needed to produce electricity. The advantage to this is less emission to the atmosphere which may cause acid rain.

Nuclear Power Production

Electricity is produced in a nuclear power station in essentially the same way as in a fossil-fueled station. Heat changes water to steam that turns a turbine. In a fossil-fueled station, the fuel is burned in a furnace, which is also a boiler. Inside the boiler, water is turned into steam. In a nuclear station, the furnace is replaced by a reactor containing a core of nuclear fuel, primarily uranium. Heat is produced when the atoms of uranium are split, or fissioned, inside the reactor.

What is Fission?

A special attractive force called the binding force holds the protons and neutrons together in the nucleus of the atom. The strength of this binding force varies from atom to atom. If the bond is weak enough, the nucleus can be split when bombarded by a free neutron (Figure 1-5). This causes the entire atom to split, producing smaller atoms, more free neutrons, and heat. In a nuclear reactor, a chain reaction of fission events provides the heat necessary to boil the water to produce steam.

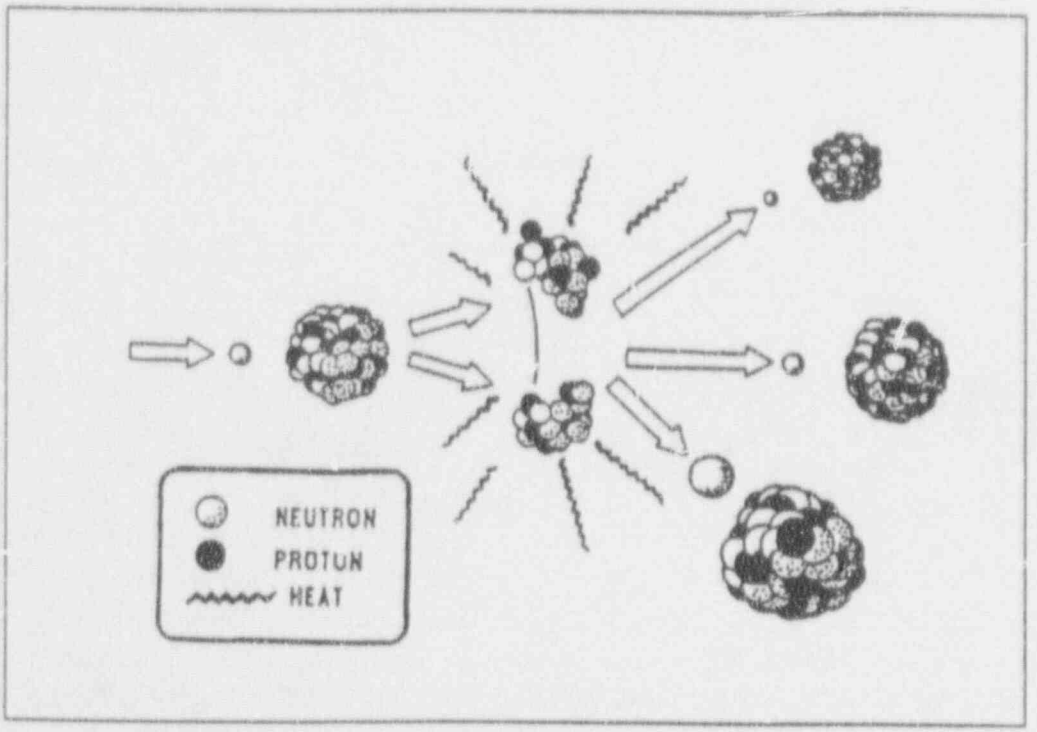


Figure 1-5: When a heavy atom, such as uranium-235 is split, or fissioned, heat, free neutrons, and fission fragments result. The free neutrons can then strike neighboring atoms causing them to fission also. In the proper environment, this process can continue indefinitely in a chain reaction.

Nuclear Fuel

The fissioning of one uranium atom releases approximately 50 million times more energy that the combustion of a single carbon atom common to all fossil fuels. Since a single small reactor fuel pellet contains trillions of atoms, each pellet can release an extremely large amount of energy. The amount of electricity that can be generated from three small fuel pellets would require about 3.5 tons of coal or 12 barrels of oil to generate.

Nuclear fission occurs spontaneously in nature, but these natural occurrences cannot sustain themselves because the freed neutrons either are absorbed by non-fissionable atoms or quickly decay. In contrast, a nuclear reactor minimized neutron losses, thus sustaining the fission process by several means:

- using fuel that is free of impurities that might absorb the freed neutrons;

- increasing the concentration of the rarer fissionable isotope of uranium (U-235) relative to the concentration of U-238, a more common isotope that does not fission easily;
- and slowing neutrons down to increase the probability of fission by providing a "moderator" such as water.

Natural uranium contains less than one percent U-235 compared to the more abundant U-238 when it is mined. Before it can be economically used in a nuclear reactor, it is enriched to approximately three percent U-235 to U-238. In contrast, the nuclear material used in nuclear weapons has been enriched to over 97 percent. Because of the low levels of U-235 in nuclear fuel, a nuclear power station cannot explode like a bomb.

After the uranium is separated from the earth and rock in the ore, it is concentrated by a milling process. After milling the ore to a granular form and dissolving out the uranium with acid, the uranium is converted to **uranium hexafluoride (UF6).** A chemical form of uranium that exists as a gas at temperatures slightly above room temperature. The uranium is then highly purified and shipped to an enrichment facility where **gaseous diffusion converters** increase the concentration of U-235 in the fuel. The enriched gaseous UF6 is then converted into powdered **uranium dioxide** (UO_2) a highly stable ceramic material. The UO_2 powder is put under high pressure to form **fuel pellets,** each about 5/8 inch long and 3/8 inch in diameter (refer to Figure 1-6). Approximately five pounds of these pellet are placed into a 12 foot long metal tube made of zirconium alloy. The tubes constitute the **fuel cladding.** The fuel cladding is highly resistant of heat, radiation and corrosion. When the tubes are filled with fuel pellets, they are called **fuel rods.**

The Reactor Core

Two hundred eight fuel rods comprise a single **fuel assembly.** The **reactor core** at Davis-Besse contains 177 of these fuel assemblies, each approximately 14 feet tall and 2,000 pounds in weight. In addition to the fuel rods, the fuel assembly also contains 16 vacant holes for the insertion of **control rods,** and one vacant hole for an **incore monitoring probe.** This probe monitors temperature and neutron levels in the fuel assembly. The Davis-Besse reactor vessel weighs 838,000 pounds, has a diameter of 14 feet, is 39 feet high, and has 8 1/2 inch thick steel walls.

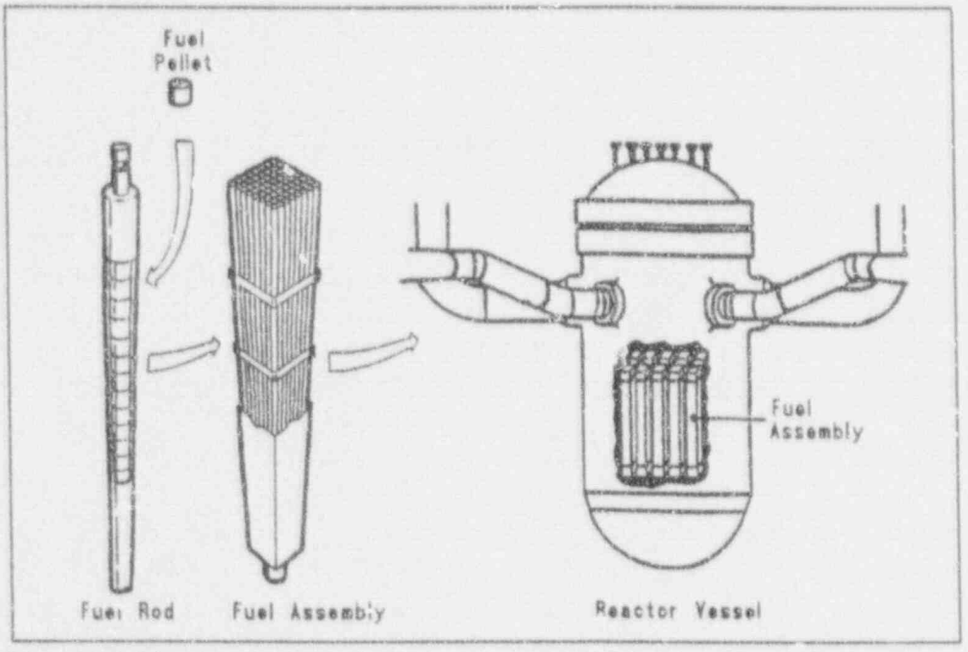


Figure 1-6: The reactor core at Davis-Besse contains 177 fuel assemblies. Each assembly contains 208 fuel rods. Each fuel rod is filled with approximately five pounds of fuel pellets, each pellet approximately 3/8 inch in diameter a[illegible]/8 inch long.

Fission Control

The fission rate inside the reactor core is controlled by raising or lowering control **rod assemblies** into the reactor core. Each assembly consist of "fingers" containing silver, indium, and cadmium metals that absorb free neutrons, thus disrupting the fission chain reaction. When control rod assemblies are slowly withdrawn from the core, fissioning begins and heat is produced. If the control rod assemblies are inserted rapidly into the reactor core, as during a plant "trip," the chain reaction ceases. A slower acting (but more evenly distributed) method of fission control is achieved by the addition of a **neutron poison** to the reactor coolant water. At Davis-Besse, boric acid can be concentrated or diluted as necessary, in the coolant to achieve the desired level of fission. After boric acid is added to the coolant water, the acid turns into boron-10. Boron-10 readily absorbs free neutrons, hence the term "neutron poison," forming boron-11. The boron-11 in turn decays to non-radioactive lithium by the emission of an alpha particle.

Reactor Types

Virtually all of the commercial reactors in this country are either **boiling water reactors (BWRs)** or **pressurized water reactors (PWRs)**. Both

types are also called **light water reactors (LWRs)** because their coolant, or medium to transfer heat, is ordinary water, containing the light isotope of hydrogen. Some reactors use the heavy isotope of hydrogen (deuterium) in the reactor coolant. Such reactions are called **heavy water reactors,** or **HWRs.**

In BWRs, water passes through the core and boils to steam. The steam passes through separators which removes water droplets. The steam then travels to dryers before entering the turbine. After passing though the turbine the water returns to the core to repeat the cycle.

In PWRs, the reactor water or coolant is pressurized to prevent it from boiling. The hot water is pumped to a **steam generator** (heat exchanger) where its heat is transferred to a separate water supply. The water inside the generator boils into steam which is used to turn the turbine. Davis-Besse uses a PWR, while the Perry Nuclear Power Plant, owned by Toledo Edison's sister company, Cleveland Electric Illuminating, uses a BWR. The Davis-Besse and Perry Nuclear Power Stations are the only two commercial reactors in the State of Ohio.

Future Reactor Types

In the future, the BWRs and PWRs may not be the only types of commercial reactors in operation in the United States. Presently, several reactor types are being designed or developed which would be licensed by design or class. The new reactors will be smaller and more modular units, approximately 80-600 Megawatts electric (MWe) in size. These proposed reactors would have more passive systems relying on gravity, natural air flow (convection) and evaporation cooling systems in the event of a loss of coolant situation. Also, these reactors could be fabricated at the manufacturers and shipped to a plant for installation. This would save money and time during construction. The following paragraphs discuss five reactors that may be licensed in this country.

Advanced Pressurized Water Reactors

The Advanced Pressurized Water Reactor (APWR) or passive water-cooled reactor by Westinghouse Electric Corporation is a 600 MWe reactor which replaces many active systems with more passive ones. The AP-600, Westinghouse's version, is similar to current PWRs with the following exceptions. The containment building is larger than usual. Safety features

that aid in the maintenance of the building pressure and the prevention of a reactor vessel rupture include cooling sprinklers located above the reactor vessel and air baffles that allow natural convection cooling. Gravity-Feed Emergency Flood Tanks located above the core allow water to free-flow down in case of a loss of coolant situation.

The reactor uses a uranium dioxide pellet as fuel and operates at 600°F. Construction of the AP-600 is estimated to take five years. Since prefabricated modules (reactors) can be purchased and installed, construction time and cost would be considerably less than building a reactor at a site.

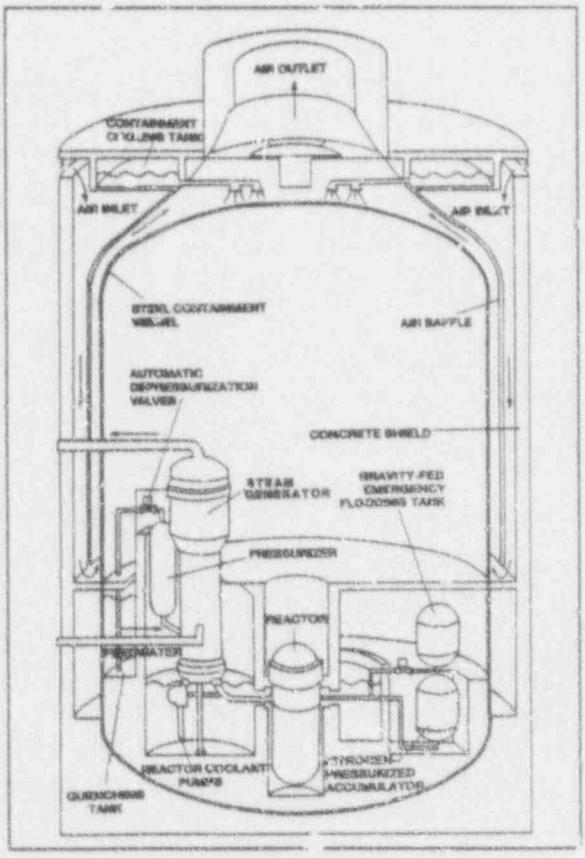


Figure 1-7: The AP600, shown here,is fabricated at the manufacturers' and shipped to a site for installation. This reduces both construction time and cost without compromising plant safety.

Advanced Boiling Water Reactor

The Advanced Boiling Water Reactor (ABWR), developed by General Electric Company, is similar to current BWRs with a few exceptions. The circulating pumps are located in the reactor vessel. This reduces the amount of shielding required and the number of welds in the system. Also, the control systems are driven electromechanically rather than hydraulically, thereby reducing maintenance. Safety systems are more redundant, requiring less operator intervention.

The ABWR would be capable of producing 1350 MWe and would use uranium dioxide as a fuel. Tokyo Electric Power Company in Japan has plans to build the first ABWR once pre-approved certification is completed. The plant construction time is estimated to take five to six years.

Simplified Boiling Water Reactor (SBWR)

The General Electric Company is also developing a second type of BWR called the Simplified Boiling Water Reactor. This design focuses on safety and simplicity, relying on gravity and natural circulation for cooling during a loss of coolant situation. The reactor core is at the bottom of the containment building. A Gravity-Feed Cooling Tank, located above the core, is used to flood the core during a loss of coolant situation. This reactor is considered an inherently safe design which means reactor operator would have 72 hours to respond to a loss of coolant situation instead of 20 minutes like current reac[illegible]. Also, this response time can be lengthened by adding more water to the core. The SBWR would produce 600 MWe and use a uranium dioxide fuel. Pre-approval certification is targeted for 1995, with construction time being 30 months.

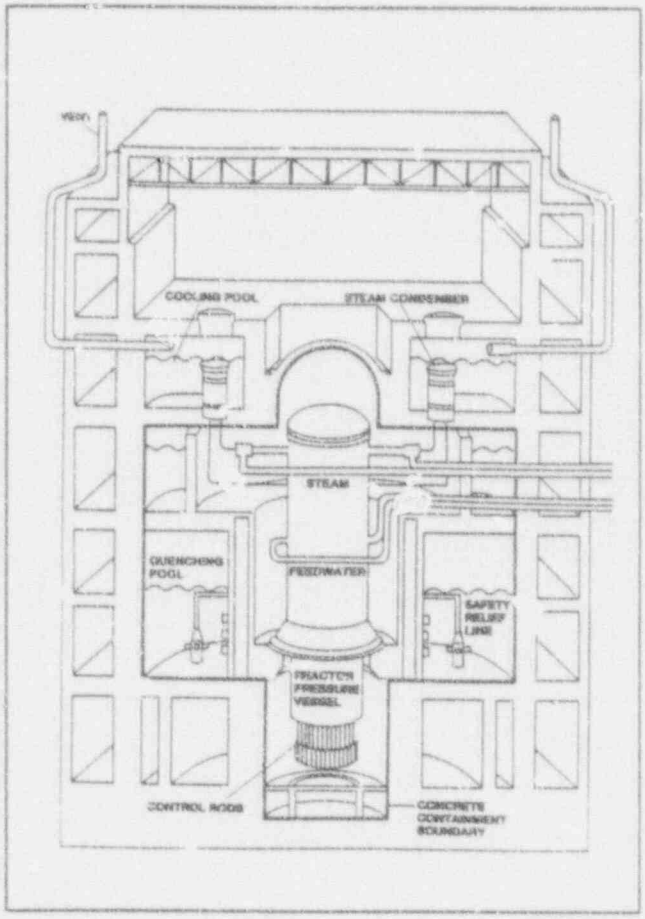


Figure 1-8: The Simplified Boiling Water Reactor by General Electric relies on gravity and natural circulation for cooling during loss of coolant situations. This gives operators 72 hours to react rather than 20 minutes as in present reactors.

Liquid Metal Reactor

Presently, General Electric Company is designing their version of a Liquid Metal Reactor (LMR) called PRISM (Power Reactor Inherently Safe Module). The PRISM is considered walk away safe because the reactor coolant surround the core is liquid (molten) sodium. Theoretically, the sodium would never reach its boiling point where it would boil into vapor and uncover the reactor core. The PRISM uses a three loop system to produce steam for the turbine. The first loop has liquid sodium passing through the core to be heated. The sodium from the first loop goes to a heat exchanger and heats the liquid sodium in the second loop. This sodium then travels to a second heat exchanger where it converts water to steam, for running the turbine. By using sodium as the coolant the primary system can operate at higher temperatures without being pressurized. Since the reactor operates at a higher temperature (1156°F), a thermal efficiency of 40% is achievable compared to 33% for current BWRs and PWRs.

A group of nine LMRs with a capacity of 155 MWe each, would form a 1345 MWe plant. The reactors are fueled with uranium-plutonium-zirconium alloy. The PRISM is a breeder reactor, which means it converts uranium-238 to plutonium-239. The Pu-239 would later be used to fuel another nuclear plant. One major draw back of the PRISM is that sodium is highly reactive with air and water, but design features eliminate most of the problems.

Modular High Temperature Gas-Cooled Reactor

The last reactor being considered in the United States is the Modular High Temperature Gas-Cooled Reactor (HTGR) which uses helium as the reactor coolant. It is being designed under the cooperation of General Atomics, Gas Cooled Reactor Associates, and Electric Power Research Institute (EPRI). In the HTGR, helium heated in the reactor core passes to a heat exchanger, then back to the reactor again. In the heat exchanger, water is converted to steam to run the turbine, just as in PWRs. Since there is no possibility of phase change of reactor coolant, the system can operate at a high temperature (1268°F) without pressurization, allowing thermal efficiency of 40%.

The core of the HTGR is made of graphite blocks with vertical and horizontal holes drilled through the blocks. In the vertical holes fuel rods, containing carbon and silicon carbide coated uranium pellets and control rods are inserted. The horizontal holes allow helium to pass through and be heated before going to the heat exchangers. This design is considered walk

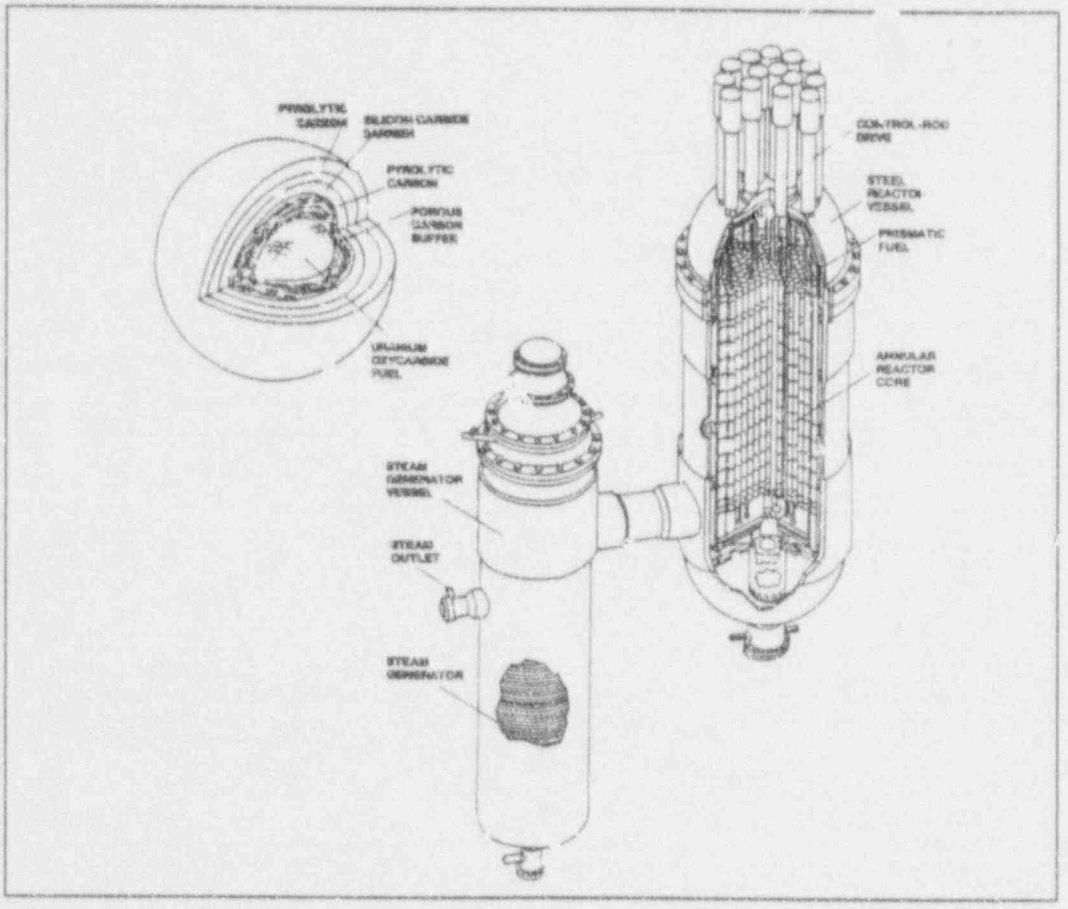


Figure 1-9: The High Temperature Gas-Cooled Reactor is considered walk-away safe because the fuel pellet, shown above, can withstand temperatures higher than that created during a loss of coolant situation.

away safe because the fuel can withstand temperatures higher than that produced during a loss of coolant situation. This design calls for four 135-MWe reactors to be grouped together to from a 540 MWe plant.

These designs are based on forty years of progressing technology and operating experience. The safety systems are less dependent on operator assistance and outside power supplies. The smaller size allows them to be more modular and facilitate construction. Utilities looking to increase their power production by a small amount may find that these newer designs will allow for this. Less time invested in the licensing and construction phases means less capital tied for long periods of time.

Station Systems

The following paragraphs describe the various systems illustrated in Figure 1-10. Major systems in the Davis-Besse Station are assigned a different color in the figure.

FIGURE 1-10 LEGEND

GREEN - Reactor Coolant System (Primary Coolant Water)

RED - Main Steam System

BLUE - Condensate/Main Feedwater System (Secondary Coolant Water)

YELLOW - Circulating Water System (Tertiary Coolant Water)

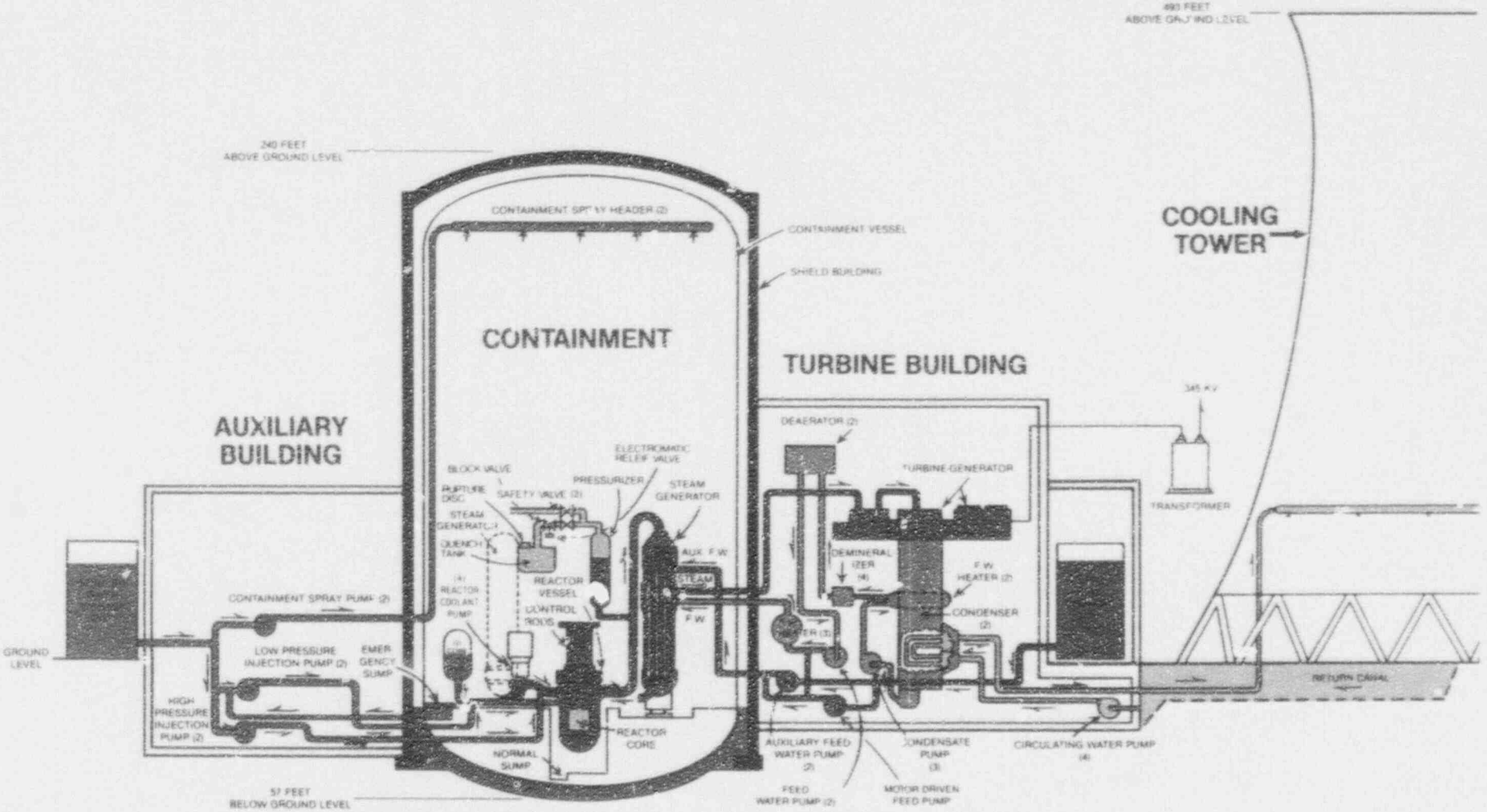
GOLD - Emergency Core Cooling System

SCARLET - Auxillary Feedwater System

GREY - Pressurizer and Associated Structures

Figure 1-10:

Davis-Besse Nuclear Power Station
Unit No. 1



Containment Building and Fission Product Release Barriers

The **containment building** at Davis-Besse houses the reactor vessel, the pressurizer and two steam generators. The building is constructed of an inner 1 inch thick steel liner or **containment vessel**, and the **shield building** with steel reinforced concrete walls 2 feet thick. The shield building protects the containment vessel from a variety of environmental factors, and provides an area for a **negative pressure boundary** around the steel containment vessel. In the event that the integrity of the shield building is compromised (e.g., a crack develops), this negative pressure boundary ensures that any airborne radioactive contamination present in the containment vessel is prevented from leaking out into the environment. It accomplishes this by maintaining the pressure inside the shield building lower than that outdoors, thus forcing clean outside air to leak in, while making it impossible for the contaminated air inside the containment vessel to leak out. The free-standing containment vessel is the third in a **series of barriers** that prevent the release of fission products in the unlikely event of an accident. The first barrier to the release of fission products is the fuel cladding itself. The second barrier is the walls of the primary system, i.e. the reactor vessel, steam generator and associated piping.

The Steam Generators

The **steam generators** at Davis-Besse perform the same function as a boiler at a fossil-fueled power station. The steam generator uses the heat of the primary coolant inside the steam generator tubes to boil the secondary side **feedwater** (secondary coolant) surrounding the tubes on the outside. Fission heat must be transferred from the reactor core to the steam generator in order to provide the steam necessary to drive the turbine. However, heat must also be removed from the core even after reactor shutdown in order to prevent damage to the fuel cladding. Therefore, pumps maintain a continuous flow of coolant through the reactor and steam generator. **Primary loop water** (green in Figure 1-10) exits the reactor at approximately 606°F, passes through the steam generator, transferring some of its heat energy to the **secondary loop water** (blue in Figure 1-10) without ever actually coming in contact with it. Primary coolant water exits the steam generator at approximately 558°F to be circulated back into the reactor where it is again heated to 606°F as it passes up through the fuel assemblies. Under ordinary conditions, water inside the primary system would boil long before it reached such temperatures. However, it is kept under a pressure of approximately 2,200 pounds-per-square-inch (psi) at all times. This prevents the water from

boiling and is the reason the reactor at Davis-Besse is called a Pressurized Water Reactor. Secondary loop water enters the base of the steam generator at approximately 460°F and under 1100 psi pressure. At this pressure, the water can easily boil into steam as it passes over the tubes containing the primary coolant water.

Both the primary and the secondary coolant water are considered **closed loop systems**. This means they are designed not to come in physical contact with one another. Rather, the coolant (i.e., water) contained in each loop transfers heat energy by the process of **convection**. Convection is a method of **heat transfer** that can occur between two fluid media. It is the same process by which radiators are used to heat homes. The water circulating inside the radiator is separated from the air (a "fluid" medium) by the metal piping.

The Turbine - Generator

The turbine, main generator, and the condenser are all housed in what is commonly referred to as the **Turbine Building**. The purpose of the **turbine** is to convert the **thermal energy** of the steam produced in the steam generator (referred to as **main steam**, red in Figure 1-10) to **rotational energy** of the turbine -generator shaft. The turbine at Davis-Besse is actually composed of one six- stage high pressure turbine and two seven-stage low pressure turbines aligned on a common shaft. A **turbine stage** refers to a set of blades. Steam enters at the center of each turbine and flows outward along the shaft in opposite directions through each successive stage of blading. As the steam passes over the turbine blades, it loses pressure. Thus, the blades must be proportionally larger in successive stages to extract enough energy from the steam to rotate the shaft at the correct speed.

The purpose of the **main generator** is to convert the rotational energy of the shaft to **electrical energy** for commercial usage and support of station systems. The main generator is composed of two parts, a stationary **stator** that contains coils of copper conductors, and a **rotor** that supplies a rotating magnetic field within the coils of the stator. Electrical current is generated in the stator portion of the main generator. From this point, the electric current passes through a series of **transformers** for transmission and use throughout northern Ohio.

The Condenser

After the spent steam in the secondary loop (blue in Figure 1-10) passes through the high and low pressure turbines, it is collected in a cavernous

condenser several stories tall and containing more than 70,000 small tubes. **Circulating (circ) water** (yellow in Figure 1-10) goes to the **cooling tower** after passing through the tubes inside the condenser. As the steam from the low pressure turbines passes over these tubes, it is cooled and condensed. The condensed water is then purified and reheated before being circulated back into the steam generator again in a closed loop system. Circ water forms the third (or **tertiary**) and final loop of cooling water used at the Davis-Besse Station.

As the primary to secondary interface, the secondary to tertiary interface is based on a closed loop design. In other words, the circulating water is able to cool the steam in the condenser, without ever actually coming in contact with it, by the process of convection. Even in the event of a primary to secondary leak, the water vapor exiting the Davis-Besse cooling tower would remain non-radioactive. Closed loops are an integral part of the design of any nuclear facility. This design feature greatly reduce the chance of environmental impact from station operation.

The Cooling Tower

The cooling tower at Davis-Besse is easily the most noticeable and the most misunderstood, feature of the plant. The tower stands 493 feet high and the diameter of the base is 411 feet. The two pipes circulating 480,000 gallons of water per minute to the tower are 9 feet in diameter. This is enough water to fill a swimming pool the size of a football field 32 feet deep. The purpose of the tower is to recycle water from the condenser by cooling it.

After passing through the condenser, the circulating water has warmed to approximately 100°F. In order to cool the water back down to around 70° F, the circulating water enters the cooling tower about 40 feet above the ground. The water is sprayed evenly over a series of baffles called **fillsheets** which are suspended vertically in the base of the tower. A natural draft of air blowing up through these baffles cools the water through the process of **evaporation**. The evaporated water exits the top of the cooling tower in the form of **water vapor.**

As much as 10,000 gallons of water per minute are lost to the atmosphere via the cooling tower. Even so, approximately 98 percent of the water drawn from Lake Erie for station operation can be recycled through the cooling tower for reuse. A small portion of the circulating water is discharged back to Lake Erie at essentially the same temperature it was withdrawn earlier. In 1991, the average difference between the intake and discharge water temperatures was only 6.2°F. The slightly warmer discharge water had no

adverse environmental impact on the area of lake surrounding the discharge point.

Many power stations, both nuclear and fossil-fueled, utilize cooling towers to cool station discharge water. Federal regulations governing the water temperature of rivers, lakes, and bays require that power station operation introduce relatively small changes in water temperature. An increase in water temperature is not necessarily detrimental to aquatic life. Fishermen usually find that the best fishing areas are in the vicinity of warm water effluents from power stations. Warm water has also been found to accelerate the growth and increase the size of oysters and shrimp harvested by commercial fishermen. Unfortunately, the same warm water may also attract undesirable aquatic organisms such as the zebra mussel. In addition, an increase in water temperature during the summer months could decrease the water's oxygen content and could therefore precipitate a fish kill.

Miscellaneous Station Safety Systems

The gold system in Figure 1-10 is part of the **Emergency Core Cooling System (ECCS)** housed in the **Auxilliary Building** of the station. The ECCS consists of three overlapping means of keeping the reactor core covered with water, in the unlikely event of a Loss Of Coolant Accident (LOCA), thereby protecting the fuel cladding barrier against temperature failure. Depending upon the severity of the loss of pressure inside the primary system, the ECCS will automatically channel borated water into the reactor by either **high pressure injection pumps, a core flood tank, or low pressure injection pumps**. Borated water can also be sprayed from the ceiling of the containment vessel to cool and condense any steam that may escape from the primary system.

The grey system illustrated in Figure 1-10 is responsible for maintaining the primary coolant water in a liquid state. It accomplishes this by adjusting the pressure inside the primary system. Heaters inside the **pressurizer** turn water into steam. This steam takes up more space inside the pressurizer, therefore increasing the overall pressure inside the primary system. The pressurizer is also equipped with spray heads that shower cool water over the steam in the pressurizer. In this case, the steam condenses and the overall pressure inside the primary system drops. The **quench tank** pictured in Figure 1-10 is simply where excess steam is directed and condensed for storage.

The scarlet system in Figure 1-10 is part of the **Auxilliary Feedwater System**, a key safety system in event the main feedwater supply (blue in

Figure 1-10) to the steam generator is inadequate. Following a reactor shutdown, the Auxiliary Feedwater System can supply water to the steam generators from the **Condensate storage Tanks**. The Auxiliary Feedwater System is housed in the Turbine Building along with the turbine, main generator, and the condenser.

Reactor Safety and Summary

Nuclear power plants are inherently safe, not only by the laws of physics, but by design. Nuclear power plants cannot explode like a bomb because the concentration of fissionable material is far less than is necessary for such a nuclear explosion. Just as the battery of a flashlight provides enough energy to produce light, the amount of energy produced by the battery is not enough to cause an electrical shock to a person handling the flashlight.

Many safety features are also equipped with several backup systems to ensure that any possible accident would be prevented from causing a serious health or safety threat to the public, or serious impact on the local environment. Davis-Besse, like all U.S. nuclear units, has many overlapping, or redundant safety features. If one system should fail, there would still be back-up systems to assure the safe operation of the Station. During normal operation, the **Reactor Control System** regulates the power output by adjusting the position of the control rods The reactor can be automatically shut down by a separate **Reactor Protection System** that causes all the control rod assemblies to be quickly and completely inserted into the reactor core, stopping the chain reaction. To guard against the possibility of a Loss Of Coolant Accident, the Emergency Core Cooling System is designed to pump reserve water into the reactor automatically if the reactor coolant pressure drops below a predetermined level.

The Davis-Besse Nuclear Power Station was designed, constructed and operates to produce a reliable, safe, and environmentally sound source of electricity.

Description of the Davis-Besse Site

The Davis-Besse site is located in Carroll Township of Ottawa County, Ohio. It is on the southwestern shore of Lake Erie, just north of the mouth of the Toussaint River. The site lies north and east of Ohio State Route 2, approximately 10 miles northwest of Port Clinton, 7 miles north of Oak Harbor, and 25 miles east of Toledo, Ohio (Figure 1-11).

This section of Ohio is flat and marshy, with maximum elevations of only a few feet above the level of Lake Erie. The area originally consisted of swamp forest and marshland, rich in wildlife but unsuitable for settlement and farming. During the nineteenth century, the land was cleared and drained, and has been farmed successfully since. Today, the terrain consists of farmland with marshes extending in some places for up to two miles inland from the Sandusky Lake Shore Ridge.

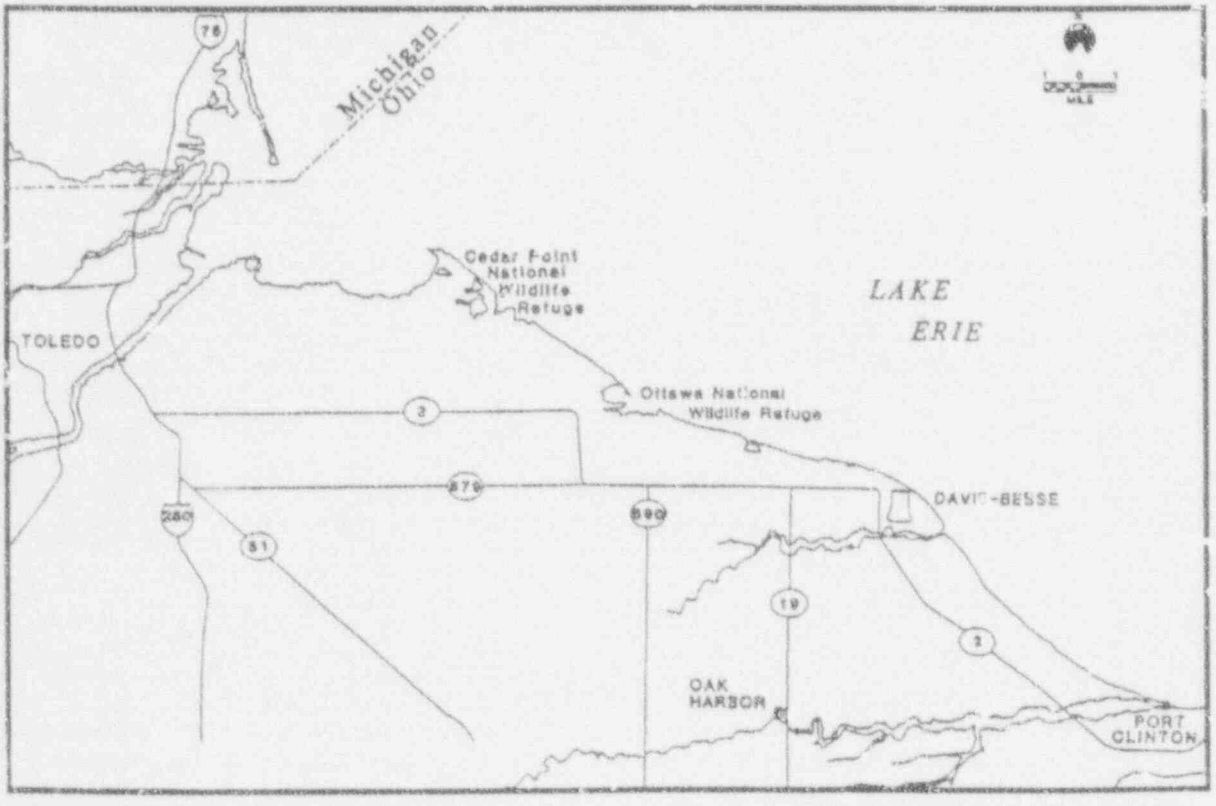


Figure 1-11: Davis-Besse is near Oak Harbor, Port Clinton and the Ottawa National Wildlife Refuge

More than half of the Davis-Besse site area is marshland. A small portion of the site was farmland. The marshes are part of a valuable ecological resource, providing a breeding ground for a variety of wildlife, and a refuge for migratory birds. Major species of birds using this portion of the Lake Erie marshes include mallards, black ducks, widgeon, egrets, great blue herons, blue-winged teal, and Canada geese. In fact, there are hundreds of geese living right on site. Bald eagles, osprey, swans, great horned owls, and a large number of hawks are also seen in the area. The site includes a tract known as Navarre Marsh, which was acquired for the U.S. Bureau of Sport Fisheries and Wildlife, Department of the Interior. In 1971, Toledo Edison purchased the 188 acre Toussaint River Marsh. The Toussaint River Marsh is contiguous with the 610-acre Navarre Marsh section of the Ottawa National Wildlife Refuge.

Most of the remaining marshes in the area have been maintained by private hunting clubs, the U.S. Fish and Wildlife Service, and the Ohio Department of Natural Resources, Division of Wildlife. There are some residences along the lake shore used mainly as summer homes. However, the major resort area of the county is farther east, around Port Clinton, Lakeside, and the Bass Islands.

The immediate area near Davis-Besse is sparsely populated; Ottawa County had a population of only 40,029 in the 1990 census. The nearest incorporated communities are:

- Port Clinton - 10 miles southeast, population 7,106
- Oak Harbor - 7 miles south, population 2,637
- Rocky Ridge - 7 miles west southwest, population 425
- Toledo (the nearest major city) - 25 miles west, population 322,943

The non-marsh areas around the Davis-Besse site are used primarily for farming. The major crops include soybeans, corn, wheat, oats, hay, fruits and vegetables. Meat and dairy animals are not major sources of income in the area. The main industries within five miles of the site are located in Erie Industrial Park, about four miles southeast of the Station.

The State of Ohio Department of Natural Resources operates many wildlife and recreational areas within 10 miles of the Station. These include Magee Marsh, Turtle Creek, Crane Creek State Park, and the Ottawa National Wildlife Refuge. Magee Marsh and Turtle Creek lie between three and six

miles WNW of the Station. Magee Marsh is a wildlife preserve allowing public fishing, nature study, and controlled hunting in season. Turtle Creek, a wooded area at the southern end of Magee Marsh, offers boating and fishing. Crane Creek State Park is adjacent to Magee Marsh and is a popular picnicking, swimming, and fishing area. The Ottawa National Wildlife Refuge lies four to nine miles WNW of the site, immediately west of Magee Marsh.

The 1991 Summary of Radioactivity Released in Liquid and Gaseous Effluents

Protection Standards

Soon after the discovery of x-rays in 1895 by Wilhelm Roentgen, the potential hazards of ionizing radiation were recognized and efforts were made to establish radiation protection standards.

The primary source of recommendations for radiation protection standards within the United States is the National Council on Radiation Protection and Measurements (NCRP). Many of these recommendations have been given legislative authority through publication in the Code of Federal Regulations (CFR) by the Nuclear Regulatory Commission (NRC).

The main objective in the control of radiation exposure is to ensure that any necessary exposures are kept as low as is reasonably achievable (ALARA). The ALARA principle applies to reducing radiation exposure both to the individual working at Davis-Besse and the general public. "Reasonably achievable" means that exposure reduction is based on sound economic decisions and operating practices. By practicing ALARA, Davis-Besse and Centerior Energy minimize health risk and environmental detriment and ensure that doses do not exceed certain specified limits.

Limits

To protect the general public, guidelines and limits have been established governing the release of radioactivity in liquid and gaseous Station effluents. The Code of Federal Regulations, Title 10, Part 50, Appendix I (10CFR50, App.I) provides guidelines for the Technical Specifications which are part of the license authorizing nuclear reactor operation. Davis-Besse's Technical Specifications restrict the release of radioactivity to the environment and the resulting dose to the public. Table 1-3 presents these limits.

Table 1-3: Dose Limits to a Member of the Public

Source	NRC Limits for Davis-Besse
Liquid Effluents	
Whole body	less than or equal to 3 mrem/year
Organ	less than or equal to 10 mrem/year
Gaseous Effluents	
Noble Gases	
gamma air dose	less than or equal to 10 mrad/year
beta air dose	less than or equal to 20 mrad/year
Iodine-131, tritium and particulates with half-lives greater than 8 days	less than or equal to 15 mrem/yr

The Davis-Besse limits are only a small fraction of the dose limits established by the Environmental Protection Agency (EPA). In its environmental dose standard, 40 CFR 190, the EPA established environmental radiation protection standards for nuclear power operations. These standards for normal operation provide that the dose from all discharges of radioactivity should not exceed:

- 25 mrem/year to the whole body,
- 75 mrem/year to the thyroid, and
- 25 mrem/year to any other organ.

Sources of Radioactivity Released

Through the normal operation of a nuclear power station, most of the fission products are retained within the fuel and fuel cladding. However, small amounts of radioactive fission products and trace amounts of the component and structure surfaces which have been activated are present in the primary coolant water. The three types of radioactive material released are noble gases, iodine and particulates, and tritium.

The noble gas fission products in the primary coolant are given off as a gas when the coolant is depressurized. These gases are then collected by a sys-

tem designed for gas collection and storage for radioactive decay prior to release.

Small releases of radioactivity in liquids may occur from valves, piping or equipment associated with the primary coolant system. These liquids are collected through a series of floor and equipment drains and sumps. All liquids of this nature are processed and carefully monitored prior to release.

Noble Gas

Some of the fission products released in airborne effluents are radioactive isotopes of noble gases, such as xenon and krypton. Noble gases are biologically and chemically nonreactive. They do not concentrate in humans or other organisms. They contribute to human radiation exposure by being a source of external whole body exposure. Xenon-133 and xenon-135, with half-lives of approximately five days and nine hours, respectively, are the major radioactive noble gases released. They are readily dispersed in the atmosphere.

In 1991, approximately 1160 curies of noble gases were released in gaseous effluents. The calculated offsite gamma and beta air doses due to the release of this activity were 0.015 mrad and 0.047 mrad, respectively, and are less than 0.25% of their respective Technical Specification limits. Additional dose information is provided in Table 1-4 and page 1-43.

Iodine and Particulates

Annual releases of radioisotopes of iodine and particulates (with half-lives greater than eight days) in gaseous and liquid effluents are small. Factors such as their high chemical reactivity and solubility in water, combined with the high efficiency of gaseous and liquid processing systems, minimize their discharge. The predominant radioiodine released is iodine-131 with a half-life of approximately eight days. The main contribution of radioactive iodine to human exposure is internal exposure of the thyroid gland, where the body concentrates iodine.

The principal radioactive particulates released are fission products (cesium-134 and cesium-137) and activation products (cobalt-58 and cobalt-60). Radioactive cesiums and cobalts contribute to internal radiation exposure of tissues such as the muscle, liver, and intestines. These particulates are also a source of external exposure if deposited on the ground.

During 1991, the amount of radioactive iodine and particulates (excluding tritium) released was approximately 0.01 curie in gaseous effluents and 0.17 curie in liquid effluents. These releases were well below all applicable regulatory limits. Additional dose information is provided in Table 1-4 on page 1-43.

Tritium

Tritium, a radioactive isotope of hydrogen, is the predominant radionuclide in liquid effluents. It is also present in gaseous effluents. Tritium is produced in the reactor coolant as a result of neutron interaction with deuterium (also a hydrogen isotope) present in the water and with the boron in the primary coolant used for reactivity control of the reactor. When tritium is ingested or inhaled it disperses throughout the body and exposes all tissues until it is eliminated.

The amount of tritium released in 1991 was approximately 64.6 curies in gaseous effluents and 325.6 curies in liquid effluents. The associated doses were well below all regulatory limits, and additional dose information is provided in Table 1-4.

Processing and Monitoring

Effluents are strictly controlled to ensure radioactivity released to the environment is minimal and does not exceed release limits. Effluent control includes the operation of monitoring systems, in-plant and environmental sampling and analysis programs, quality assurance programs for effluent and environmental programs, and procedures covering all aspects of effluent and environmental monitoring.

The radioactive waste treatment systems at Davis-Besse are designed to collect and process the liquid and gaseous wastes which contain radioactivity. For example, the Waste Gas Decay Tanks are holding tanks which allow radioactivity in gases to decay prior to release via the station vent.

Radioactivity monitoring systems are used to ensure that all releases are below regulatory limits. These instruments provide a continuous indication of the radioactivity present and are sensitive enough to measure 100 to 1000 times lower than the release limits. Each instrument is equipped with alarms with indicators in the control room. The alarm setpoints are low to ensure the limits will not be exceeded. If a monitor alarms, a release from a tank is automatically stopped.

All wastes are sampled prior to release and analyzed in a laboratory to identify the specific concentrations of radionuclides being released. Sampling and analysis provide a more sensitive and precise method of determining effluent composition than with monitoring instruments alone.

A meteorological tower is located in the southwest sector of the Station. It is linked to computers which record the meteorological data. Coupled with the effluent release data, the meteorological data are used to calculate the dose to the public.

Beyond the plant, devices maintained in conjuction with the Radiological Environmental Monitoring Program constantly sample the air in the surrounding environment. Frequent samples of other environmental media, such as water and vegetation, are also taken to determine if buildup of deposited radioactivity has occurred in the area.

Exposure Pathways

Radiological exposure pathways define the methods by which people may become exposed to radioactivity. The major pathways of concern are those which could cause the highest calculated radiation dose. These pathways are determined from the type and amount of radioactivity released, the environmental transport mechanism, and the use of the environment. The environmental transport mechanism includes consideration of physical factors, such as the hydrological (water) and meteorological (weather) characteristics of the area. Information on the water flow, wind speed and wind direction at the time of a gaseous or liquid release is used to evaluate how the radionuclides will be distributed in the area. An important factor in evaluating the exposure pathways is the use of the environment. Many factors are considered such as dietary intake of residents, recreational use of the area, and the location of homes and farms in the area.

The external and internal exposure pathways considered are shown in Figures 1-12 and 1-13. The release of radioactive gaseous effluents involves pathways such as external whole body exposure, deposition of radioactive material on plants, deposition on soil, inhalation by animals destined for human consumption, and inhalation by humans. The release of radioactive in liquid

effluents involves pathways such as drinking water, fish consumption, and direct exposure from the lake at the shoreline and while swimming.

Although radionuclides can reach humans by many different pathways, some result in more dose than others. The **critical pathway** is the exposure pathway which will provide, for a specific radionuclide, the greatest dose to a population, or to a specific group of the population, called the **critical group.** The critical group may vary depending on the radionuclides involved, the age and diet of the group, or other cultural factors. The dose may be delivered to the whole body or to a specific organ. The organ receiving the greatest fraction of the dose is called the **critical organ.**

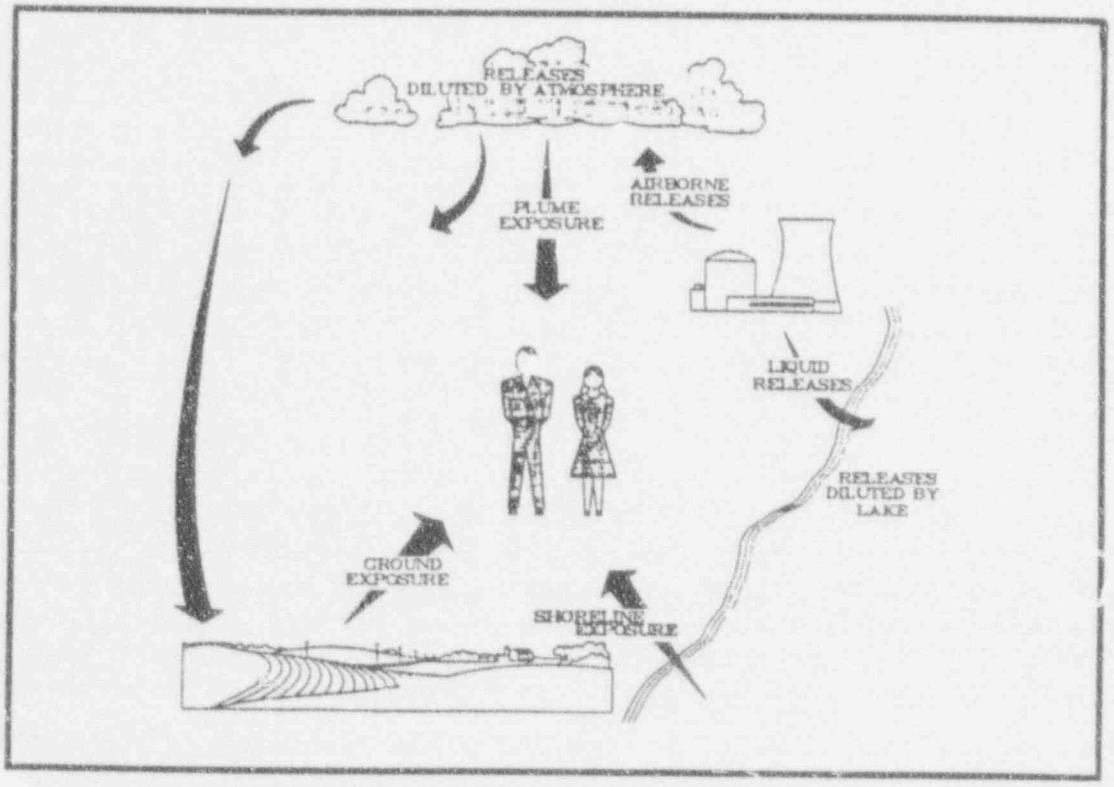


Figure 1-12 The external exposure pathways shown here, are monitoried through the Radiological Environmental Monitoring Program (REMP), and are considered when calculating doses to the public.

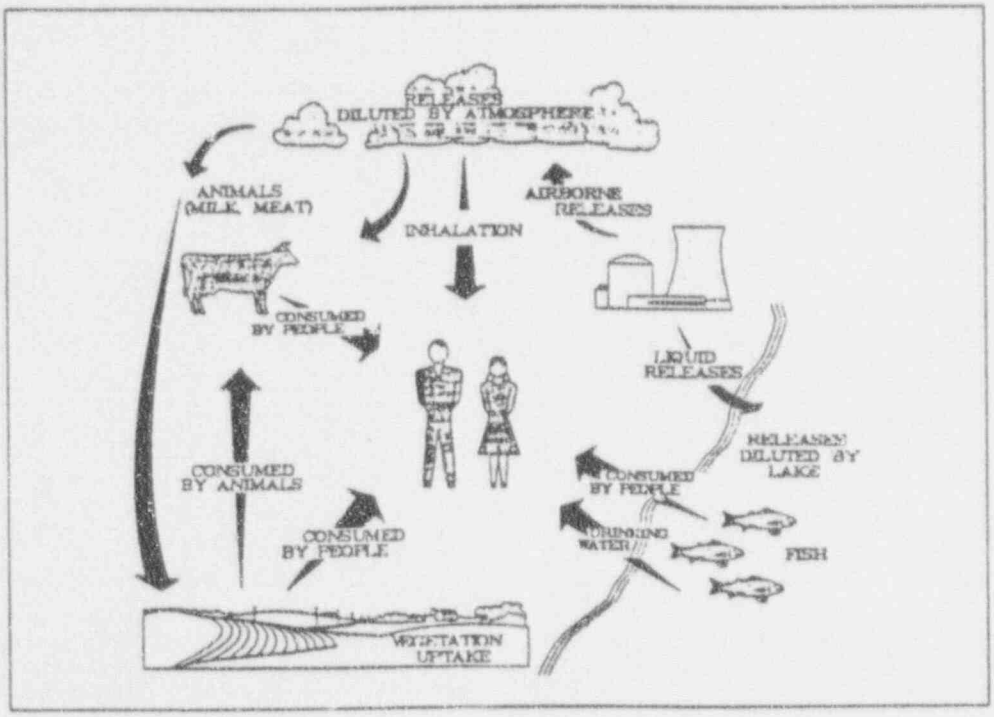


Figure 1-13: Internal exposure pathways include the methods by which radioactivity could reach people around the Station viathte foods they eat, the milk they drink, and the air they breathe.

Dose Assessment

Dose is the energy deposited by radiation in an exposed individual. Whole body radiation exposure involves the exposure of all organs. Most background exposures are of this form. Both non-radioactive and radioactive elements can enter the body through inhalation or ingestion. When they do, they are usually not distributed evenly. For example, iodine concentrates in the thyroid gland, cesium collects in muscle and liver tissue, and strontium collects in bone tissue.

The total dose to organs from a given radionuclide depends on the amount of radioactivity present in the organ and the amount of time that the radionuclide remains in the organ. Some radionuclides remain for very short times due to their rapid radioactive decay and/or elimination rate from the body, while other radionuclides may remain in the body for longer periods of time.

The dose to people in the area surrounding Davis-Besse is calculated for each liquid or gaseous release. The dose due to radioactivity released in gaseous effluents is calculated using factors such as the amount of radioactivity released, the concentration of radioactivity beyond the site boundary, the weather conditions at the time of the release, the locations of exposure pathways (cow milk, goat milk, vegetable gardens, and residences), and usage factors (inhalation, food consumption). The dose due to radioactivity released in liquid effluents is calculated using factors such as the total volume of radioactive liquid, the total volume of dilution water, near field dilution, and usage factors (water and fish consumption, shoreline and swimming factors). These calculations produce a conservative estimation of the dose.

Results

The results of the effluent monitoring program are reported to the Nuclear Regulatory Commission in the Semiannual Radioactive Effluent and Waste Disposal Report. For 1991, the doses from radioactivity released in gaseous and liquid effluents were a small fraction of the Davis-Besse Technical Specifications limits. The offsite whole body dose due to radioactivity released in liquid effluents was approximately 2.3% of the annual Technical Specifications limits. The offsite gamma and beta air doses due to radioactivity released in gaseous effluents were smaller; each was less than 0.39% of the annual Technical Specifications limits. Table 1-4 summarizes the dose due to radioactivity released in effluents in 1991.

Table 1-4 Annual Doses to the Public Due to Radioactivity Released in Gaseous and Liquid Effluents

	1991 Dose	Annual Limit	Percent of Limit
Liquid Effluents			
Whole Body	0.07 mrem	3 mrem	2.3%
Organ (GI-LLI)	0.11 mrem	10 mrem	1.1%
Gaseous Effluents			
Gamma air dose	0.015 mrad	10 mrad	0.15%
Beta air dose	0.047 mrad	20 mrad	0.24%
Iodine-131, tritium and particulates with half-lives greater than 8 days	0.06 mrem	15 mrem	0.40%

References

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Radiological Environmental Monitoring Program

Introduction

The **Radiological Environmental Monitoring Program** (REMP) was established at Davis-Besse for several reasons: to provide a supplementary check on the adequacy of containment and effluent controls, to assess the radiological impact, if any, that Station operation has on the surrounding area, and to determine compliance with applicable radiation protection guides and standards. Environmental surveillance has been a part of the radiological programs for approximately 20 years. The Radiological Environmental Monitoring Program was established in 1972, five years before the Station became operational. This **preoperational surveillance program** was established to describe and quantify the radioactivity, and its variability, in the area prior to commerical operation. When Davis-Besse became operational in 1977, the REMP continued to measure radiation and radioactivity in the surrounding areas. The **operational surveillance program** has been collecting environmental data for over 14 years.

A wide variety of environmental samples are collected as part of the REMP. The selection of sample types is based on the established critical pathways for the transfer of radionuclides through the environment to humans. The selection of sampling locations is based on sample availability, local meteorological and hydrological characteristics, local population characteristics, and land usage in the area of interest. The selection of sampling frequencies for the various environmental media is based on the radionuclides of interest, their respective half-lives, and their behavior in both the biological and physical environments.

A description of the Radiological Environmental Monitoring Program is provided in the following section. In addition, a brief history of analytical results for each sample type collected since 1972, and a more detailed summary of the analyses performed in 1991, are also provided.

Preoperational Surveillance Program

All nuclear facilities are required by the federal government to conduct radiological environmental monitoring prior to constructing the facility. This preoperational surveillance program should be aimed at collecting the data needed to identify critical pathways, including selection of the radioisotope and sample media combinations to be included in the surveillance program conducted after facility operation begins. Radiochemical analyses performed on the environmental samples should include not only those nuclides expected to be released during facility operation, but should also include typical fallout radionuclides and natural background radioactivity. All environmental media with a potential to be affected by facility operation, as well as those media directly in the critical pathways, should be sampled on at least an annual basis during the preoperational phase of the environmental surveillance program.

The preoperational surveillance design, including nuclide/media combinations, sampling frequencies and locations, collection techniques, and radioanalyses performed, should be carefully considered and incorporated in the design of the operational surveillance program. In this manner, data can be compared in a variety of ways (for example: from year to year, location to location, etc.), in order to detect any radiological impact the facility has on the surrounding environment. Total data collection during the preoperational phase should be planned to provide a comprehensive database for evaluating any future changes in the environment surrounding the nuclear facility.

Davis-Besse began its preoperational environmental surveillance program five years before the Station began producing power for commercial use in 1977. Data accumulated during those early years provide an extensive database from which Station personnel are able to identify trends in the radiological characteristics of the local environment. The environmental surveillance program at Davis-Besse will continue well after the Station has reached the end of its economically useful life and decommissioning has begun. Such a rigorous, long term environmental surveillance program provides a measure of insurance that any radiological impact the operation of Davis-Besse has had on the surrounding environment, is detected to preserve the integrity of the local environment.

Operational Surveillance Program Objectives

The operational phase of the environmental surveillance program at Davis-Besse was designed with the following objectives in mind:

- to fulfill the obligations of the radiological surveillance sections of the Stations Technical Specifications,
- to determine whether any significant increase occurs in the concentration of radionuclides in critical pathways,
- to identify and evaluate the buildup, if any, of radioactivity in the local environment, or any changes in normal background radioactivity, and
- to verify the adequacy of Station controls for the release of radioactivity.

Quality Assurance

An important part of the environmental monitoring program at Davis-Besse is the **Quality Assurance** (QA) **Program**. QA consists of all the planned and systematic actions that are necessary to provide adequate confidence in the results of an activity such as the REMP. QA is a program which checks the adequacy and validity of the monitoring program through routine audits, strict adherence to written policies and procedures, and attention to good record-keeping practices.

The QA program at Davis-Besse is conducted in accordance with the guidelines specified in NRC Regulatory Guide 4.15, "Quality Assurance for Radiological Monitoring Programs." The QA program is designed to identify possible deficiencies in the REMP so that corrective actions can be initiated promptly. Davis-Besse's Quality Assurance program also provides confidence in the results of the REMP through:

- performing regular audits (investigations) of the REMP, including a careful examination of sample collection techniques and record keeping,
- performing audits of contractor laboratories which analyze the environmental samples,
- requiring analytical contractor laboratories to participate in the United States Environmental Protection Agency Cross-Check Program,
- requiring analytical contractor laboratories to split samples for separate analysis followed by a comparison of results,
- splitting samples prior to analysis by independent laboratories, and then comparing the results for agreement, and finally,
- requiring analytical contractor laboratories to perform in-house spiked sample analyses.

QA audits and inspections of the Davis-Besse REMP are performed by groups such as Davis-Besse's QA department and representatives from the NRC. In

addition, the NRC and the Ohio Department of Health (ODH) also perform independent environmental monitoring in the vicinity of Davis-Besse. The types of samples collected and the sampling locations used by the NRC and ODH were incorporated in Davis-Besse's REMP. Hence, the analytical results from the different programs can be compared. This practice of comparing results from identical samples, collected and analyzed by different parties, provides a valuable QA tool to verify the quality of both the laboratories' analytical procedures and the data generated.

In 1987, environmental sampling personnel at Davis-Besse incorporated their own Quality Assurance program into the REMP. Duplicate samples, called quality control samples, were collected at several locations. These duplicate samples were assigned different identification numbers than the numbers assigned to the routine samples. This ensured the analytical laboratory would not know the samples were identical. The laboratory results from analyses of the quality control samples and the routine samples could then be compared for agreement. Quality control sampling has become an important part of the REMP since 1987, providing a check on the quality of analyses performed at the contracted analytical laboratory. Quality control sampling locations are changed frequently in order to duplicate as many sampling locations as possible, and to ensure the contractor laboratory has no way of correctly pairing a quality control sample with its routine sample counterpart.

Program Description

Overview

The Radiological Environmental Monitoring Program at Davis-Besse consists of the collection and analysis of a wide variety of environmental samples. Samples are collected on a routine basis either weekly, monthly, quarterly, semiannually, or annually, depending upon the sample type and nature of the radionuclides of interest. Environmental samples collected by Davis-Besse personnel are divided into four general categories:

- **atmospheric** -- including samples of airborne particulates and airborne radioiodine,
- **terrestrial** -- including samples of milk, groundwater, broad leaf vegetation, fruit, animal/wildlife feed, soil, and wild and domestic meat,
- **aquatic** -- including samples of treated and untreated surface water, fish, and shoreline sediments,

- **direct radiation** -- measured by thermoluminescent dosimeters. All environmental samples are labeled using a sampling code. Table 2-1 provides the sample codes and collection frequency for each sample type.

Table 2-1: Sample Codes and Collection Frequencies

Sample Type	Sample Code	Collection Frequency
Airborne Particulate	AP	Weekly
Airborne Iodine	AI	Weekly
Thermoluminescent Dosimeter	TLD	Quarterly, Annually
Milk	MIL	Monthly (semi-monthly during grazing season)
Groundwater	GW	Quarterly
Broad Leaf Vegetation and Fruits	BLV/ FRU	Monthly (July-September)
Surface Water - Treated	SWT	Weekly
Surface Water - Untreated	SWU	Weekly
Fish	FIS	Semiannually
Shoreline Sediments	SED	Semiannually
Soil	SOI	Semiannually
Animal/Wildlife Feed	AF	Semiannually
Meat-Domestic	Me(D)	Annually
Meat-Wild	Me(W)	Annually

Sample Analysis

When environmental samples are analyzed for radioactivity, several types of measurements may be performed to provide information about the types of radiation and radionuclides present. The major analyses that are performed on environmental samples collected for the Davis-Besse REMP include:

- Gross beta analysis
- Gamma spectral analysis
- Tritium analysis
- Strontium analysis
- Gamma dose (TLDs only)

Gross beta analysis measures the total amount of beta emitting radioactivity present in a sample. Beta radiation may be released by many different radionuclides. Since beta decay gives a continuous energy spectrum rather than the discrete lines or "peaks" associated with gamma radiation, identification of specific beta emitting nuclides is much more difficult. Therefore, gross beta analysis only indicates whether the sample contains normal or abnormal concentrations of beta emitting radioactivity; it does not identify specific radionuclides. Gross beta analysis merely acts as a tool to identify samples that may require further analysis.

Gamma spectral analysis provides more specific information than does gross beta analysis. Gamma spectral analysis identifies each radionuclide present in the sample that emits gamma radiation and the amount of radioactivity emitted by each. Each radionuclide has a very specific "fingerprint" that allows for swift and accurate identification. For example, gamma spectral analysis can be used to identify the presence and amount of iodine-131 in a sample. Iodine-131 is a man-made radioactive isotope of iodine that may be present in the environment as a result of fallout from nuclear weapons testing, routine medical uses in diagnostic tests, and routine releases from nuclear power stations.

Tritium analysis indicates whether a sample contains the radionuclide tritium (H-3) and the amount of radioactivity present as a result. As discussed in Chapter One, tritium is an isotope of hydrogen that emits low energy beta particles.

Strontium analysis identifies the presence and amount of strontium-89 and strontium-90 in a sample. These man-made radionuclides are found in the en-

vironment as a result of fallout from nuclear weapons testing. Strontium is usually incorporated into the calcium pool of the biosphere. In other words, strontium tends to replace calcium in living organisms and becomes incorporated in bone tissue. The principal strontium exposure pathway is via milk produced by cattle grazed on pastures exposed to deposition from gaseous releases.

Gamma Doses received by thermoluminescent dosimeters while in the field are read by a special laboratory procedure that is more thoroughly discussed on page 2-11.

Table 2-2 provides a listing of the types of analyses performed on environmental samples collected for the Davis-Besse REMP.

Often samples will contain little radioactivity, and may be below the lower limit of detection. The lower limit of detection (LLD) is the smallest amount of sample activity which can be detected with a reasonable degree of confidence at a predetermined level. When a measurement of radioactivity is reported as less than LLD (<LLD), it means that the radioactivity is so low that it cannot be accurately measured by that particular method for an individual analysis with any degree of confidence.

Sample History Comparison

The concentration of radioactivity present in the environment will vary due to factors such as weather or variations in sample collection techniques or sample analysis. This is one reason why the results of sample analysis are compared with results from other locations and from earlier years. Generally, the results of sample analyses are compared with preoperational and operational data. Additionally, the results of indicator and control locations are also compared. This allows REMP personnel to track and trend the radioactivity present in the environment, to assess whether a buildup of radionuclides is occurring and to determine the effects, if any, the operation of Davis-Besse is having on the environment. If any unusual radioactivity is detected, it is investigated to determine whether it is attributable to the operation of Davis-Besse, or to some other source such as nuclear weapons testing. A summary of the REMP sample analyses performed from 1972 to 1991 is provided in the following section.

Table 2-2: Radiochemical Analyses Performed on REMP Samples

Sample Type	Analyses Performed
ATMOSPHERIC MONITORING	
Airborne Particulates	Gross Beta Gamma Spectral Strontium-89 Strontium-90
Airborne Radioiodine	Iodine-131
TERRESTRIAL MONITORING	
Milk	Gamma Spectral Iodine-131 Strontium-89 Strontium-90 Stable Calcium Stable Potassium
Groundwater	Gross Beta Gamma Spectral Tritium Strontium-89 Strontium-90
Broad Leaf Vegetation and Fruits	Gamma Spectral Iodine-131 Strontium-89 Strontium-90
Animal/Wildlife Feed	Gamma Spectral
Soil	Gamma Spectral
Wild and Domestic Meat	Gamma Spectral

Table 2-2: Radiochemical Analyses Performed On REMP Samples

Sample Type	Analyses Performed
AQUATIC MONITORING	
Untreated Surface Water	Gross Beta Gamma Spectral Tritium Strontium-89 Strontium-90
Treated Surface Water	Gross Beta Gamma Spectral Tritium Strontium-89 Strontium-90 Iodine-131
Fish	Gross Beta Gamma Spectral
Shoreline Sediments	Gamma Spectral
DIRECT RADIATION MONITORING	
Thermoluminescent Dosimeters	Gamma Dose

Atmospheric Monitoring

- **Airborne Particulates**: No radioactive particulates have been detected as a result of Davis-Besse's operation. Only natural and fallout radioactivity from nuclear weapons testing and the 1986 nuclear accident at Chernobyl have been detected.
- **Airborne Radioiodine**: Radioactive iodine-131 fallout was detected in 1976, 1977, and 1978 from nuclear weapons testing, and in 1986 (0.12 to 1.2 picocuries per cubic meter) from the nuclear accident at Chernobyl.

Terrestrial Monitoring:

- **Groundwater**: Only naturally occurring background radioactivity has been detected in groundwater.
- **Milk**: Iodine-131 from nuclear weapons testing fallout was detected in 1976 and 1977 at concentrations of 1.36 and 23.9 picocuries/liter respectively. In 1986, concentrations of 8.5 picocuries/liter were detected from the nuclear accident at Chernobyl. No iodine-131 detected has been attributable to the operation of Davis-Besse.
- **Domestic and Wild Meat**: Only naturally occurring potassium-40 and very low cesium-137 activity have been detected in meat samples. Potassium-40 has ranged from 1.1 to 4.6 picocuries/gram wet weight. Cesium-137 was detected in 1974,1975, and 1981 due to fallout from nuclear weapons testing.
- **Broad Leaf Vegetation and Fruits**: Only natural background radioactivity and radioactivity from nuclear weapons testing have been detected.
- **Soil**: Only natural background radioactivity and radioactivity from nuclear weapons testing and the 1986 nuclear accident at Chernobyl have been detected.
- **Animal/Wildlife Feed**: Only natural background radioactivity and radioactivity from weapons testing have been detected.

Aquatic Monitoring

- **Surface Water (Treated and Untreated)**: In 1979 and 1980, the tritium concentrations at location T-7 were above normal background. Location T-7 is a beach well fed directly by Lake Erie. The fourth quarter sample in 1979 read 590 picocuries per liter, and the first quarter sample in 1980 had a concentration of 510 picocuries per liter compared with the normal background concentration of 450 picocuries per liter. A follow up sample was collected in Lake Erie between T-7 and the Davis-Besse liquid discharge point. This sample contained tritium at a concentration of 2737 picocuries per liter. These concentrations could be attributed to the operation of Davis-Besse. Even so, the results at T-7 were more than 39 times lower that the annual average concentration allowed by the EPA National Interim Primary Drinking Water Regulations (40CFR141), and were only 0.018% of the Maximum Permissible Concentration (MPC of 3,000,000 picocuries per liter) for tritium in unrestricted areas. The follow-up sample was less than 0.1% of the MPC. None of the subse-

quent samples indicate any significant difference between the background tritium concentration and the concentration at T-7.

- **Fish**: Only natural background radioactivity and radioactivity from nuclear testing have been detected.
- **Shoreline Sediments**: Only natural background radioactivity and radioactivity from nuclear testing and the 1986 nuclear accident at Chernobyl have been detected.

Direct Radiation Monitoring:

- **Thermoluminescent Dosimeters (TLDs)**: The annual average gamma dose rates recorded by TLDs have ranged from 42 to 87 millirems per year at control locations and between 36.8 and 86.1 millirems per year at indicator locations. No increase above natural background radiation attributable to the operation of Davis-Besse has been observed.

1991 Sampling Program

The Radiological Environmental Monitoring Program (REMP) is conducted in accordance with the Davis-Besse Nuclear Power Station Operating License, Appendix A, Technical Specifications. The program includes the collection and analysis of airborne particulates, airborne radioiodine, groundwater, milk, eggs, domestic and wild meat, fruits and broad leaf vegetation, soil, treated and untreated surface water, fish, shoreline sediments, and measurements of direct radiation (refer to Table 2-3). All samples are sent to an independent laboratory for analysis.

Although previous years' sampling programs satisfied all regulatory requirements, in 1987, a REMP Enhancement Program was initiated. In an effort to implement a more comprehensive REMP, the number of samples collected and analyzed was selectively increased. Expansion of the REMP was achieved by increasing the number of sampling locations, and types of samples collected, and by collecting duplicate, or quality control samples.

As a result of the REMP Enhancement efforts, over 2600 samples were collected during 1991. Of these samples collected, only 33% were required to satisfy regulatory requirements or Technical Specification. In addition, of the 143 sampling locations utilized in 1991, 14% were quality control locations.

Table 2-3: Sample Collection Summary

Sample Type (Remarks)	Collection Type*/ Frequency**	Number of Locations	Number of Samples Collected	Number of Samples Missed
ATMOSPHERIC				
Airborne Particulates	C/W	10	520	0
Airborne Radioiodine	C/W	10	520	0
TERRESTRIAL				
Milk (May-Oct.)	G/GM	4	36	0
(Nov.-Apr.)	G/M	4	19	0
Groundwater	G/Q	5	19	1
Edible Meat				
wild	G/A	1		0
domestic	G/A	2	2	0
Broad Leaf				
Vegetation/Fruit	G/M	5	22	0
Soil	G/S	11	22	0
Animal/Wildlife Feed	G/A	6	10	0
AQUATIC				
Treated Surface				
Water	G/WM	7	362	2
Untreated Surface				
Water	G/Wm	16		
	Comp/WM	5	260	0
Fish (3 species)	G/SA	2	6	6
Shoreline Sediments	G/SA	7	15	0
DIRECT RADIATION				
Thermoluminescent				
Dosimeters	C/Q	111	435	9
	C/A	111	105	6

* **Type of Collection:**
C/ = Continuous; G/ = Grab; Comp/ = Composite.

** **Frequency of Collection:**
/WM = Weekly composited Monthly; /W = Weekly
/SM = Semimonthly; /M = Monthly;
/Q = Quarterly; /SA = Semiannually; /A = Annually

1991 Program Deviations

Provided below is a description and explanation of 1991 environmental sample collection deviations.

- A composite sample of T-12 untreated surface water could not be collected on 1-14-91 because lines leading to compositor were frozen. A grab sample was substituted in place of the composite sample.
- Treated surface water samples at T-144 were unavailable on January 28, and March 14, 1991 because the waterline to tnat faucet was frozen.
- There were no data for TLD locations T-91, T-114, T-203 and T-204 for first quarter 1991. TLDs were lost due to vandalism.
- TLD locations, T-78 and T-79 were eliminated from the sampling program.
- The T-23 groundwater sample for first Quarter 1991 was unavailable from the Put-In-Bay Water Treatment Plant because their well is sealed up during the winter months.
- Precipitation / snow samples were eliminated from the 1991 sampling program.
- The treated surface water sample at T-28 for week of March 19, 1991 was inadvertently discarded. A grab sample was collected as a substitute for the lost sample.
- There was no TLD for location T-116 second quarter 1991. The TLD was lost due to vandalism.
- T-12 composite of untreated surface water for week of May 20, 1991 was not collected. The water sample container was damaged after collection of composite, the sample leaked out of the container while in transit from the intake crib back to the Toledo Water Treatment Plant Lab. A grab sample was collected as a substitute.
- There were no data for TLD locations T-93,T-203, and T-204 for third quarter 1991. TLDs lost due to vandalism.
- No fish samples were collected during October 1991 because desired fish species were unavailable.
- There were no data for TLD locations T-202 and T-204 for fourth quarter 1991. TLDs lost due to vandalism.
- The annual 1991 TLD for T-108 was lost in transit from field to laboratory.

- The annual 1991 TLD for T-108 was lost in transit from field to laboratory.
- There were no data for Annual TLDs at T-6, T-91, T-97, T-114, T-202, and T-203, these being TLDs lost due to vandalism.

Sampling Locations

REMP samples are collected at numerous locations, both onsite and up to 25 miles away from the Station. Sampling locations may be divided into two general categories: indicator and control. Indicator locations are those which would be most likely to display the effects caused by the operation of Davis-Besse. Generally, they are located within five miles of the station. Control locations are those which should be unaffected by Station operations and are typically, more than five miles away. Data obtained from the indicator locations are compared with data from the control locations. This comparison allows REMP personnel to take into account naturally occurring background radiation, or fallout from weapons testing, in evaluating any radiological impact Davis-Besse has on the surrounding environment. Data from indicator and control locations are also compared with preoperational data to determine whether significant variations or trends exist.

Atmospheric Monitoring

Air Samples

Environmental air sampling is conducted to detect any increase in the concentration of airborne radionuclides that may be inhaled by humans, or serve as an external radiation source. Inhaled radionuclides may be absorbed from the lung, gastrointestinal tract, or from the skin. Air samples collected by the REMP include both **airborne particulates** and **airborne radioiodine.** Air sampling pumps are used to draw continuous samples through particulate membrane filters and charcoal cartridges at a rate of approximately one cubic foot per minute. The samples are collected on a weekly basis.

Airborne particulate samples are collected on 47 mm diameter membrane filters. Charcoal cartridges are installed downstream of the particulate filters to sample for the presence of airborne radioiodine. The airborne samples are sent to a contractor laboratory for analysis. At the laboratory, the airborne particulate filters are stored for 72 hours before they are analyzed to allow for the decay of naturally occurring short-lived radionuclides. However, due to the short half-life of iodine-131 (approximately eight days), the airborne radioiodine cartridges are analyzed upon receipt by the contractor laboratory.

Airborne Particulates

Davis-Besse samples air for airborne radioactivity continuously at ten locations. There are six indicator locations including four around the site boundary, one at Sand Beach, and another at a local farm. There are four control locations, Oak Harbor, Port Clinton, Toledo and Magee Marsh.

Gross beta analysis is performed on each of the weekly samples. Each quarter, the filters from each location are combined (composited) and analyzed for gamma emitting radionuclides. The gross beta analyses yield an annual average of .021 pCi/m^3 at indicator locations and .022 pCi/m^3 at control locations for 1991. Evidence of the similarity of results of control and indicator locations may be seen in the average monthly results shown in Fig 2-1. The highest annual average (.023 pCi/m^3) was detected at the Toledo location. The 1991 annual average was .021 pCi/m^3 which is similar to previous years.

Beryllium-7 was the only gamma emitting radionuclide detected by the gamma spectroscopic analyses of the quarterly composites. Beryllium-7 is a naturally occurring radionuclide produced in the upper atmosphere by cosmic radiation. No other radionuclides were detected above their respective LLD.

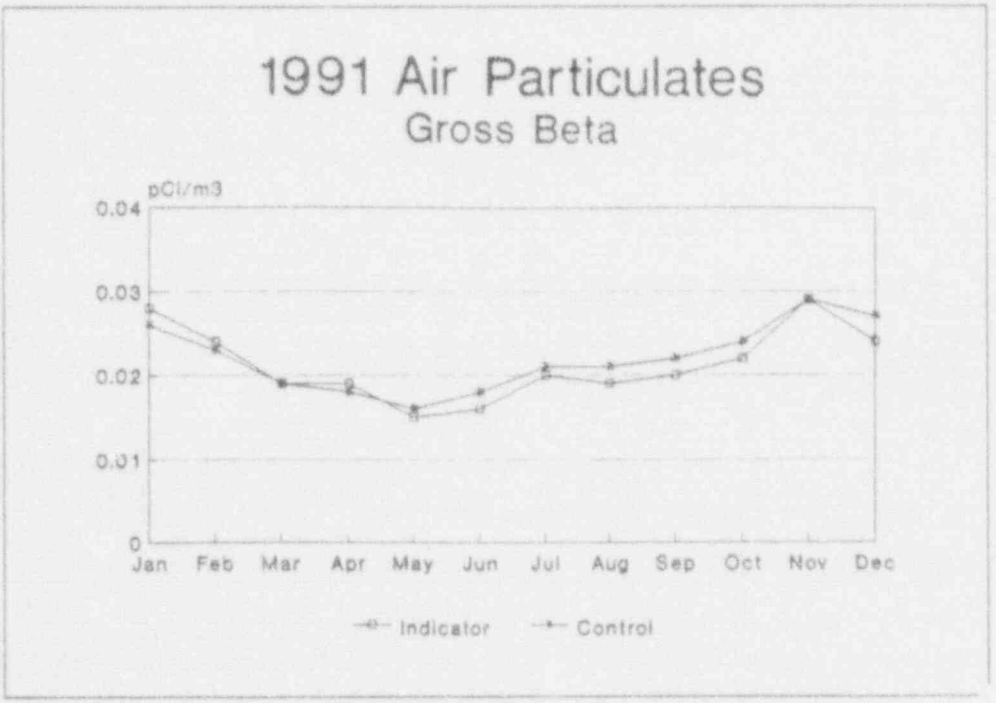


Figure 2-1: Concentration of Beta emitting radionuclides in airborne particulate samples were essentially identical at indicator and control locations.

Airborne Iodine-131

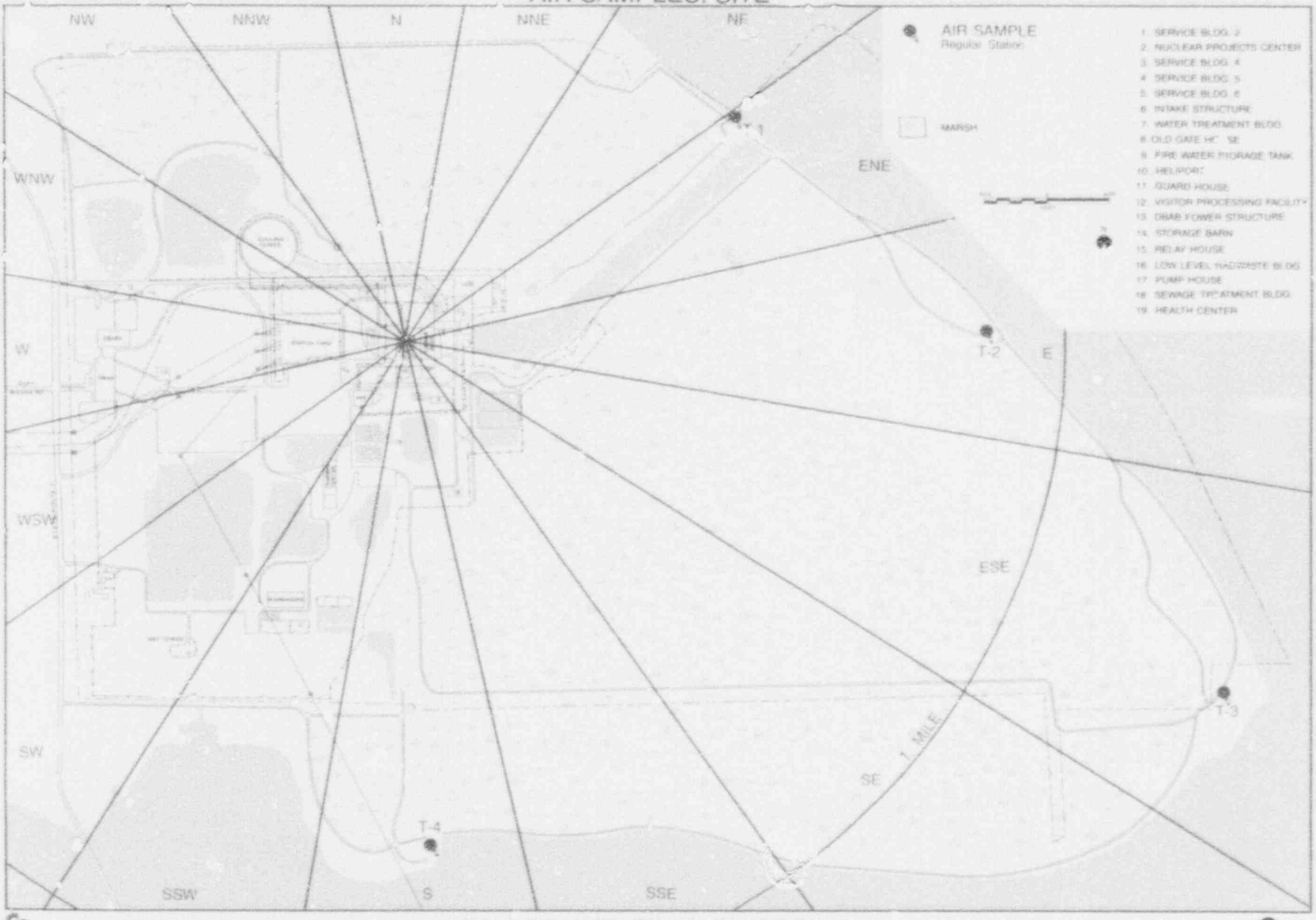
Airborne iodine-131 samples are collected at the same ten locations and with the same samplers as the airborne particulate filters to sample for the presence of airborne radioiodine. These cartridges are collected weekly, sealed in separate collection bags and sent to the laboratory for gamma spectral analysis. In all of the samples collected in 1991, there was no detectable iodine-131 above the LLD of 0.07 pCi/m^3.

Table 2-4: Air Monitoring Locations

Sample Location Number	Type of Location	Location Description
T-1	I	Site boundary, 0.6 mile ENE of Station
T-2	I	Site boundary, 0.9 mile E of Station
T-3	I	Site boundary, 1.4 miles ESE of Station
T-4	I	Site boundary, 0.8 mile S of Station
T-7	I	Sand Beach, main entrance, 0.9 mile NW of Station
T-8	I	Earl Moore Farm, 2.7 miles WSW of Station
T-9	C	Oak Harbor Substation, 6.8 miles SW of Station
T-11	C	Port Clinton Water Treatment Plant, 9.5 miles SE of Station
T-12	C	Toledo Water Treatment Plant, 23.5 miles WNW of Station
T-27	C	Crane Creek State Park, 5.3 miles WNW of Station-

*I = Indicator C = Control

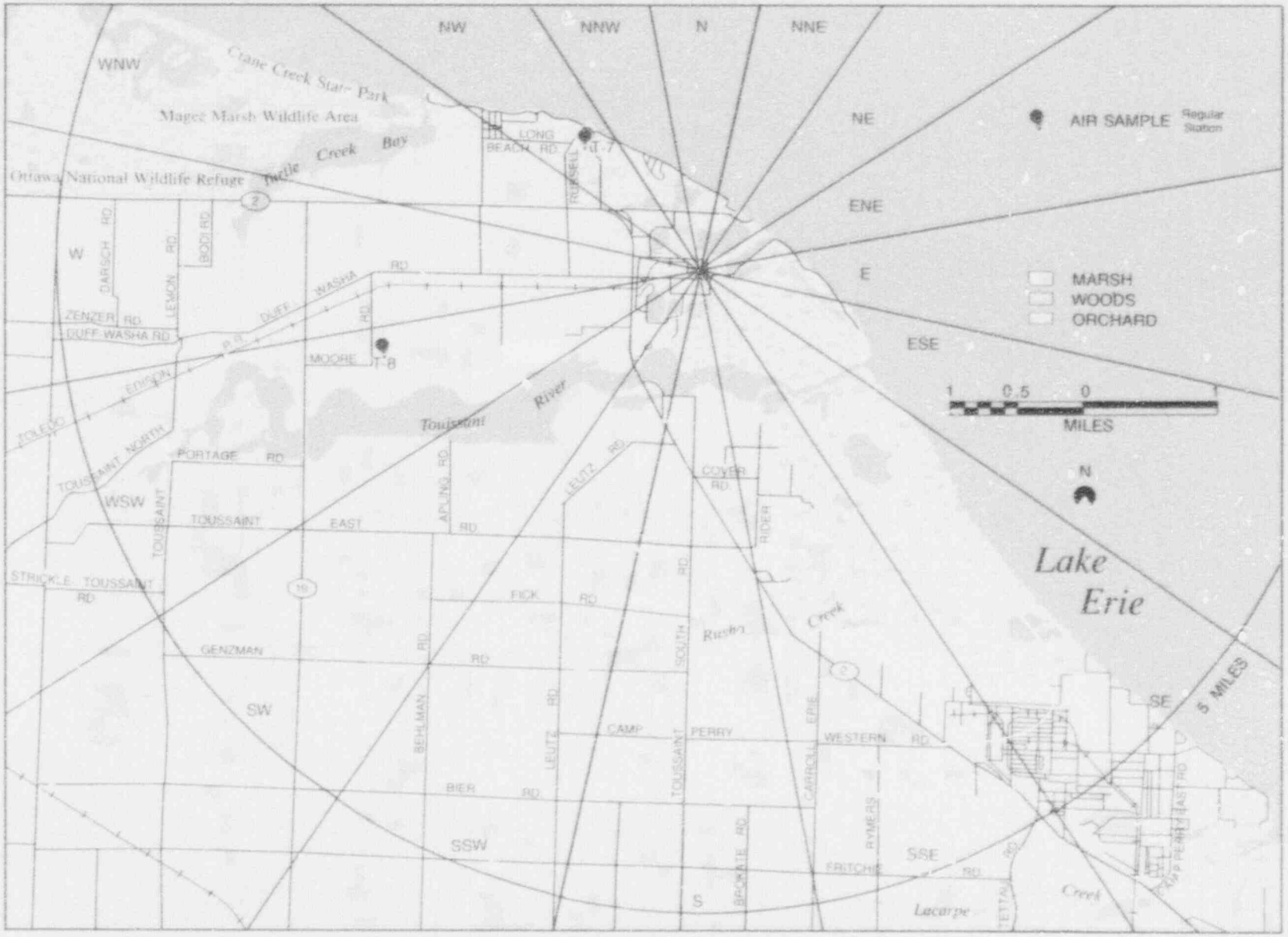
DAVIS – BESSE NUCLEAR POWER STATION
RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
AIR SAMPLES: SITE



ENVIRONMENTAL MONITORING

Figure 2-2

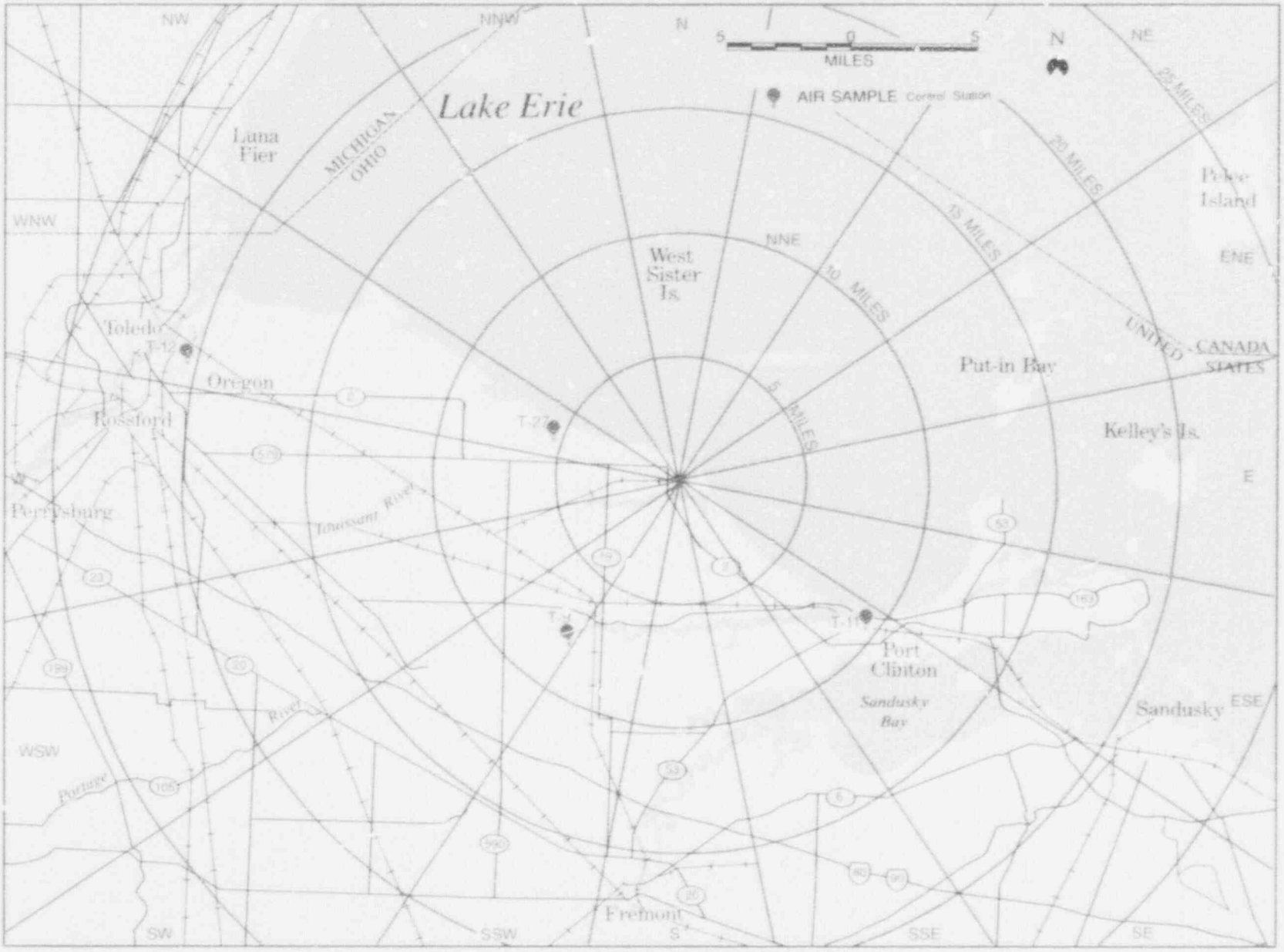
DAVIS-BESSE NUCLEAR POWER STATION
RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
AIR SAMPLES: 5 MILE RADIUS



ENVIRONMENTAL MONITORING

Figure 2-3

DAVIS-BESSE NUCLEAR POWER STATION
RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
AIR SAMPLES: 5–25 MILE RADIUS



ENVIRONMENTAL MONITORING

Figure 2-4

TERRESTRIAL MONITORING

The collection and analyses of groundwater, milk, meat, fruits and broad leaf vegetation provides data to assess the buildup of radionuclides that may be ingested by humans. Animal and wildlife feed samples provide additional information on radionuclides that may be present in the food chain. The data from soil sampling provides information on the deposition of radionuclides from the atmosphere.

Many radionuclides are present in the environment due to sources such as cosmic radiation and fallout from nuclear weapons testing. Some of the radionuclides present are:

- **tritium**, present as a result of the interaction of cosmic radiation with the upper atmosphere and as a result of routine releases from nuclear facilities.
- **beryllium-7**, present as a result of the interaction of cosmic radiation with the upper atmosphere.
- **cesium-137**, a man-made radionuclide which has been deposited in the environment, (for example, in surface soils), as a result of fallout from nuclear weapons testing and routine releases from nuclear facilities
- **potassium-40**, a naturally occurring radionuclide normally found in humans and throughout the environment..
- **fallout radionuclides** which come from nuclear weapons testing, including strontium-89, strontium-90, cesium-134, cerium-141, cerium-144, ruthenium-103. These radionuclides may also be released in minute amounts from nuclear facilities.

The radionuclides listed above are expected to be present in many of the environmental samples collected in the vicinity of Davis-Besse. The contribution of radionuclides from the plant operation is assessed by comparing sample results with preoperational data, operational data from previous years, control location data, and the types and amounts of radioactivity normally released from the Station in liquid and gaseous effluents.

Milk sampling is very important in environmental surveillance because it provides a direct basis for assessing the build up of radionuclides in the environment that may be ingested by human. Milk is particularly important because it is one of the few foods commonly consumed soon after production. The milk pathway involves the deposition of radionuclides from atmospheric releases onto forage consumed by cows. The radionuclides present in the forage eating cow become incorporated into the milk which is then consumed by humans.

Samples of milk are collected at three farms and a commercial dairy store once a month from November through April, and twice a month from May through October. Sampling is increased in the summer when the herds are usually outside on pasture and not on stored feed. The sample locations consist of one indicator and three control locations.

The milk samples are analyzed for strontium-89, strontium-90, iodine-131 and other gamma emitting radionuclides, stable calcium and potassium. A total of 55 milk samples were collected in 1991.

Strontium-89 was not detected above the LLD of 1.1 pCi/l in any of the samples. Strontium-90 activity was detected in 54 of the 55 samples collected and ranged from 0.5 to 2.1 pC/l. The annual average concentration of strontium-90 was 0.99 pCi/l at the indicator locations and 1.21 pCi/l at the control locations. For all sample sites, the annual average concentration were similar to those measured in the previous years (Fig 2-5).

A total of 55 analyses for iodine-131 in milk were performed during 1991. Iodine-131 was not detected in milk samples above the LLD of 0.4 pCi/l.

The concentrations of barium-140 and cesium-137 were below their respective LLDs in all samples collected. The results for potassium-40, a naturally occurring radionuclide, were similar at indicator and control locations, as is to be expected.

Since the chemistries of calcium and strontium, and potassium and cesiums are similar, organisms tend to deposit strontium radioisotopes in bones, and cesium radioisotopes in muscle tissue. In order to detect the potential environmental accumulation of these radionuclides, the ratios of the strontium radioisotopes radioactivity (pCi/l) to the concentration of calcium (g/l), and cesium radioisotopes radioactivity (pCi/l) to the concentration of potassium (g/l) were monitored in milk. These ratios are compared to standard values to determine if build up is occurring. No statistically significant variations in the ratios were observed. The results of the analyses performed on he milk samples collected in 1991 indicate no effect due to the operation of Davis-Besse.

ratios were observed. The results of the analyses performed on he milk samples collected in 1991 indicate no effect due to the operation of Davis-Besse.

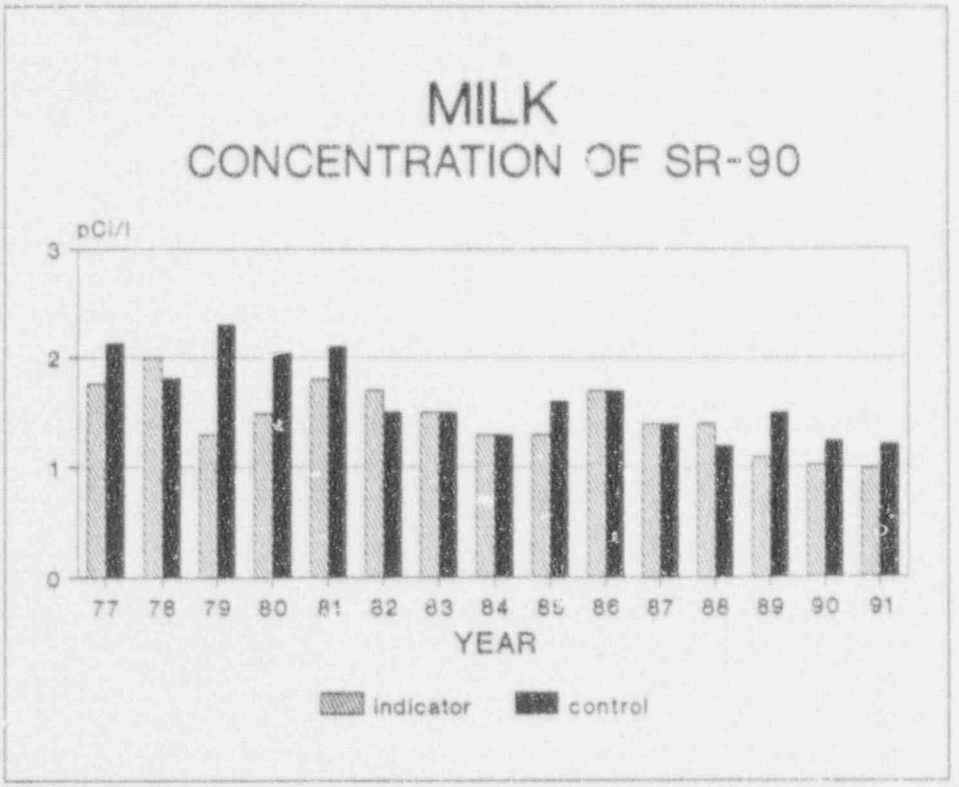


Figure 2-5: The 1991 average concentration of strontium-90 detected, in milk samples, were similar at indicator and control locations; a trend exhibited in previous years.

Table 2-5: Milk Monitoring Locations

Sample Location Number	Type of Location	Location Description
T-8	I	Moore Farm, 2.7 miles WSW of Station
T-24	C	Toft Dairy, Sandusky, 21.0 miles SE of Station
T-57	C	Meek Farm, 22.0 miles SSE of Station
T-199	C	Ewing Farm 6.5 miles SW of Station

* I = indicator C = control

Groundwater Samples

It is unlikely that groundwater will accumulate radioactivity from nuclear facilities, except for those facilities which discharge liquid effluents to the ground via cribs, pits, or trenches. This is because the soil acts as a filter and an ion exchange medium for most radionuclides. However, tritium and other radionuclides such as ruthenium-106 have a potential to seep through the soil into the groundwater. Although Davis-Besse does not discharge its liquid effluents directly to the ground, samples from local wells are collected on a quarterly basis to ensure the detection of any adverse impact on the local groundwater supplies due to Station operation. The four wells sampled include two indicator locations, and two control locations. In addition, a quality control sample is collected at one of the four wells each quarter.

The groundwater samples are analyzed for beta emitting radioactivity in dissolved and suspended solids, tritium, strontium-89, strontium-90 and gamma emitting radionuclides.

Beta emitting radionuclides concentration in suspended solids were not detected above LLD of 0.8 pCi/l. In dissolved solids, the concentration averaged 3.0 pCi/l at indicator locations and 2.0 pCi/l at control locations.

Tritium was not detected in any sample above the LLD of 330 pCi/l. Also, strontium-89 was not detected above the LLD of 1.5 pCi/l. Strontium-90 was detected in two indicator samples at an average of 0.8 pCi/l. There were no gamma emitting radionuclides detected in any of the samples collected. All sample analyses were within normal ranges and were similar to results of previous years.

Table 2-6: Groundwater Monitoring Locations

Sample Location Number	Type of Location	Location Description
T-7	I	Sand Beach, 0.9 mile NW of Station
T-23	C	Put-in-Bay Waterworks, 14.3 miles ENE of Station
T-27	C	Crane Creek State Park, 5.3 miles WNW of Station

Table 2-6: Groundwater Monitoring Locations con't

Sample Location Number	Type of Location	Location Description
T-24	I	Weis Farm, 4.8 miles SW of Station
T-141	QC	Roving Site

* I = indicator C = control QC = quality control

Broad Leaf Vegetation and Fruit Samples

Fruits and broad leaf vegetation also represent a direct pathway to humans from ingestion. Fruits and broad leaf vegetation may become contaminated from atmospheric deposition from airborne sources (nuclear weapons fallout or gaseous releases form nuclear facilities) or form irrigation water drawn from lake water receiving liquid effluents (from hospitals, nuclear facilities, etc.). Also, radionuclides from the soil may be absorbed by the roots of the plants and become incorporated into the edible portions. During the growing season (July through September) edible broad leaf vegetation and fruits are collected from farms in the vicinity of Davis-Besse.

In 1991, broad leaf vegetation samples were collected at two indicator locations and one control location. Fruit samples were collected at two indicator locations and three control locations. Broad leaf vegetation was collected once a month during the growing season and consisted of lettuce, cabbage, spinach, kale, parsley, pepper leafs, broccoli and horse radish leaves. The fruits collected were apples, and grapes. All samples were analyzed for gamma emitting radionuclides, strontium-89, strontium-90, and iodine-131.

Iodine-131 was not detected above the LLD of 0.047 pCi/g wet in any broad leaf vegetation samples. The LLD for iodine-131 could not be reached in two samples collected (T-25 and T-37) on 07-16-91 because of a delay in counting. Iodine-131 was not detected above the LLD of 0.041 pCi/g wet in fruit.

The only gamma emitting radionuclide detected in the fruit and broad leaf vegetation samples was potassium-40 which is naturally occurring. In both fruit and broad leaf vegetation, strontium-89 was not detected above LLD of 0.010 pCi/g wet. Strontium-90 was detected at a concentration of 0.005 pCi/g wet at control location T-173 for fruit samples. In broad leaf vegetation, strontium-90 averaged 0.004 pCi/g wet for indicator locations. All results of analyses were similar to results observed in previous years.

Table 2-7: Broad Leaf Vegetation and Fruit Locations

Sample Number Location	Type of Location	Location Description
T-8	I	Moore Farm, 2.7 miles WSW of Station
T-23	C	Heineman Winery, Put-IN-Bay, 14.3 miles ENE of Station.
T-25	I	Miller Farm, 3.7 miles S of Station
T-37	C	Bench Farm, 13.0 miles SW of Station
T-173	C	Firelands Winery, Sandusky, 20.0 miles SE of station.

* I = indicator C = control

Animal / Wildlife Feed Samples

As with broad leaf vegetation and fruit samples, samples of domestic animal feed, as well as vegetation consumed by wildlife, provide and indication of airborne radionuclides deposited in the vicinity of the Station. Analyses from animal/wildlife feed samples also provide data for determining radionuclide concentration in the food chain. Domestic animal feed samples are collected both at the milk and domestic meat sampling locations. Wildlife feed samples are collected from the Navarre Marsh onsite and from a local marsh within five miles of the Station. As in all terrestrial samples, naturally occurring potassium-40, cosmic ray produced radionuclides such as beryllium-7, and fallout radionuclides from nuclear weapons testing may be present in the feed samples.

- Domestic Animal Feed - Domestic animal feed was collected semi-annually at dairy farms and annually at chicken sampling locations. There are two indicator locations and two control locations. The feed collected consisted of hay, haylage, mixed feed, chicken feed and corn. All samples were analyzed for gamma emitting radionuclides.
- Wildlife Feed - Wildlife feed was collected annually at two indicator locations. The samples consisted of edible portions of cattails and smartweed. Samples were analyzed for gamma emitting radionuclides.

In both the animal and wildlife feed only naturally occurring Be-7 and K-40 were detected. All other radionuclides were below the respective LLDs.

Table 2-8: Animal / Wildlife Feed Locations

Sample Location Number	Type of Location	Location Description
T-8	I	Moore farm, 2.7 miles WSW of Station
T-31	I	Davis-Besse, onsite roving location
T-34	C	Bertsch farm, Sandusky, 20.0 miles SE of Station
T-57	C	Meek Farm, 22.0 miles SSE of Station
T-197	I	Feisman Farm 1.7 miles W of Station
T-198	I	Toussaint Creek Wildlife Area 4.0 miles WSW of Station

* I = indicator C = control

Wild and Domestic Meat Samples

Sampling of domestic and wild meat provides information on environmental radionuclide concentration that humans may be exposed to through an ingestion pathway. The principle pathways for radionuclide contamination of meat animals include atmospheric deposition from airborne releases on their food, contamination of their drinking water through atmospheric deposition or contamination of their drinking water from radionuclides released in liquid effluents.

The REMP generally collects wild meat, domestic meat, (chickens) and eggs on an annual basis. Wild animals commonly consumed by residents in the vicinity of Davis-Besse include water fowl, deer, and muskrats. Analyses from animals whose meat is eaten by humans provides general information on radionuclide concentration in the food chain. When evaluating the results from analyses performed on meat animals, it is important to consider the age, diet and mobility of the animal before drawing conclusions on radionuclide concentration in the local environment or in a species as a whole.

Both wild and domestic meat samples and eggs were sampled in 1991 as follows:

- Domestic Meat: Chickens were collected at one indicator location and one control location.
- Wild Meat: One Canada goose was collected from onsite. Four muskrats were collected from the marsh on site. All meat samples were analyzed for gamma emitting radionuclides.
- Eggs: Eggs were collected from one indicator location and one control location. The samples were analyzed for gamma emitting radionuclides.

The only radionuclide detected in both the meat and eggs samples was K-40 which is naturally occurring and not produced by nuclear power plants. Cs-137 was not detected above LLD of 0.029 pCi/g wet. These results are similar to previous years.

Table 2-9: Wild and Domestic Meat Locations

Sample Location Number	Type of Location	Location Description
T-31	I	Onsite roving location
T-34	C	Bertsch Egg Farm, Sandusky 20.0 miles SE of Station
T-197	I	Priesman Farm, 1.7 miles W of Station.

* I = indicator C = control

Soil Samples

During June and October of 1991, soil samples were collected at all sites which are equipped with air samplers and Put-In-Bay, the top layer of soil is sampled in an effort to identify possible trends in the local environmental nuclide concentration caused by atmospheric deposition of fallout and station released radionuclides. Generally, the sites are relatively undisturbed, so that the sample will be representative of the actual deposition in the area. Ideally,

there should be little or no vegetation present, because the vegetation could affect the results of analyses. Approximately five pounds of soil are taken from the top two inches at each site. Many naturally occurring radionuclides (e.g. beryllium -7 and potassium-40) and fallout radionuclides from nuclear weapons testing are detected. Fallout radionuclides which are often detected include strontium-90, cesium-137, cerium-141 and ruthenium-106.

All soil samples were analyzed for gamma emitting radionuclides. The results show that the only gamma emitter detected in addition to naturally occurring Be-7 and K-40, was Cs-137. Cs-137 was found in both indicator and control location at a concentration of 0.21 and 0.40 pCi/g dry, respectively. The concentrations were similar to that observed in previous year (Figure 2-6).

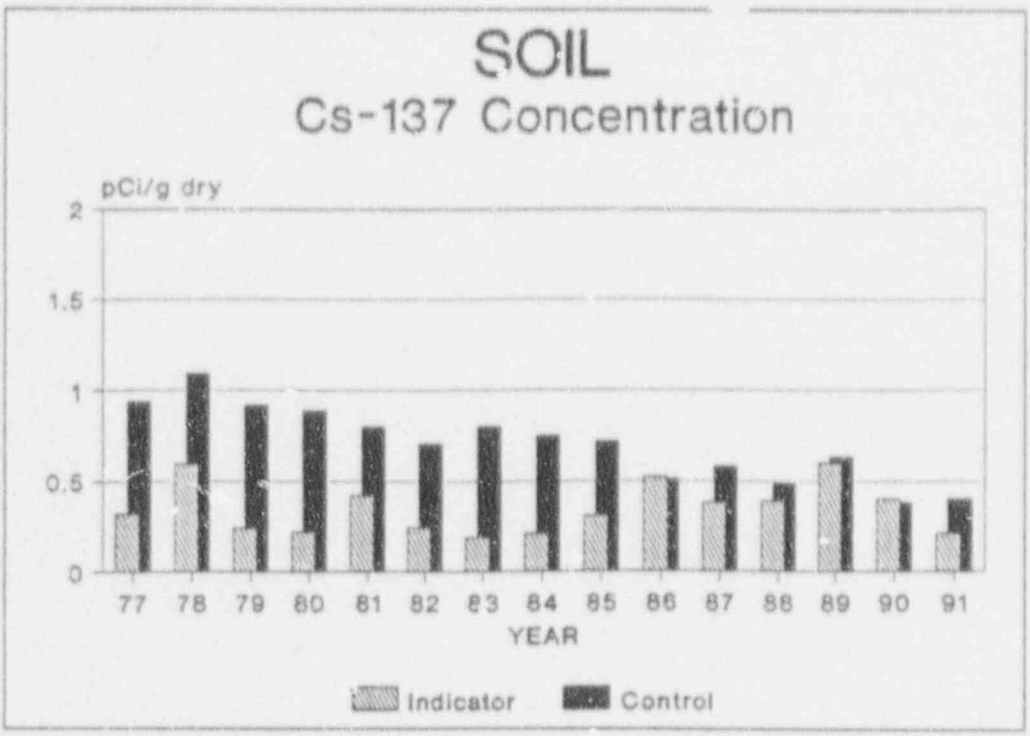


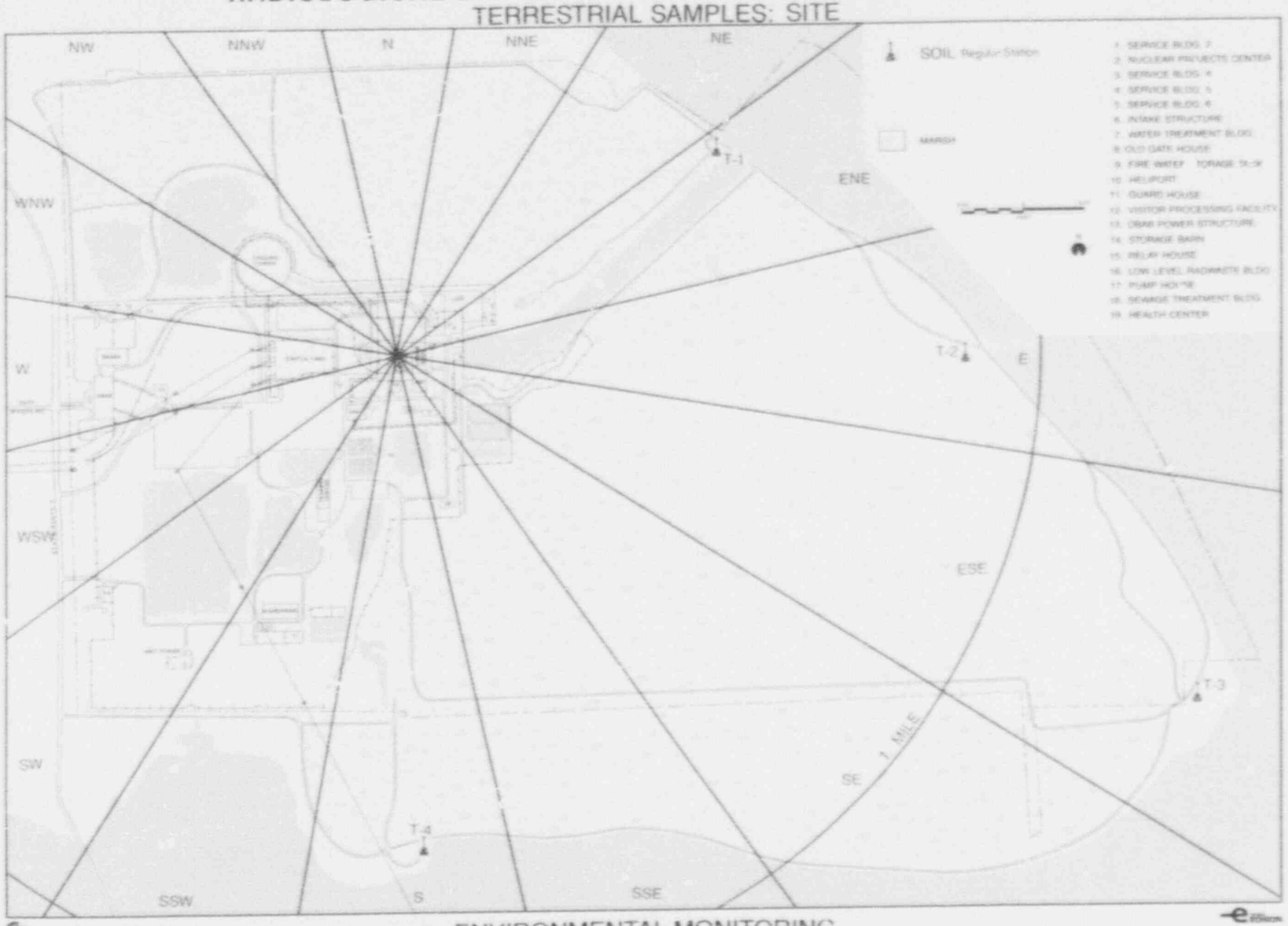
Figure 2-6: The concentration of cesium-137 in soil has remained fairly constant over the years the REMP has been conducted. The peak seen in 1978 was due to fallout form nuclear weapons testing.

Table 2-10: Soil Locations

Sample Location Number	Type of Location	Location Description
T-1	I	Site boundary, 0.6 miles ENE of Station
T-2	I	Site boundary, 0.9 miles E of Station
T-3	I	Site boundary 1.4 miles ESE of Station
T-4	I	Site boundary 0.8 miles S of Station
T-7	I	Sand Beach, main entrance, 0.9 miles NW of Station
T-8	I	Moore Farm, 2.7 miles WSW of Station
T-9	C	Oak Harbor substation, 6.8 miles SW of Station
T-11	C	Port Clinton Water Treatment Plant, 9.5 miles SE of Station
T-12	C	Toledo Water Treatment Plant, 23.5 miles WNW of Station
T-23	C	South Bass Island, 14.3 miles ENE of Station
T-27	C	Crane Creek State Park, 5.3 miles WNW of Station

* I = indicator C = control

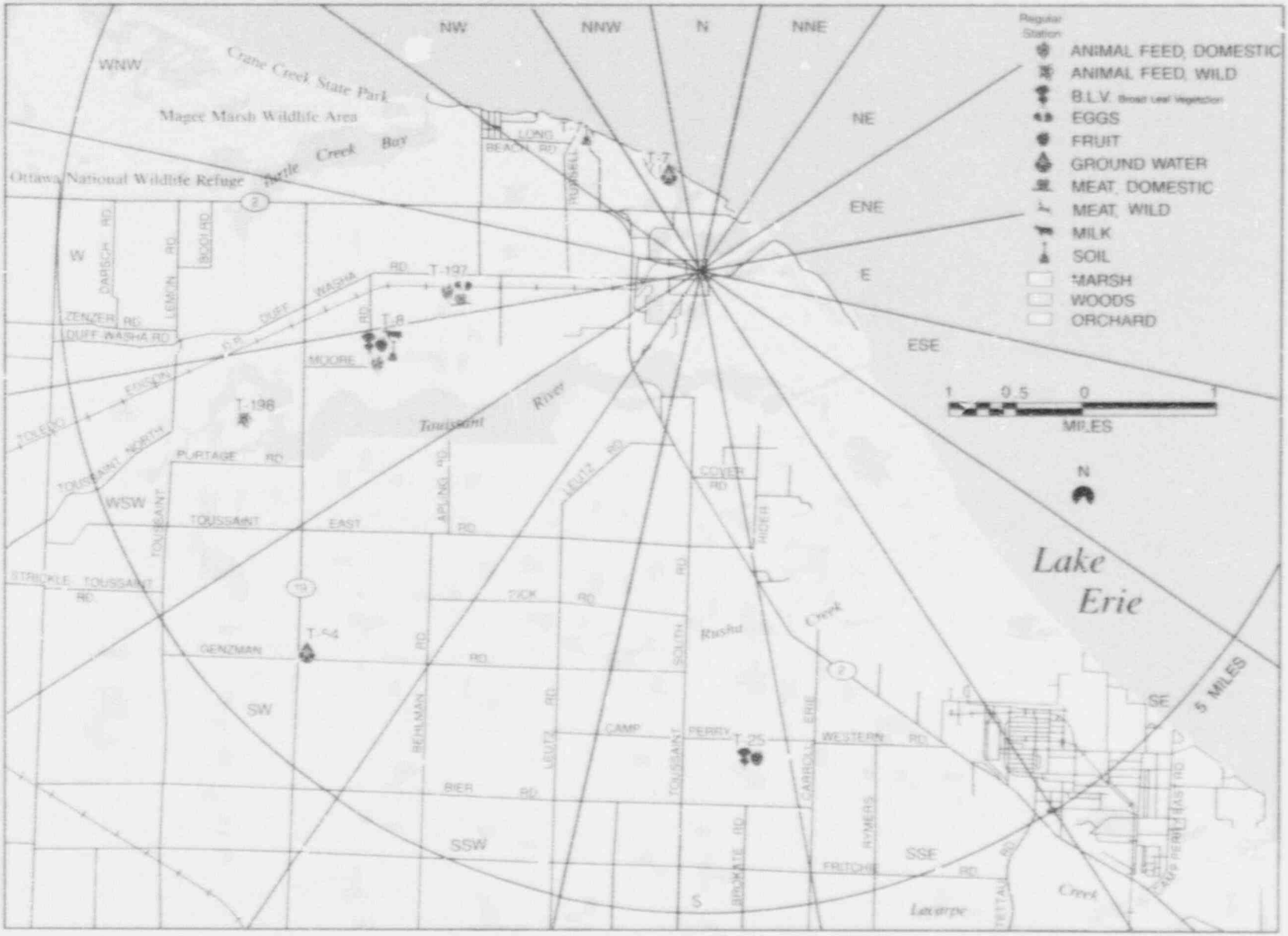
DAVIS – BESSE NUCLEAR POWER STATION
RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
TERRESTRIAL SAMPLES: SITE



ENVIRONMENTAL MONITORING

Figure 2-7

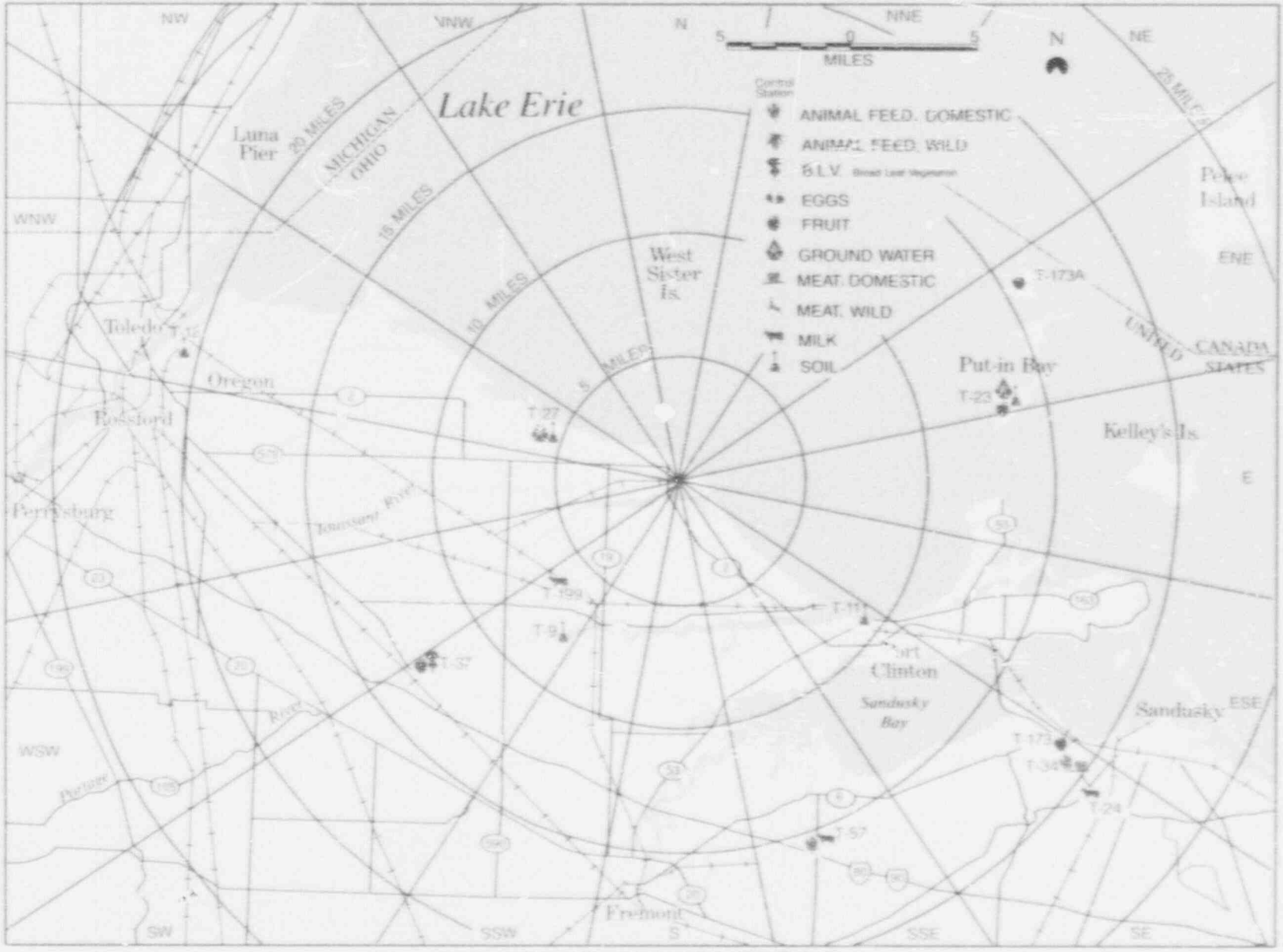
DAVIS-BESSE NUCLEAR POWER STATION
RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
TERRESTRIAL SAMPLES: 5 MILE RADIUS



ENVIRONMENTAL MONITORING

Figure 2-8

DAVIS-BESSE NUCLEAR POWER STATION
RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
TERRESTRIAL SAMPLES: 5–25 MILE RADIUS



ENVIRONMENTAL MONITORING

Figure 2-9

AQUATIC MONITORING

Radionuclides may be present in Lake Erie from many sources including atmospheric deposition, run-off/soil erosion, and releases of radioactivity in liquid effluents from hospitals or nuclear facilities. These sources provide two forms of potential radiation exposure, external and internal. External exposure can occur from the surface of the water, shoreline sediments, and the immersion (swimming) in the water. Internal exposure can occur from ingestion of radionuclides, either directly from drinking water, or as a result of the transfer of radionuclides through the aquatic food chain with eventual consumption of an aquatic organism, such as fish. To monitor these pathways, treated surface water (drinking water), untreated surface water (lake or river water), fish, and shoreline sediments are sampled and analyzed.

Treated Surface Water

Treated surface water is water from Lake Erie which has been processed for human consumption. Radiochemical analysis of this processed water provides a direct basis for assessing the dose to humans from ingestion of drinking water.

Samples of treated surface water were collected form three indicator and three control locations. These locations include the water treatment facilities for Davis-Besse, Erie Industrial Park, Port Clinton, Toledo and Put-In-Bay. Samples were collected weekly and composited monthly. The monthly composites were analyzed for beta emitting radioactivity. The samples were also composited in a quarterly sample and analyzed for strontium-89, strontium-90, gamma emitting radionuclides and tritium. One Quality Control (QC) sample was collected from a routine location which was changed each month.

In treated water samples, beta emitting radionuclides were not detected above the LLD of 0.9 pCi/l for suspended solids. The average concentration was similar in dissolved solids for indicator and control locations (2.3 and 2.2 pCi/l, respectively). The annual average for beta emitting radionuclides for all locations was similar to previous years as shown on the following page:

1972 3.4 pCi/l	1982 2.5 pCi/l
1973 2.9 pCi/l	1983 3.1 pCi/l
1974 2.3 pCi/l	1984 2.4 pCi/l
1975 2.3 pCi/l	1985 2.2 pCi/l
1976 2.3 pCi/l	1986 2.2 pCi/l
1977 2.8 pCi/l	1987 1.9 pCi/l
1978 3.1 pCi/l	1988 2.7 pCi/l
1979 2.6 pCi/l	1989 2.5 pCi/l
1980 2.5 pCi/l	1990 2.2 pCi/l
1981 2.9 pCi/l	1991 2.2 pCi/l

All quarterly tritium analyses results were less than the LLD of 330 pCi/l for all routine sites. One monthly tritium analysis on a QC sample showed some detectable concentration of tritium (393±108 pCi/l). The QC sample was collected from T-11 Port Clinton water treatment plant (a control location) and is attributed to a natural source because tritium concentrations of this level were detected during the preoperational monitoring period.

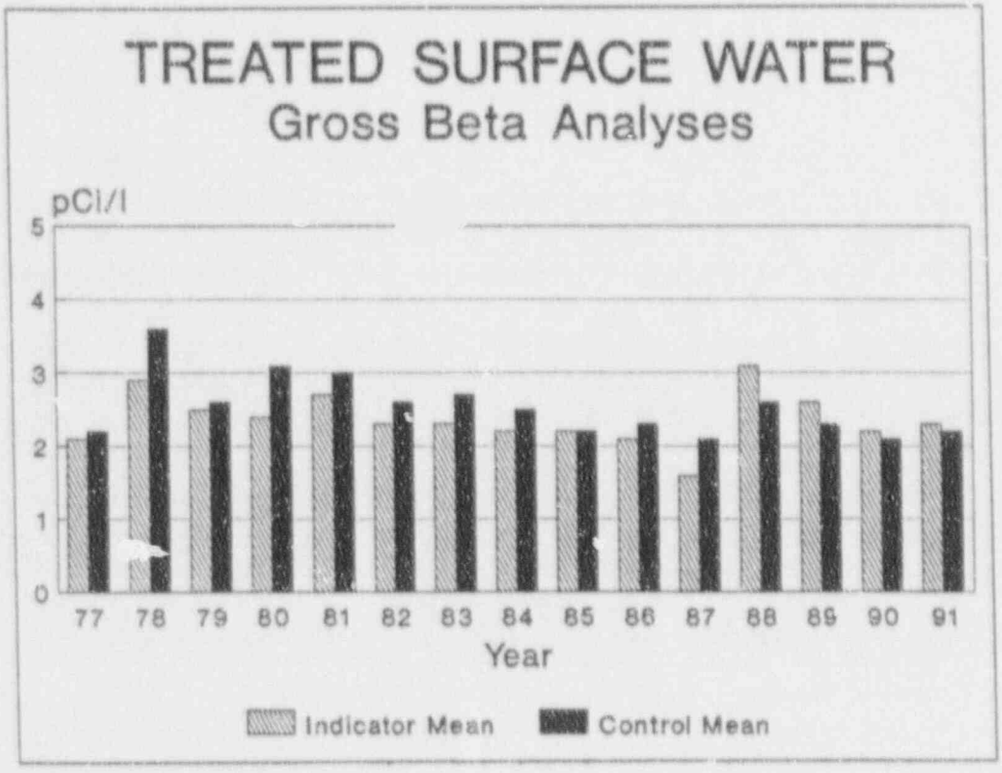


Figure 2-10: Over the past 15 years, the annual concentrations of beta emitting radionuclides in treated surface water samples collected from indicator locations have been consistant with those from control locations. This shows that Davis-Besse has had no measurable radiological impact on surfact water used to make drinking water.

All cesium-137 results were less than the LLD of 10.0 pCi/l. Strontium-89 was not detected above 1.6 pCi/l in any samples. Strontium-90 was detected at an average concentration of 0.6 at both indicator and control location. These results are similar to those of previous years and indicate no significant impact on the environment resulting from the operation of Davis-Besse.

Table 2-11 Treated Surface Water Locations

Sample Location Number	Type of Location	Location Description
T-11	C	Port Clinton Water Treatment Plant 9.5 miles SE of Station
T-12	C	Toledo Water Treatment Plant 23.5 miles WNW of Station
T-23	C	Put-In-Bay water Treatmont Plant 14.3 miles ENE of Station.
T-28	I	Treated water supply from Davis-Besse site
T-50	I	Erie Industrial Park, Port Clinton, 4.5 miles SE of Station
T-143	QC	Quality Control Site
T-144	I	Green Cove Condominiums, 0.9 miles NNW of Station

* I - indicator C= control QC = quality control

Untreated Surface Water

Sampling and analysis of untreated surface water provides a method of assessing the dose to humans from external exposure from the lake surface as well as immersion in the water. It also provides information on the radionuclides present which may affect drinking water, fish, and irrigated crops.

Routine Program:

The routine program is the basic sampling program which is performed year round. Untreated water samples are collected in the areas of the station intake and discharge and at the water intakes used by nearby water treatment plants. Routine samples are collected at Port Clinton, Toledo, Davis-Besse, Erie Industrial Park, and Put-In Bay Water Treatment Plants. A sample is also collected from Lake Erie at the mouth of the Toussaint River. These samples are collected weekly and composited monthly. The monthly composite is analyzed for beta emitting radionuclides, tritium, and gamma emitting radionuclides. The samples are further composited quarterly and analyzed for strontium-89 and strontium-90. A QC sample was collected weekly at a different location each month.

Summer Program :

The summer program is designed to supplement the routine untreated water sampling program in order to provide a more comprehensive study during the months of high lake recreational activity, such as boating, fishing, and swimming. These samples are obtained in areas along the shoreline of Lake Erie and around the islands.

The samples are collected weekly and composited monthly. The monthly composites are analyzed for beta emitting radioactivity, tritium, strontium-89, strontium-90 and gamma emitting radionuclides.

In untreated water samples, beta emitting radionuclides in suspended solids ranged from 0.3 to 6.8 pCi/l, with and average concentration of 0.5 and 2.8 pCi/l at indicator and control locations, respectively. In dissolved solids, the average concentration was 2.5 pCi/l at indicator and 2.4 pCi/l at control locations.

Of the 182 tritium analyses performed on the untreated water, 176 were less than the LLD of 330 pCi/l. The concentration of tritium detected in samples ranged form 333 to 884 pCi/l with an average concentration 531 and 333 pCi/l at indicator and control locations, respectively.

Only the August composite for tritium at T-130 (mouth Toussaint River) could be attributed to the routine operation of the station. The tritium concentration for that composite was 884 pCi/l. This is only .03% of the maximum permissible concentration of 3,000,000 pCi/l for tritium in an unrestricted area, as stated in 10 CFR 20, Appendix B, Part 20, Table 2. Subsequent samples

Subsequent samples collected during September and October showed that the tritium concentration has returned to below LLD of 330 pCi/l.

Cesium-137 and strontium-89 were not detectable in samples of untreated water above their LLDs of 10 pCi/l and 1.9 pCi/l, respectively. Strontium-90 was detected at both indicator and control locations and had an average concentration of 0.7 pCi/l and 0.9 pCi/l, respectively. The analysis results from untreated water samples show that the operation of Davis-Besse has not had significant impact on nearby residents or on the environment.

Each month, weekly quality control samples were collected at different location. The results of the analyses from the quality control samples were consistent with those from the routine samples. Some of the samples collected during the summer months in Lake Erie were close to the collection points of some of the routine untreated surface water samples. Thus, they served as quality control samples and helped to verify the accuracy of the measurements performed. A comparison of their results from the routine sites and nearby summer collection sites illustrates the value of using quality control samples to check the accuracy of analyses performed by the laboratory. The average concentrations of beta emitting radionuclides for these samples were 2.6 pCi/l for routine sites and 2.2 pCi/l for Lake Erie sample.

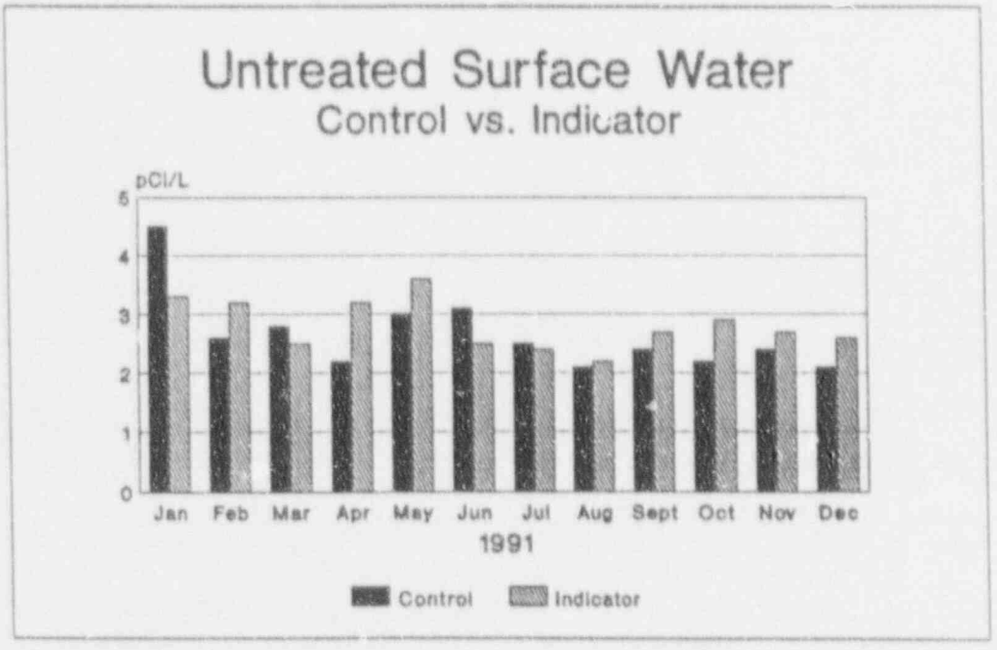


Figure 2-11: The average concentration of beta emitting radionuclides in untreated water was similiar between control and indicator locations. This demonstrates that Davis-Besse had no impact on the surrounding environment.

Table 2-12: Untreated Surface Water Locations

Sample Location Number	Type of Location	Location Description
T-3	I	Site boundary, 1.4 miles ESE of Station
T-11	C	Port Clinton Water Treatment Plant 9.5 miles SE of Station
T-12	C	Toledo Water Treatment Plant, sample taken form in take crib 11.25 miles NW of Station
T-23	C	Put-In-Bay Treatment Plant, 14.3 miles ENE of Station
T-28	I	Davis-Besse Water Treatment Plant
T-50	I	Erie Industrial Park, Port Clinton, 4.5 miles SE of Station
T-130	I	Lake Erie, 1.7 miles ESE of Station
T-131	I	Lake Erie, 0.8 mile NE of Station
T-132	I	Lake Erie, 1.0 mile E of Station
T-133	I	Lake Erie, 0.8 mile N of Station
T-134	I	Lake Erie, 1.4 miles NW of Station
T-135	I	Lake Erie, 2.5 miles WNW of Station
T-137	C	Lake Erie, 5.8 miles WNW of Station
T-138	C	Lake Erie, 11.0 miles NW of Station
T-145	QC	Roving Quality Control Site
T-152	C	Lake Erie, 15.6 miles WNW of Station
T-158	C	Lake Erie, 10.0 miles WNW of Station

Table 2-12: Untreated Surface Water Location continued

Sample Location Number	Type of Location	Location Description
T-162	C	Lake Erie, 5.4 miles SE of Station
T-164	C	Lake Erie, 9.5 miles ESE of Station
T-167	C	Lake Erie, 11.5 miles E of Station
T-168	C	Lake Erie, 15.5 miles ENE of Station

* I = indicator C = control

Shoreline Sediment

The sampling of shoreline sediments can provide an indication of the accumulation of undissolved radionuclides which may lead to internal dose to humans through the ingestion of fish, through resuspension into drinking water supplies, or as an external radiation source from shoreline dose to fishermen and swimmers.

Samples of deposited sediments in water were collected in May and October from four indicator locations and four control locations. All samples were analyzed for gamma emitting radionuclides.

Naturally occurring potassium-40 was detected at both controls and indicator locations. Cesium-137 was detected at a concentration of 0.12 pCi/g at indicator locations and 0.41 pCi/g at control locations.

Atmospheric testing of nuclear weapons has been the principal source of cesium-137 in the environment to date. Although no atmospheric nuclear weapons tests have been reported since 1980, cesium-137 is still present in shoreline sediment samples because of its long half-life (approximately 30 years). No other gamma emitting radionuclides were detected in any of the samples, and the concentrations of those detected were consistent with normal concentrations for this area.

Table 2-13: Shoreline Sediment Location

Sample Location Number	Type of Location	Location Description
T-3	I	Site boundary, 1.4 miles ESE of Station
T-4	I	Site boundary, 0.8 mile S of Station
T-23	C	South Bass Island, 14.3 miles ENE of Station
T-27	C	Crane Creek State Park, 5.3 miles WNW of Station
T-130	I	Lake Erie, 1.7 miles ESE of Station
T-132	I	Lake Erie, 1.0 mile E of Station
T-138	C	Lake Erie, 11.0 miles NW of Station
T-164	C	Lake Erie, 9.5 miles ESE of Station

* I = indicator C = control

Fish Samples

Fish are analyzed primarily to quantify the dietary radionuclide intake by humans, and secondary to serve as indicators of radioactivity in the aquatic ecosystem. The principle nuclides which may be detected in fish include naturally occurring potassium-40, as well as cesium-137, and strontium-90. Depending upon the feeding habit of the species (e.g., bottom-feeder versus predator), results from sample analyses may vary.

With the aid of local commercial fishermen, Davis-Besse routinely collects three species of fish (walleye, white bass and carp) twice a year from sampling locations near the Station's liquid discharge point and more than ten miles away from the Station where fish populations would not be expected to be impacted by the Station operation. Walleye are collected because they are a popular sport fish, white bass because they are an important commercial fish. Carp are collected because they are bottom feeders and thus would be more likely to be affected by radionuclides deposited in lake sediments. Due to seasonal unavailability no fish samples were obtained for the second half of 1991.The edible portion of fish were analyzed for beta and gamma emitting radionuclides.

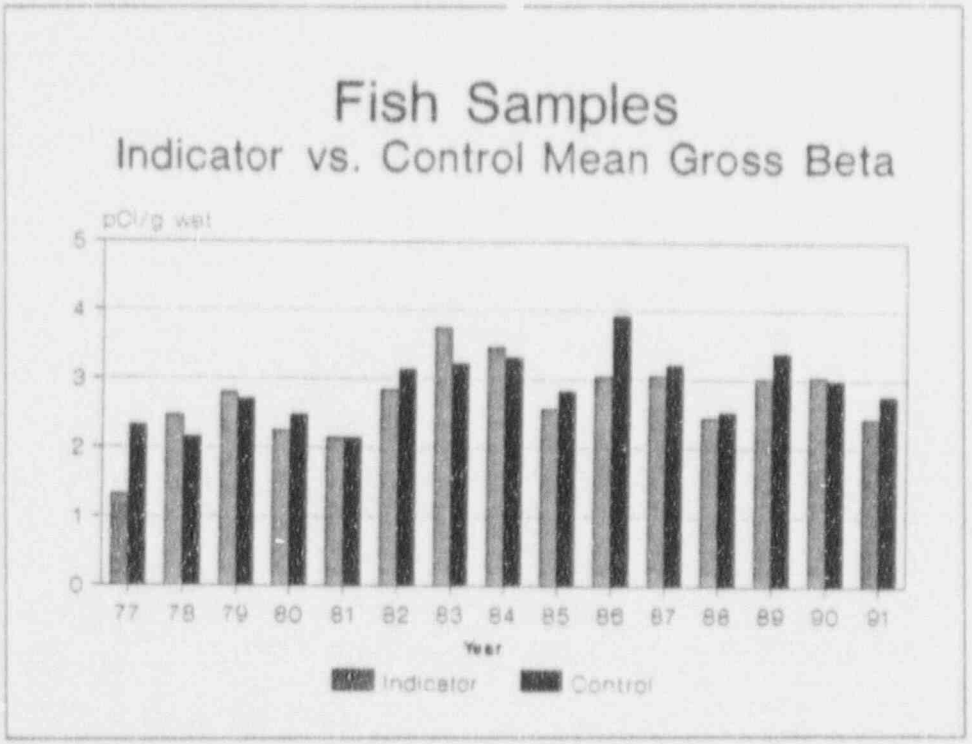


Figure 2-12: Average concentrations of beta emitting radionuclides in fish samples were similar at indicator and control locations and were within the range of results of previous years.

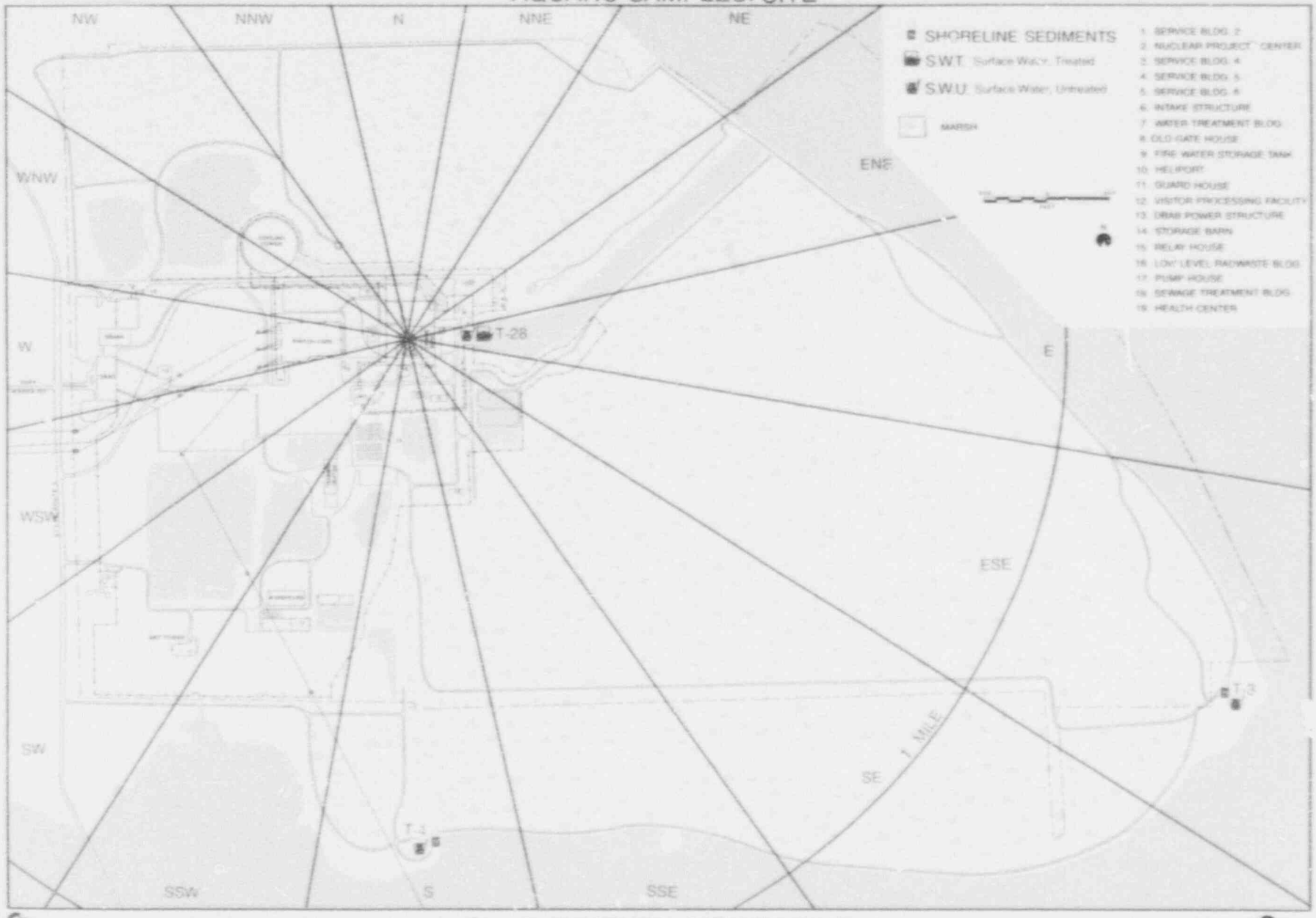
The average concentration of beta emitting radionuclides in fish muscle was similar for indicator and control location (2.46 and 2.76 pCi/g wet weight, respectively). Cesium-137 was detected in one indicator location (T-33, white bass sample) at a concentration of 0.026 pCi/g wet weight. All sample analysis results were within normal ranges compared to previous years.

Table 2- 14. Fish Locations

Sample Location Number	Type of Location	Location Description
T-33	I	Lake Erie, within 5 miles radius of Station
T-35	C	Lake Erie, greater than 10 mile radius of Station

* I = indicator C= control

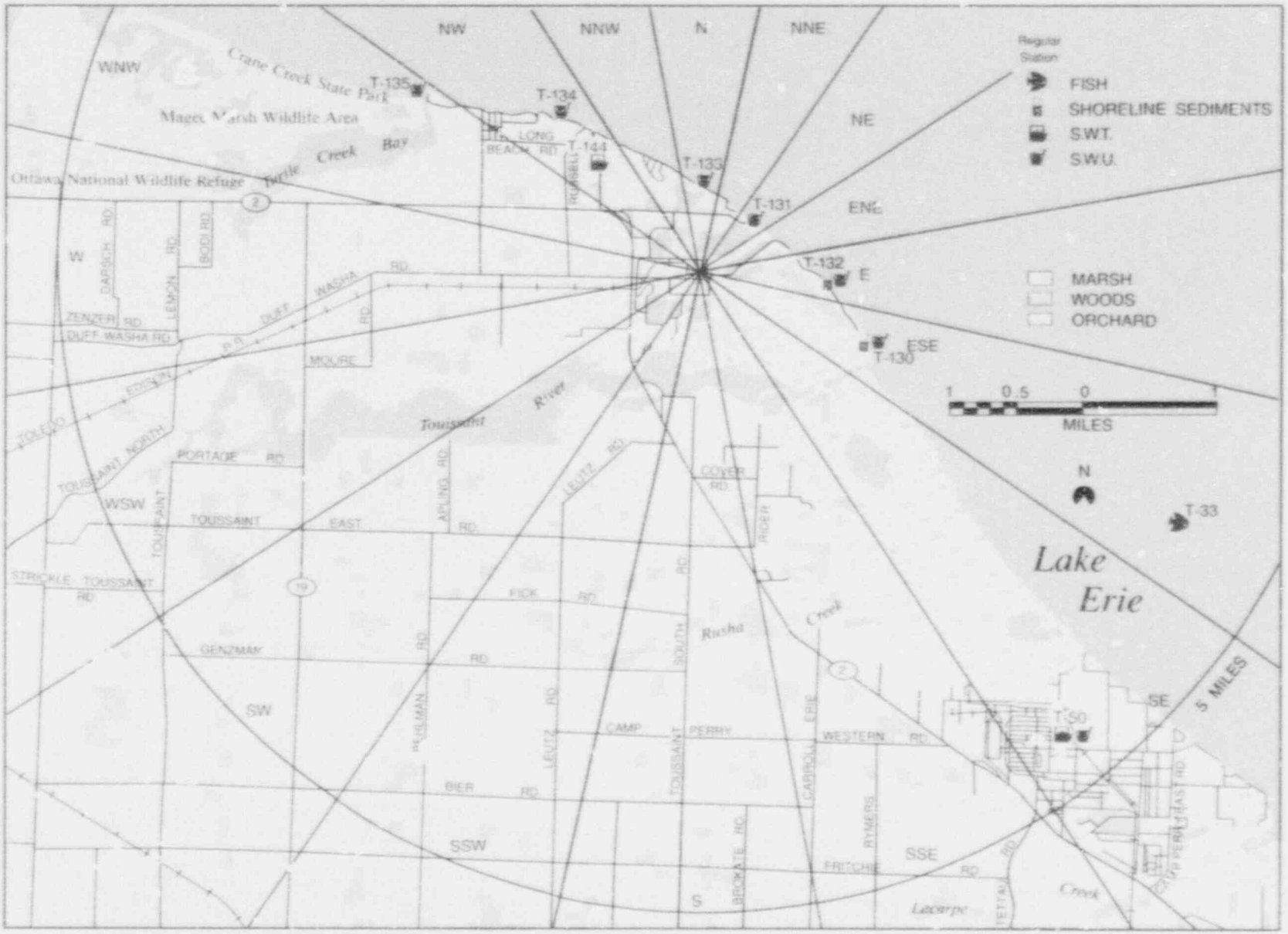
DAVIS – BESSE NUCLEAR POWER STATION
RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
AQUATIC SAMPLES: SITE



ENVIRONMENTAL MONITORING

Figure 2-13

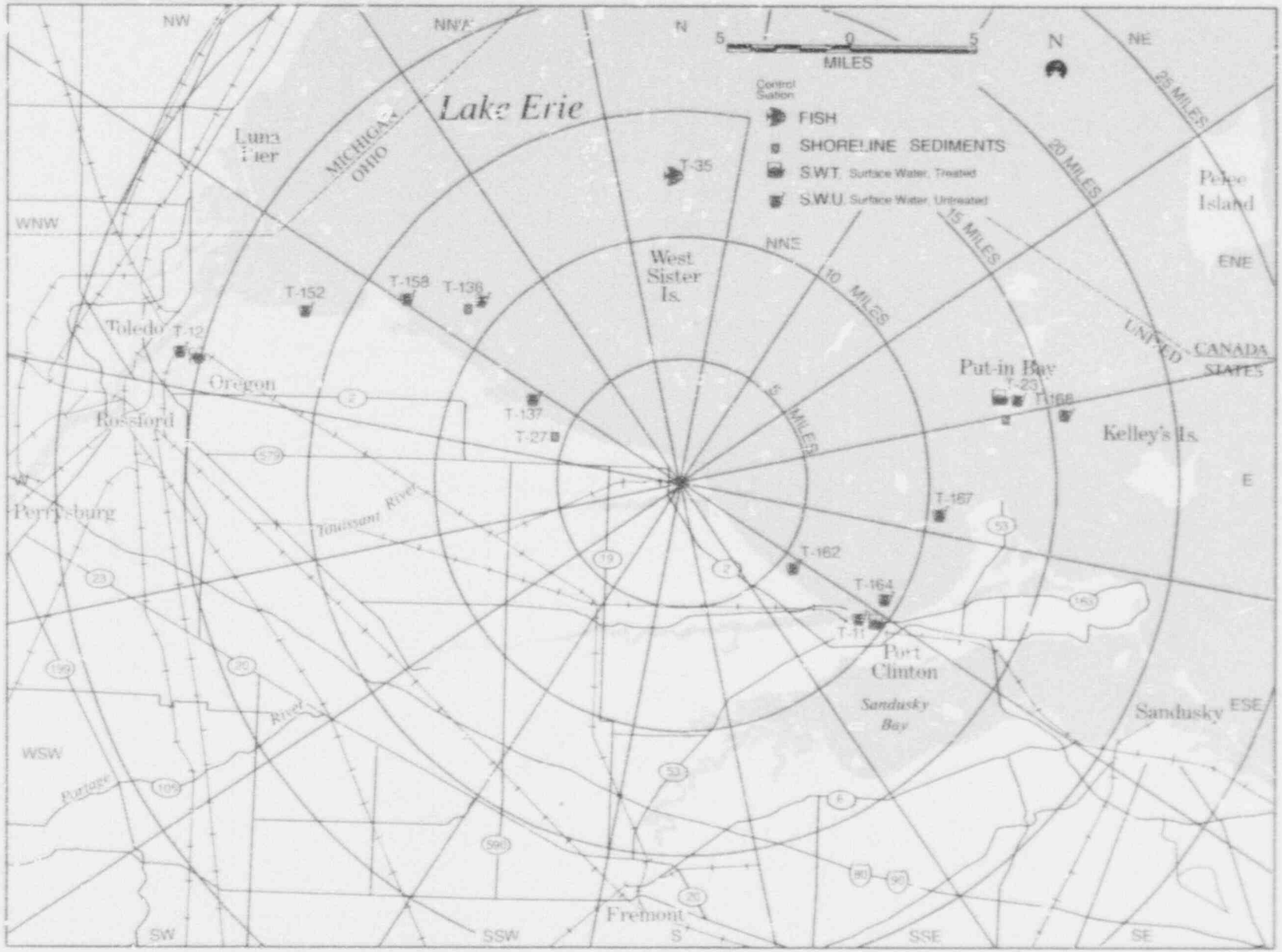
DAVIS-BESSE NUCLEAR POWER STATION
RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
AQUATIC SAMPLES: 5 MILE RADIUS



ENVIRONMENTAL MONITORING

Figure 2-14

DAVIS-BESSE NUCLEAR POWER STATION
RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
AQUATIC SAMPLES: 5–25 MILE RADIUS



ENVIRONMENTAL MONITORING

Figure 2-15

DIRECT RADIATION MONITORING

Populations may be exposed to extremely small amounts of external radiation from nuclear facilities by several pathways, including airborne radioactivity or radionuclide deposition in soil, vegetation, or lake bottom sediments. Some radiation will always be present from background sources, both man-made and natural. The amount of normal background radiation can be determined by examining preoperational measurements or data collected at control locations.

Thermoluminescent Dosimeters

Radiation at and around Davis-Besse is constantly monitored by a network of thermoluminescent dosimeters (TLDs). TLDs are small devices which store radiation dose information. The TLDs used at Davis-Besse contain a calcium sulfate: dysprosium ($CaSO_4$: Dy) card with four main readout areas. Multiple readout areas are used to ensure the precision of the measurements.

Thermoluminescence is a process by which ionizing radiation interacts with the sensitive material in the TLD, the phosphor. Energy is trapped in the TLD material and can be stored for several months or years. This provides an excellent method to measure the dose received over long periods of time. The amount of energy that was stored in the TLD as a result of interaction with radiation is removed and measured by a controlled heating process in a calibrated reading system. As the TLD is heated, the phosphor releases the stored energy as light. The amount of light detected is directly proportional to the amount of radiation to which the TLD was exposed. The reading process rezeros the TLD and prepares it for reuse.

TLD Collection

Davis-Besse has 94 TLD locations (71 indicator and 23 control) which are collected and replaced on a quarterly and annual basis. An additional seventeen QC TLDs are also collected on a quarterly and annual basis or at any given time. There are a total of 222 TLDs in the environment surrounding Davis-Besse. By collecting TLDs on a quarterly and annual basis from a single site, the two measurements serve as a quality control check on each other.

In 1991, the annual average dose for all indicator locations was 15.0 mR/91 days, and for all control locations was 16.2 mR/91 days. The annual average dose equivalent for all TLDs in 1991 was 15.3 mrem days. These averages are similar to those observed in previous years as shown on the next page:

1972 - 22.4 mrem/91 days
1973 - 14.3 mrem/91 days
1974 - 11.7 mrem/91 days
1975 - 12.8 mrem/91 days
1976 - 15.6 mrem/91 days
1977 - 16.5 mrem/91 days
1978 - 16.7 mrem/91 days
1979 - 13.4 mrem/91 days
1980 - 14.5 mrem/91 days
1981 - 14.8 mrem/91 days
1982 - 14.5 mrem/91 days
1983 - 13.2 mrem/91 days
1984 - 13.2 mrem/91 days
1985 - 14.4 mrem/91 days
1986 - 14.8 mrem/91 days
1987 - 14.5 mrem/91 days
1988 - 14.5 mrem/91 days
1989 - 15.9 mrem/91 days
1990 - 15.4 mrem/91 days
1991 - 15.3 mrem/91 days

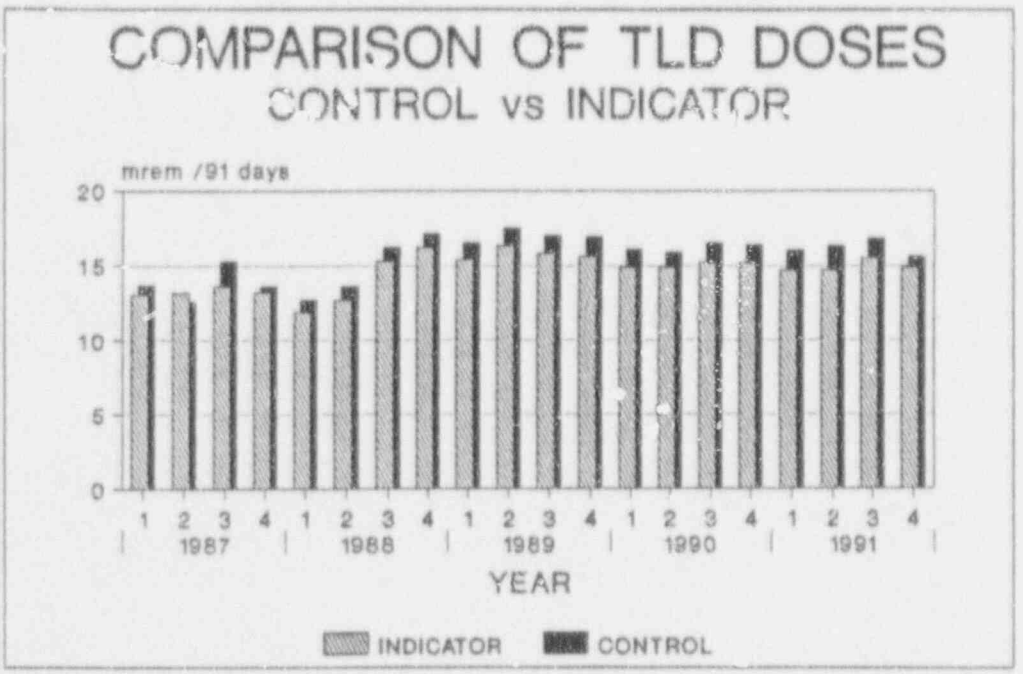


Figure 2-16: similarity between indicator and control results from the last five years demonstrated that the operation of Davis-Besse has not caused any abnormal gamma dose.

Quality Control TLDs

Duplicate TLDs have been established at 17 sites. These TLDs were placed in the field at the same time and at the same location as some of the routine TLDs, but were assigned quality control site numbers. This allows us to take several measurements at the location without the laboratory being aware that they are the same. A comparison of the quality control and routine results provides a method to check the accuracy of the measurements. The average dose equivalent at the routine TLDs averaged 14.4 mrem/91 days while the quality control TLDs yielded an average dose equivalent of 15.2 mrem/91 days. All

the quality control and routine sample results were similar demonstrating the accuracy of both the TLDs and the laboratory's measurements.

NRC TLD Monitoring

The NRC has 22 TLDs located around Davis-Besse as part of their Direct Monitoring Network Program. Davis-Besse maintains TLDs at all the NRC TLD monitoring sites. The NRC collects their TLDs on a quarterly basis, whereas Davis-Besse collects TLDs quarterly and annually at these locations. The NRC TLDs are collected and read independently of Davis-Besse's TLDs, thus providing a quality control check on both laboratories.

The NRC uses Panasonic Model UD801 TLDs, which have two elements of lithium borate: copper ($Li_2B_4O_7$: Cu) and two elements of calcium sulfate: thulium ($CaSO_4$: Tm). The difference in TLD material used by the NRC and Davis-Besse causes some variation in results.

The results of TLD monitoring at these 22 locations show good consistency for the NRC TLDs and the Davis-Besse TLDs. The average of the quarterly results are 16.2 mrem/91 days for the Davis-Besse TLDs and 16.3 mrem/91 days for the NRC TLDs (data from first, second, and third quarter). The variance in these measurements is most likely due to the differences in the TLD materials.

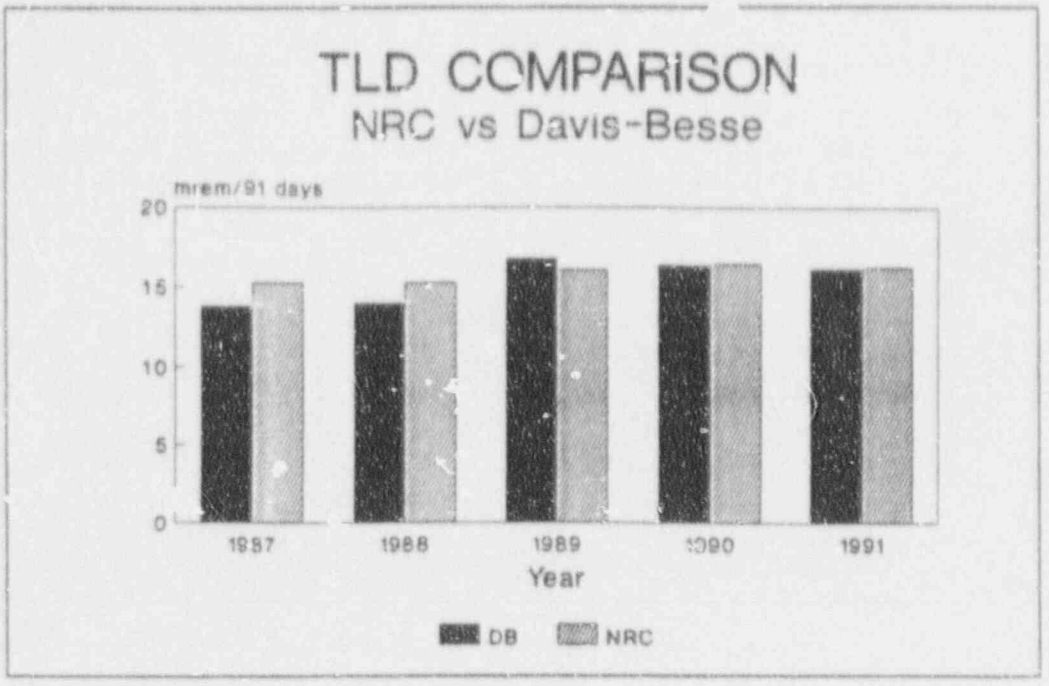


Figure 2-17: Compares NRC and Davis-Besse TL's for last five years.

Table 2-15: Thermoluminescent Dosimeters Locations

Sample Location Number	Type of Location	Location Description
T-1	I	Site boundary, 0.6 mile ENE of Station
T-2	I	Site boundary, 0.9 mile E of Station
T-3	I	Site boundary, 1.4 miles ESE of Station
T-4	I	Site boundary, 0.8 mile S of Station
T-5	I	Site boundary, 0.5 mile W of Station
T-6	I	Site boundary, 0.5 mile NNE of Station
T-7	I	Sand Beach, main entrance, 0.9 mile NW of Station
T-8	I	Earl Moore Farm, 2.7 miles WSW of Station
T-9	C	Oak Harbor Substation, 6.8 miles SW of Station
T-10	I	Site boundary, 0.5 mile SSW of Station near warehouse
T-11	C	Fort Clinton Water Treatment Plant, 9.5 miles SE of Station
T-12	C	Toledo Water Treatment Plant, 23.5 miles WNW of Station
T-23	C	South Bass Island, 14.3 miles ENE of Station, near lighthouse
T-24	C	Sandusky, 21.0 miles SE of Station
T-27	C	Crane Creek State Park, 5.3 miles WNW of Station
T-38	I	Site boundary, 0.6 mile ENE of Station

Table 2-15: Thermoluminescent Dosimeters Locations continued

Sample Location Number	Type of Location	Location Description
T-39	I	Site boundary 1.2 miles ENE of Station
T-40	I	Site boundary, 0.7 mile SE of Station
T-41	I	Site boundary, 0.6 mile SSE of Station
T-42	I	Site boundary, 0.8 mile SW of Station
T-43	I	Site boundary, 0.5 mile SW of Station
T-44	I	Site boundary, 0.5 mile WSW of Station
T-45	I	Site boundary, 0.5 mile WNW of Station
T-46	I	Site boundary, 0.5 mile NW of Station
T-47	I	Site boundary, 0.5 mile N of Station
T-48	I	Site boundary, 0.5 mile NE of Station
T-49	I	Site boundary, 0.5 mile NE of Station
T-50	I	Erie Industrial Park, Port Clinton, 4.5 miles SE of Station
T-51	C	Daup Farm, 5.5 miles SSE of Station
T-52	I	Miller Farm, 3.7 miles S of Station
T-53	I	Nixon Farm, 4.5 miles S of Station
T-54	I	Weis Farm, 4.8 miles SW of Station
T-55	I	King Farm, 4.5 miles W of Station
T-60	I	Site boundary, 0.3 mile S of Station
T-61	I	Site boundary, 0.6 mile SE of Station

Table 2-15: Thermoluminescent Dosimeters Locations continued

Sample Location Number	Type of Location	Location Description
T-62	I	Site boundary, 1.0 mile SE of Station
T-63	I	Site boundary, 1.1 miles ESE of Station
T-64	I	Site boundary, 0.9 mile E of Station
T-65	I	Site boundary, 0.3 mile E of Station
T-66	I	Site boundary, 0.3 mile ENE of Station
T-67	I	Site boundary, 0.3 mile NNW of Station
T-68	I	Site boundary, 0.5 mile WNW of Station
T-69	I	Site boundary, 0.4 mile W of Station
T-70	I	Site boundary, 0.3 mile WNW of Station
T-71	I	Site boundary, 0.1 mile NNW of Station
T-73	I	Site boundary, 0.1 mile WSW of Station
T-74	I	Site boundary, 0.1 mile SSW of Station
T-75	I	Site boundary, 0.2 mile SSE of Station
T-76	I	Site boundary, 0.1 mile SE of Station
T-77	I	Site boundary, 0.1 mile ENE of Station
T-80	QC	Quality Control Site
T-82	QC	Quality Control Site
T-83	QC	Quality Control Site
T-84	QC	Quality Control Site

Table 2-15: Thermoluminescent Dosimeters Location continued

Sample Location Number	Type of Location	Location Number
T-85	QC	Quality Control Site
T-86	QC	Quality Control Site
T-88	QC	Quality Control Site
T-89	QC	Quality Control Site
T-90	I	Toussaint East and Leutz Roads, 2.0 miles SSW of Station
T-91	I	State Route 2 and Rankie Road, 2.5 miles SSE of Station
T-92	I	Locust Point Road, 2.7 miles WNW of Station
T-93	I	Twelfth Street, Sand Beach, 0.6 mile NNE of Station
T-94	I	State Route 2, 1.8 miles WNW of Station
T-95	C	State Route 579, 9.3 miles W of Station
T-96	C	State Route 2 and Howard Road, 10.5 miles WNW of Station
T-97	I	Duff Washa and Zetzer Road, 1.5 miles W of Station
T-98	C	Toussaint-Portage and Bier Road, 6.0 miles SW of Station
T-99	I	Benlman Road, 4.7 miles SSW of Station
T-100	C	Ottawa County Highway Garage, Oak Harbor, 6.0 miles S of Station

Table 2-15:Thermoluminescent Dosimeters Locations continued

Sample Location Number	Type of Location	Location Description
T-101	C	Finke Street, Oak Harbor, 6.5 miles SSW of Station
T-102	C	Oak Street, Oak Harbor, 6.5 miles SSW of Station
T-103	C	Licker-Harder Road, 8.5 miles SW of Station
T-104	C	Salem-Carroll Road, 7.3 miles SW of Station
T-105	C	Lake Shore Drive Port Clinton, 6.0 miles SE of Station
T-106	C	Third Street, Port Clinton, 8.9 miles SE of Station
T-107	C	Little Portage East Road, 8.5 miles SSE of Station
T-108	C	Boysen Road, 9.0 miles S of Station
T-109	C	Stange Road, 8.0 miles W of Station
T-110	C	Toussaint North and Graytown Road, 10.0 miles WSW of Station
T-111	C	Toussaint North Road, 8.3 miles WSW of Station
T-112	I	Thompson Road, 1.5 miles SSW of Station
T-113	QC	Quality Control Site
T-114	QC	Quality Control Site
T-115	QC	Quality Control Site

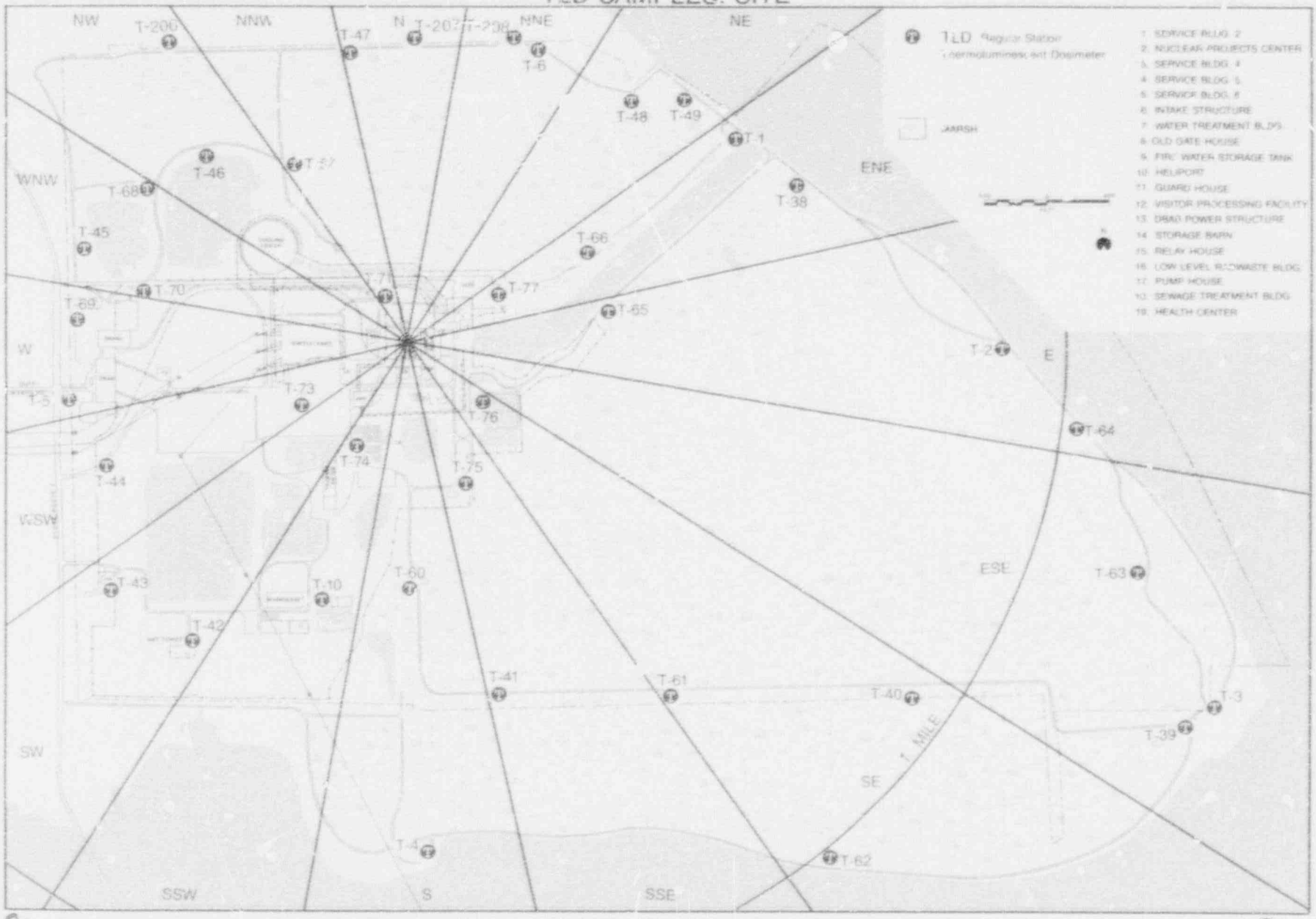
Table 2-15: Thermoluminescent Dosimeters Locations continued

Sample Location Number	Type of Location	Location Description
T-116	QC	Quality Control Site
T-117	QC	Quality Control Site
T-118	QC	Quality Control
T-119	QC	Quality Control Site
T-120	QC	Quality Control Site
T-121	I	State Route 19, 2.0 miles W of Station
T-122	I	Duff Washa and Humphrey Road, 1.7 miles W of Station
T-123	I	Zetzer Road, 1.6 miles WSW of Station
T-124	C	Church and Walnut Street, Oak Harbor, 6.5 miles SSW of Station
T-125	I	Behlman and Bier Roads, 4.4 miles SSW of Station
T-126	I	Camp Perry Western and Toussaint South Road, 3.7 miles S of Station
T-127	I	Camp Perry Western and Rymers Road, 4.0 miles SSE of Station
T-128	I	Erie Industrial Park, Port Clinton Road, 4.0 miles SE of Station
T-150	I	Humphrey and Hollywood Road, 2.1 miles NW of Station
T-151	I	State Route 2 and Humphrey Road, 1.8 miles WNW of Station

Table 2-15: Thermoluminescent Dosimeters Locations continued

Sample Location Number	Type of Location	Location Description
T-153	I	Leutz Road, 1.4 miles SSW of Station
T-154	I	State Route 2, 0.7 mile SW of Station
T-155	C	Fourth and Madison Street, Port Clinton, 9.5 miles SE of Station
T-200	QC	Quality Control Site
T-201	I	Sand Beach, 1.1 miles NNW of Station
T-202	I	Sand Beach 0.8 mile NNW of Station
T-203	I	Sand Beach, 0.7 mile N of Station
T-204	I	Sand Beach, 0.7 mile N of Station
T-205	I	Sand Beach, 0.5 mile NNE of Station
T-206	I	Site Boundary, 0.6 mile NW of Station
T-207	I	Site Boundary, 0.5 mile N of Station
T-208	I	Site boundary, 0.5 mile NNE of Station.

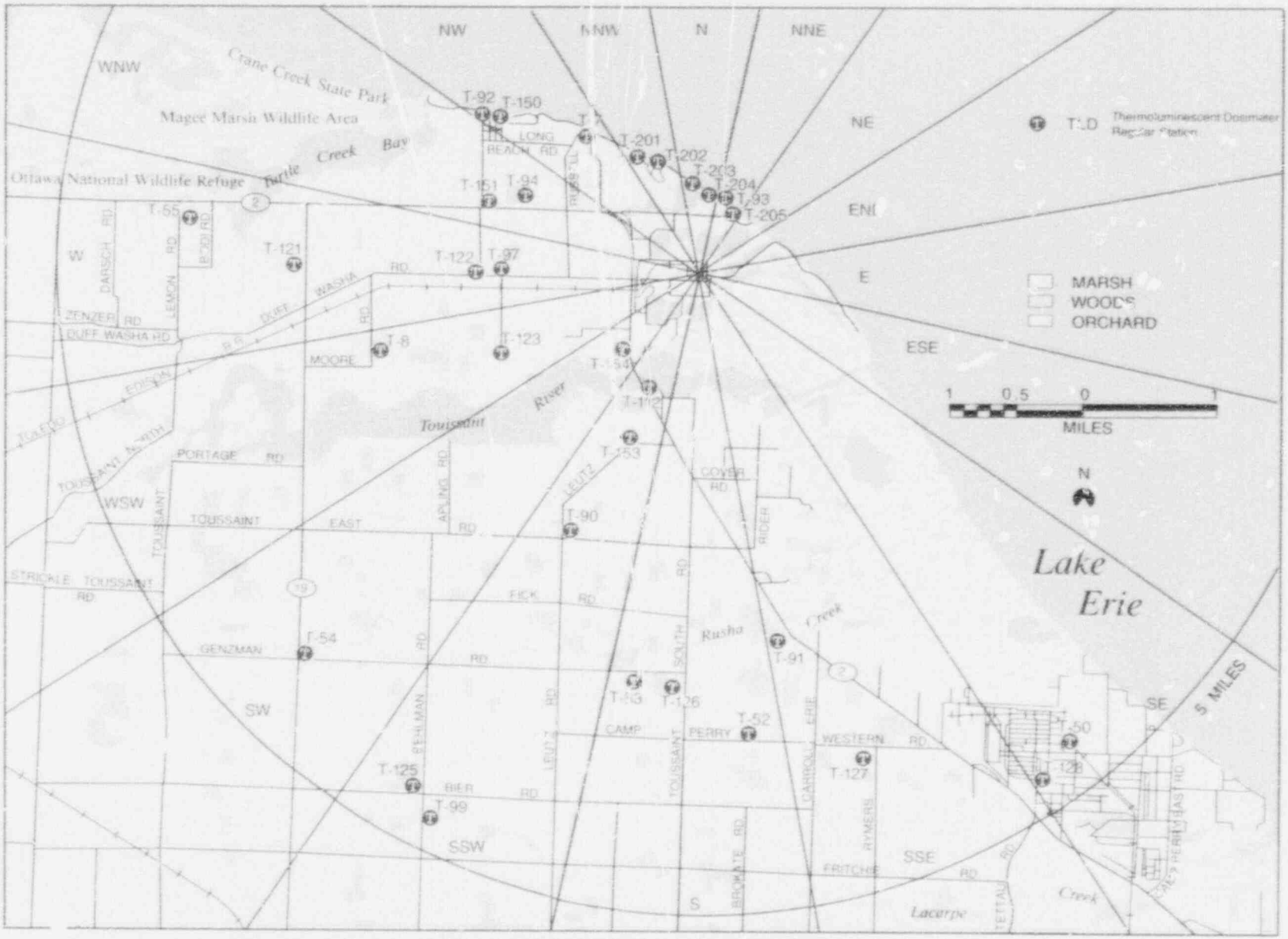
DAVIS – BESSE NUCLEAR POWER STATION
RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
TLD SAMPLES: SITE



ENVIRONMENTAL MONITORING

Figure 2-18

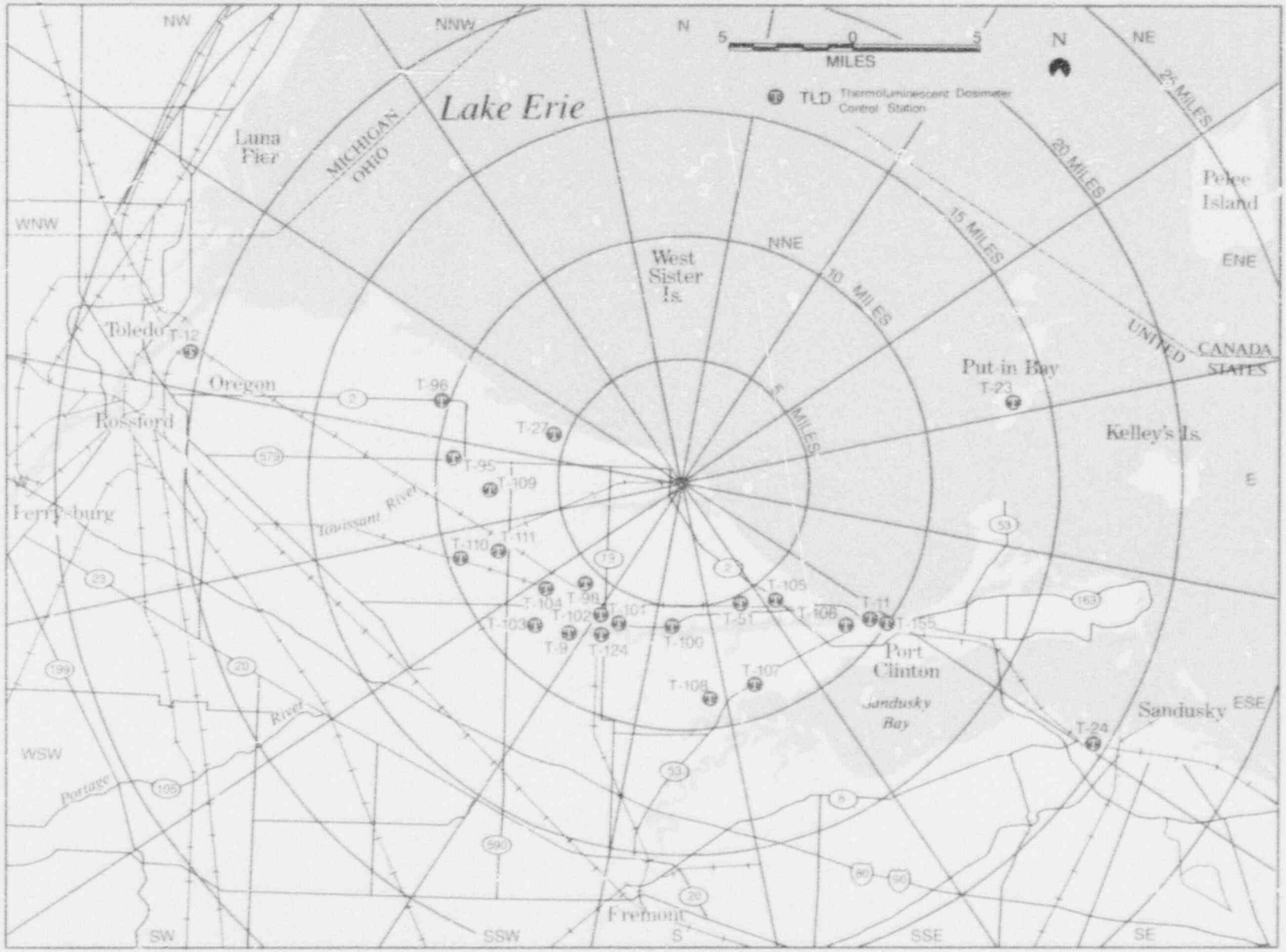
DAVIS-BESSE NUCLEAR POWER STATION
RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
TLD SAMPLES: 5 MILE RADIUS



ENVIRONMENTAL MONITORING

Figure 2-19

DAVIS-BESSE NUCLEAR POWER STATION
RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
TLD SAMPLES: 5–25 MILE RADIUS



ENVIRONMENTAL MONITORING

Figure 2-20

Conclusion

The Radiological Environmental Monitoring Program at Davis-Besse is conducted to determine the radiological impact of the Station's operation on the environment. Radionuclide concentrations measured at indicator locations were compared with concentrations measured at control locations, in previous operational studies and in the preoperational surveillance program. These comparisons indicate normal concentrations of radioactivity in all environmental samples collected in 1991. Davis-Besse's operation in 1991 had no adverse impact on the residence and environment surrounding the station. In fact, the dose to local residence from exposure to normal sources of radiation, both natural and man-made, is much more significant than the dose associated with the operation of Davis-Besse.

The results of the sample analyses performed during the period of January through December 1991 are summarized in Appendix E of this report.

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Land Use Census

Program Design

Each year a Land Use Census is conducted by Davis-Besse in order to gather information necessary to sample media representative of conservative radioactivity exposure pathways in the environment. The Land Use Census is required by Title 10 of the Code of Federal Regulation, Part 50, Appendix I and the Davis-Besse Technical Specifications, Section 3/4.12.2. Radiological exposure pathways, as discussed in Chapter 1 of this report, indicate the methods by which people may become exposed to radioactivity. The Land Use Census identifies the various pathways by which radioactivity may reach the population around Davis-Besse. These pathways include:

- **Inhalation Pathway**- Internal exposure as a result of breathing radioactivity carried in the air.
- **Ground Exposure Pathway**- External exposure from radioactivity deposited on the ground.
- **Plume Exposure Pathway**- External exposure directly from a plume or cloud of radioactive material.
- **Vegetation Pathway**- Internal exposure as a result of eating vegetables, fruit, etc. which have a build up of deposited radioactivity or which have absorbed radionuclides through the soil.
- **Milk Pathway**- Internal exposure as a result of drinking milk which may contain radioactivity as a result of a cow or goat grazing on a pasture contaminated by radionuclides.

The information gathered during the Land Use Census for dose assessment and input into the Radiological Environmental Monitoring Program ensures that these programs are as current as possible. For instance, if the Land Use Census identifies the presence of a dairy animal closer to the Station than was previously identified, then information from this new location can be used to estimate the potential dose to the surrounding population. Also, the milk at this location can be sought as a new sample for the Radiological Environmental Monitoring Program.

Methodology

The Land Use Census consists of recording and mapping the locations of all residences, dairy cattle and goats, and broad leaf vegetable gardens (greater than 500 square feet) within a five mile radius of Davis-Besse.

The surveillance portion of the 1991 Land Use Census was performed during the month of July. In order to gather as much information as possible, the location of residences, dairy cows, dairy goats, vegetable gardens, beef cattle, fowl, fruit trees, grapes, sheep, and swine were recorded. However, only the residences, vegetable gardens (greater than 500 square feet), and milk animals are used in the dose assessment program. The Ottawa County Cooperative Extension Agency confirmed the presence of dairy cattle and goats reported within the five mile radius.

Each residence is tabulated as having an inhalation pathway, as well as ground and plume exposure pathways. Each garden is tabulated as a vegetation pathway. Each milk animal is tabulated as a milk pathway.

All of the locations identified are plotted on a map (based on the U.S. Geological Survey 7.5 minute series of the relevant quadrangles) which has been divided into 16 equal sectors corresponding to the 16 cardinal compass points (Figure 3-1). The closest residence, milk animal, and vegetable garden in each sector are determined by measuring the distance from each to the station vent at Davis-Besse.

Results

The following changes in the pathways were recorded in the 1991 census:

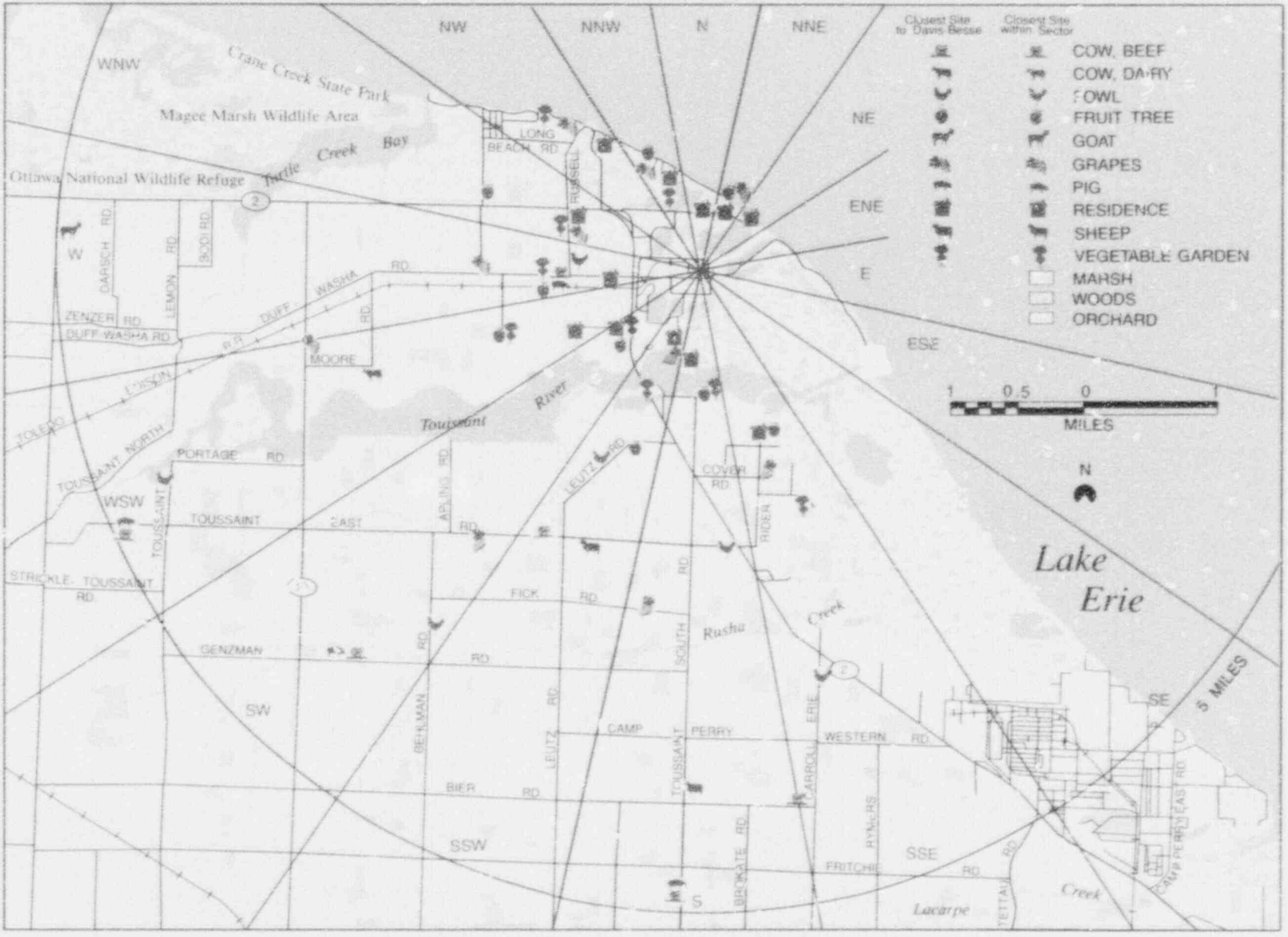
- **SSW Sector**- The vegetation pathway at 2180 meters was deleted in favor of a closer garden at 1560 meters.
- **SW Sector**- The vegetation pathway at 1340 meters was deleted in favor of a closer garden at 1050 meters.
- **W Sector** - The garden at 1050 meters was not present during the 1990 census. The vegetation pathway has changed to 1750 meters.
- **WNW Sector**- The vegetation pathway at 3290 meters was deleted in favor of a closer garden at 1750 meters.

- **NW Sector**- The garden at 2040 meters was not present during 1990. The vegetation pathway has moved to 2630 meters.

The detailed list in Table 3-1 was used to update the database of the effluent dispersion model used in dose calculations. Table 3-1 is divided by sectors and lists the distance (in meters) of the closest pathway in each meteorological sector.

Table 3-2 provided information on pathways, critical age group, atmospheric dispersion (X/Q) and deposition (D/Q) parameters for each sector. This information is used to update the Offsite Dose Calculations Manual (ODCM). The ODCM describes the methodology and parameters used in calculating offsite doses from radioactivity released in liquid and gaseous effluents, and in calculating liquid and gaseous effluent monitoring instrumentation alarm/trip setpoints.

DAVIS-BESSE NUCLEAR POWER STATION
RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
PRIMARY PATHWAYS WITHIN 5 MILE RADIUS



ENVIRONMENTAL MONITORING

Figure 3-1

Table 3-1: Closest Exposure Pathways Present in 1991

Sector	Distance from Station (meters)	Closest Pathways
N	880	Inhalation Ground Exposure Plume Exposure
NNE	870	Inhalation Ground Exposure Plume Exposure
NE	900	Inhalation Ground Exposure Plume Exposure
ENE,E,ESE,SE	N/A	Located over Lake Erie
SSE	2010	Inhalation Ground Exposure Plume Exposure
SSE	2900	Inhalation Ground Exposure Plume Exposure Vegetation
S	1070	Inhalation Ground Exposure Plume Exposure
S	1450	Inhalation Ground Exposure Plume Exposure Vegetation
SSW	980	Inhalation Ground Exposure Plume Exposure

Table 3-1: Closest Exposure Pathways Present in 1991 (continued)

Sector	Distance from Station (meters)	Closest Pathways
SSW	980	Inhalation Ground Exposure Plume Exposure
*SSW	1560	Inhalation Ground Exposure Plume Exposure Vegetation
*SW	1050	Inhalation Ground Exposure Plume Exposure Vegetation
WSW	1620	Inhalation Ground Exposure Plume Exposure
WSW	2640	Inhalation Ground Exposure Plume Exposure Vegetation
WSW	4270	Inhalation Ground Exposure Plume Exposure Vegetation Cow Milk
W	980	Inhalation Ground Exposure Plume Exposure

*Changes Since 1990

Table 3-1: Closest Exposure Pathways Present in 1991 (continued)

Sector	Distance from Station (meters)	Closest Pathways
*W	1720	Inhalation Ground Exposure Plume Exposure Vegetation
WNW	1730	Inhalation Ground Exposure Plume Exposure
*WNW	1750	Inhalation Ground Exposure Plume Exposure Vegetation
NW	1980	Inhalation Ground Exposure Plume Exposure
*NW	2630	Inhalation Ground Exposure Plume Exposure Vegetation
NNW	1210	Inhalation Ground Exposure Plume Exposure Vegetation

*Changes since 1990

Table 3-2: Pathway Locations and Corresponding Atmospheric Dispersion (X/Q) and Deposition (D/Q) Parameters

SECTOR	METERS	CRITICAL PATHWAY	AGE GROUP	X/Q (SEC/M^3)	D/Q (M^{-2})
N	880	inhalation	child	9.15E-07	8.40E-09
NNE	870	inhalation	child	1.27E-06	1.47E-08
NE	900	inhalation	child	1.26E-06	1.58E-08
ENE*	----	----	----	----	----
E*	----	----	----	----	----
ESE*	----	----	----	----	----
SE*	----	----	----	----	----
SSE	2900	vegetation	child	6.80E-08	7.90E-10
S	1450	vegetation	child	1.21E-07	2.46E-09
SSW**	1560	vegetation	child	1.03E-07	2.28E-09
SW**	1050	vegetation	child	2.92E-07	5.33E-09
WSW	4270	cow/milk	infant	5.71E-08	5.31E-10
W**	1720	vegetation	child	2.47E-07	3.81E-09
WNW**	1750	vegetation	child	1.46E-07	1.72E-09
NW**	2630	vegetation	child	5.96E-08	4.50E-10
NNW	1210	vegetation	child	2.70E-07	1.92E-09

* Since these sectors are located over marsh areas and Lake Erie, no ingestion pathways are present.

** Changes since 1990.

Meteorological Monitoring

Introduction

The Meteorological Monitoring Program at Davis-Besse is required by the Nuclear Regulatory Commission (NRC) as part of the program for evaluating the effects of routine operation of nuclear power stations on the surrounding environment. Both NRC regulations and Davis-Besse Technical Specifications provide guidelines for the Meteorological Monitoring Program. These guidelines ensure that Davis-Besse has the proper equipment, in good working order, to support the Radiological Environmental Monitoring Program.

Meteorological observations at began in October 1968. The Meteorological Monitoring Program at has provided data and records of meteorological information that can be used by many other programs. The Radiological Environmental Monitoring Program uses the meteorological data to evaluate the effects of radioactivity released in Station effluents. The meteorological conditions at the time of these releases are used to calculate doses to the general public. Meteorological data are also used to evaluate where new radiological environmental monitoring sites should be located.

The meteorological monitoring system is also valuable in monitoring weather conditions, predicting the development of adverse weather conditions, and predicting the development of adverse weather trends, such as flooding or high winds. This provides an early warning system so precautions can be taken to protect the facilities and personnel at Davis-Besse. Onsite meteorological data would also be a valuable tool in the unlikely event of an emergency. Atmospheric dispersion characteristics necessary for evaluating conditions, distribution, and doses to the public could be readily obtained.

Onsite Meteorological Monitoring

This section describes the onsite Metecrological Monitoring Program at Davis-Besse. A description of the meteorological system , and data handling and analysis procedures, as well as a table and discussion of the annual data recovery are also provided.

System Description

Meteorological data collection at Davis-Besse consists of **wind speed, wind direction, sigma theta** (standard deviation of wind direction), ambient (outside air at 10 m) **temperature, differential temperature** (the air temperature at 100 or 75 m minus air temperature at 10m), **dew point temperature** (the air temperature where moisture begins to condense out of the air), and precipitation. Two towers equipped with a variety of meteorological instruments are used to gather these data.

Meteoritical Instrumentation

The meteorological system consists of one monitoring site located at a grade level of 577 feet above mean sea level. A 100 m free-standing tower located about 3,000 feet SSW of the cooling tower, and an auxiliary 10 m tower located 100 feet west of the 100 m tower, are used to gather the meteorological data. The 100 m tower has instruments for wind speed and wind direction at 100 m and 75 m. The 10 m tower is instrumented for wind speed and wind direction. The 100 m tower also measures two **differential temperatures** (***delta T's***) : 100-10m and 75-10m. Differential temperatures are used to determine stability of the lower atmosphere. This gives an indication of how fast airborne effluents can mix and disperse. Precipitation is measured by a tipping bucket rain gauge located near the base of the 10m tower. According to the Davis-Besse Nuclear Power Station Operating License, Appendix A, Technical Specification, a minimum of six instruments are required to be operable at the two lower levels (75 m and 10 m) to measure temperature, wind speed and wind direction.

The signals from each meteorological instrument are translated by modules located inside the meteorological shelter. These signals are then transmitted to various places as shown in Figure 4-1.

Meteorological System Maintenance and Calibration

Personnel at Davis-Besse inspect the meteorological site and instrumentation regularly. Tower instrumentation maintenance and semi-annual calibrations are performed by inhouse facilities and a outside consulting firm.

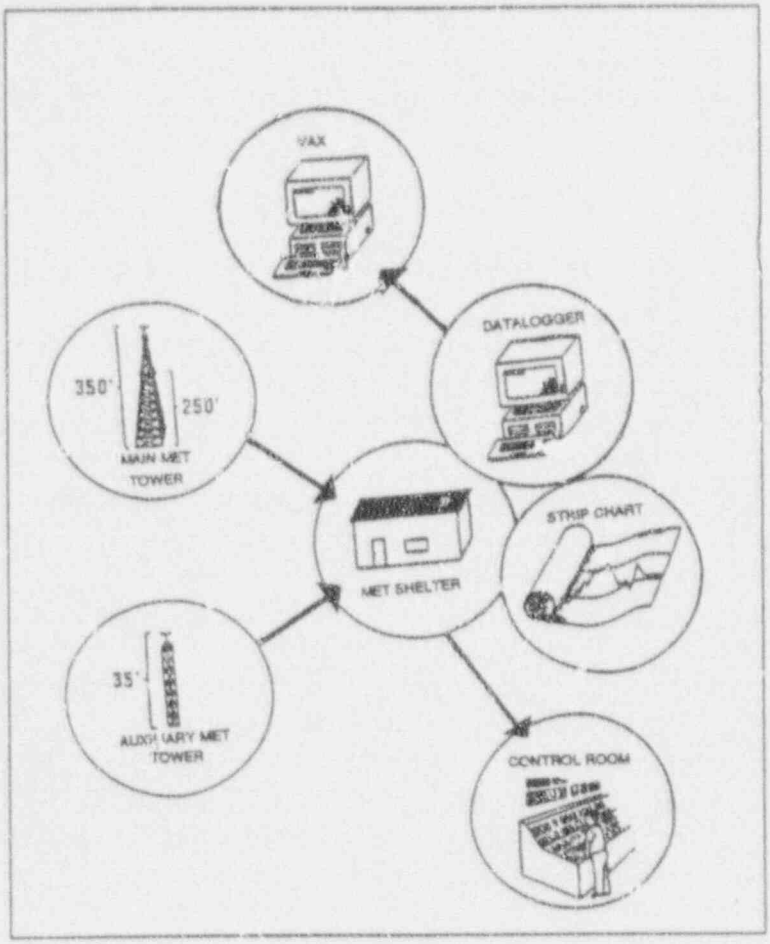


Figure 4-1: The signals from the two meteorological towers are transmitted to many computers located onsite. The information from these towers aid in calculating population doses.

Meteorological Data Handling and Reduction

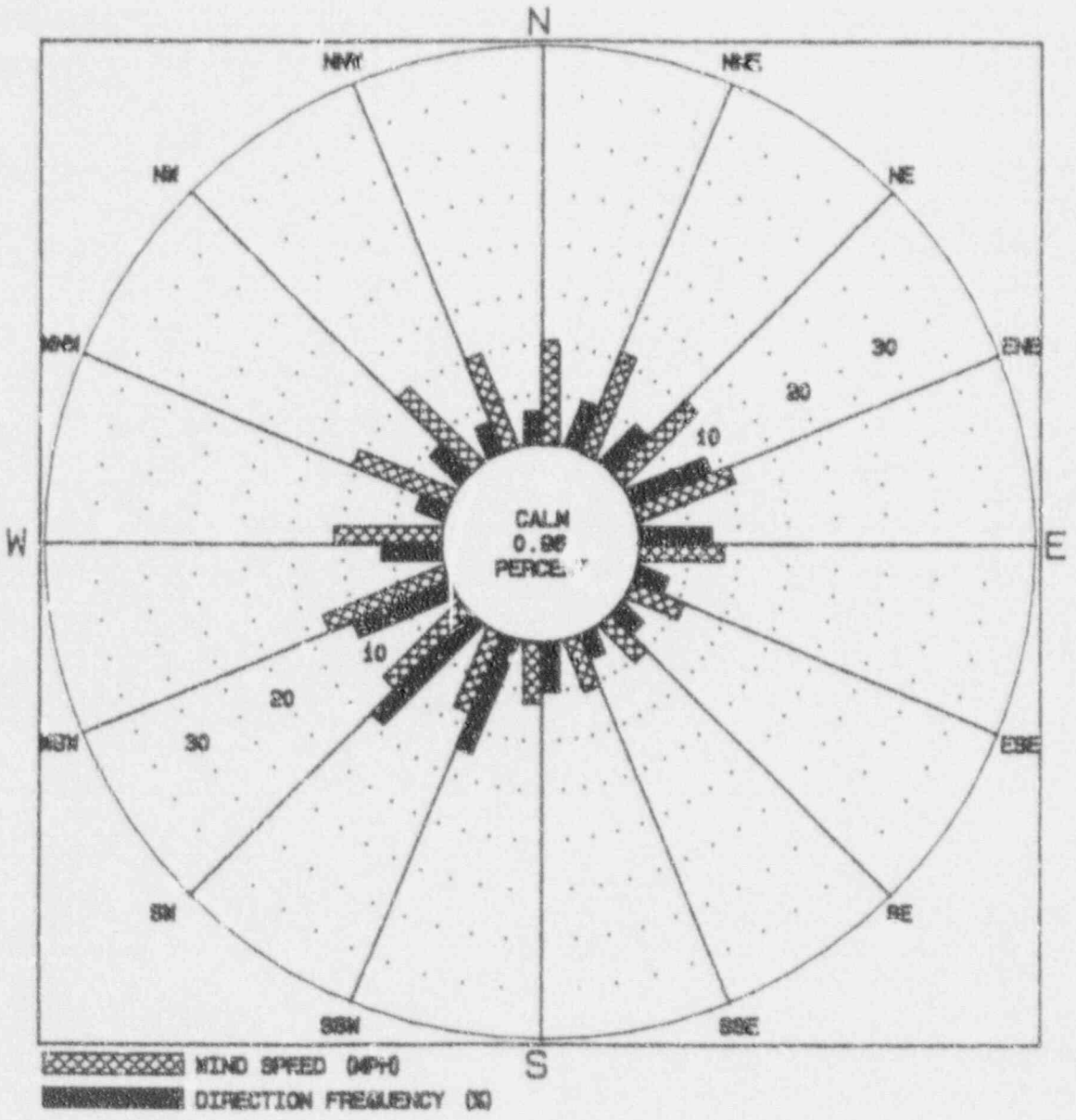
The Campbell Datalogger 21X in the meteorological shelter communicates data to the PDP 11/84. The PDP 11/84 take 900 averages and stores them for each hour in a disk files. This information is then transferred to the vax system. The data are processed and analyzed by several computer programs. Computer listings of the data are generated and values are compared to specified range and rate-of-chance criteria in order to identify anomalies.

Summary statistics and Joint Frequency Distributions (JFDs) of wind and stability data are generated and the results are reviewed for consistency in terms of known site characteristic and regional climatology. The end result of the review process is a validated final database suitable for use by atmospheric dispersion models and for site meteorological characterizations.

Meteorological Data Recovery

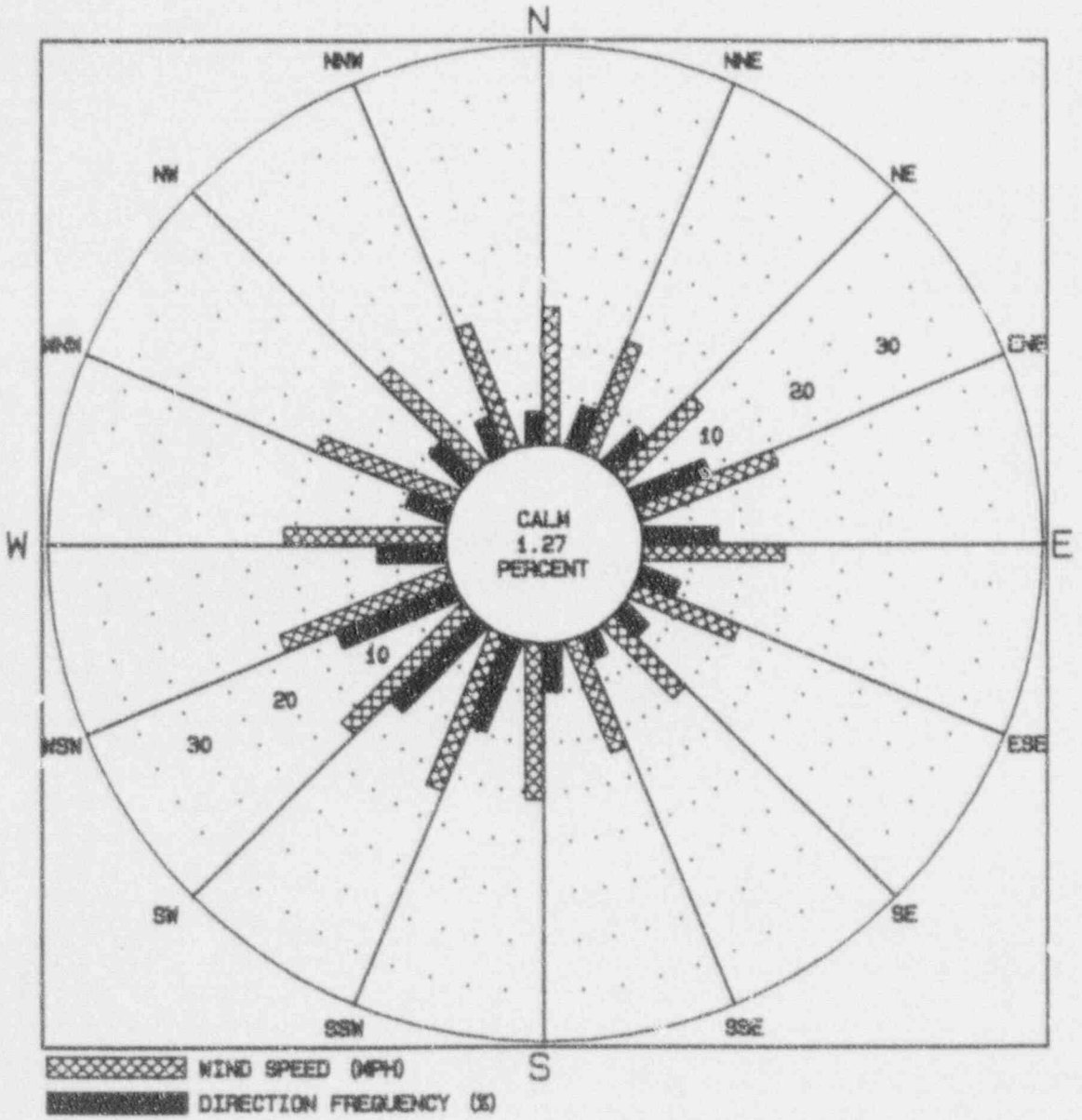
The monthly and annual data recovery statistics for all parameters measured during 1991 are provided in Table 4-1. Data recoveries in Table 4-1 represent the percentage of time a given instrument was operable for the month/year divided by the maximum number of hours in that month/year that the instrument could be operable . Data recovery for 1991 was above 90 percent for all measured parameters. Data recovery for 1991 for the six instruments required by Technical Specification to be operable was also above 90 percent. Table 4-1 also gives monthly and annual recovery rates for joint operability of wind measurements and delta T (differential temperature) for 1991. Annual joint recovery rates were above 90 percent for all combinations of wind and stability data, and above 90 percent for the six instruments required to be operable . Minor losses of data occurred during routine instrument maintenance and calibration and data validation.

Figure 4-2: 10 meter Wind Rose for January through December 1991



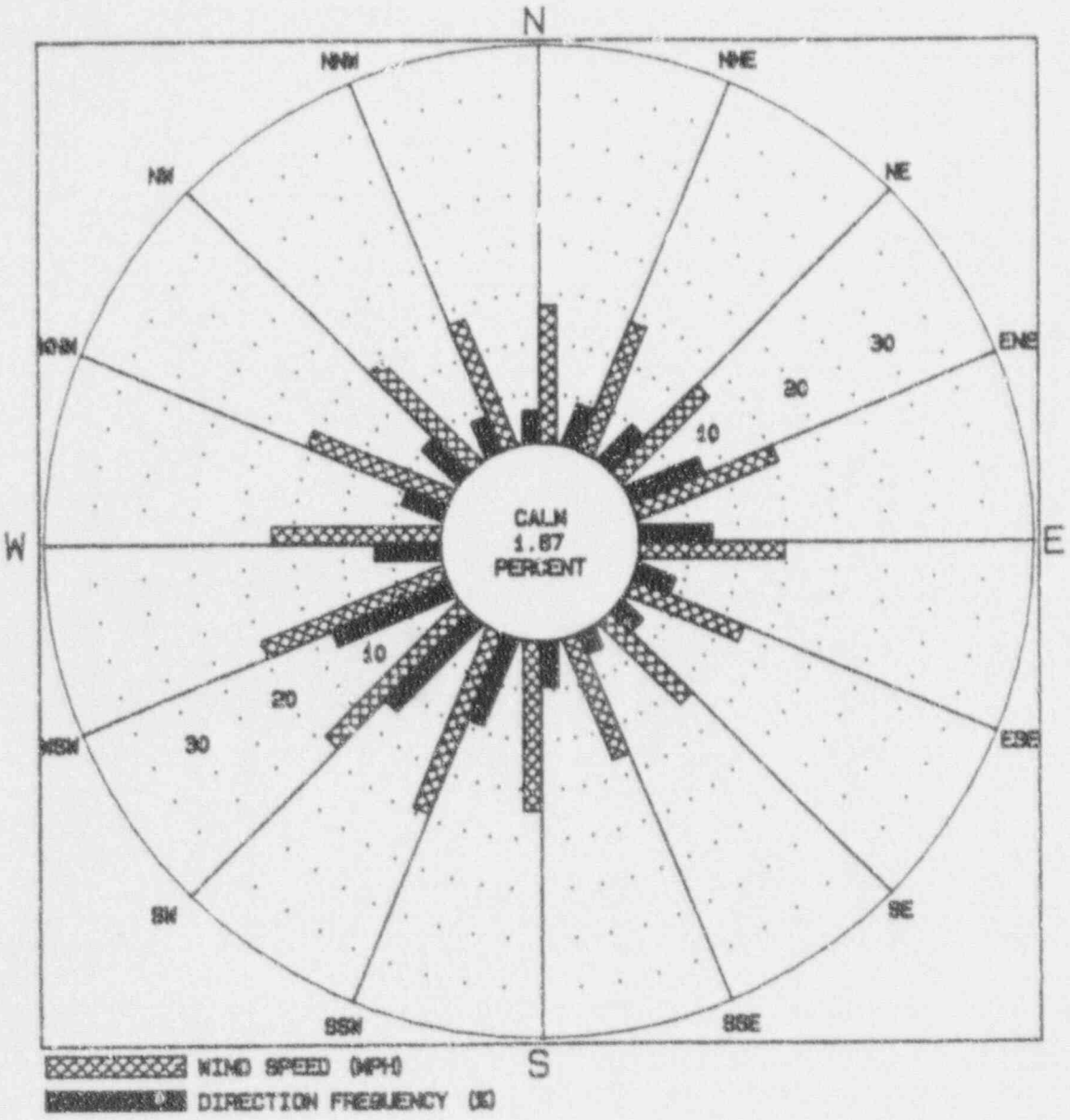
DAVIS-BESSE
ANNUAL 1991
10M LEVEL

Figure 4-3: 75 meter WInd Rose for January through December 1991



DAVIS--BESSE
ANNUAL 1991
75M LEVEL

Figure 4-4: 100 meter WInd Rose for January through December 1991



DAVIS-BESSE
ANNUAL 1991
100M LEVEL

Table 4-1

Summary Of Meteorological Data Recovery For The Davis-Besse Nuclear Power Station
January 1, 1991 Through December 31, 1991*

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
100m Wind Speed	99.73	82.59	100.00	100.00	95.56	100.00	96.51	98.12	99.72	100.00	99.03	99.87	97.56
100m Wind Direction	99.73	99.85	100.00	100.00	95.56	100.00	100.00	98.39	99.72	100.00	97.50	99.87	99.21
75m Wind Speed	99.73	99.85	100.00	100.00	95.56	100.00	100.00	97.85	99.72	98.66	99.03	99.87	98.09
75m Wind Direction	99.73	99.85	100.00	100.00	95.56	100.00	100.00	97.85	99.72	99.06	99.03	99.87	99.22
10m Wind Speed	99.73	88.39	100.00	100.00	95.56	100.00	100.00	98.12	99.72	100.00	99.03	99.87	99.20
10m Wind Direction	99.73	99.85	100.00	100.00	95.56	100.00	100.00	98.39	99.72	100.00	97.36	99.87	99.20
10m Ambient Air Temp	100.00	99.11	99.87	99.31	95.43	100.00	99.60	98.25	99.58	99.06	97.92	99.87	99.02
10m Dew Point Temp	100.00	99.70	100.00	99.58	95.43	100.00	100.00	98.25	99.58	100.00	97.92	05.24	91.13
Delta T (100m-10m)	100.00	99.40	99.87	99.58	95.83	100.00	99.60	98.39	99.44	99.06	07.92	99.87	99.08
Delta T (75m-10m)	100.00	99.85	89.78	99.58	95.83	100.00	99.60	98.39	99.58	99.06	97.92	99.87	98.26
Joint 100m winds and Delta T (100m-10m)	99.73	82.14	99.87	99.58	93.28	100.00	96.10	98.12	99.44	99.06	97.50	99.87	97.16
Joint 75m winds and Delta T (100m-10)	99.73	85.27	99.87	99.58	94.62	100.00	99.60	97.72	99.44	97.18	97.50	99.87	97.16
Joint 75m winds and Delta T (75m-10m)	99.73	85.71	89.78	99.58	94.62	100.00	99.60	97.72	99.58	97.18	97.50	99.87	96.80
Joint 10m winds and Delta T (75m-10m)	99.73	88.39	89.87	99.58	94.62	100.00	99.60	98.12	99.58	99.06	95.83	99.87	97.07

* All data for individual monthes expressed as percent of time instrument was operable during the month, divided by the maximum number of hours in that month that the instrument could be operable. Values for annual data recoveries = percent of time instrument was operable during the year, divided by the number of hours in the year that the instrument was operable.

Table 4-2

Summary of Meteorological Data Measured at Davis-Besse Nuclear Power Station
January 1, 1991 through December 31, 1991

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
100m Wind												
Max Speed (mph)	42.9	34.0	51.4	38.7	35.8	27.1	51.2	33.7	30.8	38.1	45.1	45.1
Date of Max Speed	23	22	28	15	18	3	7	20	16	5	30	14
Min Speed (mph)	1.7	2.4	1.3	2.1	1.3	1.3	2.1	1.6	1.8	1.4	0.5	1.7
Date of Min Speed	6	28	11	28	21	8	10	2	5	30	8	19
75m Wind												
Max Speed (mph)	40.7	31.3	49.7	56.6	33.8	24.8	23.4	29.8	29.5	36.7	44.1	42.5
Date of Max Speed	23	22	28	15	18	15	7	3	16	5	30	14
Min Speed (mph)	1.0	2.6	1.3	2.6	1.8	1.0	2.1	1.1	1.4	0.8	0.2	1.8
Date of Min Speed	29	28	11	24	21	8	16	20	21	26	8	11
10m Wind												
Max Speed (mph)	33.2	21.8	39.1	42.4	27.1	20.7	15.9	25.6	22.3	27.6	39.2	32.2
Date of Max speed	23	22	28	15	7	3	5	8	16	5	12	14
Min Speed (mph)	1.3	1.4	1.1	1.1	1.1	1.3	1.2	1.1	1.4	1.9	0.5	0.7
Date of Min Speed	5	1	10	25	21	8	15	12	6	12	9	14
10m Ambient Temp												
Max (^{0}F)	45.6	55.6	71.3	80.9	88.0	91.5	91.9	88.0	90.8	NA	63.8	60.4
Date of Max	15	4	21	7	16	15	20	1	15	NA	20	8
Min (^{0}F)	6.7	6.0	23.6	30.7	44.2	59.3	60.2	57.4	39.7	33.0	15.7	10.1
Date of Min	22	16	12	2	3	14	25	21	27	20	8	5

Table 4-2

Summary of Meteorological Data Measured at Davis-Besse Nuclear Power Station
January 1, 1991 through December 31, 1991 (con't)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
10m Dew Point Temp												
Mean (°F)	20.3	24.5	31.1	42.8	56.6	50.9	62.7	62.1	52.3	44.4	31.7	26.3
Max (°F)	40.9	47.5	50.0	67.4	78.8	73.3	75.4	73.5	72.9	63.9	59.5	32.6
Date of Max	16	19	27	29	9	15	22	28	9	25	19	1
Min (°F)	-3.5	-1.5	11.2	13.6	33.1	42.0	51.3	45.6	27.0	21.3	6.7	17.1
Date of Min	21	1	30	2	2	13	28	11	23	16	6	2
Precipitation												
Total (inches)	2.79	1.15	1.08	3.74	3.61	2.07	1.36	10.54	1.68	6.19	3.10	NA

NA- Not Available

Marsh Management

Navarre Marsh

The Navarre Marsh is approximately 733 acres of low lying wetland which surrounds the Davis-Besse Nuclear Power Station, located on the southwestern shore of Lake Erie. The Toledo Edison and Cleveland Electric Illuminating Companies co-own the marsh. It is leased to the U.S. Fish and Wildlife Service (USFWS), who manages it as part of the Ottawa National Wildlife Refuge. Protective dikes and access roads in the marsh are maintained by the Toledo Edison Company. Environmental Compliance (EC) personnel at Davis-Besse are responsible for conducting marsh inspections and generating monthly status reports, recommending management actions, and actively controlling undesirable plant species. Results from the marsh inspections are compared to the activity levels expected by the USFWS for each seasonal period, and from this comparison an evaluation of the marsh progress is made.

The Navarre Marsh is completely enclosed by a system of dikes and revetments to protect it from flooding and the wave action of Lake Erie. A **dike** is a retaining structure designed to hold back water for purposes of flood control and to aid in managing a marsh for waterfowl and wildlife. Dikes are also routinely used to convert wetlands into land suitable for farming. When used as a marsh management tool, dikes aid in controlling the water levels required to obtain the desired vegetation beneficial to wildlife. Manipulating water levels is one of the most important management tools used in the Navarre Marsh. Simply by lowering or raising water levels within the marsh, certain plant species can be encouraged or discouraged to grow. From a wildlife management standpoint, plant species that provide either food (e.g. smartweed) or shelter (e.g. cattail) for native wildlife, are more desirable that plant species than serve do not provide these (e.g. purple loosestrife).

A **revetment** is also a retaining structure designed to hold back water for purposes of erosion control and to encourage beach formation. Revetments are built at a gentler slope (e.g. a ratio of three to one). As waves strike the gradual slope of a revetment, their energy dissipates, allowing the sediment load to drop out at the base of the revetment. Because a revetment extends

well out into the water, it actually encourages beach formation by this passive deposition of sediment.

A marsh is generally found in low-lying flat areas and are characterized by a wide diversity of plant life as the elevation changes. The Navarre Marsh has a varied landscape with different plants found in each elevation. The majority of vegetation is found in the **fresh water marsh.** Three kinds of vegetation grow here: **emergents, submergents,** and **floating plants**. Emergents grow in wet soil or out of the water and include cattails, smartweed, and arrowhead. Submergents, such as pondweed and water milfoil, thrive beneath the water's surface. Floating on the water are greater and lesser duckweed , and water lilies. All these plants provide food, cover and nesting areas essential to wildlife.

The Navarre Marsh is bordered by a narrow, dry beach ridge along the lake front. The beach supports a limited number of woody plants and has many standing dead trees, frequently occupied by birds of prey such as bald eagles. Extending out from the beach is a sandbar which formed over the last several years after the revetment was constructed in early 1988. As discussed earlier, the revetment helps dissipate lake wave action, allowing suspended particles in the water to settle out and accumulate, eventually forming a sandbar. The sandbar then acts as a natural barrier, protecting the shore from storms and wave action. In addition to protecting the shoreline, the sandbar also benefits local wildlife. Shorebirds and waterfowl are often seen resting and feeding in this area. Lower lake levels in 1989 also exposed shorelines that were underwater during previous years. These lower levels also contributed to the formation of the beach at the base of the revetment.

The Navarre Marsh also supports a variety of other habitats, including a swamp forest and wet meadows. Bluejoint grass and rice-cut grass are the major wet meadow plants. In the swamp forest, the soil is poorly drained or underwater for part of the growing season. The swamp forest supports woody plants such as cottonwood, willows, buttonbush and several understory plants such as poison ivy, sumac, and swamp loosestrife. Navarre Marsh is unique to this area because of the buttonbush found in the swamp forest. Buttonbush (*Cephalanthus Occidentalis*) is becoming rare along Lake Erie and so it is becoming increasingly important to protect those habitats that support the buttonbush population. Studies have shown that 90% of Navarre Marsh's black-crowned night heron use the buttonbush swamp for feeding and resting. Green herons have also been observed resting in the area (Meeks and Hoffman, 1979).

A wide variety of birds utilize Navarre Marsh. The best-known resident is the Canada goose, abundant throughout the marsh and around the site. Besides natural nesting sites, several artificial nesting structures, such as wood duck boxes and goose tubs, are provided. The boxes and tubs represent a collective effort of U.S. Fish and Wildlife Service, Ohio Department of Natural Resources (ODNR), and Davis-Besse personnel. The marsh also provides waterfowl with a feeding and resting place during their migration. Besides waterfowl, raptors such as owls, hawks, and eagles also frequent the marsh. In the spring and fall, warblers, vireos, kinglets and a variety of other songbirds stop here during their migration. Great blue herons and great egrets use the marsh as a feeding and resting area during the breeding season. Gulls, rails, killdeer and a wide variety of other wading birds can be observed throughout the year in the Navarre Marsh.

Mammals also use the Navarre Marsh throughout the year. The most noticeable resident is the muskrat. The marsh is dotted with muskrat houses which serve a dual purpose: they provide homes for muskrats and nesting places for waterfowl. The muskrat population in Navarre Marsh is kept in balance by trappers who are supervised by personnel from the Ottawa National Wildlife Refuge. Other mammals inhabiting the Navarre Marsh include raccoon, red fox, mink, and whitetail deer.

Special Projects in 1991

Toledo Edison is committed to protecting the Navarre Marsh and has gone to great lengths to preserve this valuable resource. This is best illustrated by the extensive dike system built to protect the area from flooding, and by the many special projects conducted in the marsh each year. In 1991, these special projects included controlling undesirable plant species, songbird banding, Canada goose banding and nesting surveys, wood duck banding and nesting box relocation. A brief description of each of these projects is provided in the following paragraphs.

Not all of the plants found in Navarre Marsh are beneficial to wildlife. **Purple loosestrife** *(Lythrum salicaria)* is one such undesirable species. This exotic plant, introduced from Europe, is an aggressive species which tends to crowd out valuable plants. Each summer, Environmental Compliance personnel record and map the locations of all purple loosestrife plants found within the marsh. Once sighted, the staff attempts to control the spread of the species through the use of approved herbicides and by removing smaller individual plants.

One other undesirable plant species found in Navarre Marsh is the **giant reed** (*Phragmites australis*). These tall plants often grow thick, dense stand which crowd out more beneficial plant species. Environmental Compliance personnel attempt to control the giant reed through limited herbicide spraying under the direction of the U.S. Fish and Wildlife Service. In controlling these undesirable plant species, the rich plant diversity in the Navarre Marsh is maintained.

The songbird banding project was conducted in cooperation with the ODNR from March through June 1991. The project involved capturing and banding song birds migrating through the area. A total of 6,932 individual birds were banded.

Many of the wood duck boxes installed in 1990 were used in 1991. Several of the boxes housed families of wood ducks. Other boxes were utilized by a hooded merganser, starlings and screech owls. Similar efforts for providing nest structures will be taken in 1992. Potential species for which artificial structures will be provided include: wood duck, black duck, mallards, martins, and bats.

References

1. "The Audubon Society Nature Guides: Wetlands," National Audubon Society, Inc. (Marsh 1985).

2. "The Ecology of Coastal Marshes of Western Lake Erie: A Community Profile,"Biological 85(7.9), U.S. Fish and Wildlife Service, Dept. of Interior and Corps of Engineers, U.S. Department of Army (February 1987).

3. Meeks and Hoffman, "Bird Populations Common to the Sister Islands, the Role of the Navarre Marsh", (1979).

Zebra Mussel Control

Introduction

(*Dreissena polymorpha*), is more commonly known as the zebra mussel because of its striated shell, is a native European bivalve that was accidentally introduced into North American waters in 1988 and was discovered in Lake Erie in 1989. Zebra mussels are prolific breeders which rapidly colonize an area by secreting byssal threads which enable them to attach to solid surfaces and to each other. Because of their ability to attach like this, they may form layers several inches deep. This poses a problem to facilities that rely on water intakes from Lake Erie because mussels may attach to the intake structures and restrict water flow. Zebra mussels have not yet caused significant problems at Davis-Besse, but mussels were found attached to the intake crib (the structure that allows water to be pulled in from the lake) and the first section of the intake conduit (the pipe that connects the crib to the intake canal). However, mussels have not attached to the latter portion of the conduit of the intake canal which supplies water to the plant. The mussel were removed from the crib with high pressure water which also destroys the mussels as well. In 1991, zebra mussels were found covering approximately 80% of the trash racks (moving screens which filter out large debris),however, this did not affect plant operations.

At Davis-Besse, zebra mussels are monitored to estimate their population density, which will determine the severity of the problems they may cause. The life cycle of the mussel and the effects of certain variables (wind, temperature, and chemicals) on mussels and veligers, the larvae stage of the mussel, are being studied to determine a means of controlling mussel population.

Monitoring

The Zebra Mussel Monitoring Program, implemented by the Environmental Compliance Unit, has been in place since April 1990. The program involves the collection of several types of samples which are observed for the presence of adult zebra mussels or the free-swimming larval forms, veligers. The frequency of sampling is determined by lake water temperature. Samples are only taken when the lake temperature is above 12 ° C because this is the

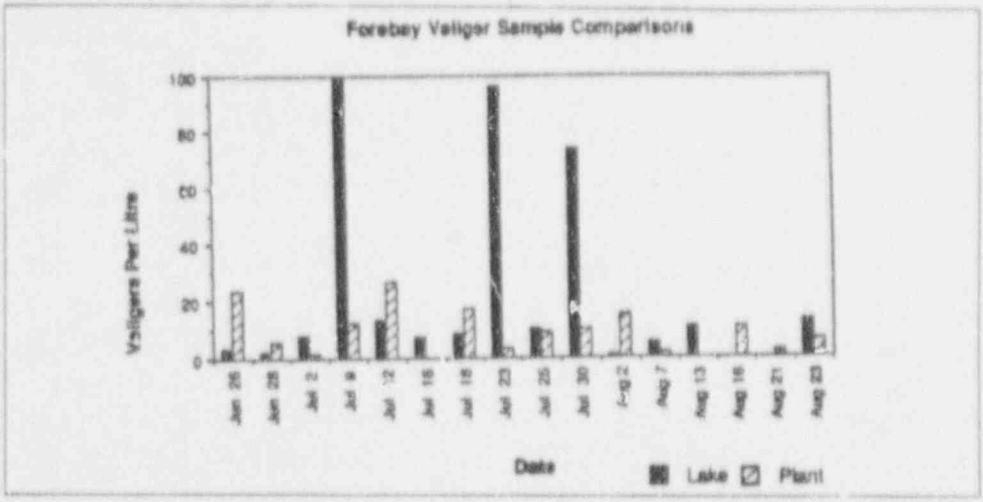


Figure 6-1: The graph (above) shows the peaks in veliger population during July 1991 and that the veliger population is less dense in the intake near the station compared to the veligers near the lake.

temperature at which spawning may occur. At temperatures above 18°C, when spawning conditions are most favorable, more frequent samples are taken. Weather data and water temperatures are also recorded to determine their effects on mussel population.

Water samples are collected monthly in the Toussaint River and bi-weekly in the station's intake forebay. These samples are collected using a plankton net sampler: a net support system with a straining bucket used for plankton-size (microscopic) organisms which include veligers. One milliliter from each sample is observed under a microscope to check for the presence of veligers to determine the average number of veligers per liter. Then a standard comparison may be made from water samples of different volumes (Figure 6-1).

One other type of sample is collected, but it is observed for the presence of adult mussels rather than for veliger stages. This sample is taken from the bottom of the screenwash basin which collects debris from the water intake traveling screen. It is collected by using a device called an Eckman Dredge. The dredge has a pair of spring loaded jaws that close to trap a sediment sample. The sample is then dumped onto a screen and sifted through to count the number of adult mussels.

Research

The Environmental Compliance Unit is involved with the Electric Power Research Institute (EPRI) in studying the effects of proprietary and commercial

cals on zebra mussels. The purpose of the study is to determine what may influence mussel mortality and/or detachment. Figure 6-2, shows a skid designed by EPRI to roughly simulate an in-plant water system was constructed for use at Davis-Besse. The skid consists of four different-sized cells, ranging from 1-1/2" to 3" in diameter with a valve connected to each that allows the water flow to be adjusted. Mussels are placed inside the cells then water is pumped from the forebay through the system. A chemical feed pump is connected to the system so that chemicals can be introduced into three of the cells. The fourth is the control cell that enables comparisons to be made with different chemical conditions in the other cells.

The skid was used in the summer and fall of 1991 to test the efficiency of a Union Carbide molluscide. The chemical was shown to be very effective against zebra mussels in higher water temperatures (approximately 23°C). However, the chemical was found to be rather ineffective in lower water temperatures below 15 °C. Present plans for 1992 are continuing experimentation with molluscides to determine the effectiveness on controlling zebra mussels.

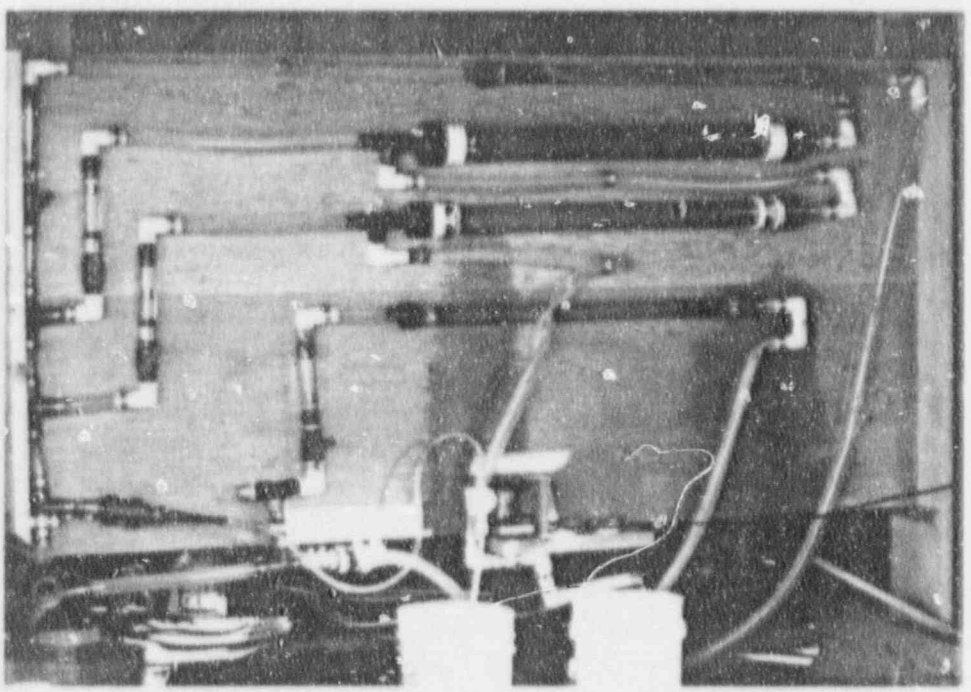


Figure 6-2: The skid designed by EPRI that is used for zebra mussel experimentation at Davis-Besse.

Water Treatment

Water Treatment Plant Operation

Description

The Davis-Besse Nuclear Power Station uses Lake Erie as a water source for its water treatment plant. The lake water is treated with chlorine, lime, sodium aluminate, and coagulant aid to make the water clean and safe for consumption. This water may also be further treated by a demineralizing process to produce water which is used by much of the Station's equipment, including the turbine. This process is used to produce high purity water to maintain plant system integrity.

Operation of the water treatment plant falls under the purview of the Ohio Environmental Protection Agency (OEPA) and the Ohio Department of Health. The operation of the facility is reviewed by a certified operator, Public Water Supply. Activities at the water treatment plant are conducted in compliance with the Safe Drinking Water Act, and the regulations for public water supply as set forth by the OEPA.

Monthly operational reports, required by the OEPA, are completed and submitted to the agency. These reports include the Drinking Water Operation Report (OEPA form 5002) and the Drinking Water Contaminant Report (OEPA form 5001). These reports contain sample dates and analytical results, which are compared to standards established by the OEPA. Operation of the water treatment plant is maintained by the Chemistry Department and monitored by the Environmental Compliance (EC) Unit through weekly inspections. Operational data are also reviewed for compliance with the limits set by the OEPA. As a further means of monitoring water quality, drinking water is sampled annually for pesticides, herbicides, and heavy metals (such as chromium, arsenic, mercury, lead) and quarterly for radioactivity and certain organic chemicals. The health and safety of the water treatment plant operators and other site personnel are ensured through weekly housekeeping inspection of the facility.

Clarifier Operation

The water treatment plant at Davis-Besse uses upflow clarifiers, or precipitators, to remove sediment, organic debris and dissolved agents from the raw water prior to filtration. Clarifiers combine the conventional treatment steps of coagulation, flocculation, and sedimentation into a single unit. Coagulation is the process by which a chemical, called a coagulant, is added, causing the small particles in the water to adhere to each other and form larger particles. During flocculation, the water is gently circulated, allowing these conglomerate particles to mass together further. Finally, during sedimentation, large conglomerate particles settle to the bottom of the clarifier. These processes normally require large separate tanks. However, the use of clarifiers saves both space and the manpower needed to operate the treatment plant.

The sediment removed during clarification is routed to settling basins. The sediment settles to the bottom of the basin, allowing the clear supernatant to be discharged to the lake.

The water treatment plant has two precipitators with separate chemical addition systems, allowing for operation of one or both of the units. Throughout 1991, precipitator number two was operational while precipitator number one was out of service for cleaning and maintenance.

New Drinking Water Rules

The OEPA has issued several new rules for water treatment plants utilizing surface water sources, which includes Davis-Besse. More rigid turbidity standards and additional bacteriological monitoring requirements are among those new rules which took effect in 1991.

The OEPA has also issued additional rules concerning disinfection requirements and turbidity standards which will take effect in June 1993. These additional requirements are more stringent than current rules. Some modifications to the water treatment plant will be required. For example, the new disinfection requirements may require baffling of the clearwell in order to increase the amount of time the water remains in the treatment system. Also, new continuous monitoring equipment and additional computer access to data are being considered in order to better comply with these requirements, as well as those of the future.

Wastewater Treatment Plant Operation

The wastewater treatment plant (WWTP) operation is supervised by a state certified Wastewater Operator. Wastewater generated by site personnel is treated at an onsite extended aeration package treatment facility designed to accommodate a flow of 38,000 gallons per day (gpd). This facility (Figure 7-1) consists of two units, WWTP Number 1 is a 15,000 gpd plant, and WWTP Number 2 is a 23,000 gpd plant. In the treatment process, wastewater from the various collection points around the site, called lift stations, enters the facility at the equalization chamber. This structure is simply a chamber which collects raw wastewater and distributes it to the surge tanks of the treatment plants.

The wastewater is then pumped into the aeration tanks. Here, organic materials are digested by microorganisms which must be provided with a source of oxygen. This is accomplished through the use of blowers. The mixture of organics, microorganisms, and decomposed wastes are called activated sludge. The treated wastewater settles in a clarifier, and the clear liquid (supernatant) passes over a weir, leaving the plant by an effluent trough. The activated sludge contain the organisms necessary for continued treatment, and is pumped back to the front of the plant to digest more incoming wastewater. The effluent leaving the plant is disinfected with chlorine and is pumped to the wastewater treatment basin (NPDES Outfall 601) where further reduction in solids content and in Biochemical Oxygen Demand (BOD) takes place.

Summary of 1991 Wastewater Treatment Plant Operations

WWTP Number 1 was taken out of service in early May 1989 after operators observed that the walls separating two of the plant's treatment tanks were bowing several inches. The plant was completely drained and supports were installed to alleviate this problem. The plant was also painted at that time. The plant was originally scheduled to be returned to service in 1991, but due to delays caused by the refueling outage and other activities, work was not completed until the end of 1991. Current plans are to place WWTP Number 1 back into service early in 1992. Later that year WWTP Number 2 will be removed from service for cleaning and maintenance.

The domestic water supply for the wastewater treatment facility was disrupted for most of 1991. The first time this occurred was in March when a ruptured pipe was discovered. The pipe was repaired and the domestic water supply was returned in August. The water supply was disrupted again in

October, when another ruptured water pipe was discovered. Repair to the line is currently in progress.

Biochemical Oxygen Demand (BOD) is an analytical procedure designed to determine how polluted the water is. The more organically active the wastewater is, the more oxygen it will consume. Hence, BOD measures the demand for this oxygen; the higher the BOD, the greater the treatment required. In 1991, water entering the treatment system had an average BOD of 163 mg/L, while water leaving the system averaged only 5 mg/L. This represents a total BOD reduction of 97%.

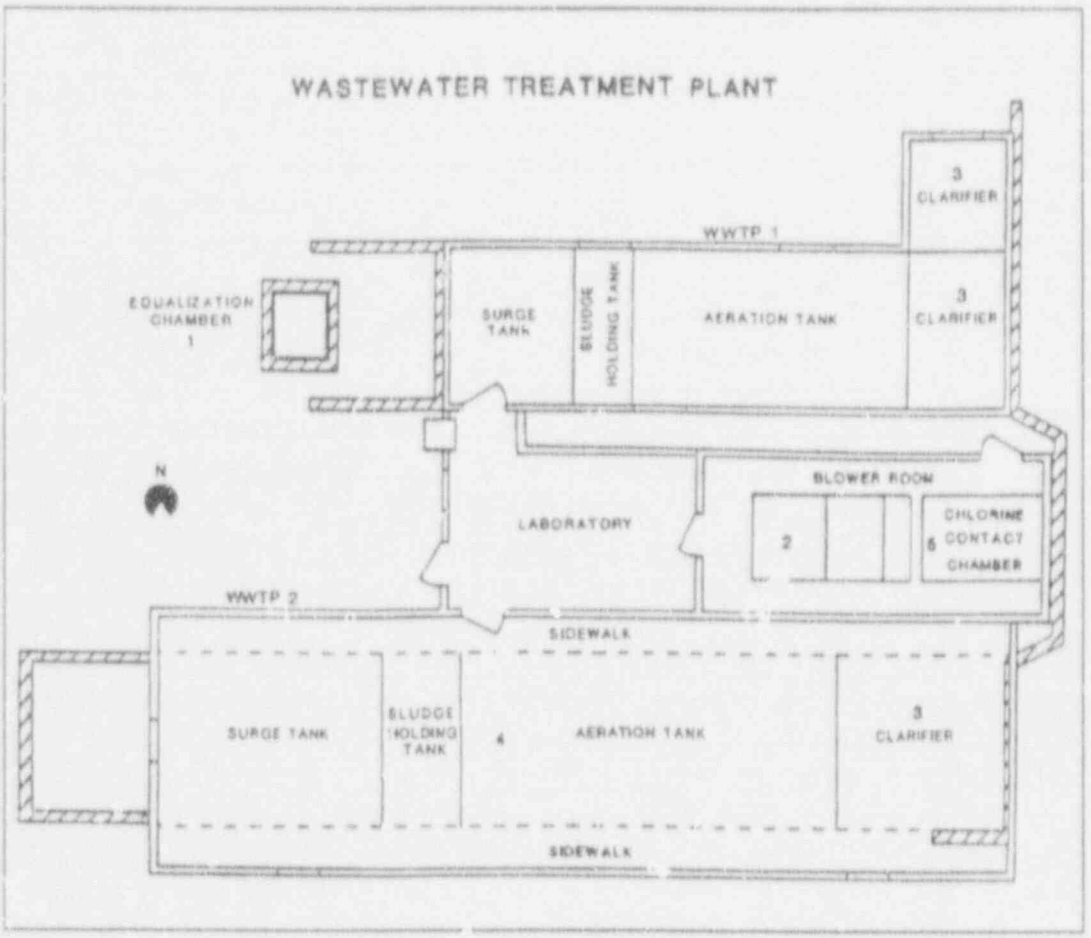


Figure 7-1: A diagram of the Wastewater Treatment Plant.

National Pollutant Discharge Elimination System (NPDES) Reporting

The OEPA has established limits on the amount of pollutants that Davis-Besse may discharge to the environment. These limits are regulated through the Station's National Pollutant Discharge Elimination System (NPDES) permit, number 2iB0011 * ED. Parameters such as chlorine, suspended solids and pH are monitored under the NPDES permit. Davis-Besse personnel prepare the NPDES Reports and submit them to the OEPA by the fifteenth day of each month.

Davis-Besse has six sampling points described in the NPDES permit. Five of these locations are discharged points, or *outfalls*, and one is a temperature monitoring location. Descriptions of these sampling points follow:

Outfall 001

Collection Box: At a point representative of discharge to Lake Erie.
Source of Wastes: Low volume wastes (Outfalls 601 and 602), circulation system blow down and occasional service water (sample collected at Davis-Besse Beach Sampling Station).

Outfall 002

Area Runoff: Discharge to Toussaint River.
Source of Wastes: Storm water runoff, turbine building drains, circulating pump house sumps (sample collected at discharge of Training Center Pond).

Outfall 003

Screenwash Catch Basin: Outfall to Navarre Marsh.
Source of Wastes: Wash debris from water intake screens (sample collected at overflow of screenwash basin).

Outfall 601

Wastewater Plant Tertiary Treatment Basin: Discharge from wastewater treatment system.
Sources of Wastes: Wastewater Treatment Facility.

Outfall 602

Low Volume Wastes: Discharge from settling basins.
Sources of Wastes: Water treatment residues, condensate polishing resins (sample collected at overflow number 2 basin),and condensate pit sumps.

Sampling Point 801

Intake Temperature: Intake water prior to cooling operation (temperature taken at the east end of the intake forebay).

1991 NPDES Summary

Outfall 001

Through conscientious operation and careful monitoring of discharges, chlorine levels at the outfall were consistently well below established limits, while pH values remained within the required range.

Outfall 002

The discharge gate was isolated from March until August due to station drainage to the pool 3 via the station storm water system. The gate was opened in late August due to high flow condition resulting from heavy rains. The discharge was again isolated at the end of October due to station drainage, but it was opened in November in preparation for the winter months.

Outfall 003

The screenwash catch basin overflow requires a single total suspended solids analysis each month and has no set limitations. No significant problems occurred at this outfall in 1991.

Outfall 601

Algae populations thrive on the nutrient-rich water in the wastewater treatment basin. Although algae play an important role in tertiary, or final clean-up, excessive numbers can adversely impact effluent quality. Algae concentrations in 1991 were surprisingly moderate. A single algicide treatment and isolation of the basin stabilized conditions. The established limits for outfall 601 were not exceeded in 1991.

ment and isolation of the basin stabilized conditions. The established limits for outfall 601 were not exceeded in 1991.

Outfall 602

The established limits for Outfall 602 were not exceeded in 1991. No significant problems occurred at this outfall.

Sampling Point 801

The intake temperature is monitored continuously. Temperature variations between intake and discharge temperatures only ranged as high as 12°F. An average difference of 6.2°F was recorded for the year.

Storm Water Monitoring

In 1991, the United States Environmental Protection Agency (USEFA) issued new requirements for storm water discharges. These requirements have been part of the NPDES program for several years, but no formal requirements for monitoring were issued until 1991.

In this new program, the USEPA requires all industries who discharge storm water to waterways of the state to monitor all such outfalls and submit applications to the USEPA for the issuance of a permit to discharge. Davis-Besse has three required discharge points which are currently being monitored. The parameters monitored vary at each discharge location according to what is expected to be discharged, but these parameters are very similar to those in the NPDES program.

Sampling of these discharge points is conducted during storm events with average duration and quantity of rain fall. Sampling consists of collecting a grab sample of water during the first thirty minutes of discharge and grab samples every twenty minutes thereafter up to four hours. All samples are combined to make a single composite sample. Flow measures are taken simultaneously with each grab samples in order to get a flow-weighted composite. Only one set of data for each discharge point is required for the permit application, but sampling may be conducted as often as time permits.

All applications must be submitted to the USEPA by November 1992. After that time, the USEPA will evaluate the information and provide additional guidance as to what is required for each industry and each discharge location on a case-by-case basis.

CHEMICAL WASTE MANAGEMENT PROGRAM

Introduction

The Chemical Waste Management Program for chemical, hazardous and non-hazardous wastes generated at the Davis-Besse Nuclear Power Station was developed to ensure wastes are managed and disposed of off site in accordance with all applicable state and federal regulations.

The Chemical Waste Management Program is regulated by the United States Environmental Protection Agency (USEPA) under the Resource Conservation and Recovery Act (RCRA); the Hazardous and Solid Waste Amendment (HSWA); the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund); the Toxic Substance Control Act (TSCA); and the Clean Air Act. The waste transported from Davis-Besse is also regulated by Ohio Department of Transportation (DOT) under the Transportation Safety Act. A brief description of these programs is provided in the following paragraphs.

Waste Management

Resource Conservation and Recovery Act

The Resource Conservation and Recovery Act (RCRA) is the federal law which regulates solid hazardous waste. Solid waste is defined as a solid, liquid, semisolid or contained gaseous material. The major goals of RCRA are to establish a hazardous waste regulatory program to protect human health and the environment and to encourage the establishment of solid waste management, resource recovery, and resource conservation systems. The intent of the hazardous waste management program is to control hazardous wastes from the time they are generated until they are properly disposed of, commonly referred to as "cradle to grave" management. Anyone who generates, transports, stores, treats or disposes of hazardous waste is subject to regulation under RCRA.

Hazardous and Solid Waste Amendment

The Hazardous and Solid Waste Amendment (HSWA) is an important addition to the RCRA. The goals of HSWA are to significantly increase federal regulation of hazardous waste management and to ban the land disposal of most hazardous wastes. In cases where it is not possible to entirely ban hazardous waste from landfills, the regulations state that the waste should be treated according to guidelines and stored or disposed of in a manner that minimizes the present and future threat to human health and the environment. This amendment also promotes the recycling, recovery, or reuse of waste by sending it to waste-to-energy facilities, distillation facilities, and fuel blending facilities. These activities would result in a reduction of waste being disposed of in our nation's dwindling landfill space. An additional HSWA goal is to minimize the generation of waste through such methods as source reduction, product substitution, technology/process modification and raw material modification.

The Davis-Besse Nuclear Power Station has been designated as a large quantity generator of hazardous waste. This limits the Station to a maximum storage period of 90 days for hazardous waste. RCRA also mandates other requirements for large quantity generators, such as the use of proper storage and shipping containers, labels, manifests, reports, personnel training, spill control plan and an accident contingency plan, all of which are part of the Chemical Management Program at Davis-Besse. In 1991, 7,533 gallons of hazardous waste were transported off site for disposal. An additional 323 gallons of non-hazardous waste were disposed of in 1991. The following are completed as part of the hazardous waste management program to ensure compliance with the RCRA regulations

- Inspections

Chemical Waste Storage and Accumulation Areas are designed throughout the site to ensure proper handling and disposal of chemical waste. The Chemical Waste Accumulation and Storage Areas are routinely patrolled by security personnel and inspected weekly by Environmental Compliance personnel. Inspection log sheets, inspection reports and maintenance work requests are completed as needed after each inspection. The log sheets and in-spection reports are retained for three years. All areas used for storage or accumulation of hazardous waste are posted as such with warning signs, and drums are color-coded for easy identification of waste categories by Davis-Besse employees. EC personnel also periodically inspect the Hazardous Waste Emergency Equipment and areas throughout the Station and site to ensure waste is not stored in unapproved areas.

- Waste Inventory Forms

Inventory forms are placed on waste accumulation drums or pasted in the accumulation area to allow employees to record the waste type and amount as it is added to the drum. This ensures that incompatible wastes are not mixed and also identifies the drum contents for proper disposal. It also ensures that nonhazardous waste is not mixed with hazardous waste. This eliminates the possibility of unnecessarily increasing the volume and number of containers of hazardous waste and increasing disposal costs.

- Testing of Waste Oil

The majority of waste oil generated at Davis-Besse is not disposed of, but is removed to a recycling facility for thermal energy recovery. Before removal for recycling, the oil is tested to determined that it is nonhazardous. Waste oil that contains less than 1,000 parts per million of halogens and has a flash point above 140° F is considered to be nonhazardous waste. This testing minimizes waste due to the fact that the nonhazardous waste oil is recyclable. Also, disposal cost is minimized due to the lower cost of waste oil recycling than hazardous waste disposal.

- Waste Minimization

Davis-Besse reduced the volume of waste sent to disposal facilities by sending 648 pounds of hazardous waste (used solvents), 7,355 gallons of waste oil and 24 nickel-cadmium battery cells to recycling firms and fuel blenders for thermal energy recovery purposes.

Other measures in waste minimization include the return of polystyrene resins to a plastic manufacturer for reuse, drum recycling and return, and inventorying unused materials being sent to the Centerior Investment Program.

Emergency Response Planning

Comprehensive Environmental Response, Compensation and Liability Act

The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA, sometimes referred to as Superfund) established a federal authority and source of funding for responding to spills and other releases of hazardous materials, pollutants, and contaminants into the environment. Superfund establishes "reportable quantities" for several hundred hazardous material, and regulates the cleanup of abandoned hazardous waste disposal sites.

Superfund Amendment and Reauthorization Act (SARA)

Superfund was amended in October 1986 to establish new reporting programs dealing with emergency preparedness and community right-to-know laws. As part of this program, CERCLA is enhanced by ensuring that the potential for release of hazardous substances is minimized and adequate and timely responses are made to protect surrounding populations. Also, the regulation required the USEPA to develop a list of extremely hazardous substances (EHS), and to established threshold planning quantities (TPQ) for each chemical. Any facility that has these EHS at or greater than the TPQ must submit reports to the State Emergency Response Commission (SERC). The SERC will in turn provide this information to local emergency planning committees to aid in the implementation of emergency response plans.

Davis-Besse conducts site-wide inspections to identify and record all hazardous products and chemicals onsite as required by SARA. Determinations were made as to which products and chemicals were in sufficient quantities to report and, in 1991, the following list was:

- diesel fuel
- hydrazine
- lubricating (petroleum) oils
- Nalco Surecool 1332 (aqueous mixture of organophosphorous compound and acrylic polymer)
- sodium hydroxide
- sodium hypochlorite
- sulfuric acid
- unleaded gasoline

These chemicals are found onsite in quantities greater than or equal to 10,000 pounds. Two of these chemicals, hydrazine and sulfuric acid, are extremely hazardous substances (EHS and exceed the TPQ of 500 lbs). Any new chemicals found to be present in sufficient quantities to report or at threshold planning quantities prior to the next reporting year (1992), must be reported within 90 days of discovery. The TPQ is simply a limit at which certain reporting is required. This allows for the appropriate regulation and tracking of these chemicals. In 1992, the required reporting quantity was the same pound limits as in 1991. Annual SARA reports are submitted by March 1 for the preceding calendar year.

Fifty-five gallon drums containing protective equipment and spill control equipment are maintained throughout the Station at chemical storage areas and at appropriate hazardous chemical and oil use points. Equipment in the kits includes such items as waterproof coveralls, gloves, absorbent cloth, goggles, and warning signs. The spill kits are strategically placed throughout the Station and inspected on a periodic basis to allow for fast and easy response in the event of a chemical or oil spill.

Other Regulating Acts

The Toxic Substance Control Act (TSCA) was enacted to provide the USEPA with the authority to require of new chemical substances for potential health effects before they are introduced into the environment, and to regulate them where necessary. This law would have little impact on utilities except for the fact that one family of chemicals, polychlorinated biphenyls (PCBs), has been singled out by TSCA. This has resulted in an extensive PCB management system, very similar to the hazardous waste management system established under RCRA.

Although TSCA requires inspections every three months, the Davis-Besse PCB Program requires that PCB transformers are inspected on a weekly basis to ensure effective management of PCBs. Visual inspection of the transformers are conducted to detect leakage and avoid potential problems which may arise. In 1991, Davis-Besse continued an aggressive program of reducing the number of PCB transformers on site. There were originally eleven PCB transformers located in the Auxiliary Building, Water Treatment Plant, near Service Building Two and the Personnel Processing Facility.

... 1991, ten of these PCB transformers underwent the final retrofill cycle and were reclassified as "non-PCB". A retrofill cycle involves flushing the PCB fluid out of the transformer, refilling it with PCB-leaching solvents and allowing the solvent to circulate in the transformer during operation. The transformers are retrofilled three times with a leaching solvent and twice with silicone fluid. The entire process takes two to three years and will extract almost all of the PCBs. The transformers were tested in 1991 for PCB levels, and were less than 50 parts per million (ppm), allowing the transformers to be reclassified as non-PCB. The eleventh PCB transformer has received the final retrofill and will be analyzed for non-PCB status in 1992. In 1991, 4,708 kilograms of PCB waste were disposed of.

Clean Air Act

The Clean Air Act identifies several substances which are considered hazardous air pollutants. Of particular significance is asbestos removal from renovation and demolition projects for which USEPA has outlined specific regulations concerning handling, removal, environmental protection and disposal. Also the Occupational Safety and Health Protection Administration (OSHA) strictly regulates asbestos with a concern for worker protection. Removal teams must meet medical surveillance, respirator fit tests, and training requirements prior to removing asbestos-containing material.

In 1991, a notification letter was prepared and submitted to the EPA concerning the removal and disposal of asbestos-containing material from Davis-Besse. The Davis-Besse cooling tower was renovated and approximately 180 cubic yards of cement boards containing nonfriable asbestos were removed and replaced with non-asbestos cement boards. Asbestos is not considered an RCRA hazardous waste, but the EPA does require special handling and disposal of this waste under the Clean Air Act.

Transportation Safety Act

The transportation of hazardous chemicals, including chemical waste, is regulated by the Transportation Safety Act of 1976. These regulations are enforced by the United States Department of Transportation (DOT) and cover all aspects of transporting hazardous materials, including packing, handling, labeling, marking, and placarding. For DOT purposes, the term "hazardous material" encompasses a wide range of materials including explosives, compressed gases, poisonous materials, inhalation hazards, flammable materials, oxidizing materials, irritants, corrosive materials, radioactive materials, and hazardous wastes. Before any wastes are transported off site, Davis-Besse must ensure that the wastes are identified, labeled and marked according to DOT regulations, including verification that the vehicle has appropriate placards and it is in good operating condition.

As stated under RCRA, hazardous wastes are transported for disposal within 90 days from the date accumulation and storage began. Before shipping the waste, approval for disposal is received from the Treatment, Storage and Disposal Facility (TSDF). Prior to transportation, a Uniform Hazardous Waste Manifest is completed and signed by both the generator and the transporter. Once the transporter has delivered the waste to the designated TSDF, the TSDF signs the manifest for shipment receipt and returns the completed manifest to DB.

Other Programs

Underground Storage Tanks

According to RCRA, facilities with Underground Storage Tanks (USTs) are required to notify the State. This regulation was implemented in order to provided protection from tank contents leaking and causing damage to the environment. An UST includes the tank system and its piping which has at least 10% of its volume underground. Additional standards require leak detection systems and performance standards for new tanks. At Davis-Besse the two 40,000-gallon and one 8,000-gallon diesel fuel storage tanks, and the one 2,000-gallon waste oil tank are regulated as USTs.

Burn Permits

As required by the EPA under the Clean Air Act, burn permits for Davis-Besse were submitted for approval. The Station has a small area on site for training employees on proper fire-fighting techniques. Most instruction is on the proper use of a fire extinguisher. A burn permit is submitted every three months to remain in compliance with the Ohio EPA regulations.

Summary

Davis-Besse will continue to remain dedicated to protecting the environment and human health through the use aggressive chemical waste management practices. These practices include recycling of waste oil and batteries and thermal energy recovery for waste solvents. Also, Davis-Besse will continue training employees on the proper handling, storage and disposal of chemical waste.

Glossary

A

absorbed dose	The amount of radiation energy absorbed by any material exposed to ionizing radiation.
ALARA	Acronym for "As Low As Reasonably Achievable," a basic concept of radiation protection that specifies radioactive discharges from nuclear plants and radiation exposure to personnel be kept as far below regulatory limits as possible.
alpha particle	A positively charged particle ejected from the nuclei of some radioactive elements.
atom	The smallest portion of an element that shares the general characteristics of that element and cannot be divided or broken up by chemical means.
atomic number	The number of protons in the nucleus of an atom.
atomic weight	The number of neutrons and protons in the nucleus of an atom.

B

background radiation	The radiation in man's environment, including cosmic rays from space and radiation that exists everywhere in the air, in the earth, and in man-made materials that surround us.

beta particle	A charged particle emitted from a nucleus during radioactive decay, with a mass equal to 1/1837 that of a proton. A negatively charged beta particle is identical to an electron. A positively charged beta particle is called a positron. Beta particles are easily stopped by a thin sheet of metal, plastic, or wood.
borated water	Water containing the element boron used to cool the reactor core in the event of a Loss Of Coolant Accident. Borated water can be sprayed inside the containment building, thus protecting the Reactor Coolant System. Borated water can also be flushed into the reactor vessel. The boron in the water actually absorbs free neutrons, thus removing the catalysts required to drive the nuclear fission process.

C

calibrate	To standardize a measuring instrument by determining its deviation from a standard. The deviation determined allows one to apply a correction factor to a measured value to yield the true value.
chain reaction	A reaction that stimulates its own repetition. In a fission chain reaction, a fissionable nucleus absorbs a neutron and splits, releasing additional neutrons which perpetuate the fission reaction in the nuclei of neighboring atoms.
charged particle	An ion. An elementary particle carrying a positive or negative electric charge.
cladding	The thin-walled tube of zirconium alloy that forms the outer jacket of a fuel rod. The cladding is highly resistant to heat, corrosion and radiation, and comprises the first barrier to the release of fission products.

composite sample	A sample made of grab or continuous samples combined to represent a particular location or a set period of time.
containment vessel	A steel liner inside the concrete shield building. Designed to isolate the primary system from the environment and other systems.
continuous sample	A sample that is collected non-stop and is used to evaluate conditions over a specific period of time.
control location	A sample collection location generally more than 5 miles away from Davis-Besse. It is used to measure the normal background radiation levels.
control rod	A rod containing material such as hafnium or boron, used to control the power of a nuclear reactor. By absorbing neutrons, control rods slow down and eventually stop the fission process.
coolant	A fluid, usually water, used to cool the nuclear reactor core by transferring the heat energy emitted during the fission process into the fluid medium.
cooling tower	A heat exchanger designed to aid in the cooling of water that was used to cool exhaust steam exiting the turbines of the power plant. The cooling tower transfers exhaust heat into the air instead of into a body of water.
cosmic radiation	Penetrating ionizing radiation, both particulate and electromagnetic, that originates in space.
critical group	The segment of the population that could receive the greatest radiation dose.
critical organ	The body organ receiving a radiation dose that could result in the greatest overall effect.

critical pathway	The exposure pathway that will provide, for a given radionuclide, the greatest radiation dose to a population, or to a specific segment of the population.
curie (Ci)	The basic unit used to describe the intensity of radioactivity in a sample or material. One curie is equal to 37 billion disintegrations per second, which is approximately the rate of decay of one gram of radium. A curie is also a quantity of any radionuclide that decays at a rate of 37 billion disintegrations per second.

D

daughter products	Isotopes that are formed by the radioactive decay of other radionuclides.
decay series	A radioactive sequence which an unstable element goes through before reaching a stable state; it usually involves the loss or gain of energy and/or matter.
dike	A retaining structure designed to hold back water for flood control
dissolved solids	Solids incapable of removal through physical means, e.g., via filtration.
dose	A quantity (total or accumulated) of ionizing radiation received in tissue.
dose rate	The radiation dose delivered per unit of time. Measured, for example, in rem per hour

E

effluent	In general, a waste material, such as smoke, liquid, industrial refuse, or sewage discharged into the environment.

electromagnetic	A travelling wave motion resulting from simultaneous changes electric and magnetic fields. Familiar electromagnetic waves range from X rays and gamma rays of short wavelength, through the ultra-violet, visible, and infrared regions, to radar and radio-waves of relatively long wavelength.
electron	An elementary particle with a negative charge and a mass 1/1837 that of the proton. Electrons orbit around the positively charged nucleus and can determine the chemical property of the atom.
element	One of the 103 known chemical substances that cannot be broken down further without changing its chemical properties. Some examples include carbon, hydrogen, nitrogen, gold, lead, and uranium.
external radiation	Irradiation by a source located outside the body.

F

fission	The splitting or breaking apart of a heavy atom into two or more fragments. When a heavy atom such as uranium is split, large amounts of energy in the form of heat, radiation and one or more neutrons are released.
fission products	The nuclei (fission fragments) formed by the fission of heavy elements, plus the nuclides formed by the radioactive decay of the fragments.
fuel assembly	A cluster of fuel rods or plates. Also called a fuel element. Many fuel assemblies make up a reactor core.
fuel rod	A long, slender tube that holds fissionable material (fuel) for nuclear reactor use. Fuel rods are assembled into bundles called fuel elements or fuel assemblies, which are loaded individually into the reactor core.

G

gamma ray — High energy, short wavelength electromagnetic radiation emitted from the nucleus of a radioactive atom. Gamma radiation frequently accompanies alpha and beta emissions and always accompanies fission. Gamma rays are very penetrating but may be shielded by dense materials, such as lead or concrete. Gamma rays are similar to X rays, but are usually more energetic.

grab samples — A grab sample represents a single sample collected in a finite period of time.

H

half-life — The time in which half the atoms of a particular radioactive substance disintegrate to another nuclear form. Measured half-lives vary from millionths of a second to billions of years.

I

indicator location — A sample collection location generally within 5 miles of Davis-Besse. It is used to measure the effects of Davis-Besse on the surrounding environment.

internal radiation — Nuclear radiation resulting from radioactive substances in the body. Some examples are iodine-131 deposited in the thyroid gland, and strontium-90 and plutonium-239, deposited in bone tissue.

ion	An atom that carries a positive or negative electric charge as a result of having lost or gained one or more electrons. May also refer to a free electron, i.e., an electron that is not associated (in orbit) with a nucleus.
ionization	The process of adding or removing one ore more electrons to from atoms or molecules, thereby creating ions. High temperatures, electrical discharges, or ionizing (atomic) radiation may cause ionization.
ionizing radiation	Any radiation capable of displacing electrons from atoms or molecules, thereby producing ions.
isotope	One of two or more atoms with the same number of protons, but different numbers of neutrons in their nuclei.

J K L

lower limit of detection	The smallest amount of sample activity that will give a net count, for which there is a confidence at a predetermined level that the activity is present.

M

micro-	A prefix that divides a basic unit by one million.
milli-	A prefix that divides a basic unit by one thousand.

N

neutron	An uncharged elementary particle with a mass slightly greater than that of a proton, and found in the nucleus of every atom heavier than hydrogen-1.

noble gas	A gaseous chemical element that does not readily enter into chemical combination with other elements. An inert gas such as krypton, xenon, neon or argon.
nucleus nuclei (plural)	The central, positively charged region of an atom that contains essentially all of the mass of that atom. Except for the nucleus of ordinary hydrogen, which has a single proton, all atomic nuclei contain both protons and neutrons. The number of protons determines the total positive charge, or atomic number; this is the same for all the isotopes of a given chemical element. The total number of neutrons and protons is called the mass number.
nuclide	A general term referring to all known isotopes, both stable (279) and unstable (about 5000), of the chemical elements.

O P

pico-	A prefix that divides a basic unit by one trillion.
proton	An elementary particle that carries a positive charge and has a mass of 1.67×10^{-24} gram.

Q R

quality factor	The factor by which the absorbed dose is multiplied to obtain a quantity (rem) that expresses, on a common scale the potential for biological damage to exposes persons.
rad	An acronym for "radiation absorbed dose". The basic unit of absorbed dose of radiation. One rad equals the absorption of 100 ergs (a small but measurable amount of energy) per gram of absorbing material.
radiation	The conveyance of energy through space, for example, the radiation of heat from a stove. Ionizing radiation

	is the emission of particles or gamma rays from the nucleus of an unstable (radioactive) atom as a result of radioactive decay.
radioactive contamination	Radioactive material in an undesirable location. Contamination can be loose on surfaces, fixed on surfaces (soaked or ground into the surface) or airborne.
radioactive decay	The decrease in the amount of radioactivity with the passage of time due to the spontaneous emission of particulate or electromagnetic radiation from the atom nuclei.
radioactivity	The spontaneous emission of radiation from the nucleus of an unstable isotope. Radioactivity is a process and radiation is the product.
radionuclide	A radioactive isotope of an element.
reactor trip	A sudden shutting down of a nuclear reactor, usually by rapid insertion of control rods, either automatically or manually by the reactor operator. A reactor trip sometimes called a scram.
rem	Acronym for ("roentgen equivalent man") . The unit of dose of any ionizing radiation that produces the same biological effect as a unit of absorbed dose of x rays.
revetment	A retaining structure designed to hold back water for purposes of erosion control.
roentgen	A unit of exposure to ionizing radiation. It is that amount of gamma or x rays required to produce ions carrying one electrostatic unit of electrical charge in one cubic centimeter of dry air at standard temperature and pressure.

S

shielding	Any material or obstruction that absorbs radiation and thus tends to protect personnel or materials from the effects of ionizing radiation.

spent fuel	Nuclear reactor fuel that has been used to the extent that it can no longer effectively sustain a chain reaction.
steam generator	A piece of equipment used to transfer heat from the primary system (reactor coolant) to the secondary (steam) system without the water of the two systems actually touching.
suspended solids	Solids capable of removal through a filter such as a screen.

T

Technical Specifications (Tech Specs)	A part of the operating license for any nuclear facility insured by the Nuclear Regulatory Commission (NRC), the Tech Specs delineate the requirements the facility must meet in order to maintain its operating license.
terrestrial radiation	The portion of natural radiation (background) that is emitted by naturally occurring radioactive materials in the earth.
tritium	A radioactive isotope of hydrogen (one proton, two neutrons). Because it is chemically identical to natural hydrogen, tritium can easily be taken into the body by any ingestion path. Tritium decays by beta emission. Its radioactive half-life is about 12-1/2 years.

U V W

whole-body dose	An exposure of the body to radiation in which the entire body rather than an isolated part is irradiated.

X Y Z

X rays

Penetrating electromagnetic radiation (photon) having a wavelength that is much shorter than that of visible light. In nuclear reactions, it is customary to refer to photons originating in the nucleus as gamma rays, and to those originating in the electron field of the atom as X rays.

APPENDIX B
Interlaboratory Comparison program

Appendix B

Interlaboratory Comparison Program Results

Teledyne Isotopes Midwest Laboratory (formerly Hazleton Environmental Sciences) has participated in interlaboratory comparison (crosscheck) programs since the formulation of its quality control program in December 1971. These programs are operated by agencies which supply environmental-type samples (e.g., milk or water) containing concentrations of radionuclides known to the issuing agency but not to participant laboratories. The purpose of such a program is to provide an independent check on the laboratory's analytical procedures and to alert it to any possible problems.

Participant laboratories measure the concentration of specified radionuclides and report them to the issuing agency. Several months later, the agency reports the known values to the participant laboratories and specifies control limits. Results consistently higher or lower than the known values or outside the control limits indicate a need to check the instruments or procedures used.

The results in Table B-1 were obtained through participation in the environmental sample crosscheck program for milk, water, air filters, and food samples during the period January 1988 through November 1991. This program has been conducted by the U.S. Environmental Protection Agency Intercomparison and Calibration Section, Quality Assurance Branch, Environmental Monitoring and Support Laboratory, Las Vegas, Nevada.

The results in Table B-2 were obtained for thermoluminescent dosimeters (TLDs) during the period 1976, 1977, 1979, 1980, 1984, and 1985-86 through participation in the Second, Third, Fourth, Fifth, Seventh, and Eighth International Intercomparison of Environmental Dosimeters under the sponsorships listed in Table B-2. Also Teledyne testing results are listed.

Table B-3 lists results of the analyses on in-house spiked samples.

Table B-4 lists results of the analyses on in-house "blank" samples.

Attachment B lists acceptance criteria for "spiked" samples.

Addendum to Appendix B provides explanation for out-of-limit results.

Table B-1. U.S. Environmental Protection Agency's crosscheck program, comparison of EPA and Teledyne Isotopes Midwest Laboratory results for milk, water, air filters, and food samples, 1988 through 1991.[a]

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L[b] TIML Result ±2σ[c]	EPA Result[d] 1s, N=1	Control Limits
STW-521	Water	Jan 1988	Sr-89	27.3±5.0	30.0±5.0	21.3-38.7
			Sr-90	15.3±1.2	15.0±1.5	12.4-17.6
STW-523	Water	Jan 1988	Gr. alpha	2.3±1.2	4.0±5.0	0.0-12.7
			Gr. beta	7.7±1.2	8.0±5.0	0.0-16.7
STW-524	Food	Jan 1988	Sr-89	44.0±4.0	46.0±5.0	37.3-54.7
			Sr-90	53.0±2.0	55.0±2.8	50.2-59.8
			I-131	102.3±4.2	102.0±10.2	84.3-119.7
			Cs-137	95.7±6.4	91.0±5.0	82.3-99.7
			K	1011±158	1230±62	1124-1336
STW-525	Water	Feb 1988	Co-60	69.3±2.3	69.0±5.0	60.3-77.7
			Zn-65	99.0±3.4	94.0±9.4	77.7-110.3
			Ru-106	92.7±14.4	105.0±10.5	86.8-123.2
			Cs-134	61.7±8.0	64.0±5.0	55.3-72.7
			Cs-137	99.7±3.0	94.0±5.0	85.3-102.7
STW-526	Water	Feb 1988	H-3	3453±103	3327±362	2700-3954
STW-527	Water	Feb 1988	Uranium	3.0±0.0	3.0±6.0	0.0-13.4
STW-528	Milk	Feb 1988	I-131	4.7±1.2	4.0±0.4	3.3-4.7
STW-529	Water	Mar 1988	Ra-226	7.1±0.6	7.6±1.1	5.6-9.6
			Ra-228	NA[e]	7.7±1.2	5.7-9.7
STW-530	Water	Mar 1988	Gr. alpha	4.3±1.2	6.0±5.0	0.0-14.7
			Gr. beta	13.3±1.3	13.0±5.0	4.3-21.7
STAF-531	Air Filter	Mar 1988	Gr. alpha	21.0±2.0	20.0±5.0	11.3-28.7
			Gr. beta	48.0±0.0	50.0±5.0	41.3-58.7
			Sr-90	16.7±1.2	17.0±1.5	14.4-19.6
			Cs-137	18.7±1.3	16.0±5.0	7.3-24.7
STW-532	Water	Apr 1988	I-131	9.0±2.0	7.5±0.8	6.2-8.8

Table B-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L[b] TIML Result ±2σ[c]	EPA Result[d] 1s, N=1	Control Limits
STW-533 534	Water (Blind)	Apr 1988				
	Sample A		Gr. alpha	ND[f]	46.0±11.0	27.0-65.0
			Ra-226	ND	6.4±1.0	4.7-8.1
			Ra-228	ND	5.6±0.8	4.2-7.0
			Uranium	6.0±6.0	6.0±6.0	0.0-16.4
	Sample B		Gr. beta	ND	57.0±5.0	48.3-65.7
			Sr-89	3.3±1.2	5.0±5.0	0.0-13.7
			Sr-90	5.3±1.2	5.0±1.5	2.4-7.6
			Co-60	63.3±1.3	50.0±5.0	41.3-58.7
			Cs-134	7.7±1.2	7.0±5.0	0.0-15.7
			Cs-137	8.3±1.2	7.0±5.0	0.0-15.7
STU-535	Urine	Apr 1988	H-3	6483±155	6202±620	5128-7276
STW-536	Water	Apr 1988	Sr-89	14.7±1.3	20.0±5.0	11.3-28.7
			Sr-90	20.0+2.0	20.0±1.5	17.4-22.6
STW-538	Water	Jun 1988	Cr-51	331.7±13.0	302.0±30.0	250.0-354.0
			Co-60	16.0±2.0	15.0±5.0	6.3-23.7
			Zn-65	107.7±11.4	101.0±10.0	83.7-118.3
			Ru-106	191.3±11.0	195.0±20.0	160.4-229.6
			Cs-134	18.3±4.6	20.0±5.0	11.3-28.7
			Cs-137	26.3±1.2	25.0±5.0	16.3-33.7
STW-539	Water	Jun 1988	H-3	5586±92	5565±557	4600-6530
STW-541	Milk	Jun 1988	Sr-89	33.7±11.4	40.0±5.0	31.3-48.7
			Sr-90	55.3±5.8	60.0±3.0	54.8-65.2
			I-131	103.7±3.1	94.0±9.0	78.4-109.6
			Cs-137	52.7±3.1	51.0±5.0	42.3-59.7
			K	1587±23	1600±80	1461-1739
STW-542	Water	Jul 1988	Gr. alpha	8.7±4.2	15.0±5.0	6.3-23.7
			Gr. beta	5.3±1.2	4.0±5.0	0.0-12.7
STF-543	Food	Jul 1988	Sr-89	ND[f]	33.0±5.0	24.3-41.7
			Sr-90	ND	34.0±2.0	30.5-37.5
			I-131	115.0±5.3	107.0±11.0	88.0-126.0
			Cs-137	52.7±6.4	49.0±5.0	40.3-57.7
			K	1190±66	1240±62	1133-1347

Table B-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L[b] TIML Result ±2σ[c]	EPA Result[d] 1s, N=1	Control Limits
STW-544	Water	Aug 1988	I-131	80.0±0.0	76.0±8.0	62.1-89.9
STW-545	Water	Aug 1988	Pu-239	11.0±0.2	10.2±1.0	8.5-11.9
STW-546	Water	Aug 1988	Uranium	6.0±0.0	6.0±6.0	0.0-16.4
STAF-547	Air Filter	Aug 1988	Gr. alpha	8.0±0.0	8.0±5.0	0.0-16.7
			Gr. beta	26.3±1.2	29.0±5.0	20.3-37.7
			Sr-90	8.0±2.0	8.0±1.5	5.4-10.6
			Cs-137	13.0±2.0	12.0±5.0	3.3-20.7
STW-548	Water	Sep 1988	Ra-226	9.3±0.5	8.4±2.6	6.2-10.6
			Ra-228	5.8±0.4	5.4±1.6	4.0-6.8
STW-549	Water	Sep 1988	Gr. alpha	7.0±2.0	8.0±5.0	0.0-16.7
			Gr. beta	11.3±1.2	10.0±5.0	1.3-18.7
STW-550	Water	Oct 1988	Cr-51	252.0±14.0	251.0±25.0	207.7-294.3
			Co-60	26.0±2.0	25.0±5.0	16.3-33.7
			Zn-65	158.3±10.2	151.0±15.0	125.0-177.0
			Ru-106	153.0±9.2	152.0±15.0	126.0-178.0
			Cs-134	28.7±5.0	25.0±5.0	16.3-33.7
			Cs-137	16.3±1.2	15.0±5.0	6.3-23.7
STW-551	Water	Oct 1988	H-3	2333±127	2316±350	1710-2927
STW-552 553	Water (Blind)	Oct 1988				
	Sample A		Gr. alpha	38.3±8.0	41.0±10.0	23.7-58.3
			Ra-226	4.5±0.5	5.0±0.8	3.6-6.4
			Ra-228	4.4±0.6	5.2±0.8	3.6-6.4
			Uranium	4.7±1.2	5.0±6.0	0.0-15.4
	Sample B		Gr. beta	51.3±3.0	54.0±5.0	45.3-62.7
			Sr-89	3.7±1.2	11.0±5.0	2.3-19.7
			Sr-90	10.7±1.2	10.0±1.5	7.4-12.6
			Cs-134	15.3±2.3	15.0±5.0	6.3-23.7
			Cs-137	16.7±1.2	15.0±5.0	6.3-23.7

Table B-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L[b] TIML Result ±2σ[c]	EPA Result[d] 1s, N=1	Control Limits
STM-554	Milk	Oct 1988	Sr-89	40.3±7.0	40.0±5.0	31.3-48.7
			Sr-90	51.0±2.0	60.0±3.0	54.8-65.2
			I-131	94.0±3.4	91.0±9.0	75.4-106.6
			Cs-137	45.0±4.0	50.0±5.0	41.3-58.7
			K	1500±45	1600±80	1461-1739
STU-555	Urine	Nov 1988	H-3	3030±209	3025±359	2403-3647
STW-556	Water	Nov 1988	Gr. alpha	9.0±3.5	9.0±5.0	0.3-17.7
			Gr. beta	9.7±1.2	9.0±5.0	0.3-17.7
STW-557	Water	Dec 1988	I-131	108.7±3.0	115.0±12.0	94.2-135.8
STW-559	Water	Jan 1989	Sr-89	40.0±8.7	40.0±5.0	31.3-48.7
			Sr-90	24.3±3.1	25.0±1.5	22.4-27.6
STW-560	Water	Jan 1989	Pu-239	5.8±1.1	4.2±0.4	3.5-4.9
STW-561	Water	Jan 1989	Gr. alpha	7.3±1.2	8.0±5.0	0.0-16.7
			Gr. beta	5.3±1.2	4.0±5.0	0.0-12.7
STW-562	Water	Feb 1989	Cr-51	245±46	235±24	193.4-276.6
			Co-60	10.0±2.0	10.0±5.0	1.3-18.7
			Zn-65	170±10	159±16	139.2-186.7
			Ru-106	181±7.6	178±18	146.8-209.2
			Cs-134	9.7±3.0	10.0±5.0	1.3-18.7
			Cs-137	11.7±1.2	10.0±5.0	1.3-18.7
STW-563	Water	Feb 1989	I-131	109.0±4.0	106.0±11.0	86.9-125.1
STW-564	Water	Feb 1989	H-3	2820±20	2754±356	2137-337.
STW-565	Water	Mar 1989	Ra-226	4.2±0.3	4.9±0.7	3.7-6.1
			Ra-228	1.9±1.0	1.7±0.3	1.2-2.2
STW-566	Water	Mar 1989	U	5.0±0.0	5.0±6.0	0.0-15.4
STAF-567	Air Filter	Mar 1989	Gr. alpha	21.7±1.2	21.0±5.0	12.3-29,7
			Gr. beta	68.3±4.2	62.0±5.0	53.3-70.7
			Sr-90	20.0±2.0	20.0±1.5	17.4-22.6
			Cs-137	21.3±1.2	20.0±5.0	11.3-28.7

Table B-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L[b] TIML Result ±2σ[c]	EPA Result[d] 1s, N=1	Control Limits
STW-568 569	Water (Blind)	Apr 1989				
	Sample A		Gr. alpha	22.7±2.3	29.0±7.0	16.9-41.2
			Ra-226	3.6±0.6	3.5±0.5	2.6-4.4
			Ra-228	2.6±1.0	3.6±0.5	2.7-4.5
			U	3.0±0.0	3.0±6.0	0.0-13.4
	Sample B		Gr. beta	52.3±6.1	57.0±5.0	43.3-65.7
			Sr-89	9.3±5.4	8.0±5.0	0.0-16.7
			Sr-90	7.0±0.0	8.0±1.5	5.4-10.6
			Cs-134	21.0±5.2	20.0±5.0	11.3-28.7
			Cs-137	23.0±2.0	20.0±5.0	11.3-28.7
STM-570	Milk	Apr 1989	Sr-89	26.0±10.0	39.0±5.0	30.3-47.7
			Sr-90	45.7±4.2	55.0±3.0	49.8-60.2
			Cs-137	54.0±6.9	50.0±5.0	41.3-58.7
			K-40	1521±208	1600±80	1461-1739
STW-571	Water	May 1989	Sr-89	<0.7	6.0±5.0	0.0-14.7
			Sr-90	5.0±1.0	6.0±1.5	3.4-8.6
STW-572	Water	May 1989	Gr. alpha	24.0±2.0	30.0±8.0	16.1-43.9
			Gr. beta	49.3±15.9	50.0±5.0	41.3-58.7
STW-573	Water	Jun 1989	Ba-133	50.7±1.2	49.0±5.0	40.3-57.7
			Co-60	31.3±2.3	31.0±5.0	22.3-39.7
			Zn-65	167±10	165±17	135.6-194.4
			Ru-106	123±9.2	128±13	105.5-150.5
			Cs-134	40.3±1.2	39±5	30.3-47.7
			Cs-137	22.3±1.2	20±5	11.3-28.7
STW-574	Water	Jun 1989	H-3	4513±136	4503±450	3724-5282
STW-575	Water	Jul 1989	Ra-226	16.8±3.1	17.7±2.7	13.0-22.4
			Ra-228	13.8±3.7	18.3±2.7	13.6-23.0
STW-576	Water	Jul 1989	U	40.3±1.2	41.0±6.0	30.6±51.4
STW-577	Water	Aug 1989	I-131	84.7±5.8	83.0±8.0	69.1-96.9
STAF-579	Air Filter	Aug 1989	Gr. alpha	6.0±0.0	6.0±5.0	0.0-14.7
			Cs-137	10.3±2.3	10.0±5.0	1.3-18.7

Table B-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L[b] TIML Result ±2σ[c]	EPA Result[d] 1s, N=1	Control Limits
STW-580	Water	Sep 1989	Sr-89	14.7±1.2	14.0±5.0	5.3-22.7
			Sr-90	9.7±1.2	10.0±1.5	7.4-12.6
STW-581	Water	Sep 1989	Gr. alpha	5.0±0.0	4.0±5.0	0.0-12.7
			Gr. beta	8.7±2.3	6.0±5.0	0.0-14.7
STW-583	Water	Oct 1989	Ba-133	60.3±10.0	59.0±6.0	48.6-69.4
			Co-60	29.0±4.0	30.0±5.0	21.1-38.7
			Zn-65	132.3±6.0	129.0±13.0	106.5-151.5
			Ru-106	155.3±6.1	161.0±16.0	133.3-188.7
			Cs-134	30.7±6.1	29.0±5.0	20.3-37.7
			Cs-137	66.3±4.6	59.0±5.0	50.3±67.7
STW-584	Water	Oct 1989	H-3	3407±150	3496±364	2866±4126
STW-585 586	Water (Blind)	Oct 1989				
	Sample A		Gr. alpha	41.7±9.4	49.0±12.0	28.2-69.8
			Ra-226	7.9±0.4	8.4±1.3	6.2-10.6
			Ra-228	4.4±0.8	4.1±0.6	3.1-5.1
			U	12.0±0.0	12.0±6.0	1.6-22.4
	Sample B		Gr. beta	31.7±2.3	32.0±5.0	23.3-40.7
			Sr-89	13.3±4.2	15.0±5.0	6.3-23.7
			Sr-90	7.0±2.0	7.0±3.0	4.4-9.6
			Cs-134	5.0±0.0	5.0±5.0	0.0-13.7
			Cs-137	7.0±0.0	5.0±5.0	0.0-13.7
STW-587	Water	Nov 1989	Ra-226	7.9±0.4	8.7±1.3	6.4-11.0
			Ra-228	8.9±1.2	9.3±1.2	6.9-11.7
STW-588	Water	Nov 1989	U	15.0±0.08	15.0±6.0	4.6-25.4
STW-589	Water	Jan 1990	Sr-89	22.7±5.0	25.0±5.0	16.3-33.7
			Sr-90	17.3±1.2	20.0±1.5	17.4-22.6
STW-591	Water	Jan 1990	Gr. alpha	10.3±3.0	12.0±5.0	3.3-20.7
			Gr. beta	12.3±1.2	12.0±5.0	3.3-20.7

Table B-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L[b] TIML Result ±2σ[c]	EPA Result[d] 1s, N=1	Control Limits
STW-592	Water	Jan 1990	Co-60	14.7±2.3	15±5.0	6.3-23.7
			Zn-65	135.0±6.9	139.0±14.0	114.8-163.2
			Ru-106	133.3±13.4	139.0±14.0	114.8-163.2
			Cs-134	17.3±1.2	18.0±5.0	9.3-26.7
			Cs-137	19.3±1.2	18.0±5.0	9.3-26.7
			Ba-133	78.0±0.0	74.0±7.0	61.9-86.1
STW-593	Water	Feb 1990	H-3	4827±83	4976±498	4113-5839
STW-594	Water	Mar 1990	Ra-226	5.0±0.2	4.9±0.7	4.1-5.7
			Ra-228	13.5±0.7	12.7±1.9	9.4-16.0
STW-595	Water	Mar 1990	U	4.0±0.0	4.0±6.0	0.0-14.4
STAF-596	Air Filter	Mar 1990	Gr. alpha	7.3±1.2	5.0±5.0	0.0-13.7
			Gr. beta	34.0±0.0	31.0±5.0	22.3-39.7
			Sr-90	10.0±0.0	10.0±1.5	7.4-12.6
			Cs-137	9.3±1.2	10.0±5.0	1.3-18.7
STW-597 598	Water (Blind)	Apr 1990				
	Sample A		Gr. alpha	81.0±3.5	90.0±23.0	50.1-129.9
			Ra-226	4.9±0.4	5.0±0.8	3.6-6.4
			Ra-228	10.6±0.3	10.2±1.5	7.6-12.8
			U	18.7±3.0	20.0±6.0	9.6-30.4
	Sample B		Gr. beta	51.0±10.1	52.0±5.0	43.3-60.7
			Sr-89	9.3±1.2	10.0±5.0	1.3-18.7
			Sr-90	10.3±3.1	10.0±1.5	8.3-11.7
			Cs-134	16.0±0.0	15.0±5.0	6.3-23.7
			Cs-137	19.0±2.0	15.0±5.0	6.3-23.7
STM-599	Milk	Apr 1990	Sr-89	21.7±3.1	23.0±5.0	14.3-31.7
			Sr-90	21.0±7.0	23.0±5.0	14.3-31.7
			I-131	98.7±1.2	99.0±10.0	81.7-116.3
			Cs-137	26.0±6.0	24.0±5.0	15.3-32.7
			K	1300.0±69.2	1550.0±78.0	1414.7-1685.3
STW-600	Water	May 1990	Sr-89	6.0±2.0	7.0±5.0	0.0-15.7
			Sr-90	6.7±1.2	7.0±5.0	0.0-15.7
STW-601	Water	May 1990	Gr. alpha	11.0±2.0	22.0±6.0	11.6-32.4
			Gr. beta	12.3±1.2	15.0±5.0	6.3-23.7

Table B-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L[b] TIML Result ±2σ[c]	EPA Result[d] 1s, N=1	Control Limits
STW-602	Water	Jun 1990	Co-60	25.3±2.3	24.0±5.0	15.3-32.7
			Zn-65	155.0±10.6	148.0±15.0	130.6-165.4
			Ru-106	202.7±17.2	210.0±21.0	173.6-246.4
			Cs-134	23.7±1.2	24.0±5.0	18.2-29.8
			Cs-137	27.7±3.1	25.0±5.0	16.3-33.7
			Ba-133	100.7±8.1	99.0±10.0	81.7-116.3
STW-603	Water	Jun 1990	H-3	2927±306	2933±358	2312-3554
STW-604	Water	Jul 1990	Ra-226	11.8±0.9	12.1±1.8	9.0-15.2
			Ra-228	4.1±1.4	5.1±1.3	2.8-7.4
STW-605	Water	Jul 1990	U	20.3±1.7	20.8±3.0	15.6-26.0
STW-606	Water	Aug 1990	I-131	43.0±1.2	39.0±6.0	28.6±49.4
STW-607	Water	Aug 1990	Pu-239	10.0±1.7	9.1±0.9	7.5-10.7
STAF-608	Air Filter	Aug 1990	Gr. alpha	14.0±6.0	10.0±5.0	1.3-18.7
			Gr. beta	65.3±1.2	62.0±5.0	53.3-70.7
			Sr-90	19.0±6.9	20.0±5.0	11.3-28.7
			Cs-137	19.0±2.0	20.0±5.0	11.3-28.7
STW-609	Water	Sep 1990	Sr-89	9.0±2.0	10.0±5.0	1.3-18.7
			Sr-90	9.0±2.0	9.0±5.0	3.3-17.7
STW-610	Water	Sep 1990	Gr. alpha	8.3±1.2	10.0±5.0	1.3-18.7
			Gr. beta	10.3±1.2	10.0±5.0	1.3-18.7
STM-611	Milk	Sep 1990	Sr-89	11.7±3.1	16.0±5.0	7.3-24.7
			Sr-90	15.0±0.0	20.0±5.0	11.3-28.7
			I-131	63.0±6.0	58.0±6.0	47.6-68.4
			Cs-137	20.0±2.0	20.0±5.0	11.3-28.7
			K	1673.3±70.2	1700.0±85.0	1552.5-1847.5
STW-612	Water	Oct 1990	Co-60	20.3±3.1	20.0±5.0	11.3-28.7
			Zn-65	115.3±12.2	115.0±12.0	94.2-135.8
			Ru-106	152.0±8.0	151.0±15.0	125.0-177.0
			Cs-134	11.0±0.0	12.0±5.0	3.3-20.7
			Cs-137	14.0±2.0	12.0±5.0	3.3-20.7
			Ba-133	116.7±9.9	110.0±11.0	90.9-129.
STW-613	Water	Oct 1990	H-3	7167±330	7203±720	5954-8452

Table B-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L[b] TIML Result ±2σ[c]	EPA Result[d] 1s, N=1	Control Limits
STW-614 615	Water	Oct 1990				
	Sample A		Gr. alpha	68.7±7.2	62.0±16.0	34.2-89.8
			Ra-226	12.9±0.3	13.6±2.0	10.1-17.1
			Ra-228	4.2±0.6	5.0±1.3	2.7-7.3
			U	10.4±0.6	10.2±3.0	5.0-15.4
	Sample B		Gr. beta	55.0±8.7	53.0±5.0	44.3-61.7
			Sr-89	15.7±2.9	20.0±5.0	11.3-28.7
			Sr-90	12.0±2.0	15.0±5.0	6.3-23.7
			Cs-134	9.0±1.7	7.0±5.0	0.0-15.7
			Cs-137	7.7±1.2	5.0±5.0	0.0-13.7
STW-616	Water	Nov 1990	Ra-226	6.8±1.0	7.4±1.1	5.5-9.3
			Ra-228	5.3±1.7	7.7±1.9	4.4-11.0
STW-617[g]	Water	Nov 1990	U	35.0±0.4	35.5±3.6	29.3±41.7
STW-618	Water	Jan 1991	Sr-89	4.3±1.2	5.0±5.0	0.0 -13.7
			Sr-90	4.7±1.2	5.0±5.0	0.0-13.7
STW-619	Water	Jan 1991	Pu-239	3.6±0.2	3.3±0.3	2.8-3.8
STW-620	Water	Jan 1991	Gr. alpha	6.7±3.0	5.0±5.0	0.0-13.7
			Gr. beta	6.3±1.2	5.0±5.0	0.0-13.7
STW-621	Water	Feb 1991	Co-60	41.3±8.4	40.0±5.0	31.3-48.7
			Zn-65	166.7±19.7	149.0±15.0	123.0-175.0
			Ru-106	209.7±18.6	186.0±19.0	153.0-219.0
			Cs-134	9.0±2.0	8.0±5.0	0.0-16.7
			Cs-137	9.7±1.2	8.0±5.0	0.0-16.7
			Ba-133	85.7±9.2	75.0±8.0	61.1-88.9
STW-622	Water	Feb 1991	I-131	81.3±6.1	75.0±8.0	61.1-88.9
STW-623	Water	Feb 1991	H-3	4310.0±144.2	4418.0±442.0	3651.2-5184.8
STW-624	Water	Mar 1991	Ra-226	31.4±3.2	31.8±4.8	23.5-40.1
			Ra-228	ND[h]	21.1±5.3	11.9-30.3
STW-625	Water	Mar 1991	U	6.7±0.4	7.6±3.0	2.4-12.8

Table B-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L[b] TIML Result ±2σ[c]	EPA Result[d] 1s, N=1	Control Limits
STAF-626	Filter	Mar 1991	Gr. alpha	38.7±1.2	25.0±6.0	14.6-35.4
			Gr. beta	130.0±4.0	124.0±6.0	113.6-134.4
			Sr-90	35.7±1.2	40.0±5.0	31.3-48.7
			Cs-137	33.7±4.2	40.0±5.0	31.3-48.7
STW-627 628	Water	Apr 1991				
	Sample A		Gr. alpha	51.0±6.0	54.0±14.0	29.7-78.3
			Ra-226	7.0±0.8	8.0±1.2	5.9-10.1
			Ra-228	9.7±1.9	15.2±3.8	8.6-21.8
			U	27.7±2.4	29.8±3.0	24.6-35.0
	Sample B		Gr. beta	93.3±6.4	115.0±17.0	85.5-144.5
			Sr-89	21.0±3.5	28.0±5.0	19.3-36.7
			Sr-90	23.0±0.0	26.0±5.0	17.3-34.7
			Cs-134	27.3±1.2	24.0±5.0	15.3-32.7
			Cs-137	29.0±2.0	25.0±5.0	16.3-33.7
STM-629	Milk	Apr 1991	Sr-89	24.0±8.7	32.0±5.0	23.3-40.7
			Sr-90	28.0±2.0	32.0±5.0	23.3-40.7
			I-131	65.3±14.7	60.0±6.0	49.6-70.4
			Cs-137	54.7±11.0	49.0±5.0	40.3-57.7
			K	1591.7±180.1	1650.0±83.0	1506.0-1794.0
STW-630	Water	May 1991	Sr-89	40.7±2.3	39.0±5.0	30.3-47.7
			Sr-90	23.7±1.2	24.0±5.0	15.3-32.7
STW-631	Water	May 1991	Gr. alpha	27.7±5.8	24.0±6.0	13.6-34.4
			Gr. beta	46.0±0.0	46.0±5.0	37.3-54.7
STW-632	Water	Jun 1991	Co-60	11.3±1.2	10.0±5.0	1.3-18.7
			Zn-65	119.3±16.3	108.0±11.0	88.9-127.1
			Ru-106	162.3±19.0	149.0±15.0	123.0-175.0
			Cs-134	15.3±1.2	15.0±5.0	6.3-23.7
			Cs-137	16.3±1.2	14.0±5.0	5.3-22.7
			Ba-133	74.0±6.9	62.0±6.0	51.6-72.4
STW-633	Water	Jun 1991	H-3	13470.0±385.8	12480.0±1248.0	10314.8-14645.2
STW-634	Water	Jul 1991	Ra-226	14.9±0.4	15.9±2.1	11.7-20.1
			Ra-228	17.6±1.8	16.7±4.2	9.4-24.0

Table B-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L[b] TIML Result ±2σ[c]	EPA Result[d] 1s, N=1	Control Limits
STW-635	Water	Jul 1991	U	12.8±0.1	14.2±3.0	9.0-19.4
STW-636	Water	Aug 1991	I-131	19.3±1.2	20.0±6.0	9.6-30.4
STW-637	Water	Aug 1991	Pu-239	21.4±0.5	19.4±1.9	16.1-22.7
STW-638	Filter	Aug 1991	Gr. alpha	33.0±2.0	25.0±6.0	14.6-35.4
			Gr. beta	88.7±1.2	92.0±10.0	80.4-103.6
			Sr-90	27.0±4.0	30.0±5.0	21.3-38.7
			Cs-137	26.3±1.2	30.0±5.0	21.3-38.7
STW-639	Water	Sep 1991	Sr-89	47.0±10.4	49.0±5.0	40.3-57.7
			Sr-90	24.0±2.0	25.0±5.0	16.3-33.7
STW-640	Water	Sep 1991	Gr. alpha	12.0±4.0	10.0±5.0	1.3-18.7
			Gr. beta	20.3±1.2	20.0±5.0	11.3-28.7
STM-641	Milk	Sep 1991	Sr-89	20.3±5.0	25.0±5.0	16.3-33.7
			Sr-90	19.7±3.1	25.0±5.0	16.3-33.7
			I-131	130.7±16.8	108.0±11.0	88.9-127.1
			Cs-137	33.7±3.2	30.0±5.0	21.3-38.7
			K	1743.3±340.8	1740.0±87.0	1589.1-1890.9
STW-642	Water	Oct 1991	Co-60	29.7±1.2	29.0±5.0	20.3-37.7
			Zn-65	75.7±8.3	73.0±7.0	60.9-85.1
			Ru-106	196.3±15.1	199.0±20.0	164.3-233.7
			Cs-134	9.7±1.2	10.0±5.0	1.3-18.7
			Cs-137	11.0±2.0	10.0±5.0	1.3-18.7
			Ba-133	94.7±3.1	98.0±10.0	80.7-115.3
STW-643	Water	Oct 1991	H-3	2640.0±156.2	2454.0±352.0	1843.3-3064.7
STW-644	Water	Oct 1991				
645	Sample A		Gr. alpha	73.0±13.1	82.0±21.0	45.6-118.4
			Ra-226	20.9±2.0	22.0±3.3	16.3-27.7
			Ra-228	19.6±2.3	22.2±5.6	12.5-31.9
			U	13.5±0.6	13.5±3.0	8.3-18.7
	Sample B		Gr. beta	55.3±3.1	65.0±10.0	47.7-82.3
			Sr-89	9.7±3.1	10.0±5.0	1.3-18.7
			Sr-90	8.7±1.2	10.0±5.0	1.3-18.7
			Co-60	20.3±1.2	20.0±5.0	11.3-28.7
			Cs-134	9.0±5.3	10.0±5.0	1.3-18.7
			Cs-137	14.7±5.0	11.0±5.0	2.3-19.7

Table B-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L[b] TIML Result ±2σ[c]	EPA Result[d] 1s, N=1	Control Limits
STW-646	Water	Nov 1991	Ra-226	5.6±1.2	6.5±1.0	4.8-8.2
			Ra-228	9.6±0.5	8.1±2.0	4.6-11.6
STW-647	Water	Nov 1991	U	24.7±2.3	24.9±3.0	19.7-30.1

[a] Results obtained by Teledyne Isotopes Midwest Laboratory as a participant in the environmental sample crosscheck program operated by the Intercomparison and Calibration Section, Quality Assurance Branch, Environmental Monitoring and Support Laboratory, U.S. Environmental Protection Agency (EPA), Las Vegas, Nevada.

[b] All results are in pCi/l, except for elemental potassium (K) data in milk, which are in mg/l; air filter samples, which are in pCi/filter; and food, which is in mg/kg.

[c] Unless otherwise indicated, the TIML results are given as the mean ± 2 standard deviations for three determinations.

[d] USEPA results are presented as the known values and expected laboratory precision (1s, 1 determination) and control limits as defined by EPA.

[e] NA = Not analyzed.

[f] ND = No data; not analyzed due to relocation of lab.

[g] Sample was analyzed but the results not submitted to EPA because deadline was missed (all data on file).

[h] ND = No data; sample lost during analyses.

Table B-2. Crosscheck program results, thermoluminescent dosimeters (TLDs).

Lab Code	TLD Type	Measurement ±2σ[a]	mR: Teledyne Result Value[c]	mR: Known	mR: Average ±2σ[d] (All Participants)
2nd International Intercomparison[b]					
115-2	CaF_2:Mn Bulb	Field	17.0±1.9	17.1	16.4±7.7
		Lab	20.8±4.1	21.3	18.8±7.6
3rd International Intercomparison[e]					
115-3	CaF_2:Mn Bulb	Field	30.7±3.2	34.9±4.8	31.5±3.0
		Lab	89.6±6.4	91.7±14.6	86.2±24.0
4th International Intercomparison[f]					
115-4	CaF_2:Mn Bulb	Field	14.1±1.1	14.1±1.4	16.0±9.0
		Lab (Low)	9.3±1.3	12.2±2.4	12.0±7.4
		Lab (High)	40.4±1.4	45.8±9.2	43.9±13.2
5th International Intercomparison[g]					
115-5A	CaF_2:Mn Bulb	Field	31.4±1.8	30.0±6.0	30.2±14.6
		Lab at beginning	77.4±5.8	75.2±7.6	75.8±40.4
		Lab at the end	96.6±5.8	88.4±8.8	90.7±31.2
115-5B	LiF-100 Chips	Field	30.3±4.8	30.0±6.0	30.2±14.6
		Field at beginning	81.1±7.4	75.2±7.6	75.8±40.4
		Lab at the end	85.4±11.7	88.4±8.8	90.7±31.2
7th International Comparison[h]					
115-7A	LiF-100 Chips	Field	75.4±2.6	75.8±6.0	75.1±29.8
		Lab (Co-60)	80.0±3.5	79.9±4.0	77.9±27.6
		Lab (Cs-137)	66.6±2.5	75.0±3.8	73.0±22.2

Table B-2. Crosscheck program results, thermoluminescent dosimeters (TLDs).

Lab Code	TLD Type	Measurement ±2σ[a]	mR: Teledyne Result Value[c]	mR: Known	mR: Average ±2σ[d] (All Participants)
115-7B	CaF_2:Mn Bulbs	Field	71.5±2.6	75.8±6.0	75.1±29.8
		Lab (Co-60)	84.8±6.4	79.9±4.0	77.9±27.6
		Lab (Cs-137)	78.8±1.6	75.0±3.8	73.0±22.2
115-7C	$CaSO_4$:Dy Cards	Field	76.8±2.7	75.8±6.0	75.1±29.8
		Lab (Co-60)	82.5±3.7	79.9±4.0	77.9±27.6
		Lab (Cs-137)	79.0±3.2	75.0±3.8	73.0±22.2
Etec International Intercomparison[i]					
115-8A	LiF-100 Chips	Field Site 1	29.5±1.4	29.7±1.5	28.9±12.4
		Field Site 2	11.3±0.8	10.4±0.5	10.1±9.06
		Lab (Cs-137)	13.7±0.9	17.2±0.9	16.2±6.8
115-8B	CaF_2:Mn Bulbs	Field Site 1	32.3±1.2	29,7±1.5	28.9±12.4
		Field Site 2	9.0±1.0	10.4±0.5	10.1±9.0
		Lab (Cs-137)	15.8±0.9	17.2±0.9	16.2±6.8
115-8C	$CaSO_4$:Dy Cards	Field Site 1	32.2±0.7	29.7±1.5	28.9±12.4
		Field Site 2	10.6±0.6	10.4±0.5	10.1±9.0
		Lab (Cs-137)	18.1±0.8	17.2±0.9	16.2±6.8
Teledyne Testing[j]					
89-1	LiF-100 Chips	Lab	21.0±0.4	22.4	–
89-2	Teledyne $CaSO_4$:Dy Cards	Lab	20.9±1.0	20.3	–

Table B-2. (continued)

Lab Code	TLD Type	Measurement ±2σ[a]	mR: Teledyne Result Value[c]	mR: Known	mR: Average ±2σ[d] (All Participants)
Teledyne Testing[j]					
90-1[k]	Teledyne $CaSO_4$:Dy Cards	Lab	20.6±1.4	19.6	–
90-1[l]	Teledyne $CaSO_4$:Dy Cards	Lab	100.8±4.3	100.0	–
91-1[m]	Teledyne $CaSO_4$:Dy Cards	Lab	33.4±[illegible] 55.2±4.7 87.8±6.2	32.0 58.8 85.5	– – –

[a] Lab result given is the mean ±2 standard deviations of three determinations.

[b] Second International Intercomparison of Environmental Dosimeters conducted in April of 1976 by the Health and Safety Laboratory (HASL), New York, New York, and the School of Public Health of the University of Texas, Houston, Texas.

[c] Value determined by sponsor of the intercomparison using continuously operated pressurized ion chamber.

[d] Mean ±2 standard deviations of results obtained by all laboratories participating in the program.

[e] Third International Intercomparison of Environmental Dosimeters conducted in summer of 1977 by Oak Ridge National Laboratory and the School of Public Health of the University of Texas, Houston, Texas.

[f] Fourth International Intercomparison of Environmental Dosimeters conducted in summer of 1979 by the School of Public Health of the University of Texas Houston, Texas.

[g] Fifth International Intercomparison of Environmental Dosimeters conducted in fall of 1980 at Idaho Falls, Idaho and sponsored by the School of Public Health of the University of Texas, Houston, Texas and Environmental Measurements Laboratory, New York, New York, U.S. Department of Energy.

[h] Seventh International Intercomparison of Environmental Dosimeters conducted in the spring and summer of 1984 at Las Vegas, Nevada, and sponsored by the U.S. Department of Energy, The U.S. Nuclear Regulatory Commission, and the U.S. Environmental Protection Agency.

[i] Eighth International Intercomparison of Environmental Dosimeters conducted in the fall and winter of 1985-1986 at New York, New York, and sponsored by the U.S. Department of Energy.

[j] Chips were submitted in September 1989 and cards were submitted in November 1989 to Teledyne Isotopes, Inc., Westwood, NJ for irradiation.

[k] Cards were irradiated by Teledyne Isotopes, Inc., Westwood, NJ on June 19, 1990.

[l] Cards were irradiated by Dosimetry Associates, Inc., Northville, MI on October 30, 1990.

[m] Irradiated cards were provided by Teledyne Isotopes, INC., Westwood, NJ. Irradiated on October 8, 19[illegible]

Table B-3. In-house spiked samples.

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L TIML Result n=1	Known Activity	Expected Precision 1s, n=1[a]
QC-MI-16	Milk	Feb 1988	Sr-89	31.8±4.7	31.7±6.0	8.7
			Sr-90	25.5±2.7	27.8±3.5	5.2
			I-131	26.4±0.5	23.2±5.0	10.4
			Cs-134	23.8±2.3	24.2±6.0	8.7
			Cs-137	26.5±0.8	25.1±6.0	8.7
QC-MI-17	Milk	Feb 1988	I-131	10.6±1.2	14.3±1.6	10.4
QC-W-35	Water	Feb 1988	I-131	9.7±1.1	11.6±1.1	10.4
QC-W-36	Water	Mar 1988	I-131	10.5±1.3	11.6±1.0	10.4
QC-W-37	Water	Mar 1988	Sr-89	17.1±2.0	19.8±8.0	8.7
			Sr-90	18.7±0.9	17.3±5.0	5.2
QC-MI-18	Milk	Mar 1988	I-131	33.2±2.3	26.7±5.0	10.4
			Cs-134	31.3±2.1	30.2±5.0	8.7
			Cs-137	29.9±1.4	26.2±5.0	8.7
QC-W-38	Water	Apr 1988	I-131	17.1±1.1	14.2±5.0	10.4
QC-W-39	Water	Apr 1988	H-3	4439±31	4176±500	724
QC-W-40	Water	Apr 1988	Co-60	23.7±0.5	26.1±4.0	8.7
			Cs-134	25.4±2.6	29.2±4.5	8.7
			Cs-137	26.6±2.3	26.2±4.0	8.7
QC-W-41	Water	Jun 1988	Gr. alpha	12.3±0.4	13.1±5.0	8.7
			Gr. beta	22.6±1.0	20.1±5.0	8.7
QC-MI-19	Milk	Jul 1988	Sr-89	15.1±1.6	16.4±5.0	8.7
			Sr-90	18.0±0.6	18.3±5.0	5.2
			I-131	88.4±4.9	86.6±8.0	10.4
			Cs-137	22.7±0.8	20.8±6.0	8.7
QC-W-42	Water	Sep 1988	Sr-89	48.5±3.3	50.8±8.0	8.7
			Sr-90	10.9±1.0	11.4±3.5	5.2
QC-W-43	Water	Oct 1988	Co-60	20.9±3.2	21.4±3.5	8.7
			Cs-134	38.7±1.6	38.0±6.0	8.7
			Cs-137	19.0±2.4	21.0±3.5	8.7
QC-W-44	Water	Oct 1988	I-131	22.2±0.6	23.3±3.5	10.4

Table B-3. In-house spiked samples(continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L TIML Result n=1	Known Activity	Expected Precision 1s, n=1[a]
QC-W-45	Water	Oct 1988	H-3	4109±43	4153±500	724
QC-MI-20	Milk	Oct 1988	I-131	59.8±0.9	60.6±9.0	10.4
			Cs-134	49.6±1.8	48.6±7.5	8.7
			Cs-137	25.8±4.6	24.7±4.0	8.7
QC-W-46	Water	Dec 1988	Gr alpha	11.5±2.3	15.2±5.0	8.7
			Gr. beta	26.5±2.0	25.7±5.0	8.7
QC-MI-21	Milk	Jan 1989	Sr-89	25.5±10.3	34.0±10.0	8.7
			Sr-90	28.3±3.2	27.1±3.0	5.2
			I-131	540±13	550±20	10.4
			Cs-134	24.5±2.6	22.6±5.5	8.7
			Cs-137	24.0±0.6	20.5±5.0	8.7
QC-W-47	Water	Mar 1989	Sr-89	15.2±3.8	16.1±5.0	8.7
			Sr-90	16.4±1.7	16.9±3.0	5.2
QC-MI-22	Milk	Apr 1989	I-131	36.3±1.1	37.2±5.0	10.4
			Cs-134	20.8±2.8	20.7±8.0	8.7
			Cs-137	22.2±2.4	20.4±8.0	8.7
QC-W-48	Water	Apr 1989	Co-60	23.5±2.0	25.1±8.0	8.7
			Cs-134	24.2±1.1	25.9±8.0	8.7
			Cs-137	23.6±1.2	23.0±8.0	8.7
QC-W-49	Water	Apr 1989	I-131	37.2±3.7	37.2±5.0	10.4
QC-W-50	Water	Apr 1989	H-3	3011±59	3089±500	724
QC-W-51	Water	Jun 1989	Gr. alpha	13.0±1.8	15.0±5.0	8.7
			Gr. beta	26.0±1.2	25.5±8.0	8.7
QC-MI-23	Milk	Jul 1989	Sr-89	19.4±6.5	22.0±10.0	8.7
			Sr-90	27.6±3.5	28.6±3.0	5.2
			I-131	46.8±3.2	43.4±5.0	10.4
			Cs-134	27.4±1.8	28.3±6.0	8.7
			Cs-137	24.1±1.8	20.8±6.0	8.7
QC-MI-24	Milk	Aug 1989	Sr-89	25.4±2.7	27.2±10.0	8.7
			Sr-90	46.0±1.1	47.8±9.6	8.3
QC-W-52	Water	Sep 1989	I-131	9.6±0.3	9.7±1.9	10.4

Table B-3. In-house spiked samples (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L TIML Result n=1	Known Activity	Expected Precision 1s, n=1[a]
QC-W-53	Water	Sep 1989	I-131	19.0±0.2	20.9±4.2	10.4
QC-W-54	Water	Sep 1989	Sr-89	25.8±4.6	24.7±4.0	8.7
			Sr-90	26.5±5.3	29.7±5.0	5.2
QC-MI-25	Milk	Oct 1989	I-131	70.0±3.3	73.5±20.0	10.4
			Cs-134	22.1±2.6	22.6±8.0	8.7
			Cs-137	29.4±1.5	27.5±8.0	8.7
QC-W-55	Water	Oct 1989	I-131	33.3±1.3	35.3±10.0	10.4
QC-W-56	Water	Oct 1989	Co-60	15.2±0.9	17.4±5.0	8.7
			Cs-134	22.1±4.4	18.9±8.0	8.7
			Cs-137	27.2±1.2	22.9±8.0	8.7
QC-W-57	Water	Oct 1989	H-3	3334±22	3379±500	724
QC-W-58	Water	Nov 1989	Sr-89	10.9±1.4[d]	11.1±1.0[d]	8.7
			Sr-90	10.4±1.0[d]	10.3±1.0[d]	5.2
QC-W-59	Water	Nov 198-	Sr-89	101.0±6.0[d]	104.1±10.5[d]	17.5
			Sr-90	98.0±3.0[d]	95.0±10.0[d]	17.0
QC-W-60	Water	Dec 1989	Gr. alpha	10.8±1.1	10.6±4.0	8.7
			Gr. beta	11.6±0.5	11.4±4.0	8.7
QC-MI-26	Milk	Jan 1990	Cs-134	19.3±1.0	20.8±8.0	8.7
			Cs-137	25.2±1.2	22.8±8.0	8.7
QC-MI-27	Milk	Feb 1990	Sr-90	18.0±1.6	18.8±5.0	5.2
QC-MI-28	Milk	Mar 1990	I-131	63.8±2.2	62.6±6.0	6.3
QC-MI-61	Water	Apr 1990	Sr-89	17.9±5.5	23.1±8.7	8.7
			Sr-90	19.4±2.5	23.5±5.2	5.2
QC-MI-29	Milk	Apr 1990	I-131	90.7±9.2	82.5±8.5	10.4
			Cs-134	18.3±1.0	19.7±5.0	8.7
			Cs-137	20.3±1.0	18.2±5.0	8.7
QC-W-62	Water	Apr 1990	Co-60	8.7±0.4	9.4±5.0	8.7
			Cs-134	20.0±0.2	19.7±5.0	8.7
			Cs-137	28.7±1.4	22.7±5.0	8.7

Table B-3. In-house spiked samples (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L TIML Result n=1	Known Activity	Expected Precision 1s, n=1[a]
QC-W-63	Water	Apr 1990	I-131	63.5±8.0	66.0±6.7	6.6
QC-W-64	Water	Apr 1990	H-3	1941±130	1826.0±350.0	724
QC-W-65	Water	Jun 1990	Ra-226	6.4±0.2	6.9±1.0	1.0
QC-W-66	Water	Jun 1990	U	6.2±0.2	6.0±6.0	6.0
QC-MI-30	Milk	Jul 1990	Sr-89	12.8±0.4	18.4±10.0	8.7
			Sr-90	18.2±1.4	18.7±6.0	5.2
			Cs-134	46.0±1.3	49.0±5.0	8.7
			Cs-137	27.6±1.3	25.3±5.0	8.7
QC-W-68	Water	Jun 1990	Gr. alpha	9.8±0.3	10.6±6.0	8.7
			Gr. beta	11.4±0.6	11.3±7.0	8.7
QC-MI-31	Milk	Aug 1990	I-131	68.8±1.6	61.4±12.3	10.4
QC-W-69	Water	Sep 1990	Sr-89	17.7±1.6	19.2±10.0	8.7
			Sr-90	13.9±1.6	17.4±10.0	5.2
QC-MI-32	Milk	Oct 1990	I-131	34.8±0.2	32.4±6.5	8.7
			Cs-134	25.8±1.2	27.3±10.0	8.7
			Cs-137	25.3±2.0	22.4±10.0	8.7
QC-W-70	Water	Oct 1990	H-3	2355±59	2276±455	605
QC-W-71	Water	Oct 1990	I-131	55.9±0.9	51.6±10.4	10.4
QC-W-73	Water	Oct 1990	Co-60	18.3±2.7	16.8±5.0	8.7
			Cs-134	28.3±2.3	27.0±5.0	8.7
			Cs-137	22.7±1.3	22.4±5.0	8.7
QC-W-74	Water	Dec 1990	Gr. alpha	21.4±1.0	26.1±6.5	11.3
			Gr. beta	25.9±1.0	22.3±5.6	9.7
QC-MI-33	Milk	Jan 1991	Sr-89	20.7±3.3	21.6±5.0	5.0
			Sr-90	19.0±1.4	23.0±3.0	3.0
			Cs-134	22.2±1.7	19.6±5.0	5.0
			Cs-137	26.1±1.6	22.3±5.0	5.0
QC-MI-34	Milk	Feb 1991	I-131	40.7±1.8	40.1±6.0	6.0
QC-W-75	Water	Mar 1991	Sr-89	18.8±1.5	23.3±5.0	5.0
			Sr-90	16.0±0.8	17.2±3.0	3.0

Table B-3. In-house spiked samples (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L TIML Result n=1	Known Activity	Expected Precision 1s, n=1[a]
QC-W-76	Water	Apr 1991	I-131	56.5±1.7	59.0±5.9	5.9
QC-W-77	Water	Apr 1991	Co-60	16.4±2.2	15.7±5.0	5.0
			Cs-134	23.8±2.5	22.6±5.0	5.0
			Cs-137	25.0±2.4	21.1±5.0	5.0
QC-W-78	Water	Apr 1991	H-3	4027±188	4080±408	408
QC-MI-35	Milk	Apr 1991	I-131	48.0±0.8	49.2±6.0	6.0
			Cs-134	19.2±2.0	22.6±5.0	5.0
			Cs-137	22.8±2.2	22.1±5.0	5.0
QC-W-79	Water	Jun 1991	Gr. alpha	7.4±0.7	7.8±5.0	5.0
			Gr. beta	11.0±0.7	11.0±5.0	5.0
QC-MI-36	Milk	Jul 1991	Sr-89	28.1±2.1	34.0±10.0	10.0
			Sr-90	11.6±0.7	11.5±3.0	3.0
			I-131	14.4±1.9	18.3±5.0	5.0
			Cs-137	34.3±3.0	35.1±5.0	5.0
QC-W-80	Water	Oct 1991	Sr-89	27.4±6.9	24.4±5.0	5.0
			Sr-90	11.7±1.4	14.1±5.0	5.0
QC-W-81	Water	Oct 1991	I-131	19.1±0.7	20.6±4.2	4.2
QC-W-82	Water	Oct 1991	Co-60	22.6±2.7	22.1±5.0	5.0
			Cs-134	15.5±1.8	17.6±5.0	5.0
			Cs-137	17.5±2.1	17.6±5.0	5.0
QC-W-83	Water	Oct 1991	H-3	4639±137	4362±438	438
QC-MI-37	Milk	Oct 1991	I-131	23.6±3.2	25.8±5.0	5.0
			Cs-134	22.7±2.8	22.1±5.0	5.0
			Cs-137	38.3±3.0	35.1±5.0	5.0
QC-W-84	Water	Dec 1991	Gr. alpha	6.2±0.6	7.8±5.0	5.0
			Gr. beta	11.0±0.7	11.0±5.0	5.0

[a] n=3 unless noted otherwise.
[b] n=2 unless noted otherwise.
[c] n=1 unless noted otherwise.
[d] Concentration in pCi/ml.

Table B-4. In-house "blank" samples.

Lab Code	Sample Type	Date Collected	Analysis	Concentration (pCi/L) Results (4.66 σ)	Concentration (pCi/L) Acceptance Criteria (4.66 σ)
SPS-5386	Milk	Jan 1988	I-131	<0.1	<1
SPW-5448	"Dead" Water	Jan 1988	H-3	<177	<300
SPS-5615	Milk	Mar 1988	Cs-134	<2.4	<10
			Cs-137	<2.5	<10
			I-131	<0.3	<1
			Sr-89	<0.4	<5
			Sr-90	2.4±0.5[a]	<1
SPS-5650	D.I. Water	Mar 1988	Th-228	<0.3	<1
			Th-230	<0.04	<1
			Th-232	<0.0[illegible]	<1
			U-234	<0.03	<1
			U-235	<0.03	<1
			U-238	<0.03	<1
			Am-241	<0.06	<1
			Cm-241	<0.01	<1
			Pu-238	<0.08	<1
			Pu-240	<0.02	<1
SPS-6090	Milk	Jul 1988	Sr-89	<0.5	<1
			Sr-90	1.8±0.5	<1
			I-131	<0.4	<1
			Cs-137	<0.4	<10
SPW-6209	Water	Jul 1988	Fe-55	<0.8	<1
SPW-6292	Water	Sep 1988	Sr-89	<0.7	<1
			Sr-90	<0.7	<1
SPS-6477	Milk	Oct 1988	I-131	<0.2	<1
			Cs-134	<6.1	<10
			Cs-137	<5.9	<10
SPW-6478	Water	Oct 1988	I-131	<0.2	<1
SPW-6479	Water	Oct 1988	Co-60	<5.7	<10
			Cs-134	<3.7	<10
			Cs-137	<4.3	<10
SPW-6480	Water	Oct 1988	H-3	<170	<300

Table B-4. In-house "blank" samples (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration (pCi/L) Results (4.66 σ)	Concentration (pCi/L) Acceptance Criteria (4.66 σ)
SPW-6625	Water	Dec 1988	Gr. alpha	<0.7	<1
			Gr. beta	<1.9	<4
SPS-6723	Milk	Jan 1989	Sr-89	<0.6	<5
			Sr-90	1.9±0.5[a]	<1
			I-131	<0.2	<1
			Cs-134	<4.3	<10
			Cs-137	<4.4	<10
SPW-6877	Water	Mar 1989	Sr-89	<0.4	<5
			Sr-90	<0.6	<1
SPS-6963	Milk	Apr 1989	I-131	<0.3	<1
			Cs-134	<3.9	<10
			Cs-137	<6.2	<10
SPW-7561	Water	Apr 1989	H-3	<150	<300
SPW-7207	Water	Jun 1989	Ra-226	<0.2	<1
			Ra-228	<0.6	<1
SPS-7208	Milk	Jun 1989	Sr-89	<0.6	<5
			Sr-90	2.1±0.5[a]	<1
			I-131	<0.3	<1
			Cs-134	<6.4	<10
			Cs-137	<7.2	<10
SPW-7588	Water	Jun 1989	Gr. alpha	<0.2	<1
			Gr. beta	<1.0	<4
SPS-7322	Milk	Aug 1989	Sr-89	<1.4	<5
			Sr-90	4.8±1.0[a]	<1
			I-131	<0.2	<1
			Cs-134	<6.9	<10
			Cs-137	<8.2	<10
SPW-7559	Water	Sep 1989	Sr-89	<2.0	<5
			Sr-90	<0.7	<1
SPW-7560	Water	Oct 1989	I-131	<0.1	<1
SPW-7562	Water	Oct 1989	H-3	<140	<300

Table B-4. In-house "blank" samples (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration (pCi/L) Results (4.66 σ)	Concentration (pCi/L) Acceptance Criteria (4.66 σ)
SPS-7605	Milk	Nov 1989	I-131	<0.2	<1
			Cs-134	<8.6	<10
			Cs-137	<10	<10
SPW-7971	Water	Dec 1989	Gr. alpha	<0.4	<1
			Gr. beta	<0.8	<4
SPW-8039	Water	Jan 1990	Ra-226	<0.2	<1
SPS-8040	Milk	Jan 1990	Sr-89	<0.8	<5
			Sr-90	<1.0	<1
SPS-8208	Milk	Jan 1990	Sr-89	<0.8	<5
			Sr-90	1.6±0.5[a]	<1
			Cs-134	<3.6	<10
			Cs-137	<4.7	<10
SPS-8312	Milk	Feb 1990	Sr-89	<0.3	<5
			Sr-90	1.2±0.3[a]	<1
SPW-8312A	Water	Feb 1990	Sr-89	<0.6	<5
			Sr-90	<0.7	<5
SPS-8314	Milk	Mar 1990	I-131	<0.3	<1
SPS-8510	Milk	May 1990	I-131	<0.2	<1
			Cs-134	<4.6	<10
			Cs-137	<4.8	<10
SPW-8511A	Water	May 1990	H-3	<200	<300
SPS-8600	Milk	Jul 1990	Sr-89	<0.8	<5
			Sr-90	1.7±0.6[a]	<1
			I-131	0.3	<1
			Cs-134	<7.0	<10
			Cs-137	<7.0	<10
SPM-8877	Milk	Aug 1990	I-131	<0.2	<1
SPW-8925	Water	Aug 1990	H-3	<200	<300

Table B-4. In-house "blank" samples (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration (pCi/L) Results (4.66 σ)	Concentration (pCi/L) Acceptance Criteria (4.66 σ)
SPW-8926	Water	Aug 1990	Gr. alpha	<3	<1
			Gr. beta	<0.7	<4
SPW-8927	Water	Aug 1990	U-234	<0.01	<1
			U-235	<0.02	<1
			U-238	<0.01	<1
SPW-8928	Water	Aug 1990	Mn-54	<4.0	<5
			Co-58	<4.1	<5
			Co-60	<2.4	<5
			Cs-134	<3.3	<5
			Cs-137	<3.7	<5
SPW-8929	Water	Aug 1990	Sr-89	<1.4	<5
			Sr-90	<0.6	<1
SPW-69	Water	Sep 1990	Sr-89	<1.8	<5
			Sr-90	<0.8	<1
SPW-106	Water	Oct 1990	H-3	<180	<300
			I-131	<0.3	<1
SPM-107	Milk	Oct 1990	I-131	<0.4	<1
			Cs-134	<3.3	<5
			Cs-137	<4.3	<5
SPW-370	Water	Oct 1990	Mn-54	<1.7	<5
			Co-58	<2.6	<5
			Co-60	<1.6	<5
			Cs-134	<1.7	<5
			Cs-137	<1.8	<5
SPW-372	Water	Dec 1990	Gr. alpha	<0.3	<1
			Gr. beta	<0.8	<4
SPS-406	Milk	Jan 1991	Sr-89	<0.4	<5
			Sr-90	1.8±0.4[a]	<1
			Cs-134	<3.7	<5
			Cs-137	<5.2	<5
SPS-421	Milk	Feb 1991	I-131	<0.3	<1
SPW-451	Water	Feb 1991	Ra-226	<0.1	<1
			Ra-228	<0.9	<1

Table B-4. In-house "blank" samples (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration (pCi/L) Results (4.66 σ)	Concentration (pCi/L) Acceptance Criteria (4.66 σ)
SPW-514	Water	Mar 1991	Sr-89	<1.1	<5
			Sr-90	<0.9	<1
SPW-586	Water	Apr 1991	I-131	<0.2	<1
			Co-60	<2.5	<5
			Cs-134	<2.4	<5
			Cs-137	<2.2	<5
SPS-587	Milk	Apr 1991	I-131	<0.2	<1
			Cs-134	<1.7	<5
			Cs-137	<1.9	<5
SPW 837	Water	Jun 1991	Gr. alpha	<0.6	<1
			Gr. beta	<1.1	<4
SPM-953	Milk	Jul 1991	Sr-89	<0.7	<5
			Sr-90	0.4±0.3[a]	<1
			I-131	<0.2	<1
			Cs-137	<4.9	<5
SPM-1236	Milk	Oct 1991	I-131	<0.2	<1
			Cs-134	<3.7	<5
			Cs-137	<4.6	<5
SPW-1254	Water	Oct 1991	Sr-89	<2.8	<5
			Sr-90	<0.7	<1
SPW-1256	Water	Oct 1991	I-131	<0.4	<1
			Co-60	<3.6	<5
			Cs-134	<4.0	<5
			Cs-137	<3.6	<5
SPW-1259	Water	Oct 1991	H-3	<160	<300
SPW-1444	Water	Dec 1991	Gr. alpha	4	<1
			Gr. beta	<0.8	<4

[a] Low level of Sr-90 concentration in milk (1 - 5 pCi/L) is not unusual.

ATTACHMENT B

ACCEPTANCE CRITERIA FOR "SPIKED" SAMPLES

LABORATORY PRECISION: ONE STANDARD DEVIATION VALUES FOR VARIOUS ANALYSES[a]

Analysis	Level	One Standard Deviation for Single Determination
Gamma Emitters	5 to 100 pCi/liter or kg	5 pCi/liter
	>100 pCi/liter or kg	5% of known value
Strontium-89[b]	5 to 50 pCi/liter or kg	5 pCi/liter
	>50 pCi/liter or kg	10% of known value
Strontium-90[b]	2 to 30 pCi/liter or kg	3.0 pCi/liter
	>30 pCi/liter or kg	10% of known value
Potassium	>0.1 g/liter or kg	5% of known value
Gross alpha	<20 pCi/liter	5 pCi/liter
	>20 pCi/liter	25% of known value
Gross beta	<100 pCi/liter	5 pCi/liter
	>100 pCi/liter	5% of known value
Tritium	<4,000 pCi/liter	$1s = (pCi/liter) = 169.85 \times (known)^{.0933}$
	>4,000 pCi/liter	10% of known value
Radium-226, -228	<0.1 pCi/liter	15% of known value
Plutonium	0.1 pCi/liter, gram, or sample	10% of known value
Iodine-131, Iodine-129[b]	<55 pCi/liter	6 pCi/liter
	>55 pCi/liter	10% of known value
Uranium-238, Nickel-64[b], Technetium-99[b]	<35 pCi/liter	6 pCi/liter
	>35 pCi/liter	15% of known value
Iron-55[b]	50 to 100 pCi/liter	10 pCi/liter
	>100 pCi/liter	10% of known value

[a] From EPA publication, "Environmental Radioactivity Laboratory Intercomparison Studies Program, Fiscal Year, 1981-1982, EPA-600/4-81-004.

[b] TIML limit.

ADDENDUM TO APPENDIX B

The following is an explanation of the reasons why certain samples were outside the control limit specified by the Environmental Protection Agency for the Interlaboratory Comparions Program starting January 1988.

Lab Code	Analysis	TIML Result (pCi/L)[a]	EPA Control Limit (pCi/L)[a]	Explanation
STF-524	K	1010.7±158.5[b]	1123.5-1336.5[b]	Error in transference of data. Correct data was 1105±33 mg/kg. Results in the past have been within the limits and TIML will monitor the situation in the future.
STW-532	I-131	9.0±2.0	6.2-8.8	Sample recounted after 12 days. The average result was 8.8±1.7 pCi/L (within EPA control limits). The sample was recounted in order to check the decay. Results in the past have been within the limits and TIML will continue to monitor the situation in the future.
STW-534	Co-60	63.3±1.3	41.3-58.7	High level of Co-60 was due to contamination of beaker. Beaker was discarded upon discovery of contamination and sample was recounted. Recount results were 53.2±3.6 and 50.9±2.4 pCi/L.
STM-554	Sr-90	51.0±2.0	54.8-65.2	The cause of low result was due to very high fat content of milk. It should be noted that 63% of all participants failed this test. Also, the average for all participants was 54.0 pCi/L before the Grubb and 55.8 pCi/L after the Grubb.
STW-560	Pu-239	5.8±1.1	3.5-4.9	The cause of high results is not known though it is suspected that the standard was not properly calibrated by supplier and is under investigation. New Pu-236 standard was obtained and will be used for the next test.
STW-568	Ra-228	2.6±1.0	2.7-4.5	The cause of low results is not known. Next EPA cross check results were within the control limits. No further action is planned.

ADDENDUM TO APPENDIX B (continued)

Lab Code	Analysis	TIML Result (pCi/L)[a]	EPA Control Limit (pCi/L)[a]	Explanation
STM-570	Sr-89 Sr-90	26.0±10.0 45.7±4.2	30.3-47.7 49.8-60.2	The cause of low results was falsely high recovery due to suspected incomplete calcium removal. Since EPA sample was used up, internal spike was prepared and analyzed. The results were within control limits (See table B-3, sample QC-MI-24). No further action is planned.
STW-589	Sr-90	17.3±1.2	17.4-22.6	Sample was reanalyzed in triplicate; results of reanalyses were 18.8±1.5 pCi/L. No further action is planned.
STM-599	K	1300.0±69.2[c]	1414.7-1685.3[c]	Sample was reanalyzed in triplicate. Results of reanalyses were 1421.7±95.3 mg/L. The cause of low results is unknown.
STW-601	Gr. alpha	11.0±2.0	11.6-32.4	Sample was reanalyzed in triplicate. Results of reanalyses were 13.4±1.0 pCi/L.
STAF-626	Gr. alpha	38.7±1.2	14.6-35.4	The cause of high results is the difference in geometery between standard used in the TIML lab and EPA filter.
STW-632	Ba-133	74.0±6.9	51.6-72.4	Sample was reanalyzed. Results of the reanalyses were 63.8±6.9 pCi/L within EPA limit.
STW-641	I-131	130.7±16.8	88.9-127.1	The cause of high result is unknown. In-house spike sample was prepared with activity of I-131 68.3±6.8 pCi/L. Result of the analysis was 69.1±9.7 pCi/L.

[a] Reported in pCi/L unless otherwise noted.
[b] Concentrations are reported in mg/kg.
[c] Concentrations are reported in mg/L.

APPENDIX C - Data Reporting Conventions

Data Reporting Conventions

1.0. All activities, except gross alpha and gross beta, are decay corrected to collection time or the end of the collection period.

2.0. Single Measurements

Each single measurement is reported as follows:

$$x \pm s$$

where x = value of the measurement;

s = 2σ counting uncertainty (corresponding to the 95% confidence level).

In cases where the activity is found to be below the lower limit of detection L it is reported as

$$<L$$

where L = is the lower limit of detection based on 4.66σ uncertainty for a background sample.

3.0. Duplicate Analyses

3.1. Individual results: $x_1 \pm s_1$
$x_2 \pm s_2$

Reported result: $x \pm s$

where $x = (1/2)\ (x_1 + x_2)$

$$s = (1/2)\sqrt{s_1^2 + s_2^2}$$

3.2. Individual results: $<L_1$
$<L_2$

Reported result: $<L$

where L = lower of L_1 and L_2

3.3. Individual results: $x \pm s$
$<L$

Reported result: $x \pm s$ if $x \geq L$;
$<L$ otherwise

4.0. Computation of Averages and Standard Deviations

4.1 Averages and standard deviations listed in the tables are computed from all of the individual measurements over the period averaged; for example, an annual standard deviation would not be the average of quarterly standard deviations. The average $\bar{x}$ and standard deviation(s) of a set of n numbers $x_1, x_2, \ldots x_n$ are defined as follows:

$$\bar{x} = \frac{1}{n} \Sigma x$$

$$s = \sqrt{\frac{\Sigma (x-\bar{x})^2}{n-1}}$$

4.2 Values below the highest lower limit of detection are not included in the average.

4.3 If all of the values in the averaging group are less than the highest LLD, the highest LLD is reported.

4.4 If all but one of the values are less than the highest LLD, the single value x and associated two sigma error is reported.

4.5. In rounding off, the following rules are followed:

4.5.1. If the figure following those to be retained is less than 5, the figure is dropped, and the retained figures are kept unchanged. As an example, 11.443 is rounded off to 11.44.

4.5.2 If the figure following those to be retained is greater than 5, the figure is dropped, and the last retained figure is raised by 1. As an example, 11.446 is rounded off to 11.45.

4.5.3. If the figure following those to be retained is 5, and if there are no figures other than zeros beyond the five, the figure 5 is dropped, and the last-place figure retained is increased by one if it is an odd number or it is kept unchanged if an even number. As an example, 11.435 is rounded off to 11.44, while 11.425 is rounded off to 11.42.

APPENDIX D - Maximum Permissible Concentrations of Radioactivity in Air and Water Above Natural Background in Unrestricted Areas

Table D-1 Maximum permissible concentrations of radioactivity in air and water above natural background in unrestricted areas.[a]

Air			Water	
Gross alpha	3	pCi/m^3	Strontium-89	3,000 pCi/l
Gross beta	100	pCi/m^3	Strontium-90	300 pCi/l
Iodine-131[b]	0.14	pCi/m^3	Cesium-137	20,000 pCi/l
			Barium-140	20,000 pCi/l
			Iodine-131	300 pCi/l
			Potassium-40[c]	3,000 pCi/l
			Gross alpha	30 pCi/l
			Gross beta	100 pCi/l
			Tritium	3×10^6 pCi/l

[a] Taken from Code of Federal Regulations Title 10, Part 20, Table II and appropriate footnotes. Concentrations may be averaged over a period not greater than one year.

[b] From 10 CFR 20 but adjusted by a factor of 700 to reduce the dose resulting from the air-grass-cow-milk-child pathway.

[c] A natural radionuclide.

Appendix E - REMP Sampling Summary

Table E-1 Environmental Radiological Monitoring Program Summary

Name of Facility Davis-Besse Nuclear Power Station Docket No. 50-346

Location of Facility Ottawa, Ohio (County, State) Reporting Period January - December 1991

Sample Type (Units)	Type and Number of Analyses[a]	LLD[b]	Indicator Locations Mean (F)[c] Range[c]	Location with Highest Annual Mean		Control Locations Mean (F)[c] Range[c]	Number of Non-routine Results[e]
				Location[d]	Mean (F)[c] Range[c]		
Airborne Particulates (pCi/m^3)	GB 520	0.005	0.021 (312/312) (0.006-0.041)	T-12, Toledo Water Treatment Plant 23.5 mi WNW	0.023 (52/52) (0.009-0.042)	0.022 (208/208) (0.007-0.044)	0
	Sr-89 40	0.0013	<LLD	-	-	<LLD	0
	Sr-90 40	0.0006	<LLD	-	-	<LLD	0
	GS 40						
	Be-7	0.015	0.054 (24/24) (0.041-0.066)	T-2, Site boundary 0.9 mi E	0.058 (4/4) (0.050-0.066)	0.056 (16/16) (0.043-0.066)	0
				T-8, Farm 2.7 mi WSW	0.058 (4/4) (0.050-0.063)		
				T-9, Oak Harbor Substation 6.8 mi SW	0.058 (4/4) (0.051-0.061)		
	K-40	0.029	<LLD	-	-	<LLD	0
	Nb-95	0.0033	<LLD	-	-	<LLD	0
	Zr-95	0.0032	<LLD	-	-	<LLD	0
	Ru-103	0.0016	<LLD	-	-	<LLD	0
	Ru-106	0.014	<LLD	-	-	<LLD	0
	Cs-134	0.0013	<LLD	-	-	<LLD	0
	Cs-137	0.0016	<LLD	-	-	<LLD	0
	Ce-141	0.0027	<LLD	-	-	<LLD	0
	Ce-144	0.0081	<LLD	-	-	<LLD	0

Table E-1 Environmental Radiological Monitoing Program Summary (continued)

Name of Facility Davis-Besse Nuclear Power Station Docket No. 50-346

Location of Facility Ottawa, Ohio (County, State) Reporting Period January - December 1991

Sample Type (Units)	Type and Number of Analyses[a]		LLD[b]	Indicator Locations Mean (F)[c] Range[c]	Location with Highest Annual Mean Location[d]	Location with Highest Annual Mean Mean (F)[c] Range[c]	Control Locations Mean (F)[c] Range[c]	Number of Non-routine Results[e]
Airborne Iodine (pCi/m^3)	I-131	520	0.07	<LLD	-	-	<LLD	0
TLD (Quarterly) (mR/91 days)	Gamma	369	1.0	15.0 (277/277) (8.2-22.7)	T-66, Site boundary 0.3 mi ENE	21.5 (4/4) (20.2-22.1)	16.2 (92/92) (8.20-20.6)	0
TLD (Annual) (mR/365 days)	Gamma	88	1.0	60.5 (65/65) (36.8-88.5)	T-66 Site Boundary 0.3 mi ENE	83.4 (1/1) -	68.6 (23/23) (43.7-84.8)	0
Milk (pCi/L)	I-131	55	0.4	<LLD	-	-	<LLD	0
	Sr-89	55	1.1	<LLD	-	-	<LLD	0
	Sr-90	55	0.5[f]	1.0 (17/18) (0.5-1.4)	T-199, Farm 8.5 mi SW	2.4 (1/1)	1.2 (37/37) (0.6-2.4)	0
	GS	55						
	K-40		100	1240 (18/18) (1100-1500)	T-57, Farm 22.0 mi SSE	1260 (18/18) (1050-1460)	1250 (37/37) (1050-1460)	0
	Cs-137		10	<LLD	-	-	<LLD	0
	Ba-140		10	<LLD	-	-	<LLD	0
	Ca	55	0.50	0.84 (18/18) (0.50-1.01)	T-199, Farm 8.5 mi SW	0.96 (1/1)	0.91 (37/37) (0.61-1.16)	0
	K (stable)	55	0.04	1.43 (18/18) (1.27-1.73)	T-57, Farm 22.0 mi ESE	1.46 (18/18) (1.21-1.69)	1.45 (37/37) (1.21-1.69)	0
	Sr-90/Ca	55	0.369	1 (17/18) (0.59-2.12)	T-199, Farm 8.5 mi SW	2.50 (1/1)	1.39 (37/37) (0.58-2.55)	0
	Cs-137/K	55	8.26	<LLD	-	-	<LLD	0

Table E-1 Environmental Radiological Monitoing Program Summary (continued)

Name of Facility Davis-Besse Nuclear Power Station Docket No. 50-346

Location of Facility Ottawa, Ohio (County, State) Reporting Period January - December 1991

Sample Type (Units)	Type and Number of Analyses[a]	LLD[b]	Indicator Locations Mean (F)[c] Range[c]	Location with Highest Annual Mean: Location[d]	Location with Highest Annual Mean: Mean (F)[c] Range[c]	Control Locations Mean (F)[c] Range[c]	Number of Non-routine Results[e]
Ground Water	GB (SS) 15	0.8	<LLD	-	-	<LLD	0
	GB (DS) 15	2.3	3.0 (8/8) (2.4-3.3)	T-54, Farm 4.8 mi SW	3.1 (4/4) (2.4-3.3)	2.3 (2/7) (2.3-2.3)	0
	GB (TR) 15	2.3	3.0 (8/8) (2.4-3.3)	T-54, Farm 4.8 mi SW	3.1 (4/4) (2.4-3.3)	2.4 (5/8) (2.0-2.8)	0
	H-3 15	330	<LLD	-	-	<LLD	0
	Sr-89 15	1.5	<LLD	-	-	<LLD	0
	Sr-90 15	0.9	0.9 (1/8)	T-7, Sand Beach 0.9 mi NW	0.9 (1/1)	<LLD	0
	GS 15						
	Cs-137	10.0	<LLD	-	-	<LLD	0
Edible Meat (pCi/g wet)	GS 4						
	K-40	0.1	2.83 (3/3) (1.47-2.71)	T-197, Farm 1.7 mi W	2.71 (1/1)	1.94 (1/1)	0
	Cs-137	0.029	<LLD	-	-	<LLD	0
Fruits and Vegetables (pCi/g wet)	Sr-89 6	0.006	<LLD	-	-	<LLD	0
	Sr-90 6	0.001	0.004 (1/3)	T-173, Firelands winery Sandusky 20.0 mi SE	0.005 (1/3)	0.005 (1/3)	0
	I-131 6	0.033	<LLD	-	-	<LLD	

Table E-1 Environmental Radiological Monitoing Program Summary (continued)

Name of Facility Davis-Besse Nuclear Power Station Docket No. 50-346

Location of Facility Ottawa, Ohio (County, State) Reporting Period January - December 1991

Sample Type (Units)	Type and Number of Analyses[a]	LLD[b]	Indicator Locations Mean (F)[c] Range[c]	Location with Highest Annual Mean Location[d]	Location with Highest Annual Mean Mean (F)[c] Range[c]	Control Locations Mean (F)[c] Range[c]	Number of Non-routine Results[e]
Fruits and Vegetables (pCi/g wet) (continued)	SS 6						
	K-40	0.50	2.09 (3/3) (0.91-4.27)	I-8, Farm 2.7 mi WSW	2.59 (2/2) (0.91-4.27)	1.68 (3/3) (1.06-2.20)	0
	Nb-95	0.022	<LLD	-	-	<LLD	0
	Zr-95	0.032	<LLD	-	-	<LLD	0
	Cs-137	0.018	<LLD	-	-	<LLD	0
	Ce-141	0.026	<LLD	-	-	<LLD	0
	Ce-144	0.11	<LLD	-	-	<LLD	0
Broad Leaf Vegetation (pCi/g wet)	Sr-89 16	0.009	<LLD	-	-	<LLD	0
	Sr-90 16	0.004	0.005 (5/13) (0.004-0.005)	I-8, Farm 2.7 mi WSW	0.005 (4/7) (0.004-0.005)	<LLD	0
	I-131 16	0.047	<LLD	-	-	<LLD	0
	GS 16						
	K-40	0.1	5.30 (13/13) (3.13-8.91)	I-25, Farm 3.7 mi S	6.51 (6/6) (4.09-8.91)	1.79 (3/3) (1.57-2.06)	0
	Nb-95	0.036	<LLD	-	-	<LLD	0
	Zr-95	0.052	<LLD	-	-	<LLD	0
	Cs-137	0.019	<LLD	-	-	<LLD	0
	Ce-141	0.049	<LLD	-	-	<LLD	0
	Ce-144	0.14	<LLD	-	-	<LLD	0

Table E-1 Environmental Radiological Monitoing Program Summary (continued)

Name of Facility Davis-Besse Nuclear Power Station Docket No. 50-346

Location of Facility Ottawa, Ohio (County, State) Reporting Period January - December 1991

Sample Type (Units)	Type and Number of Analyses[a]	LLD[b]	Indicator Locations Mean (F)[c] Range[c]	Location with Highest Annual Mean		Control Locations Mean (F)[c] Range[c]	Number of Non-routine Results[e]
				Location[d]	Mean (F)[c] Range[c]		
Eggs (pCi/g wet)	GS 2						
	K-40	0.01	1.01 (1/1) -	T-34, Offsite roving location	1.33 (1/1) -	1.33 (LLD)	0
	Nb-95	0.035	<LLD	-	-	<LLD	0
	Zr-95	0.047	<LLD	-	-	<LLD	0
	Ru-103	0.023	<LLD	-	-	<LLD	0
	Ru-106	0.16	<LLD	-	-	<LLD	0
	Cs-137	0.018	<LLD	-	-	<LLD	0
	Ce-141	0.039	<LLD	-	-	<LLD	0
	Ce-144	0.11	<LLD	-	-	<LLD	0
Animal - Wildlife Feed (pCi/g wet)	GS 10						
	Be-7	0.36	1.02 (2/7) (0.84-1.20)	T-19B, Toussaint Creek, 4.0 mi WSW	1.20 (1/1) -	0.70 (1/3)	0
	K-40	0.1	5.50 (7/7) (2.03-12.70)	T-8, Farm 2.7 mi WSW	9.08 (3/3) (2.03-12.70)	7.64 (3/3) (2.59-16.40)	0
	Nb-95	0.050	<LLD	-	-	<LLD	0
	Zr-95	0.082	<LLD	-	-	<LLD	0
	Ru-103	0.043	<LLD	-	-	<LLD	0
	Ru-106	0.26	<LLD	-	-	<LLD	0
	Cs-137	0.036	<LLD	-	-	<LLD	0
	Ce-141	0.060	<LLD	-	-	<LLD	0
	Ce-144	0.23	<LLD	-	-	<LLD	0

Table E-1 Environmental Radiological Monitoing Program Summary (continued)

Name of Facility Davis-Besse Nuclear Power Station Docket No. 50-346

Location of Facility Ottawa, Ohio (County, State) Reporting Period January - December 1991

Sample Type (Units)	Type and Number of Analyses[a]	LLD[b]	Indicator Locations Mean (f)[c] Range[c]	Location with Highest Annual Mean Location[d]	Location with Highest Annual Mean Mean (f)[c] Range[c]	Control Locations Mean (f)[c] Range[c]	Number of Non-routine Results[e]
Soil (pCi/g dry)	GS 22						
	Be-7	0.56	0.98 (1/12)	I-8, Farm 2.7 mi WSW	0.98 (1/2)	<LLD	0
	K-40	1.0	13.79 (12/12) (7.33-23.68)	I-8, Farm 2.7 mi WSW	22.90 (2/2) (22.15-23.68)	15.33 (10/10) (9.92-20.18)	0
	Zr-95	0.086	<LLD	-	-	<LLD	0
	Nb-95	0.13	<LLD	-	-	<LLD	0
	Ru-103	0.063	<LLD	-	-	<LLD	0
	Ru-106	0.98	<LLD	-	-	<LLD	0
	Cs-137	0.043	0.23 (9/12) (0.084-0.36)	I-9, Oak Harbor Substation 6.8 mi SW	0.56 (2/2) (0.39-0.73)	0.40 (10/10) (0.15-0.73)	0
	Ce-141	0.12	<LLD	-	-	<LLD	0
	Ce-144	0.41	<LLD	-	-	<LLD	0
Treated Surface Water (pCi/L)	GB (SS) 72	0.9	<LLD	-	-	<LLD	0
	GB (DS) 72	1.0	2.3 (36/36) (1.6-3.3)	I-144, Green Cove Cond., 0.9 mi NNW	2.5 (12/12) (1.7-3.3)	2.2 (36/36) (1.8-2.6)	0
	GB (TR) 72	1.0	1.6 (36/36) (1.6-3.3)	I-144, Green Cove Cond., 0.9 mi NNW	2.5 (12/12) (1.7-3.3)	2.2 (36/36) (1.8-2.6)	0
	H-3 24	330	<LLD	-	-	<LLD	0
	Sr-89 24	1.6	<LLD	-	-	<LLD	0
	Sr-90 24	0.6	0.7 (2/12) (0.6-0.8)	I-144, Green Cove Cond., 0.9 mi NNW	0.8 (1/4)	0.6 (2/12) (0.6-0.6)	0
	GS 24						
	Cs-137	10.0	<LLD	-	-	<LLD	0

Table E-1 Environmental Radiological Monitoring Program Summary (continued)

Name of Facility Davis-Besse Nuclear Power Station Docket No. 50-346

Location of Facility Ottawa, Ohio (County, State) Reporting Period January - December 1991

Sample Type (Units)	Type and number of Analyses[a]	LLD[b]	Indicator Locations Mean (F)[c] Range[c]	Location with Highest Annual Mean		Control Locations Mean (F)[c] Range[c]	Number of Non-routine Results[e]
				Location[d]	Mean (F)[c] Range[c]		
Untreated Surface Water (pCi/L)	GB (SS) 156	0.9	<LLD	T-12, Toledo Water Treatment Plant 11.25 mi NW	2.7 (2/78) (1.2-4.2)	2.7 (2/78) (1.2-4.2)	0
	GB (DS) 156	1.0	2.6 (78/78) (1.5-4.4)	T-3, Site boundary 1.4 mi ESE	3.0 (12/12) (1.9-3.6)	2.3 (78/78) (1.6-4.1)	0
	GB (TR) 156	1.0	2.6 (78/78) (1.5-4.4)	T-12, Toledo Water Treatment Plant 11.25 mi NW	3.1 (12/12) (2.1-8.3)	2.4 (78/78) (1.6-8.3)	0
	H-3 156	330	531 (5/78) (337-884)	T-130, Lake Erie 1.7 mi ESE	884 (1/6) -	333 (1/78) -	0
	Sr-89 108	2.3	<LLD	-	-	<LLD	0
	Sr-90 108	0.9	1.1 (3/54) (0.9-1.2)	T-158, Lake Erie 10.0 mi WNW	1.4 (1/6)	1.1 (7/54) (0.9-1.4)	0
	GS 156						
	Cs-137	10	<LLD	-	-	<LLD	0
Fish	GB 6	0.1	2.43 (3/3) (2.20-2.66)	T-35, Lake Erie >10 mi radius	2.76 (3/3) (2.27-3.31)	2.76 (3/3) (2.27-3.31)	0
	GS 6						
	K-40	0.1	2.42 (3/3) (1.90-3.17)	T-33, Lake Erie 1.5 mi NE	2.42 (3/3) (1.90-3.17)	2.12 (3/3) (1.87-2.56)	0
	Cs-137	0.035	<LLD	--	--	<LLD	0

Table E-1 Environmental Radiological Monitoing Program Summary (continued)

Name of Facility Davis-Besse Nuclear Power Station Docket No. 50-346

Location of Facility Ottawa, Ohio (County, State) Reporting Period January - December 199[illegible]

Sample Type (Units)	Type and Number of Analyses[a]	LLD[b]	Indicator Locations Mean (F)[c] Range[c]	Location with Highest Annual Mean		Control Locations Mean (F)[c] Range[c]	Number of Non-routine Results[e]
				Location[d]	Mean (F)[c] Range[c]		
Shoreline Sediments (pCi/g dry)	GS 15						
	K-40	0.1	12.97 (9/9) (9.57-17.80)	T-138, Lake Erie 11.0 mi NW	15.46 (2/2) (13.10-17.82)	12.07 (6/6) (9.70-17.82)	0
	Cs-137	0.062	0.14 (3/9) (0.11-0.20)	T-138, Lake Erie 11.0 mi NW	0.52 (2/2) (0.47-0.57)	0.52 (2/6) (0.47-0.57)	0

[a] GB = gross beta, GS = gamma scan, SS = suspended solids, DS = dissolved solids, TR = total residue.
[b] LLD = nominal lower limit of detection based on 4.66 sigma counting error for background sample.
[c] Mean based upon detectable measurements only. Fraction of detectable measurements at specified locations is indicated in parentheses (F).
[d] Locations are specified by station code (Table 4.1) and distance (miles) and direction relative to reactor site.
[e] Non-routine results are those which exceed ten times the control station value.
[f] One result (<0.7 pCi/l) was excluded in the determination of Sr-90 in milk. The elevated LLD resulted from low carrier recovery.
[g] One result (<1.40 pCi Sr-90/g Ca) was excluded in the determination of LLD of Sr-90/Ca. The elevated LLD resulted from high LLD fo[illegible] Sr-90.

ATTACHMENT 1

to the

ANNUAL ENVIRONMENTAL OPERATING REPORT:

Radiological Environmental Monitoring

Program Sample Analysis Results

for

DAVIS-BESSE NUCLEAR POWER STATION

January 1, 1991 to December 31, 1991

Prepared by:
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Davis-Besse Nuclear Power Station
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Introduction

Attachment 1 to the Davis-Besse Nuclear Power Station 1991 Annual Environmental Operating Report (AEOR) includes the results of analysis of all radiological environmental radiation measurements taken as part of the 1991 Radiological Environmental Monitoring Program (REMP). The summaries provided in Appendix E and thoughout the text of the 1991 AEOR are based on the data presented in the following table.

Data tabulation and sample analyses results were provided by Teledyne Isotopes Midwest Laboratory (TIML) in the TIML annual report to Toledo Edison (Part II, Feb 1992).

Table 1. Airborne particulates and iodine collected at Location T-1, analyses for gross beta and iodine-131.[a]

Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)	Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)
01-07-91	304	0.028±0.003	07-08-91	288	0.017±0.003
01-14-91	298	0.025±0.003	07-15-91	274	0.014±0.003
01-21-91	297	0.032±0.004	07-22-91	301	0.034±0.004
01-28-91	305	0.021±0.003	07-29-91	280	0.014±0.003
02-04-91	298	0.026±0.003	08-05-91	282	0.016±0.003
02-11-91	299	0.029±0.004	08-12-91	292	0.016±0.003
02-18-91	297	0.015±0.003	08-19-91	305	0.013±0.003
02-25-91	309	0.021±0.003	08-26-91	285	0.014±0.003
03-04-91	299	0.020±0.003	09-02-91	284	0.022±0.002
03-11-91	281	0.025±0.004	09-09-91	283	0.020±0.003
03-18-91	275	0.015±0.003	09-16-91	279	0.021±0.003
03-25-91	285	0.016±0.004	09-23-91	202	0.027±0.003
04-01-91	283	0.016±0.003	09-30-91	280	0.012±0.002
1st Qtr. mean ± s.d.		0.022±0.006	3rd Qtr. mean ± s.d.		0.018±0.006
04-08-91	285	0.028±0.004	10-07-91	255	0.029±0.004
04-15-91	277	0.020±0.003	10-14-91	287	0.020±0.003
04-22-91	278	0.008±0.003	10-21-91	287	0.019±0.003
04-29-91	276	0.024±0.003	10-28-91	284	0.022±0.002
05-06-91	204	0.016±0.004	11-04-91	313	0.025±0.003
05-13-91	283	0.016±0.003	11-11-91	294	0.024±0.003
05-20-91	279	0.014±0.003	11-18-91	270	0.035±0.003
05-27-91	285	0.016±0.002	11-25-91	281	0.025±0.004
06-03-91	282	0.021±0.003	12-02-91	285	0.030±0.004
06-10-91	284	0.009±0.003	12-09-91	287	0.022±0.004
06-17-91	282	0.018±0.003	12-16-91	287	0.030±0.004
06-24-91	285	0.021±0.003	12-23-91	284	0.021±0.004
07-01-91	285	0.020±0.003	12-30-91	285	0.024±0.004
2nd Qtr. mean ± s.d.		0.018±0.006	4th Qtr. mean ± s.d.		0.025±0.005

[a] Iodine-131 concentrations are <0.07 pCi/m^3 unless noted otherwise in Appendix C.

Table 2. Airborne particulates and iodine collected at Location T-2, analyses for gross beta and iodine-131.[a]

Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)	Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)
01-07-91	290	0.032±0.004	07-08-91	299	0.020±0.003
01-14-91	289	0.022±0.003	07-15-91	300	0.012±0.003
01-21-91	293	0.030±0.004	07-22-91	301	0.030±0.004
01-28-91	291	0.022±0.003	07-29-91	298	0.014±0.003
02-04-91	289	0.026±0.003	08-05-91	302	0.018±0.003
02-11-91	288	0.032±0.004	08-12-91	296	0.015±0.003
02-18-91	286	0.018±0.003	08-19-91	299	0.025±0.004
02-25-91	288	0.020±0.003	08-26-91	305	0.020±0.003
03-04-91	286	0.019±0.003	09-02-91	299	0.026±0.003
03-11-91	289	0.022±0.003	09-09-91	298	0.023±0.003
03-18-91	285	0.012±0.003	09-16-91	290	0.023±0.003
03-25-91	291	0.022±0.004	09-23-91	287	0.016±0.002
04-01-91	291	0.017±0.003	09-30-91	289	0.012±0.002
1st Qtr. mean ± s.d.		0.023±0.006	3rd Qtr. mean ± s.d.		0.020±0.006
04-08-91	289	0.022±0.004	10-07-91	300	0.020±0.003
04-15-91	285	0.021±0.003	10-14-91	304	0.023±0.003
04-22-91	291	0.011±0.003	10-21-91	297	0.021±0.003
04-29-91	295	0.022±0.002	10-28-91	291	0.025±0.002
05-06-91	297	0.011±0.003	11-04-91	298	0.027±0.003
05-13-91	297	0.020±0.003	11-11-91	290	0.026±0.004
05-20-91	298	0.015±0.003	11-18-91	288	0.040±0.003
05-27-91	303	0.016±0.002	11-25-91	293	0.028±0.004
06-03-91	266	0.007±0.003	12-02-91	289	0.031±0.004
06-10-91	299	0.010±0.003	12-09-91	283	0.022±0.004
06-17-91	296	0.016±0.003	12-16-91	293	0.031±0.004
06-24-91	291	0.018±0.003	12-23-91	285	0.016±0.003
07-01-91	296	0.021±0.003	12-30-91	289	0.026±0.004
2nd Qtr. mean ± s.d.		0.016±0.005	4th Qtr. mean ± s.d.		0.026±0.006

[a] Iodine-131 concentrations are <0.07 pCi/m^3 unless noted otherwise in Appendix C.

Table 3. Airborne particulates and iodine collected at Location T-3, analyses for gross beta and iodine-131.[a]

Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)	Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)
01-07-91	287	0.032±0.004	07-08-91	285	0.023±0.004
01-14-91	284	0.024±0.003	07-15-91	278	0.014±0.003
01-21-91	293	0.032±0.004	07-22-91	285	0.032±0.004
01-28-91	282	0.022±0.003	07-29-91	283	0.016±0.003
02-04-91	298	0.028±0.003	08-05-91	285	0.017±0.003
02-11-91	288	0.032±0.004	08-12-91	292	0.017±0.003
02-18-91	274	0.018±0.003	08-19-91	292	0.023±0.003
02-25-91	279	0.024±0.003	08-26-91	290	0.018±0.003
03-04-91	274	0.024±0.003	09-02-91	291	0.025±0.003
03-11-91	279	0.025±0.004	09-09-91	284	0.019±0.003
03-18-91	271	0.013±0.003	09-16-91	293	0.025±0.004
03-25-91	282	0.019±0.004	09-23-91	292	0.019±0.002
04-01-91	265	0.018±0.004	09-30-91	293	0.010±0.002
1st Qtr. mean ± s.d.		0.024±0.006	3rd Qtr. mean ± s.d.		0.020±0.006
04-08-91	282	0.025±0.004	10-07-91	33	0.023±0.003
04-15-91	278	0.018±0.003	10-14-91	287	0.024±0.004
04-22-91	273	0.010±0.003	10-21-91	293	0.019±0.003
04-29-91	275	0.019±0.002	10-28-91	280	0.016±0.002
05-06-91	284	0.010±0.003	11-04-91	305	0.024±0.003
05-13-91	284	0.019±0.003	11-11-91	292	0.022±0.003
05-20-91	271	0.015±0.003	11-18-91	296	0.037±0.003
05-27-91	307	0.014±0.002	11-25-91	297	0.026±0.003
06-03-91	274	0.006±0.002	12-02-91	294	0.026±0.003
06-10-91	277	0.009±0.003	12-09-91	294	0.020±0.003
06-17-91	278	0.011±0.003	12-16-91	295	0.028±0.004
06-24-91	280	0.020±0.003	12-23-91	297	0.016±0.003
07-01-91	307	0.021±0.003	12-30-91	296	0.021±0.003
2nd Qtr. mean ± s.d.		0.015±0.006	4th Qtr. mean ± s.d.		0.023±0.006

[a] Iodine-131 concentrations are <0.07 pCi/m^3 unless noted otherwise in Appendix C.

Table 4. Airborne particulates and iodine collected at Location T-4, analyses for gross beta and iodine-131.[a]

Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)	Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)
01-07-91	294	0.031±0.004	07-08-91	267	0.022±0.004
01-14-91	285	0.025±0.003	07-15-91	270	0.014±0.003
01-21-91	298	0.036±0.004	07-22-91	272	0.034±0.004
01-28-91	284	0.024±0.004	07-29-91	269	0.014±0.003
02-04-91	292	0.029±0.004	08-05-91	277	0.016±0.003
02-11-91	277	0.029±0.004	08-12-91	265	0.016±0.003
02-18-91	270	0.016±0.003	08-19-91	272	0.031±0.004
02-25-91	292	0.020±0.003	08-26-91	266	0.018±0.003
03-04-91	282	0.021±0.003	09-02-91	269	0.026±0.003
03-11-91	283	0.024±0.004	09-09-91	274	0.026±0.004
03-18-91	278	0.017±0.003	09-16-91	268	0.024±0.004
03-25-91	291	0.021±0.004	09-23-91	270	0.017±0.002
04-01-91	288	0.018±0.003	09-30-91	226	0.008±0.002
1st Qtr. mean ± s.d.		0.024±0.006	3rd Qtr. mean ± s.d.		0.020±0.007
04-08-91	279	0.023±0.004	10-07-91	243	0.022±0.004
04-15-91	277	0.021±0.003	10-14-91	293	0.021±0.003
04-22-91	286	0.006±0.002	10-21-91	243	0.018±0.004
04-29-91	282	0.021±0.002	10-28-91	293	0.025±0.002
05-06-91	236	0.013±0.004	11-04-91	298	0.026±0.003
05-13-91	269	0.020±0.003	11-11-91	293	0.026±0.003
05-20-91	270	0.019±0.003	11-18-91	288	0.038±0.003
05-27-91	278	0.014±0.002	11-25-91	299	0.028±0.004
06-03-91	272	0.012±0.003	12-02-91	288	0.026±0.004
06-10-91	279	0.012±0.002	12-09-91	285	0.022±0.004
06-17-91	270	0.016±0.003	12-16-91	296	0.031±0.004
06-24-91	271	0.020±0.003	12-23-91	286	0.021±0.004
07-01-91	275	0.020±0.003	12-30-91	292	0.021±0.003
2nd Qtr. mean ± s.d.		0.017±0.005	4th Qtr. mean ± s.d.		0.025±0.005

[a] Iodine-131 concentrations are <0.07 pCi/m^3 unless noted otherwise in Appendix C.

Table 5. Airborne particulates and iodine collected at Location T-7, analyses for gross beta and iodine-131.[a]

Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)	Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)
01-07-91	264	0.027±0.004	07-08-91	308	0.020±0.003
01-14-91	271	0.025±0.004	07-15-91	296	0.016±0.003
01-21-91	275	0.031±0.004	07-22-91	298	0.033±0.004
01-28-91	274	0.024±0.004	07-29-91	298	0.016±0.003
02-04-91	295	0.025±0.003	08-05-91	298	0.019±0.003
02-11-91	275	0.026±0.004	08-12-91	299	0.016±0.003
02-18-91	268	0.014±0.003	08-19-91	297	0.027±0.004
02-25-91	273	0.021±0.003	08-26-91	308	0.018±0.003
03-04-91	274	0.021±0.003	09-02-91	298	0.025±0.002
03-11-91	273	0.020±0.003	09-09-91	300	0.027±0.004
03-18-91	270	0.019±0.003	09-16-91	297	0.031±0.004
03-25-91	282	0.019±0.004	09-23-91	290	0.018±0.002
04-01-91	270	0.018±0.004	09-30-91	298	0.012±0.002
1st Qtr. mean ± s.d.		0.022±0.004	3rd Qtr. mean ± s.d.		0.021±0.006
04-08-91	269	0.021±0.004	10-07-91	299	0.030±0.004
04-15-91	260	0.020±0.004	10-14-91	298	0.023±0.003
04-22-91	256	0.008±0.003	10-21-91	298	0.019±0.003
04-29-91	283	0.020±0.002	10-28-91	299	0.030±0.003
05-06-91	276	0.008±0.003	11-04-91	298	0.029±0.004
05-13-91	272	0.018±0.003	11-11-91	297	0.023±0.003
05-20-91	277	0.017±0.003	11-18-91	298	0.041±0.003
05-27-91	277	0.016±0.002	11-25-91	298	0.032±0.004
06-03-91	269	0.015±0.003	12-02-91	300	0.028±0.004
06-10-91	278	0.009±0.003	12-09-91	296	0.024±0.004
06-17-91	270	0.018±0.003	12-16-91	285	0.032±0.004
06-24-91	274	0.017±0.003	12-23-91	283	0.022±0.004
07-01-91	278	0.020±0.003	12-30-91	285	0.024±0.004
2nd Qtr. mean ± s.d.		0.016±0.005	4th Qtr. mean ± s.d.		0.027±0.006

[a] Iodine-131 concentrations are <0.07 pCi/m^3 unless noted otherwise in Appendix C.

Table 6. Airborne particulates and iodine collected at Location T-8, analyses for gross beta and iodine-131.[a]

Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)	Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)
01-07-91	286	0.033±0.004	07-08-91	279	0.020±0.003
01-14-91	276	0.022±0.003	07-15-91	287	0.010±0.003
01-21-91	291	0.034±0.004	07-22-91	284	0.030±0.004
01-28-91	284	0.027±0.004	07-29-91	289	0.015±0.003
02-04-91	305	0.027±0.003	08-05-91	286	0.016±0.003
02-11-91	311	0.028±0.003	08-12-91	285	0.014±0.003
02-18-91	260	0.018±0.003	08-19-91	283	0.022±0.004
02-25-91	286	0.022±0.003	08-26-91	298	0.021±0.003
03-04-91	251	0.023±0.004	09-02-91	292	0.024±0.002
03-11-91	277	0.026±0.004	09-09-91	287	0.024±0.004
03-18-91	273	0.012±0.003	09-16-91	291	0.024±0.003
03-25-91	270	0.018±0.004	09-23-91	288	0.019±0.002
04-01-91	281	0.020±0.003	09-30-91	296	0.013±0.002
1st Qtr. mean ± s.d.		0.024±0.006	3rd Qtr. mean ± s.d.		0.019±0.006
04-08-91	272	0.034±0.004	10-07-91	292	0.013±0.003
04-15-91	256	0.019±0.004	10-14-91	295	0.025±0.003
04-22-91	282	0.005±0.003	10-21-91	297	0.020±0.003
04-29-91	289	0.024±0.002	10-28-91	296	0.024±0.002
05-06-91	272	0.011±0.003	11-04-91	300	0.023±0.003
05-13-91	283	0.020±0.003	11-11-91	292	0.022±0.003
05-20-91	270	0.017±0.003	11-18-91	294	0.040±0.003
05-27-91	266	0.016±0.002	11-25-91	298	0.025±0.003
06-03-91	289	0.015±0.003	12-02-91	300	0.026±0.003
06-10-91	284	0.010±0.003	12-09-91	292	0.022±0.004
06-17-91	285	0.018±0.003	12-16-91	302	0.027±0.004
06-24-91	283	0.018±0.003	12-23-91	293	0.016±0.003
07-01-91	281	0.017±0.003	12-30-91	289	0.021±0.003
2nd Qtr. mean ± s.d.		0.017±0.007	4th Qtr. mean ± s.d.		0.023±0.006

[a] Iodine-131 concentrations are <0.07 pCi/m^3 unless noted otherwise in Appendix C.

Table 7. Airborne particulates and iodine collected at Location T-9, analyses for gross beta and iodine-131.[a]

Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)	Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)
01-07-91	292	0.028±0.004	07-08-91	294	0.024±0.003
01-14-91	294	0.024±0.003	07-15-91	297	0.017±0.003
01-21-91	292	0.034±0.004	07-22-91	234	0.023±0.004
01-28-91	295	0.022±0.003	07-29-91	294	0.015±0.003
02-04-91	289	0.026±0.003	08-05-91	299	0.019±0.003
02-11-91	299	0.031±0.004	08-12-91	296	0.019±0.003
02-18-91	292	0.014±0.003	08-19-91	290	0.026±0.004
02-25-91	294	0.019±0.003	08-26-91	295	0.020±0.003
03-04-91	288	0.022±0.003	09-02-91	285	0.025±0.003
03-11-91	291	0.023±0.003	09-09-91	292	0.028±0.004
03-18-91	287	0.015±0.003	09-16-91	292	0.027±0.004
03-25-91	299	0.018±0.004	09-23-91	294	0.021±0.002
04-01-91	286	0.020±0.003	09-30-91	299	0.012±0.002
1st Qtr. mean ± s.d.		0.023±0.006	3rd Qtr. mean ± s.d.		0.021±0.005
04-08-91	294	0.024±0.004	10-07-91	301	0.026±0.003
04-15-91	275	0.020±0.003	10-14-91	299	0.023±0.003
04-22-91	286	0.004±0.003	10-21-91	280	0.021±0.003
04-29-91	290	0.020±0.002	10-28-91	276[b]	0.028±0.003
05-06-91	290	0.011±0.003	11-04-91	285	0.027±0.004
05-13-91	295	0.017±0.003	11-11-91	284	0.023±0.003
05-20-91	323	0.020±0.003	11-18-91	289	0.039±0.003
05-27-91	297	0.017±0.002	11-25-91	283	0.030±0.004
06-03-91	297	0.017±0.003	12-02-91	271	0.033±0.004
06-10-91	304	0.011±0.003	12-09-91	275	0.024±0.004
06-17-91	296	0.019±0.003	12-16-91	286	0.036±0.004
06-24-91	301	0.018±0.003	12-23-91	288	0.021±0.004
07-01-91	295	0.022±0.003	12-30-91	284	0.027±0.004
2nd Qtr. mean ± s.d.		0.017±0.005	4th Qtr. mean ± s.d.		0.028±0.006

[a] Iodine-131 concentrations are <0.07 pCi/m^3 unless noted otherwise in Appendix C.

[b] Corrected calibration curve.

Table 8. Airborne particulates and iodine collected at Location T-11, analyses for gross beta and iodine-131.[a]

Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)	Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)
01-07-91	372	0.023±0.003	07-08-91	283	0.023±0.004
01-14-91	346	0.018±0.003	07-15-91	282	0.015±0.003
01-21-91	304	0.030±0.004	07-22-91	277	0.030±0.004
01-28-91	295	0.021±0.003	07-29-91	285	0.014±0.003
02-04-91	300	0.031±0.004	08-05-91	282	0.017±0.003
02-11-91	305	0.032±0.004	08-12-91	280	0.015±0.003
02-18-91	273	0.014±0.003	08-19-91	272	0.026±0.004
02-25-91	283	0.018±0.003	08-26-91	305	0.019±0.003
03-04-91	278	0.018±0.003	09-02-91	273	0.023±0.003
03-11-91	285	0.025±0.004	09-09-91	294	0.025±0.004
03-18-91	279	0.013±0.003	09-16-91	271	0.026±0.004
03-25-91	287	0.018±0.004	09-23-91	276	0.026±0.003
04-01-91	282	0.018±0.003	09-30-91	278	0.012±0.002
1st Qtr. mean ± s.d.		0.021±0.006	3rd Qtr. mean ± s.d.		0.021±0.006
04-08-91	285	0.022±0.004	10-07-91	285	0.026±0.004
04-15-91	285	0.019±0.003	10-14-91	272	0.024±0.004
04-22-91	277	0.010±0.003	10-21-91	277	0.020±0.003
04-29-91	280	0.021±0.002	10-28-91	275	0.028±0.003
05-06-91	283	0.009±0.003	11-04-91	269	0.027±0.004
05-13-91	283	0.018±0.003	11-11-91	294	0.026±0.003
05-20-91	279	0.016±0.003	11-18-91	273	0.044±0.003
05-27-91	283	0.017±0.002	11-25-91	316	0.018±0.003
06-03-91	285	0.017±0.003	12-03-91	304	0.024±0.003
06-10-91	287	0.010±0.003	12-09-91	237	0.026±0.004
06-17-91	280	0.018±0.003	12-16-91	279	0.037±0.004
06-24-91	277	0.023±0.004	12-23-91	273	0.021±0.004
07-01-91	277	0.019±0.003	12-30-91	278	0.026±0.004
2nd Qtr. mean ± s.d.		0.017±0.005	4th Qtr. mean ± s.d.		0.027±0.007

[a] Iodine-131 concentrations are <0.07 pCi/m^3 unless noted otherwise in Appendix C.

Table 9. Airborne particulates and iodine collected at Location T-12, analyses for gross beta and iodine-131.[a]

Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)	Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)
01-07-91	296	0.031±0.004	07-08-91	280	0.022±0.004
01-14-91	289	0.025±0.003	07-15-91	283	0.016±0.003
01-21-91	295	0.034±0.004	07-22-91	275	0.032±0.004
01-28-91	309	0.022±0.003	07-29-91	288	0.018±0.003
02-04-91	295	0.030±0.004	08-05-91	284	0.016±0.003
02-11-91	303	0.028±0.003	08-12-91	281	0.018±0.003
02-18-91	300	0.017±0.003	08-19-19	278	0.024±0.004
02-25-91	313	0.022±0.003	08-26-91	276	0.022±0.003
03-04-91	322	0.021±0.003	09-02-91	282	0.025±0.003
03-11-91	311	0.026±0.003	09-09-91	280	0.028±0.004
03-18-91	312	0.013±0.003	09-16-91	278	0.026±0.004
03-25-91	312	0.020±0.004	09-23-91	278	0.021±0.002
04-01-91	294	0.017±0.003	09-30-91	282	0.012±0.002
1st Qtr. mean ± s.d.		0.024±0.006	3rd Qtr. mean ± s.d.		0.022±0.006
04-08-91	306	0.025±0.004	10-07-91	273	0.027±0.004
04-15-91	302	0.021±0.003	10-14-91	273	0.034±0.004
04-22-91	300	0.009±0.003	10-21-91	267	0.022±0.004
04-29-91	299	0.020±0.002	10-28-91	286	0.023±0.002
05-06-91	302	0.011±0.003	11-04-91	282	0.028±0.004
05-13-91	295	0.017±0.003	11-11-91	276	0.024±0.004
05-20-91	295	0.016±0.003	11-18-91	283	0.042±0.003
05-27-91	282	0.017±0.002	11-25-91	286	0.027±0.004
06-03-91	284	0.023±0.003	12-02-91	280	0.022±0.003
06-10-91	286	0.013±0.003	12-09-91	274	0.021±0.004
06-17-91	282	0.018±0.003	12-16-91	279	0.034±0.004
06-24-91	279	0.010±0.003	12-23-91	279	0.021±0.004
07-01-91	280	0.020±0.003	12-30-91	280	0.023±0.004
2nd Qtr. mean ± s.d.		0.018±0.005	4th Qtr. mean ± s.d.		0.027±0.006

[a] Iodine-131 concentrations are <0.07 pCi/m^3 unless noted otherwise in Appendix C.

Table 10. Airborne particulates and iodine collected at Location T-27, analyses for gross beta and iodine-131.[a]

Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)	Date Collected	Volume (m^3)	Gross Beta (pCi/m^3)
01-07-91	299	0.032±0.004	07-08-91	287	0.020±0.003
01-14-91	291	0.025±0.003	07-15-91	288	0.016±0.003
01-21-91	293	0.033±0.004	07-22-91	294	0.032±0.004
01-28-91	296	0.024±0.003	07-29-91	287	0.016±0.003
02-04-91	294	0.028±0.004	08-05-91	289	0.016±0.003
02-11-91	283	0.030±0.004	08-12-91	286	0.016±0.003
02-18-91	289	0.016±0.003	08-19-91	289	0.022±0.003
02-25-91	296	0.019±0.003	08-26-91	278	0.020±0.003
03-04-91	285	0.022±0.003	09-02-91	292	0.026±0.003
03-11-91	290	0.025±0.004	09-09-91	291	0.030±0.004
03-18-91	277	0.011±0.003	09-16-91	288	0.026±0.004
03-25-91	294	0.018±0.004	09-23-91	290	0.016±0.002
04-01-91	286	0.018±0.003	09-30-91	289	0.015±0.002
1st Qtr. mean ± s.d.		0.023±0.007	3rd Qtr. mean ± s.d.		0.021±0.006
04-08-91	285	0.016±0.003	10-07-91	293	0.025±0.003
04-15-91	289	0.019±0.003	10-14-91	289	0.022±0.003
04-22-91	285	0.007±0.003	10-21-91	289	0.020±0.003
04-29-91	289	0.021±0.002	10-28-91	290	0.026±0.002
05-06-91	291	0.012±0.003	11-04-91	291	0.030±0.004
05-13-91	286	0.019±0.003	11-11-91	286	0.024±0.003
05-20-91	288	0.019±0.003	11-18-91	287	0.041±0.003
05-27-91	288	0.015±0.002	11-25-91	291	0.030±0.004
06-03-91	288	0.014±0.003	12-03-91	326	0.022±0.003
06-10-91	288	0.010±0.003	12-09-91	254	0.029±0.004
06-17-91	286	0.019±0.003	12-16-91	292	0.037±0.004
06-24-91	287	0.018±0.003	12-23-91	288	0.023±0.004
07-01-91	287	0.019±0.003	12-30-91	287	0.025±0.004
2nd Qtr. mean ± s.d.		0.016±0.004	4th Qtr. mean ± s.d.		0.027±0.006

[a] Iodine-131 concentrations are <0.07 pCi/m^3 unless noted otherwise in Appendix C.

Table 11. Airborne particulates, gross beta analyses, monthly averages, minima, and maxima, 1991.[a]

Month	Location	Number of Samples[a]	Gross Beta Activity (pCi/m^3) Average	Minimum	Maximum
January	T-1	4	0.026	0.021	0.032
	T-2	4	0.026	0.022	0.032
	T-3	4	0.028	0.022	0.032
	T-4	4	0.029	0.024	0.036
	T-7	4	0.027	0.024	0.031
	T-8	4	0.029	0.022	0.034
	All Indicators	24	0.028	0.021	0.036
	T-9	4	0.027	0.022	0.034
	T-11	4	0.023	0.018	0.030
	T-12	4	0.028	0.022	0.034
	T-27	4	0.028	0.024	0.033
	All Controls	16	0.026	0.018	0.034
February	T-1	4	0.023	0.015	0.029
	T-2	4	0.024	0.018	0.032
	T-3	4	0.026	0.018	0.032
	T-4	4	0.024	0.016	0.029
	T-7	4	0.022	0.014	0.026
	T-8	4	0.024	0.018	0.028
	All Indicators	24	0.024	0.014	0.032
	T-9	4	0.022	0.014	0.031
	T-11	4	0.024	0.014	0.032
	T-12	4	0.024	0.017	0.030
	T-27	4	0.023	0.016	0.030
	All Controls	16	0.023	0.014	0.032

[a] Unless specified otherwise, data for samples collected on the first, second, or third day of a month are grouped with data of the previous month. Numbers in parentheses indicate the number of samples with unreliable and less than value results which are excluded from the average.

Table 11. Airborne particulates, gross beta analyses, monthly averages, minima, and maxima, 1991[a] (continued)

Month	Location	Number of Samples[a]	Gross beta activity (pCi/m^3) Average	Minimum	Maximum
March	T-1	5	0.018	0.015	0.025
	T-2	5	0.018	0.012	0.022
	T-3	5	0.020	0.013	0.025
	T-4	5	0.020	0.017	0.024
	T-7	5	0.019	0.018	0.021
	T-8	5	0.020	0.012	0.026
	All Indicators	30	0.019	0.012	0.026
	T-9	5	0.020	0.015	0.023
	T-11	5	0.018	0.013	0.025
	T-12	5	0.019	0.013	0.026
	T-27	5	0.019	0.011	0.025
	All Controls	20	0.019	0.011	0.026
April	T-1	4	0.020	0.008	0.028
	T-2	4	0.019	0.011	0.022
	T-3	4	0.018	0.010	0.025
	T-4	4	0.018	0.006	0.023
	T-7	4	0.017	0.008	0.021
	T-8	4	0.020	0.005	0.034
	All Indicators	24	0.019	0.005	0.034
	T-9	4	0.017	0.004	0.024
	T-11	4	0.018	0.010	0.022
	T-12	4	0.019	0.009	0.025
	T-27	4	0.016	0.007	0.021
	All Controls	16	0.018	0.004	0.025

[a] Unless specified otherwise, data for samples collected on the first, second, or third day of a month are grouped with data of the previous month. Numbers in parentheses indicate the number of samples with unreliable and less than value results which are excluded from the average.

Table 11. Airborne particulates, gross beta analyses, monthly averages, minima, and maxima, 1991[a] (continued)

Month	Location	Number of Samples[a]	Gross beta activity (pCi/m^3) Average	Minimum	Maximum
May	T-1	5	0.017	0.014	0.021
	T-2	5	0.014	0.007	0.020
	T-3	5	0.013	0.006	0.019
	T-4	5	0.017	0.012	0.020
	T-7	5	0.015	0.008	0.018
	T-8	5	0.016	0.011	0.020
	All Indicators	30	0.015	0.006	0.021
	T-9	5	0.016	0.011	0.020
	T-11	5	0.017	0.009	0.018
	T-12	5	0.017	0.011	0.023
	T-27	5	0.016	0.012	0.019
	All Controls	20	0.016	0.009	0.023
June	T-1	4	0.017	0.009	0.021
	T-2	4	0.016	0.010	0.021
	T-3	4	0.015	0.009	0.021
	T-4	4	0.017	0.012	0.020
	T-7	4	0.016	0.009	0.020
	T-8	4	0.016	0.010	0.018
	All Indicators	24	0.016	0.009	0.021
	T-9	4	0.018	0.011	0.022
	T-11	4	0.018	0.010	0.023
	T-12	4	0.018	0.013	0.020
	T-27	4	0.016	0.010	0.019
	All Controls	16	0.018	0.010	0.023

[a] Unless specified otherwise, data for samples collected on the first, second, or third day of a month are grouped with data of the previous month. Numbers in parentheses indicate the number of samples with unreliable and less than value results which are excluded from the average.

Table 11. Airborne particulates, gross beta analyses, monthly averages, minima, and maxima, 1991[a] (continued)

Month	Location	Number of Samples[a]	Gross beta activity (pCi/m^3) Average	Minimum	Maximum
July	T-1	4	0.020	0.014	0.034
	T-2	4	0.019	0.012	0.030
	T-3	4	0.021	0.014	0.032
	T-4	4	0.021	0.014	0.034
	T-7	4	0.020	0.016	0.033
	T-8	4	0.019	0.010	0.030
	All Indicators	24	0.020	0.010	0.034
	T-9	4	0.020	0.015	0.024
	T-11	4	0.020	0.014	0.030
	T-12	4	0.022	0.016	0.032
	T-27	4	0.021	0.016	0.032
	All Controls	16	0.021	0.014	0.032
August	T-1	5	0.016	0.013	0.022
	T-2	5	0.021	0.015	0.026
	T-3	5	0.020	0.017	0.025
	T-4	5	0.018	0.016	0.031
	T-7	5	0.021	0.016	0.027
	T-8	5	0.019	0.014	0.024
	All Indicators	30	0.019	0.013	0.031
	T-9	5	0.022	0.019	0.026
	T-11	5	0.020	0.015	0.026
	T-12	5	0.021	0.016	0.025
	T-27	5	0.020	0.016	0.026
	All Controls	20	0.021	0.015	0.026

[a] Unless specified otherwise, data for samples collected on the first, second, or third day of a month are grouped with data of the previous month. Numbers in parentheses indicate the number of samples with unreliable and less than value results which are excluded from the average.

Table 11. Airborne particulates, gross beta analyses, monthly averages, minima, and maxima, 1991[a] (continued)

Month	Location	Number of Samples[a]	Gross beta activity (pCi/m^3) Average	Minimum	Maximum
September	T-1	4	0.020	0.012	0.027
	T-2	4	0.018	0.012	0.023
	T-3	4	0.018	0.010	0.025
	T-4	4	0.019	0.008	0.026
	T-7	4	0.022	0.012	0.031
	T-8	4	0.020	0.013	0.024
All Indicators		24	0.020	0.008	0.031
	T-9	4	0.022	0.012	0.028
	T-11	4	0.022	0.012	0.026
	T-12	4	0.022	0.012	0.028
	T-27	4	0.022	0.015	0.030
All Controls		16	0.022	0.012	0.030
October	T-1	4	0.022	0.019	0.029
	T-2	4	0.022	0.020	0.025
	T-3	4	0.020	0.016	0.024
	T-4	4	0.022	0.018	0.025
	T-7	4	0.026	0.019	0.030
	T-8	4	0.020	0.013	0.025
All Indicators		24	0.022	0.013	0.030
	T-9	4	0.024	0.021	0.028
	T-11	4	0.024	0.020	0.028
	T-12	4	0.026	0.022	0.034
	T-27	4	0.023	0.020	0.026
All Controls		16	0.024	0.020	0.034

[a] Unless specified otherwise, data for samples collected on the first, second, or third day of a month are grouped with data of the previous month. Numbers in parentheses indicate the number of samples with unreliable and less than value results which are excluded from the average.

Table 11. Airborne particulates, gross beta analyses, monthly averages, minima, and maxima, 1991[a] (continued)

Month	Location	Number of Samples[a]	Gross beta activity (pCi/m^3) Average	Minimum	Maximum
November	T-1	5	0.028	0.024	0.035
	T-2	5	0.030	0.026	0.040
	T-3	5	0.027	0.022	0.037
	T-4	5	0.029	0.026	0.038
	T-7	5	0.031	0.023	0.041
	T-8	5	0.027	0.022	0.040
	All Indicators	30	0.029	0.022	0.041
	T-9	5	0.030	0.023	0.039
	T-11	5	0.028	0.018	0.044
	T-12	5	0.029	0.022	0.042
	T-27	5	0.029	0.022	0.041
	All Controls	20	0.029	0.018	0.044
December	T-1	4	0.024	0.021	0.030
	T-2	4	0.024	0.016	0.031
	T-3	4	0.021	0.016	0.028
	T-4	4	0.024	0.021	0.031
	T-7	4	0.026	0.022	0.032
	T-8	4	0.022	0.016	0.027
	All Indicators	24	0.024	0.016	0.032
	T-9	4	0.027	0.021	0.036
	T-11	4	0.028	0.021	0.037
	T-12	4	0.025	0.021	0.034
	T-27	4	0.028	0.023	0.037
	All Controls	16	0.027	0.021	0.037

[a] Unless specified otherwise, data for samples collected on the first, second, or third day of a month are grouped with data of the previous month. Numbers in parentheses indicate the number of samples with unreliable and less than value results which are excluded from the average.

Table 12. Airborne particulates, quarterly composites of all indicator and all control locations, analyses for strontium and gamma-emitting isotopes, 1991.

	Sample Description and Activity (pCi/m^3)				
	January - March				
Lab Code	TAP-2525	TAP-2526	TAP-2528	TAP-2530	TAP-2532
Location	T-1	T-2	T-3	T-4	T-7
Volume (m^3)	3830	3756	3656	3714	3564
Sr-89	<0.0004	<0.0005	<0.0004	<0.0004	<0.0004
Sr-90	<0.0004	<0.0004	<0.0004	<0.0004	<0.0003
Be-7	0.058±0.013	0.066±0.011	0.046±0.011	0.058±0.012	0.060±0.015
K-40	<0.026	<0.021	<0.019	<0.021	<0.0024
Nb-95	<0.0015	<0.0012	<0.0014	<0.0015	<0.0012
Zr-95	<0.0023	<0.0026	<0.0025	<0.0025	<0.0028
Ru-103	<0.0009	<0.0009	<0.0013	<0.0010	<0.0010
Ru-106	<0.010	<0.0056	<0.0096	<0.0091	<0.011
Cs-134	<0.0010	<0.0008	<0.0010	<0.0009	<0.0009
Cs-137	<0.0012	<0.0010	<0.0011	<0.0010	<0.0012
Ce-141	<0.0016	<0.0013	<0.0016	<0.0014	<0.0018
Ce-144	<0.0061	<0.0055	<0.0066	<0.0055	<0.0052

Lab Code	TAP-2533	TAP-2534	TAP-2535	TAP-2536	TAP-2537
Location	T-8	T-9 (C)	T-11 (C)	T-12 (C)	T-27 (C)
Volume (m^3)	3651	3798	3889	3951	3773
Sr-89	<0.0003	<0.0003	<0.0003	<0.0004	<0.0003
Sr-90	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003
Be-7	0.063±0.010	0.059±0.012	0.060±0.010	0.054±0.013	0.066±0.011
K-40	<0.020	<0.023	<0.017	<0.022	<0.019
Nb-95	<0.0010	<0.0014	<0.0010	<0.0012	<0.0008
Zr-95	<0.0022	<0.0025	<0.0017	<0.0026	<0.0014
Ru-103	<0.0009	<0.0008	<0.0007	<0.0008	<0.0008
Ru-106	<0.0052	<0.008	<0.0049	<0.0076	<0.0060
Cs-134	<0.0008	<0.0009	<0.0006	<0.0010	<0.0008
Cs-137	<0.0008	<0.0012	<0.0007	<0.0012	<0.0008
Ce-141	<0.0008	<0.0016	<0.0007	<0.0014	<0.0009
Ce-144	<0.0026	<0.0054	<0.0024	<0.0058	<0.0025

Table 12. Airborne particulates, quarterly composites of all indicator and all control locations, analyses for strontium and gamma-emitting isotopes, 1991 (continued)

	Sample Description and Activity (pCi/m^3)				
	April - June				
Lab Code	TAP-2645	TAP-2646	TAP-2647	TAP-2648	TAP-2649
Location	T-1	T-2	T-3	T-4	T-7
Volume (m^3)	3585	3803	3670	3544	3539
Sr-89	<0.0004	<0.0004	<0.0003	<0.0005	<0.0005
Sr-90	<0.0003	<0.0003	<0.0002	<0.0004	<0.0004
Be-7	0.056±0.016	0.056±0.013	0.054±0.014	0.059±0.010	0.061±0.011
K-40	<0.02[illegible]	<0.019	<0.022	<0.017	<0.022
Nb-95	<0.001[illegible]	<0.0013	<0.0017	<0.0016	<0.0022
Zr-95	<0.0029	<0.0022	<0.0021	<0.0018	<0.0028
Ru-103	<0.0013	<0.0007	<0.0013	<0.0007	<0.0013
Ru-106	<0.011	<0.0079	<0.0071	<0.0075	<0.0080
Cs-134	<0.0010	<0.0004	<0.0010	<0.0006	<0.0009
Cs-137	<0.0012	<0.0007	<0.0009	<0.0007	<0.0011
Ce-141	<0.0023	<0.0011	<0.0017	<0.0008	<0.0018
Ce-144	<0.0067	<0.0022	<0.0061	<0.0024	<0.005[illegible]

Lab Code	TAP-2650	TAP-2651	TAP-2652	TAP-2653	TAP-2654
Location	T-8	T-9 (C)	T-11 (C)	T-12 (C	T-27 (C)
Volume (m^3)	3617	3617	3661	3792	3737
Sr-89	<0.0004	<0.0004	<0.0003	<0.0004	<0.0004
Sr-90	<0.0003	<0.0003	<0.0002	<0.0003	<0.0003
Be-7	0.061±0.011	0.061±0.008	0.055±0.009	0.066±0.016	0.060±0.019
K-40	<0.019	<0.012	<0.011	<0.027	<0.027
Nb-95	<0.0012	<0.0016	<0.0012	<0.0018	<0.0033
Zr-95	<0.0015	<0.0023	<0.0016	<0.0031	<0.0027
Ru-103	<0.0008	<0.0014	<0.0009	<0.0014	<0.0015
Ru-106	<0.0069	<0.010	<0.0066	<0.0095	<0.0096
Cs-134	<0.0006	<0.0009	<0.0008	<0.0008	<0.0010
Cs-137	<0.0009	<0.0011	<0.0009	<0.0013	<0.0011
Ce-141	<0.0010	<0.0024	<0.0011	<0.0022	<0.0027
Ce-144	<0.0023	<0.0065	<0.0032	<0.0065	<0.0066

Table 12. Airborne particulates, quarterly composites of all indicator and all control locations, analyses for strontium and gamma-emitting isotopes, 1991 (continued)

	Sample Description and Activity (pCi/m^3) July - September				
Lab Code	TAP-2763	TAP-2764	TAP-2765	TAP-2766	TAP-2767
Location	T-1	T-2	T-3	T-4	T-7
Volume (m^3)	3635	3869	3743	3468	3885
Sr-89	<0.0006	<0.0006	<0.0005	<0.0006	<0.0009
Sr-90	<0.0002	<0.0003	<0.0002	<0.0003	<0.0004
Be-7	0.057±0.013	0.060±0.010	0.051±0.014	0.055±0.010	0.050±0.012
K-40	<0.024	<0.016	<0.024	<0.016	<0.022
Nb-95	<0.0015	<0.0013	<0.0017	<0.0013	<0.0016
Zr-95	<0.0023	<0.0022	<0.0032	<0.0020	<0.0021
Ru-103	<0.0012	<0.0007	<0.0011	<0.0008	<0.0011
Ru-106	<0.0097	<0.0066	<0.010	<0.0072	<0.0093
Cs-134	<0.0008	<0.0008	<0.0011	<0.0006	<0.0009
Cs-137	<0.0013	<0.0008	<0.0012	<0.0008	<0.0010
Ce-141	<0.0016	<0.0008	<0.0014	<0.0009	<0.0014
Ce-144	<0.0060	<0.0027	<0.0052	<0.0031	<0.0048
Lab Code	TAP-2768	TAP-2769	TAP-2770	TAP-2771	TAP-2772
Location	T-8	T-9 (C)	T-11 (C)	T-12 (C)	T-27 (C)
Volume (m^3)	3745	3771	3658	3645	3748
Sr-89	<0.0010	<0.0008	<0.0009	<0.0008	<0.0013
Sr-90	<0.0004	<0.0004	<0.0004	<0.0004	<0.0006
Be-7	0.057±0.010	0.061±0.012	0.056±0.011	0.056±0.014	0.054±0.012
K-40	<0.015	<0.023	<0.015	<0.018	<0.021
Nb-95	<0.0012	<0.0015	<0.0013	<0.0017	<0.0015
Zr-95	<0.0016	<0.0025	<0.0023	<0.0026	<0.0022
Ru-103	<0.0008	<0.0012	<0.0009	<0.0010	<0.0009
Ru-106	<0.0063	<0.011	<0.0095	<0.012	<0.0064
Cs-134	<0.0005	<0.0011	<0.0007	<0.0009	<0.0008
Cs-137	<0.0006	<0.0010	<0.0009	<0.0014	<0.0009
Ce-141	<0.0008	<0.0017	<0.0010	<0.0017	<0.0015
Ce-144	<0.0023	<0.0053	<0.0028	<0.0048	<0.0050

Table 12. Airborne particulates, quarterly composites of all indicator and all control locations, analyses for strontium and gamma-emitting isotopes, 1991 (continued)

	Sample Description and Activity (pCi/m^3)				
	October - December				
Lab Code	TAP-2890	TAP-2891	TAP-2892	TAP-2893	TAP-2894
Location	T-1	T-2	T-3	T-4	T-7
Volume (m^3)	3699	3800	3819	3693	3834
Sr-89	<0.0004	<0.0004	<0.0005	<0.0004	<0.0004
Sr-90	<0.0004	<0.0004	<0.0005	<0.0003	<0.0004
Be-7	0.047±0.008	0.050±0.012	0.041±0.008	0.047±0.015	0.054±0.015
K-40	<0.015	<0.029	<0.024	<0.028	<0.029
Nb-95	<0.0013	<0.0021	<0.0018	<0.0017	<0.0017
Zr-95	<0.0017	<0.0032	<0.0029	<0.0023	<0.0019
Ru-103	<0.0007	<0.0015	<0.0014	<0.0012	<0.0012
Ru-106	<0.0060	<0.013	<0.013	<0.0099	<0.011
Cs-134	<0.0006	<0.0013	<0.0010	<0.0011	<0.0011
Cs-137	<0.0007	<0.0013	<0.0014	<0.0011	<0.0014
Ce-141	<0.0008	<0.0022	<0.0024	<0.0025	<0.0027
Ce-144	<0.0023	<0.0087	<0.0082	<0.0085	<0.0079
Lab Code	TAP-2895	TAP-2896	TAP-2897	TAP-2898	TAP-2899
Location	T-8	T-9 (C)	T-11 (C)	T-12 (C)	T-27 (C)
Volume (m^3)	3840	3701	3632	3617	3763
Sr-89	<0.0004	<0.0004	<0.0005	<0.0004	<0.0004
Sr-90	<0.0004	<0.0003	<0.0004	<0.0004	<0.0004
Be-7	0.050±0.015	0.051±0.016	0.044±0.009	0.048±0.008	0.043±0.008
K-40	<0.027	<0.029	<0.011	<0.011	<0.013
Nb-95	<0.0020	<0.0016	<0.0014	<0.0012	<0.0012
Zr-95	<0.0026	<0.0030	<0.0021	<0.0018	<0.0019
Ru-103	<0.0016	<0.0013	<0.0011	<0.0009	<0.0010
Ru-106	<0.014	<0.013	<0.0083	<0.0067	<0.0069
Cs-134	<0.0012	<0.0011	<0.0009	<0.0007	<0.0008
Cs-137	<0.0016	<0.0014	<0.0010	<0.0009	<0.0008
Ce-141	<0.0026	<0.0024	<0.0020	<0.0012	<0.0015
Ce-144	<0.0081	<0.0080	<0.0058	<0.0034	<0.0046

Table 13. Area monitors (TLD), quarterly, 1991.

Location	mR/91 days			
	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
Indicator				
T-1	10.5±0.3	11.1±0.4	11.2±0.7	11.9±0.6
T-2	11.9±0.4	10.9±0.2	12.3±0.6	11.9±0.5
T-3	11.9±0.5	11.4±0.8	12.7±0.6	12.2±0.9
T-4	15.0±0.6	12.6±0.4	15.0±0.7	13.9±0.4
T-5	13.1±0.8	11.5±0.3	12.7±0.7	12.2±0.3
T-6	10.4±0.6	11.0±0.5	11.6±0.6	11.6±0.7
T-7	16.4±0.8	16.1±0.7	15.9±0.7	16.8±0.6
T-8	21.0±0.8	17.7±0.9	21.4±1.1	18.1±0.5
T-10	13.8±0.6	13.1±0.5	13.9±0.8	13.4±0.7
T-38	11.8±0.3	13.1±0.5	11.7±0.5	13.3±0.7
T-39	14.0±0.7	13.8±0.3	13.4±0.7	13.7±0.6
T-40	12.6±0.7	13.2±0.6	13.7±0.6	14.2±0.6
T-41	10.1±0.6	12.3±0.4	10.9±0.8	13.1±0.7
T-42	9.9±0.6	10.4±0.6	9.9±0.5	11.3±0.4
T-43	14.2±0.9	16.0±0.7	16.2±0.8	16.6±0.7
T-44	14.5±0.7	15.2±1.0	16.1±0.9	16.8±0.6
T-45	18.9±0.9	17.5±0.6	20.7±0.8	18.1±0.9
T-46	12.3±0.5	12.1±0.5	13.3±0.5	12.6±0.9
T-47	8.2±0.5	[illegible]3±0.4	9.2±0.5	10.2±0.7
T-48	14.9±0.8	1[illegible].7±0.5	17.2±0.5	16.8±0.8
T-49	11.8±0.6	11.5±0.4	12.0±0.5	10.8±0.8
T-50	17.4±0.4	21.2±0.7	20.0±0.6	20.9±0.4
T-51	14.4±0.7	15.0±0.5	16.7±0.8	16.3±0.9
T-52	18.2±0.4	21.0±0.5	21.5±0.5	20.2±0.5
T-53	16.6±0.6	22.7±1.1	19.4±0.5	22.5±0.5
T-54	16.3±0.4	19.8±0.8	19.4±0.6	21.6±0.3
T-55	14.5±0.5	14.6±0.6	17.0±0.5	15.6±0.6
Mean ± s.d.	13.9±3.0	14.4±3.6	15.0±3.6	15.1±3.5
Control				
T-9	11.7±0.4	12.1±0.5	12.1±0.5	11.5±1.1
T-11	13.4±0.4	12.8±0.6	14.9±0.6	12.7±1.0
T-12	19.4±1.1	17.6±0.9	19.7±0.5	17.5±0.8
T-23	13.3±0.4	14.0±0.7	13.6±0.6	11.9±1.0
T-24	17.4±0.6	15.8±0.5	18.2±0.5	16.8±0.5
T-27	15.7±0.4	16.8±0.7	17.2±0.7	17.8±1.0
Mean ± s.d.	15.2±2.9	14.8±2.2	16.0±2.9	14.7±3.0

Table 13. Area monitors (TLD), quarterly, 1991 (continued)

Location	mR/91 days 1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
Indicator				
T-60	12.0±0.6	10.9±0.6	11.1±0.7	12.0±0.4
T-61	11.8±0.5	10.5±0.7	10.9±0.6	10.9±0.7
T-62	11.3±0.5	10.7±0.4	11.3±0.3	11.4±0.6
T-63	14.0±0.7	12.2±0.5	13.1±0.3	13.0±0.6
T-64	9.5±0.8	9.3±0.7	8.5±0.3	10.6±0.4
T-65	16.5±0.8	15 2±0.7	16.0±0.6	15.9±0.9
T-66	22.1±0.8	21.8±0.7	22.0±0.9	20.2±0.7
T-67	20.8±1.0	18.9±1.3	21.5±0.5	19.2±1.2
T-68	16.3±0.8	17.5±1.3	18.6±0.8	18.6±1.0
T-69	19.6±1.6	14.3±0.6	20.3±0.7	13.3±0.7
T-70	11.9±0.8	9.7±0.6	11.2±0.6	11.0±0.6
T-71	17.9±0.7	18.3±0.6	15.1±0.4	16.8±0.9
T-73	14.4±1.0	12.5±0.6	13.7±0.4	13.3±0.4
T-74	13.7±0.9	11.3±0.5	12.4±0.6	11.3±0.5
T-75	16.3±0.9	14.8±0.8	16.5±0.7	15.2±0.7
T-76	12.6±0.7	11.0±0.8	12.2±0.6	11.2±0.6
T-77	11.5±0.5	9.5±0.4	10.6±0.6	10.7±0.5
T-90	17.5±0.7	17.6±0.8	18.1±0.4	18.1±1.2
T-91	ND[a]	16.2±0.9	17.7±0.7	17.5±0.4
T-92	12.2±0.5	9.9±0.7	13.2±0.3	9.6±0.9
T-93	12.4±0.6	15.1±0.2[b]	ND[a]	11.7±0.9
T-94	17.1±0.6	11.5±0.4	18.0±0.4	12.3±0.6
T-97	18.2±0.5	17.5±0.9	20.5±0.4	17.0±0.5
T-99	18.8±0.7	18.9±0.6	20.0±0.6	19.5±0.5
T-112	15.3±1.0	15.4±0.6	15.3±0.3	15.0±0.5
T-121	17.8±0.7	19.5±0.9	19.3±0.8	19.5±0.5
T-122	15.0±0.9	13.4±0.4	16.9±0.8	14.7±0.3
T-123	14.5±1.0	15.7±0.9	16.6±0.8	16.0±0.4
T-125	16.1±0.7	17.3±0.5	18.2±0.6	18.5±0.9
T-126	15.9±0.7	16.7±1.0	18.4±0.6	17.0±0.6
T-127	20.2±0.9	20.5±0.8	22.5±0.5	20.4±0.7
T-128	18.0±0.5	19.0±0.9	19.6±0.6	18.9±0.8
T-150	12.5±0.8	9.2±0.6	12.8±0.2	9.8±0.3
T-151	18.1±0.5	19.0±1.2	20.0±0.4	19.0±1.0
T-153	19.5±1.1	21.9±1.6	21.8±0.9	21.0±0.8
T-154	16.2±0.7	16.6±1.1	18.0±0.6	15.9±0.6
T-201	14.1±0.3	15.6±0.8	14.1±0.4	13.2±0.6
T-202	14.0±0.8	17.3±0.5[b]	13.9±0.3	ND[a]
T-203	ND[a]	15.3±0.6	ND[a]	13.7±0.5
T-204	ND[a]	16.1±0.8	ND[a]	13.7±0.4
T-205	16.3±0.6	18.9±1.0	15.5±0.3	16.4±0.9
T-206	11.9±0.4	11.9±0.5	12.6±1.1	10.7±0.7
T-207	11.4±0.4	11.2±0.5	11.2±0.7	10.0±0.6
T-208	12.1±0.3	10.8±0.8	11.7±0.4	10.0±0.6
Mean±s.d.	15.3±3.1	14.9±3.7	15.9±3.8	14.7±3.5

[a] ND = No data; TLD missing.

[b] Placed 04-11-91; removed 10-09-91.

Table 13. Area monitors (TLD), quarterly, 1991 (continued)

Location	mR/91 days 1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
Control				
T-78	ND[b]	ND[b]	ND[b]	ND[b]
T-95	19.2±1.0	18.9±1.4	20.2±1.0	18.6±0.9
T-96	10.0±0.5	10.8±0.7	10.1±0.3	11.1±1.0
T-98	19.2±0.8	19.5±1.0	19.0±0.3	19.3±0.7
T-100	17.3±0.8	16.5±1.2	19.1±0.5	17.0±0.8
T-101	16.3±0.7	16.2±1.0	17.0±0.7	16.4±0.7
T-102	13.5±0.9	12.1±0.6	13.8±0.5	8.2±0.9
T-103	17.4±0.6	16.7±0.7	18.2±0.8	16.5±0.9
T-104	15.2±1.0	15.8±0.8	16.1±0.9	15.3±0.9
T-105	18.7±1.4	18.5±1.2	19.8±1.2	17.0±0.9
T-106	14.2±0.6	16.1±0.7	14.7±0.6	15.0±0.8
T-107	15.2±1.1	18.2±1.4	16.5±1.0	16.0±0.6
T-108	17.3±0.7	19.9±0.5	19.1±0.5	18.8±0.4
T-109	20.6±0.5	20.3±0.5	18.8±0.6	18.7±0.5
T-110	17.2±0.9	17.9±0.9	18.0±0.6	16.6±0.9
T-111	16.6±0.6	19.9±1.2	17.3±0.7	17.2±0.9
T-124	13.8±1.0	13.7±1.0	15.0±0.8	14.5±0.4
T-155	16.0±0.6	14.0±0.7	17.6±0.6	15.3±0.6
Mean±s.d.	16.3±2.6	16.8±2.8	17.1±2.6	16.0±2.8
QC				
T-79	ND[b]	ND[b]	ND[b]	ND[b]
T-80	13.6±0.8	11.9±0.7	13.1±0.8	12.8±0.8
T-81	13.0±0.7	11.4±0.6	12.7±0.9	12.1±0.6
T-82	9.2±0.9	9.1±0.5	8.8±0.3	9.6±0.5
T-83	10.5±0.6	9.1±0.5	10.7±0.4	9.8±0.4
T-84	14.5±0.6	13.1±0.7	13.9±0.3	13.4±0.6
T-85	14.2±0.5	12.9±0.7	13.2±0.5	13.1±0.7
T-86	10.5±0.9	9.9±0.5	10.1±0.6	10.9±0.8
T-88	20.7±0.6	18.3±0.9	21.9±0.7	18.3±0.6
T-89	15.5±0.8	13.9±0.6	14.7±0.4	14.5±0.3
T-113	13.7±0.8	15.3±0.8	14.5±0.4	14.5±0.4
T-114	ND[a]	17.2±0.5[c]	12.9±0.6	11.4±0.3
T-115	20.2±1.1	21.8±0.8	21.5±1.3	18.6±1.0
T-116	19.8±1.1	ND[a]	21.4±0.8	16.5±0.6
T-117	16.7±0.8	18.9±0.8	18.5±0.9	17.7±0.6
T-118	13.8±0.8	17.0±1.1	15.6±0.8	15.4±0.6
T-119	19.3±1.0	21.3±0.8	22.7±0.6	22.0±0.9
T-120	15.7±0.7	18.8±1.1	17.8±0.5	19.4±0.5
T-200	15.2±1.1	18.7±0.8	15.8±0.9	17.0±0.8
Mean±s.d.	15.1±3.4	15.2±4.2	15.5±4.2	14.8±3.5

[a] ND = No data. TLD missing.
[b] ND = No data; site deleted from project.
[c] Placed 04-11-91; removed 10-09-91.

Table 13 Area monitors (TLD), quarterly, 1991 (continued)

Location	mR/91 days			
	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
Shield				
T-87	6.0±0.6	4.3±0.5	5.6±0.3	4.8±0.3

Table 14. Area monitors (TLD), annually, 1991.

Location	mR/365 days
Indicator	
T-1	50.0±2.2
T-2	51.2±1.2
T-3	48.8±1.1
T-4	58.0±1.1
T-5	52.7±1.8
T-6	ND[a]
T-7	61.3±0.7
T-8	82.3±1.2
T-10	62.0±2.5
T-38	45.6±1.0
T-39	51.0±1.2
T-40	57.5±1.2
T-41	48.7±1.1
T-42	42.9±1.9
T-43	69.5±0.9
T-44	72.1±1.1
T-45	71.8±0.8
T-46	51.0±1.0
T-47	35.6±0.7
T-48	65.6±1.1
T-49	47.8±0.9
T-50	78.3±0.7
T-51	59.3±0.8
T-52	80.7±1.9
T-53	74.7±1.7
T-54	70.7±1.7
T-55	58.2±1.0
Mean ± s.d.	59.5±12.5
Control	
T-9	52.8±2.4
T-11	63.1±0.8
T-12	80.7±1.7
T-23	57.7±1.2
T-24	74.0±1.4
T-27	74.0±1.2
Mean ± s.d.	67.0±10.8

[a] ND = no data; TLD missing.

Table 14. Area monitors (TLD), annually, 1991 (continued)

Location	mR/365 days
Indicator	
T-60	48.7±1.6
T-61	47.1±1.6
T-62	46.4±0.6
T-63	52.9±0.7
T-64	39.2±0.6
T-65	65.8±1.4
T-66	83.4±2.4
T-67	79.0±1.7
T-68	72.2±1.6
T-69	77.0±1.9
T-70	43.5±1.1
T-71	68.8±1.0
T-73	55.7±1.1
T-74	54.0±1.7
T-75	61.1±1.4
T-76	47.1±2.3
T-77	44.7±0.8
T-90	79.7±2.1
T-91	ND[a]
T-92	53.7±2.0
T-93	ND[a]
T-94	72.2±1.7
T-97	77.6±1.8
T-99	78.8±1.0
T-112	61.0±1.3
T-121	76.4±2.4
T-122	63.6±1.6
T-123	65.2±1.1
T-125	72.3±1.4
T-126	62.6±2.0
T-127	73.4±0.7
T-128	76.1±2.0
T-150	56.2±1.1
T-151	73.7±1.4
T-153	81.5±2.0
T-154	66.5±1.1
T-201	53.8±1.5
T-202	ND[a]
T-203	ND[a]
T-204	ND[a]
T-205	56.8±1.7
T-206	20.2±1.5[b]
T-207	37.7±1.5
T-208	41.9±2.0
Mean ± s.d.	61.2±14.9

[a] ND = No data; TLD missing.

[b] TLD wet; may account for low reading.

Table 14. Area monitors (TLD), annually, 1991 (continued)

Location	mR/365 days
Control	
T-78	ND[a]
T-95	77.6±1.8
T-96	50.9±1.3
T-98	75.4±0.8
T-100	69.1±0.9
T-101	72.3±0.6
T-102	56.5±1.5
T-103	73.6±0.6
T-104	66.7±1.2
T-105	80.4±1.1
T-106	61.0±1.1
T-107	70.9±0.8
T-108	78.4±1.1
T-109	76.5±2.6
T-110	68.4±1.9
T-111	70.2±1.7
T-124	59.4±2.0
T-155	67.9±1.3
Mean ± s.d.	69.1±8.2
QC	
T-79	ND[a]
T-80	48.2±1.6
T-81	46.0±0.5
T-82	36.9±0.7
T-83	38.5±0.5
T-84	53.6±0.7
T-85	50.5±0.8
T-86	42.8±1.3
T-88	80.9±1.1
T-89	57.5±1.3
T-113	55.0±1.0
T-114	ND[b]
T-115	77.8±0.9
T-116	80.6±1.9
T-117	70.7±2.8
T-118	59.3±1.8
T-119	85.4±1.0
T-120	69.7±0.6
T-200	65.7±2.3
Mean ± s.d.	59.9±15.5
Shield	
T-87	24.9±1.5

[a] ND = No data; site deleted from project.

[b] ND = No data; TLD missing.

Table 15. Milk samples, analyses for Sr-89, Sr-90, I-131, and gamma-emitting isotopes. Collection: Semimonthly May through October, monthly otherwise.

Date Collected	Lab Code	Activity (pCi/L)					
		Sr-89	Sr-90	I-131	Ba-La-140	Cs-137	K-40
		T-8 Farm, 2.7 mi WSW of Station					
01-14-91	TMI-5811,2	<0.4	1.1±0.2	<0.4	<10	<10	1220±100
02-11-91	5892	<0.6	1.1±0.4	<0.3	<10	<10	1170±110
03-11-91	5970	<0.4	0.8±0.3	<0.2	<10	<10	1150±150
04-08-91	6034	<0.5	0.5±0.3	<0.2	<10	<10	1180±150
05-13-91	6163	<0.8	0.7±0.4	<0.4	<10	<10	1240±100
05-27-91	6241	<0.9	1.4±0.6	<0.3	<10	<10	1260±150
06-10-91	6324	<0.7	0.7±0.3	<0.4	<10	<10	1230±90
06-24-91	6406	<0.5	0.7±0.3	<0.3	<10	<10	1200±150
07-08-91	6486	<0.6	0.7±0.3	<0.3	<10	<10	1370±140
07-22-91	6576	<0.9	1.0±0.5	<0.2	<10	<10	1280±100
08-12-91	6725	<0.6	0.8±0.3	<0.3	<10	<10	1100±130
08-26-91	6781	<0.5	0.8±0.3	<0.3	<10	<10	1250±120
09-09-91	6848	<0.9	1.9±0.7	<0.2	<10	<10	1170±150
09-23-91	6949	<0.6	1.1±0.4	<0.3	<10	<10	1500±170
10-15-91	7066	<1.1	<0.7	<0.3	<10	<10	1280±140
10-28-91	7136	<0.5	0.9±0.4	<0.2	<10	<10	1290±140
11-12-91	7205	<0.7	0.8±0.4	<0.2	<10	<10	1130±110
12-09-91	7274	<0.7	1.8±0.6	<0.2	<10	<10	1230±130
		T-199 (C) Farm, 8.5 mi SW of Station					
01-14-91	TMI-5815	<0.4	2.4±0.5	<0.3	<10	<10	1240±150
02-12-91	NS[a]	--	--	--	--	--	--

[a] NS = No sample; location dropped from program.

Table 15. Milk samples, analyses for Sr-89, Sr-90, I-131, and gamma-emitting isotopes (continued)

Date Collected	Lab Code	Activity (pCi/L) Sr-89	Sr-90	I-131	Ba-La-140	Cs-137	K-40
		T-24 (C) Sandusky, 21.0 mi SE of Station					
01-15-91	TMI-5813	<0.4	0.9±0.3	<0.2	<10	<10	1410±160
02-12-91	5893	<0.7	1.2±0.5	<0.3	<10	<10	1230±150
03-12-91	5971	<0.4	1.4±0.4	<0.2	<10	<10	1200±100
04-09-91	6035	<0.5	1.2±0.4	<0.2	<10	<10	1260±140
05-14-91	6164	<0.7	1.8±0.5	<0.3	<10	<10	1310±110
05-28-91	6242	<0.7	2.1±0.5	<0.3	<10	<10	1200±130
06-11-91	6325,6	<0.7	1.4±0.3	<0.4	<10	<10	1260±80
06-25-91	6407	<0.5	1.4±0.4	<0.2	<10	<10	1200±150
07-09-91	6487	<0.5	2.1±0.5	<0.3	<10	<10	1270±140
07-23-91	6577	<1.1	1.7±0.4	<0.3	<10	<10	1230±110
08-13-91	6726	<0.5	1.3±0.4	<0.3	<10	<10	1110±110
08-27-91	6782	<0.6	0.9±0.4	<0.2	<10	<10	1200±130
09-10-91	6849	<0.7	1.5±0.5	<0.2	<10	<10	1330±140
09-24-91	6950	<0.6	1.1±0.4	<0.4	<10	<10	1160±130
10-15-91	7067	<0.7	1.4±0.4	<0.3	<10	<10	1180±160
10-29-91	7137	<0.5	1.8±0.4	<0.4	<10	<10	1290±140
11-12-91	7206,7	<0.9	1.1±0.3	<0.2	<10	<10	1320±90
12-10-91	7275	<0.6	1.2±0.4	<0.3	<10	<10	1270±80
		T-57 (C) Farm, 22 miles SSE of Station					
01-15-91	TMI-5814	<0.4	0.8±0.3	<0.2	<10	<10	1200±120
02-12-91	5894	<0.5	0.9±0.3	<0.2	<10	<10	1340±120
03-12-91	5972	<0.4	0.9±0.4	<0.2	<10	<10	1170±120
04-09-91	6036	<0.4	0.6±0.3	<0.2	<10	<10	1310±130
05-14-91	6165	<0.6	0.8±0.3	<0.2	<10	<10	1220±110
05-28-91	6243	<0.6	1.3±0.4	<0.3	<10	<10	1050±130
06-11-91	6327	<0.6	1.1±0.4	<0.3	<10	<10	1170±120
06-25-91	6408	<0.5	0.8±0.3	<0.3	<10	<10	1290±150
07-09-91	6488	<0.6	1.2±0.4	<0.3	<10	<10	1290±150
07-23-91	6578	<0.7	1.3±0.4	<0.2	<10	<10	1460±100
08-13-91	6727	<0.6	1.8±0.4	<0.3	<10	<10	1250±140
08-27-91	6783	<0.7	2.1±0.7	<0.3	<10	<10	1160±120
09-10-91	6850	<0.6	0.6±0.3	<0.2	<10	<10	1290±140
09-24-91	6951	<0.5	1.0±0.4	<0.3	<10	<10	1300±120
10-15-91	7068	<0.7	0.8±0.4	<0.4	<10	<10	1340±130
10-29-91	7138	<0.6	0.6±0.3	<0.3	<10	<10	1280±170
11-12-91	7208	<0.7	1.2±0.4	<0.2	<10	<10	1310±140
12-10-91	7276	<0.6	0.8±0.4	<0.3	<10	<10	1300±90

Table 16. Milk samples, analyses for calcium, stable potassium, and ratios of Sr-90 (pCi) per gram of calcium and Cs-137 (pCi) per gram of potassium. Collection: Semimonthly May through October; monthly otherwise.

Date Collected	Lab Code	Calcium (g/L)	Potassium (g/L)	Sr-90 (pCi) per gram of Calcium	Cs-137 (pCi) per gram of Potassium
	T-8 Farm, 2.7 mi WSW of Station				
01-14-91	TMI-5811,2	0.92	1.41±0.12	1.20	<7.09
02-12-91	5892	0.70	1.35±0.13	1.57	<7.41
03-12-91	5970	0.85	1.33±0.17	0.94	<7.52
04-08-91	6034	0.85	1.36±0.17	0.59	<7.35
05-13-91	6163	0.86	1.44±0.12	0.81	<6.94
05-27-91	6241	0.85	1.46±0.17	1.65	<6.85
06-10-91	6324	0.87	1.42±0.10	0.80	<7.04
06-24-91	6406	0.78	1.39±0.17	0.90	<7.19
07-08-91	6486	0.79	1.58±0.16	0.89	<6.33
07-22-91	6576	0.84	1.48±0.17	1.19	<6.75
08-12-91	6725	0.85	1.27±0.15	0.94	<7.87
08-26-91	6781	1.01	1.44±0.14	0.79	<6.94
09-09-91	6848	0.84	1.35±0.17	2.26	<7.41
09-23-91	6949	0.97	1.73±0.20	1.13	<5.78
10-15-91	7066	0.50[b]	1.48±0.16	<1.40	<6.76
10-28-91	7136	0.95	1.49±0.16	0.95	<6.71
11-12-91	7205	0.92	1.31±0.13	0.87	<7.63
12-09-91	7274	0.85	1.42±0.15	2.12	<7.03
	T-199 (C) Farm 8.6 mi SW of Station				
01-14-91	TMI-5815	0.96	1.43±0.17	2.50	<6.99
02-12-91	NS[a]	--	--	--	--

[a] NS = No sample; location dropped from program.

[b] Analysis was repeated; result of reanalysis 0.50 g/L.

Table 16. Milk samples, analyses for calcium, stable potassium, and ratios of Sr-90 (pCi) per gram of calcium and Cs-137 (pCi) per gram of potassium (continued)

Date Collected	Lab Code	Calcium (g/L)	Potassium (g/L)	Sr-90 (pCi) per gram of Calcium	Cs-137 (pCi) per gram of Potassium
	T-24 (C) Sandusky, 21.0 mi SE of Station				
01-15-91	TMI-5813	0.90	1.63±0.18	1.00	<6.13
02-12-91	5893	0.93	1.42±0.17	1.29	<7.04
03-12-91	5971	0.81	1.39±0.12	1.73	<7.19
04-09-91	6035	1.18	1.46±0.16	1.02	<6.85
05-13-91	6164	0.82	1.51±0.13	2.20	<6.62
05-27-91	6242	0.93	1.39±0.15	2.26	<7.19
06-10-91	6325,6	0.82	1.46±0.09	1.71	<6.85
06-24-91	6407	1.06	1.39±0.17	1.32	<7.19
07-09-91	6487	0.81	1.47±0.16	2.59	<6.80
07-23-91	6577	0.96	1.42±0.13	1.77	<7.04
08-13-91	6726	0.89	1.28±0.13	1.46	<7.81
08-27-91	6782	0.87	1.39±0.15	1.03	<7.19
09-10-91	6849	0.84	1.54±0.16	1.79	<6.49
09-24-91	6950	0.93	1.34±0.15	1.18	<7.46
10-15-91	7067	0.88	1.36±0.18	1.59	<7.35
10-29-91	7137	0.88	1.49±0.16	1.70	<6.71
11-12-91	7206,7	0.88	1.53±0.10	1.25	<6.54
12-10-91	7275	0.61	1.47±0.09	1.97	<6.80
	T-57 (C) Farm, 22 miles SSE of Station				
01-15-91	TMI-5814	0.89	1.39±0.14	0.90	<7.19
02-12-91	5894	0.87	1.55±0.14	1.03	<6.45
03-12-91	5972	0.88	1.35±0.14	1.02	<7.41
04-09-91	6036	1.01	1.51±0.15	0.59	<6.62
05-13-91	6165	0.83	1.41±0.13	0.96	<7.09
05-27-91	6243	0.84	1.21±0.15	1.55	<8.26
06-10-91	6327	0.92	1.35±0.14	1.20	<7.41
06-24-91	6408	0.88	1.49±0.17	0.91	<6.71
07-09-91	6488	0.91	1.49±0.17	1.32	<6.71
07-23-91	6578	0.97	1.69±0.12	1.34	<5.92
08-13-91	6727	0.97	1.44±0.16	1.86	<6.94
08-27-91	6783	0.94	1.34±0.14	2.23	<7.46
09-10-91	6850	0.92	1.49±0.16	0.65	<6.71
09-24-91	6951	0.98	1.50±0.14	1.02	<6.67
10-15-91	7068	0.94	1.55±0.15	0.64	<6.45
10-29-91	7138	1.03	1.48±0.20	0.58	<6.76
11-12-91	7208	0.87	1.51±0.16	1.38	<6.62
12-10-91	7276	0.90	1.50±0.10	0.89	<6.67

Table 17. Ground water samples, analyses for gross beta, Sr-89, Sr-90, and gamma-emitting isotopes. Collection: Quarterly.

	Sample Description and Activity (pCi/L)				Annual Mean ± s.d.
T-7					
Lab Code	TWW-9260	TWW-321	TWW-1523	TWW-2839	
Collection Period	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	
Gross Beta					
Suspended Solids	<0.4	<0.2	<0.2	<0.8	<0.8
Dissolved Solids	2.9±0.5	2.9±0.4	3.0±0.7	3.0±0.3	3.0±0.1
Total Residue	2.9±0.5	2.9±0.4	3.0±0.7	3.0±0.3	3.0±0.1
H-3	<330	<330	<330	<330	<330
Sr-89	<0.9	<0.6	<0.8	<0.8	<0.9
Sr-90	<0.9	<0.5	0.6±0.3	0.9±0.3	0.8±0.2
Cs-137	<10	<10	<10	<10	<10
T-54					
Lab Code	TWW-9262	TWW-323,4	TWW-1525	TWW-2841	
Collection Period	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	
Gross Beta					
Suspended Solids	<0.4	<0.3	<0.2	<0.8	<0.8
Dissolved Solids	2.4±1.1	3.3±0.9	3.3±2.3	3.3±0.4	3.1±0.4
Total Residue	2.4±1.1	3.3±0.9	3.3±2.3	3.3±0.4	3.1±0.4
H-3	<330	<330	<330	<330	<330
Sr-89	<0.5	<0.5	<0.8	<1.2	<1.2
Sr-90	<0.4	<0.4	<0.4	<0.5	<0.5
Cs-137	<10	<10	<10	<10	<10

Table 17. Ground water samples, analyses for gross beta, Sr-89, Sr-90, and gamma-emitting isotopes (continued)

Sample Description and Activity (pCi/L)					Annual Mean ± s.d.
T-23 (C)					
Lab Code	ND[a]	TWW-1408	TWW-3464	TWW-3716	
Collection Period	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	
Gross Beta					
Suspended Solids	--	<0.2	<0.2	<0.7	<0.7
Dissolved Solids	--	2.3±1.7	<2.3	<1.9	2.3±1.7
Total Residue	--	2.3±1.7	<2.3	<1.9	2.3±1.7
H-3	--	<330	<330	<330	<330
Sr-89	--	<0.7	<1.3	<1.1	<1.3
Sr-90	--	<0.4	<0.5	<0.4	<0.5
Cs-137	--	<10	<10	<10	<10
T-27 (C)					
Lab Code	TWW-9251	TWW-322	TWW-1524	TWW-2840	
Collection Period	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	
Gross Beta					
Suspended Solids	<0.4	<0.2	<0.2	<0.8	<0.8
Dissolved Solids	1.8±0.8	2.3±1.3	1.8±1.3	1.6±1.2	1.9±0.3
Total Residue	1.8±0.8	2.3±1.3	1.8±1.3	1.6±1.2	1.9±0.3
H-3	<330	<330	<330	<300	<330
Sr-89	<0.9	<0.7	<1.1	<1.5	<1.5
Sr-90	<0.6	<0.6	<0.5	<0.7	<0.7
Cs-137	<10	<10	<10	<10	<10

[a] ND = No data; samples not available.

Table 17. Ground water samples, analyses for gross beta, Sr-89, Sr-90, and gamma-emitting isotopes (continued)

Sample Description and Activity (pCi/L)					Annual Mean ± s.d.
T-141 (QC)					
Lab Code	TWW-9263	TWW-325	NS[a]	TWW-2842	
Collection Period	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	
Gross Beta					
Suspended Solids	<0.3	<0.2	--	<0.8	<0.8
Dissolved Solids	<1.0	3.3±0.7	--	3.3±0.4	3.3±0.0
Total Residue	<1.0	3.3±0.7	--	3.3±0.4	3.3±0.0
H-3	<330	<330	--	<330	<330
Sr-89	<0.8	<0.5	--	<1.1	<1.1
Sr-90	<0.6	<0.5	--	<0.4	<0.6
Cs-137	<10	<10	--	<10	<10

[a] NS = no sample; sample not received.

Table 18. Domestic meat samples, analysis for gamma-emitting isotopes.

Location	Date Collected	Lab Code	Sample Type	Activity (pCi/g wet) K-40	Cs-137
T-197	07-29-91	TME-149	Chicken	2.71±0.48	<0.029
T-34	09-13-91	TME-156	Chicken	1.94±0.40	<0.017

Table 19. Wildlife meat samples, analysis for gamma-emitting isotopes.

Location	Collection Date	Lab Code	Sample Type	Activity (pCi/g wet) K-40	Cs-137
T-31	09-10-91	TME-155	Goose	1.90±0.46	<0.020
	12-24-91	-157	Muskrat	1.47±0.32	<0.021

Table 20. Green leafy vegetables, analyses for strontium-89, strontium-90, I-131 and other gamma-emitting isotopes. Collection: Monthly in season.

Sample Description and Activity (pCi/g wet)						
Location	T-8	T-8	T-8	T-8	T-8	T-25
Lab Code	TVE-1116	TVE-1117	TVE-1177	TVE-1178	TVE-1179	TVE-1118
Collection Date	07-16-91	07-16-91	08-21-91	08-21-91	08-21-91	07-16-91
Type	Horseradish	Rhubarb	Horseradish	Cabbage	Broccoli	Spinach
Sr-89	<0.009	<0.007	<0.003	<0.007	<0.004	<0.010
Sr-90	0.004±0.002	0.003±0.002	<0.002	0.005±0.002	0.003±0.001	<0.004
I-131	<0.009[a]	<0.022	<0.047	<0.020	<0.024	<0.004[a]
K-40	6.91±0.17	3.13±0.48	4.91±0.63	2.55±0.29	3.64±0.51	8.01±0.19
Nb-95	<0.023	<0.011	<0.036	<0.014	<0.021	<0.016
Zr-95	<0.022	<0.017	<0.051	<0.023	<0.038	<0.015
Cs-137	<0.008	<0.010	<0.030	<0.013	<0.018	<0.004
Ce-141	<0.049	<0.004	<0.038	<0.016	<0.020	<0.026
Ce-144	<0.057	<0.019	<0.14	<0.066	<0.082	<0.029
Location	T-25	T-25	T-25	T-37	T-37	
Lab Code	TVE-1180	TVE-1181	TVE-1182	TVE-1119	TVE-1183	
Collection Date	08-21-91	08-21-91	08-21-91	07-16-91	08-21-91	
Type	Parsley	Kale	Cauliflower	Cabbage	Cabbage	
Sr-89	<0.007	<0.004	<0.006	<0.001	<0.002	
Sr-90	<0.004	<0.002	0.004±0.002	<0.001	<0.001	
I-131	<0.039	<0.036	<0.035	<0.005[a]	<0.017	
K-40	7.69±0.68	4.09±0.50	4.45±0.62	1.74±0.11	2.06±0.28	
Nb-95	<0.028	<0.026	<0.030	<0.017	<0.010	
Zr-95	<0.048	<0.040	<0.045	<0.015	<0.017	
Cs-137	<0.026	<0.026	<0.030	<0.004	<0.009	
Ce-141	<0.031	<0.030	<0.031	<0.027	<0.029	
Ce-144	<0.12	<0.13	<0.14	<0.032	<0.07[illegible]	

[a] LLD for I-131 not reached due to delay in counting. Reported result is LLD at time of measurement.

Table 20. Green leafy vegetables, analyses for strontium-89, strontium-90, I-131 and other gamma-emitting isotopes (continued)

Sample Description and Activity (pCi/g wet)						
Location	T-8	T-8	T-8	T-37	T-25	T-25
Lab Code	TVE-1246	TVE-1247	TVE-1248	TVE-1243	TVE-1245	TVE-1250
Collection Date	09-17-91	09-17-91	09-17-91	09-17-91	09-17-91	09-17-91
Type	Broccoli	Tomatoes	Horseradish	Cabbage	Pepper Leaves	Parsley
Sr-89	<0.007	<0.006	<0.006	<0.002	<0.004	<0.006
Sr-90	0.005±0.002	0.004±0.002	0.005±0.002	<0.001	<0.001	0.003±0.002
I-131	<0.047	<0.033	<0.030	<0.014	<0.033	<0.029
K-40	4.25±0.58	4.27±0.46	4.43±0.47	1.57±0.21	5.89±0.52	8.91±9.66
Nb-95	<0.035	<0.022	<0.024	<0.014	<0.020	<0.025
Zr-95	<0.052	<0.032	<0.042	<0.022	<0.031	<0.042
Cs-137	<0.029	<0.018	<0.024	<0.012	<0.020	<0.022
Ce-141	<0.038	<0.026	<0.028	<0.014	<0.026	<0.028
Ce-144	<0.14	<0.11	<0.11	<0.057	<0.10	<0.12

Table 21. Fruit Samples, analyses for strontium-89, strontium-90, I-131 and other gamma-emitting isotopes. Collection: Monthly in season.

Sample Description and Activity (pCi/g wet)					
Location	T-8	T-23	T-37	T-25	T-173
Lab Code	TVE-1249	TVE-1280	TVE-1241,2	TVE-1244	TVE-1240
Collection Date	09-17-91	10-11-91	09-17-91	09-17-91	09-09-91
Type	Apples	Grapes	Apples	Apples	Grapes
Sr-89	<0.001	<0.003	<0.001[a]	<0.002	<0.005
Sr-90	<0.001	<0.001	<0.001[a]	<0.001	0.005±0.002
I-131	<0.015	<0.012	<0.019	<0.020	<0.041
K-40	0.91±0.17	2.20±0.18	1.06±0.13	1.10±0.18	1.77±0.26
Nb-95	<0.013	<0.007	<0.010	<0.012	<0.016
Zr-95	<0.018	<0.012	<0.018	<0.018	<0.026
Cs-137	<0.009	<0.006	<0.011	<0.009	<0.012
Ce-141	<0.016	<0.010	<0.016	<0.016	<0.020
Ce-144	<0.064	<0.040	<0.062	<0.061	<0.072

Location
Lab Code
Collection Date
Type
Sr-89
Sr-90
I-131
K-40
Nb-95
Zr-95
Cs-137
Ce-141
Ce-144

[a] Result of single analysis; not enough sample to duplicate.

Table 22. Animal - wildlife feed samples, analysis for gamma-emitting isotopes. Collection: Annually.

Sample Description and Activity (pCi/g wet)			
Location	T-8	T-57	T-197
Collection Date	01-14-91	01-15-91	07-29-91
Lab Code	TCF-447	TCF-448	TCF-450
Type	Mixed Feed	Mixed Feed	Mixed Feed
Be-7	<0.18	<0.098	<0.076
K-40	12.50±0.62	2.59±0.20	3.81±0.31
Nb-95	<0.020	<0.014	<0.014
Zr-95	<0.034	<0.023	<0.025
Ru-103	<0.020	<0.012	<0.010
Ru-106	<0.17	<0.11	<0.088
Cs-137	<0.022	<0.011	<0.010
Ce-141	<0.047	<0.020	<0.006
Ce-144	<0.23	<0.090	<0.022
Location	T-8	T-8	T-57
Collection Date	08-13-91	08-13-91	08-13-91
Lab Code	TCF-452	TCF-453	TCF-454
Type	Haylage	Corn	Hay
Be-7	<0.14	<0.14	0.70±0.14
K-40	12.70±0.37	2.03±0.20	16.40±0.70
Nb-95	<0.020	<0.020	<0.029
Zr-95	<0.030	<0.029	<0.042
Ru-103	<0.018	<0.020	<0.024
Ru-106	<0.12	<0.12	<0.19
Cs-137	<0.014	<0.013	<0.023
Ce-141	<0.040	<0.041	<0.037
Ce-144	<0.11	<0.11	<0.13

Table 22. Animal - wildlife feed samples, analysis for gamma-emitting isotopes. Collection: Annually.

Sample Description and Activity (pCi/g wet)			
Location	T-31	T-31	T-34
Collection Date	09-11-91	09-11-91	09-13-91
Lab Code	TCF-463	TCF-464	TCF-462
Type	Smartweed	Cattail	Chicken Feed
Be-7	0.84±0.05	<0.36	<0.089
K-40	3.06±0.12	2.35±0.52	3.93±0.30
Nb-95	<0.007	<0.050	<0.016
Zr-95	<0.011	<0.082	<0.024
Ru-103	<0.006	<0.043	<0.012
Ru-106	<0.043	<0.26	<0.087
Cs-137	<0.005	<0.036	<0.010
Ce-141	<0.014	<0.060	<0.020
Ce-144	<0.037	<0.18	<0.059

Location	T-198
Collection Date	09-11-91
Lab Code	TCF-465
Type	Smartweed
Be-7	1.20±0.23
K-40	2.05±0.38
Nb-95	<0.032
Zr-95	<0.048
Ru-103	<0.025
Ru-106	<0.17
Cs-137	<0.020
Ce-141	<0.039
Ce-144	<0.13

Table 23. Soil samples, analysis for gamma-emitting isotopes.

Sample Description and Activity (pCi/g dry)				
Location	T-1	T-2	T-3	T-4
Date	04-15-91	04-15-91	04-15-91	04-15-91
Lab Code	TSO-522	TSO-523	TSO-524	TSO-525
Be-7	<0.33	<0.23	<0.48	<0.48
K-40	11.96±0.90	8.76±0.55	15.20±1.14	18.80±1.00
Nb-95	<0.046	<0.028	<0.063	<0.077
Zr-95	<0.073	<0.043	<0.096	<0.13
Ru-103	<0.034	<0.029	<0.050	<0.060
Ru-106	<0.35	<0.20	<0.40	<0.98
Cs-137	0.23±0.063	0.36±0.033	0.084±0.055	0.24±0.045
Ce-141	<0.067	<0.078	<0.081	<0.12
Ce-144	<0.20	<0.30	<0.28	<0.41
Location	T-7	T-8	T-9 (C)	T-11 (C)
Date	04-15-91	04-15-91	04-15-91	04-15-91
Lab Code	TSO-526	TSO-527,8	TSO-529	TSO-530
Be-7	<0.26	<0.30	<0.46	<0.31
K-40	8.56±0.50	22.15±0.79	14.10±0.85	12.40±0.63
Nb-95	<0.045	<0.054	<0.070	<0.048
Zr-95	<0.072	<0.084	<0.12	<0.080
Ru-103	<0.032	<0.037	<0.058	<0.038
Ru-106	<0.58	<0.34	<0.85	<0.58
Cs-137	0.030±0.021	0.15±0.024	0.39±0.048	0.12±0.027
Ce-141	<0.069	<0.054	<0.11	<0.076
Ce-144	<0.25	<0.20	<0.37	<0.26
Location	T-12 (C)	T-23 (C)	T-27 (C)	
Date	04-15-91	05-29-91	04-15-91	
Lab Code	TSO-531	TSO-557	TSO-532	
Be-7	<0.54	<0.43	<0.45	
K-40	20.18±1.38	15.40±0.81	18.00±0.94	
Nb-95	<0.070	<0.068	<0.075	
Zr-95	<0.11	<0.11	<0.12	
Ru-103	<0.059	<0.055	<0.058	
Ru-106	<0.49	<0.82	<0.88	
Cs-137	0.53±0.089	0.48±0.050	0.34±0.046	
Ce-141	<0.096	<0.10	<0.11	
Ce-144	<0.33	<0.35	<0.38	

Table 23. Soil samples, analysis for gamma-emitting isotopes (continued)

Sample Description and Activity (pCi/g dry)				
Location	T-1	T-2	T-3	T-4
Date	10-14-91	10-14-91	10-14-91	10-14-91
Lab Code	TSO-588	TSO-589	TSO-590	TSO-591
Be-7	<0.24	<0.56	0.47±0.36	<0.40
K-40	9.14±0.55	9.41±1.06	7.33±0.75	18.30±1.00
Nb-95	<0.036	<0.073	<0.080	<0.066
Zr-95	<0.054	<0.11	<0.085	<0.11
Ru-103	<0.031	<0.059	<0.054	<0.053
Ru-106	<0.29	<0.45	<0.29	<0.58
Cs-137	0.21±0.027	0.26±0.070	<0.041	0.23±0.040
Ce-141	<0.064	<0.10	<0.11	<0.12
Ce-144	<0.21	<0.29	<0.21	<0.38
Location	T-7	T-8	T-9(C)	T-11(C)
Date	10-14-91	10-14-91	10-14-91	10-14-91
Lab Code	TSO-592	TSO-593,4	TSO-595	TSO-596
Be-7	<0.35	0.98±0.33	0.55±0.28	<0.32
K-40	12.13±0.81	23.68±0.83	16.04±0.87	11.20±0.61
Nb-95	<0.054	<0.086	<0.069	<0.066
Zr-95	<0.072	<0.10	<0.071	<0.074
Ru-103	<0.038	<0.063	<0.0[illegible]	<0.048
Ru-106	<0.32	<0.39	<0.32	<0.24
Cs-137	<0.043	0.29±0.037	0.73±0.064	0.22±0.027
Ce-141	<0.070	<0.12	<0.062	<0.10
Ce-144	<0.19	<0.27	<0.16	<0.18
Location	T-12(C)	T-23(C)	T-27(C)	
Date	10-14-91	10-11-91	10-14-91	
Lab Code	TSO-597	TSO-587	TSO-598	
Be-7	<0.38	0.24±0.10	<0.41	
K-40	18.15±0.89	9.92±0.28	17.87±0.93	
Nb-95	<0.065	<0.019	<0.086	
Zr-95	<0.092	<0.024	<0.11	
Ru-103	<0.051	<0.014	<0.055	
Ru-106	<0.48	<0.11	<0.32	
Cs-137	0.46±0.041	0.59±0.022	0.15±0.045	
Ce-141	<0.11	<0.017	<0.11	
Ce-144	<0.32	<0.058	<0.22	

Table 24. Treated surface water samples, monthly composites of weekly grab samples, analysis for gross beta, 1991.

Collection Period	Lab Code	Gross Beta Activity (pCi/L) Suspended Solids	Dissolved Solids	Total Residue
T-11 (C)				
January	TSWT-9394,5	<0.4	3.2±0.4	3.2±0.4
February	9694	<0.2	2.0±0.4	2.0±0.4
March	31	<0.2	2.5±0.3	2.5±0.3
1st Qtr. mean±s.d.		<0.4	2.6±0.6	2.6±0.6
April	TSWT-515	<0.2	2.7±0.3	2.7±0.3
May	[illegible]	<0.2	2.2±0.6	2.2±0.6
June	[illegible]8	<0.2	2.6±0.4	2.6±0.6
2nd Qtr. mean±s.d.		<0.2	2.5±0.3	2.5±0.3
July	TSWT-1787	<0.2	2.4±0.6	2.4±0.6
August	2162,3	<0.8	2.4±0.4	2.4±0.4
September	2662	<0.9	1.8±0.5	1.8±0.5
3rd Qtr. mean±s.d.		<0.9	2.2±0.3	2.2±0.3
October	TSWT-3105	<0.5	2.8±0.7	2.8±0.7
November	3496	<0.2	2.2±0.5	2.2±0.5
December	4042	<0.2	2.2±0.6	2.2±0.6
4th Qtr. mean±s.d.		<0.5	2.4±0.3	2.4±0.3

Table 24. Treated surface water samples, monthly composites of weekly grab samples, analysis for gross beta, 1991 (continued)

Collection Period	Lab Code	Gross Beta Activity (pCi/L) Suspended Solids	Dissolved Solids	Total Residue
T-12 (C)				
January	TSWT-9396	<0.4	2.9±0.5	2.9±0.5
February	9695	<0.2	1.6±0.4	1.6±0.4
March	32	<0.2	1.7±0.3	1.7±0.3
1st Qtr. mean±s.d.		<0.4	2.1±0.7	2.1±0.7
April	TSWT-516	<0.2	2.4±0.3	2.4±0.3
May	834	<0.2	1.6±0.5	1.6±0.5
June	1239	<0.2	1.8±0.4	1.8±0.4
2nd Qtr. mean±s.d.		<0.2	1.9±0.4	1.9±0.4
July	TSWT-1788	<0.2	1.8±0.6	1.8±0.6
August	2164	<0.4	1.5±0.4	1.5±0.4
September	2663	<0.2	2.0±0.5	2.0±0.5
3rd Qtr. mean±s.d.		<0.4	1.8±0.2	1.8±0.2
October	TSWT-3106	<0.3	2.0±0.6	2.0±0.6
November	3497,8	<0.2	1.9±0.3	1.9±0.3
December	4043	<0.2	1.6±0.5	1.6±0.5
4th Qtr. mean±s.d.		<0.3	1.8±0.2	1.8±0.2

Table 24. Treated surface water samples, monthly composites of weekly grab samples, analysis for gross beta, 1991 (continued)

Collection Period	Lab Code	Gross Beta Activity (pCi/L) Suspended Solids	Dissolved Solids	Total Residue
T-23 (C)				
January	TSWT-9525,6	<0.2	2.0±0.2	2.0±0.2
February	9815	<0.4	2.2±0.5	2.2±0.5
March	192,3	<0.4	2.1±0.4	2.1±0.4
1st Qtr. mean±s.d.		<0.4	2.1±0.1	2.1±0.1
April	TSWT-600	<0.3	2.2±0.3	2.2±0.3
May	985	<0.2	2.1±0.6	2.1±0.6
June	1410	<0.2	1.9±0.5	1.9±2.5
2nd Qtr. mean±s.d.		<0.3	2.1±0.2	2.1±0.2
July	TSWT-1822,3	<0.4	1.7±0.5	1.7±0.5
August	2342	<0.4	2.1±0.5	2.1±0.5
September	2723	<0.2	2.1±0.5	2.1±0.5
3rd Qtr. mean±s.d.		<0.4	2.0±0.2	2.0±0.2
October	TSWT-3229	<0.4	2.3±0.5	2.3±0.5
November	3715	<0.4	2.0±0.5	2.0±0.5
December	4206	<0.3	3.0±0.5	3.0±2.5
4th Qtr. mean±s.d.		<0.4	2.4±0.5	2.4±0.5

Table 24. Treated surface water samples, monthly composites of weekly grab samples, analysis for gross beta, 1991 (continued)

Collection Period	Lab Code	Gross Beta Activity (pCi/L) Suspended Solids	Dissolved Solids	Total Residue
T-28				
January	TSWT-9397	<0.4	3.2±0.5	3.2±0.5
February	9696,7	<0.4	2.3±0.3	2.3±0.3
March	33	<0.2	1.9±0.3	1.9±0.3
1st Qtr. mean±s.d.		<0.4	2.5±0.7	2.5±0.7
April	TSWT-517,8	<0.7	1.8±0.2	1.8±0.2
May	835	<0.2	2.2±0.6	2.2±0.6
June	1240	<0.2	1.6±0.4	1.6±0.4
2nd Qtr. mean±s.d.		<0.7	1.9±0.3	1.9±0.3
July	TSWT-1789,90	<0.2	1.4±0.4	1.4±0.4
August	2165	<0.4	1.6±0.4	1.6±0.4
September	2664	<0.2	1.7±0.5	1.7±0.5
3rd Qtr. mean±s.d.		<0.4	1.6±0.2	1.6±0.2
October	TSWT-3107	<0.4	1.6±0.6	1.6±0.6
November	3499	<0.4	1.4±0.4	1.4±0.4
December	4044	<0.2	2.0±0.5	2.0±0.5
4th Qtr. mean±s.d.		<0.4	1.7±0.3	1.7±0.3

Table 24. Treated surface water samples, monthly composites of weekly grab samples, analysis for gross beta, 1991 (continued)

Collection Period	Lab Code	Gross Beta Activity (pCi/L) Suspended Solids	Dissolved Solids	Total Residue
Tap				
January	TSWT-9398	<0.4	3.1±0.5	3.1±0.5
February	9698	<0.4	2.2±0.5	2.2±0.5
March	34	<0.2	2.3±0.3	2.3±0.3
1st Qtr. mean±s.d.		<0.4	2.5±0.5	2.5±0.5
April	TSWT-519	<0.4	2.6±0.3	2.6±0.3
May	836	<0.2	2.3±0.6	2.3±0.6
June	1241	<0.2	2.0±0.4	2.0±0.4
2nd Qtr. mean±s.d.		<0.4	2.3±0.3	2.3±0.3
July	TSWT-1791	<0.2	2.4±0.6	2.4±0.6
August	2166	<0.4	2.2±0.5	2.2±0.5
September	2665,6	<0.2	2.3±0.4	2.3±0.4
3rd Qtr. mean±s.d.		<0.4	2.3±0.1	2.3±0.1
October	TSWT-3108	<0.4	2.4±0.7	2.4±0.7
November	3500	<0.3	2.6±0.5	2.6±0.5
December	4045	<0.2	2.1±0.6	2.1±0.6
4th Qtr. mean±s.d.		<0.4	2.4±0.2	2.4±0.2

Table 24. Treated surface water samples, monthly composites of weekly grab samples, analysis for gross beta, 1991 (continued)

Collection Period	Lab Code	Gross Beta Activity (pCi/L) Suspended Solids	Dissolved Solids	Total Residue
T-144				
January	TSWT-9400	<0.4	2.8±0.5	2.8±0.5
February	9700	<0.2	3.7±0.6	3.7±0.6
March	37	<0.2	3.4±0.3	3.4±0.3
1st Qtr. mean±s.d.		<0.4	3.3±0.5	3.3±0.5
April	TSWT-521	<0.7	2.0±0.5	2.0±0.5
May	838	<0.2	3.4±0.6	3.4±0.6
June	1243	<0.2	2.0±0.5	2.0±0.5
2nd Qtr. mean±s.d.		<0.7	2.5±0.8	2.5±0.8
July	TSWT-1793	<0.2	1.8±0.6	1.8±0.6
August	2168	<0.4	2.1±0.5	2.1±0.5
September	2668	<0.3	1.3±0.4	1.3±0.4
3rd Qtr. mean±s.d.		<0.4	1.7±0.4	1.7±0.4
October	TSWT-3110	<0.8	2.6±0.5	2.6±0.5
November	3502	<0.2	2.7±0.5	2.7±0.5
December	4047	<0.2	2.4±0.6	2.4±0.6
4th Qtr. mean±s.d.		<0.8	2.6±0.2	2.6±0.2

Table 25. Treated surface water samples, monthly composite of weekly samples, analysis for gross beta, tritium, gamma-emitting isotopes, Sr-89, and Sr-90, 1991.

Sample Description and Activity (pCi/L)				Quarterly Mean±s.d.
T-143 (QC)				
Lab Code	TSWT-9399	TSWT-9699	TSWT-35,6	
Collection Period	January	February	March	1st Qtr.
Gross Beta				
Suspended Solids	<0.3	<0.4	<0.9	<0.9
Dissolved Solids	2.8±0.3	2.0±0.5	2.5±0.4	2.4±0.4
Total Residue	2.8±0.3	2.0±0.5	2.5±0.4	2.4±0.4
H-3	<330	<330	<330	<330
Sr-89	<0.9	<1.2	<0.4	<1.2
Sr-90	<0.8	<1.1	<0.4	<1.1
Cs-137	<10	<10	<10	<10
Lab Code	TSWT-520	TSWT-837	TSWT-1242	
Collection Period	April	May	June	2nd Qtr.
Gross Beta				
Suspended Solids	<0.4	<0.2	<0.4	<0.4
Dissolved Solids	3.0±0.5	2.4±0.6	1.7±0.6	2.4±0.6
Total Residue	3.0±0.5	2.4±0.6	1.7±0.6	2.4±0.6
H-3	<330	<330	<330	<330
Sr-89	<0.6	<0.8	<0.6	<0.8
Sr-90	<0.4	<0.5	0.6±0.3	0.6±0.3
Cs-137	<10	<10	<10	<10

Table 25. Treated surface water samples, monthly composite of weekly samples, analysis for gross beta, tritium, gamma-emitting isotopes, Sr-89 and Sr-90, 1991 (continued)

Sample Description and Activity (pCi/L)				Quarterly Mean±s.d.
T-143 (QC)				
Lab Code	TSWT-1702	TSWT-2167	TSWT-2667	
Collection Period	July	August	September	3rd Qtr.
Gross Beta				
Suspended Solids	<0.2	<0.6	<0.4	<0.6
Dissolved Solids	2.2±0.5	2.5±0.6	1.8±0.4	2.2±0.4
Total Residue	2.2±0.5	2.5±0.6	1.8±0.4	2.2±0.4
H-3	<330	393±108[a]	<330	393±108
Sr-89	<0.7	<0.8	<1.4	<1.4
Sr-90	<0.4	0.8±0.4	<0.6	0.8±0.4
Cs-137	<10	<10	<10	<10
Lab Code	TSWT-3109	TSWT-3501	TSWT-4046	
Collection Period	October	November	December	4th Qtr.
Gross Beta				
Suspended Solids	<0.3	<0.2	<0.3	<0.3
Dissolved Solids	1.4±0.4	2.8±0.5	1.8±0.4	2.0±0.7
Total Residue	1.4±0.4	2.8±0.5	1.8±0.4	2.0±0.7
H-3	<330	<330	<330	<330
Sr-89	<1.2	<0.8	<0.8	<1.2
Sr-90	<0.6	0.6±0.3	<0.7	0.6±0.3
Cs-137	<10	<10	<10	<10

[a] Analysis was repeated; result of reanalysis 335±94 pCi/L.

Table 26. Treated surface water samples, quarterly composites of weekly grab samples, analysis for tritium, strontium and gamma-emitting isotopes.

Location	1991 Collection Period	Lab Code	Activity (pCi/L) H-3	Sr-89	Sr-90	Cs-137
Control						
T-11	1st Quarter	TSWT-360	<330	<0.7	<0.6	<10
	2nd Quarter	1549	<330	<1.2	<0.6	<10
	3rd Quarter	3115	<330	<1.2	0.6±0.3	<10
	4th Quarter	4133	<330	<0.6	0.6±0.3	<10
	Annual mean ± s.d.		<330	<1.2	0.6±0.0	<10
T-12	1st Quarter	TSWT-361	<330	<0.8	<0.6	<10
	2nd Quarter	1550	<330	<1.0	<0.5	<10
	3rd Quarter	3116	<330	<1.6	<0.6	<10
	4th Quarter	4134	<330	<0.8	<0.6	<10
	Annual mean ± s.d.		<330	<1.6	<0.6	<10
T-23	1st Quarter	TSWT-362	<330	<0.8	<0.5	<10
	2nd Quarter	1702	<330	<0.9	<0.5	<10
	3rd Quarter	3120	<330	<0.8	<0.4	<10
	4th Quarter	4207	<330	<0.6	<0.5	<10
	Annual mean ± s.d.		<330	<0.9	<0.5	<10

Table 26. Treated surface water samples, quarterly composites of weekly grab samples, analysis for tritium, strontium and gamma-emitting isotopes, 1991 (continued)

Location	Collected Date	Lab Code	Activity (pCi/L) H-3	Sr-89	Sr-90	Cs-137
Indicator						
T-28	1st Quarter	TSWT-363	<330	<0.8	<0.6	<10
	2nd Quarter	1551,2	<330	<1.0	<0.5	<10
	3rd Quarter	3117	<330	<1.1	<0.5	<10
	4th Quarter	4135	<330	<0.8	<0.6	<10
	Annual mean ± s.d.		<330	<1.1	<0.6	<10
T-50	1st Quarter	TSWT-364	<330	<0.7	<0.5	<10
	2nd Quarter	1553	<330	<0.8	0.5±0.3	<10
	3rd Quarter	3118	<330	<1.2	0.6±0.3	<10
	4th Quarter	4136	<330	<0.7	<0.5	<10
	Annual mean ± s.d.		<330	<1.2	0.6±0.1	<10
T-144	1st Quarter	TSWT-365	<330	<0.7	<0.5	<10
	2nd Quarter	1554	<330	<0.9	<0.5	<10
	3rd Quarter	3119	<330	<1.5	<0.6	<10
	4th Quarter	4137	<330	<0.6	0.8±0.3	<10
	Annual mean ± s.d.		<330	<1.5	0.8±0.3	<10

Table 27. Untreated surface water samples, monthly composites of weekly samples, analysis for gross beta, tritium, and gamma-emitting isotopes, 1991.

Collection Period	Lab Code	Gross Beta Activity (pCi/L) Suspended Solids	Dissolved Solids	Total Residue	Activity (pCi/L) H-3	Cs-137
Control						
T-11 (C)						
January	TSWU-9388	<0.3	2.8±0.3	2.8±0.3	<330	<10
February	9685,6	<0.4	2.7±0.4	2.7±0.4	<330	<10
March	24,5	<0.9	2.7±0.3	2.7±0.3	<330	<10
1st Qtr. mean ± s.d.		<0.9	2.7±0.1	2.7±0.1	<330	<10
April	TSWU-509	<0.2	2.5±0.5	2.5±0.5	<330	<10
May	826	<0.2	2.5±0.3	2.5±0.3	<330	<10
June	1231	<0.5	2.2±0.5	2.2±0.5	<330	<10
2nd Qtr. mean ± s.d.		<0.5	2.4±0.2	2.4±0.2	<330	<10
July	TSWU-1791	<0.2	2.8±0.4	2.8±0.4	<330	<10
August	2116,7	<0.3	2.0±0.3	2.0±0.3	<330	<10
September	2657	<0.2	2.0±0.5	2.0±0.5	<330	<10
3rd Qtr. mean ± s.d.		<0.3	2.3±0.5	2.3±0.5	<330	<10
October	TSWU-3098	<0.4	2.5±0.3	2.5±0.3	<330	<10
November	3490	<0.2	2.0±0.5	2.0±0.5	<330	<10
December	4036	<0.2	2.1±0.5	2.1±0.5	<330	<10
4th Qtr. mean ± s.d.		<0.4	2.2±0.3	2.2±0.3	<330	<10

Table 27. Untreated surface water samples, monthly composites of weekly samples, analysis for gross beta, tritium, and gamma-emitting isotopes, 1991 (continued)

Collection Period	Lab Code	Gross Beta Activity (pCi/L) Suspended Solids	Dissolved Solids	Total Residue	Activity (pCi/L) H-3	Cs-137
Control						
T-12 (C)						
January	TSWU-9389	4.2±0.5[a]	4.1±0.3	8.3±0.6	<330	<10
February	9687	<0.2	2.4±0.3	2.4±0.3	<330	<10
March	26	<0.5	2.4±0.4	2.4±0.4	<330	<10
1st Qtr. mean ± s.d.		4.2±0.5	3.0±1.0	4.4±3.4	<330	<10
April	TSWU-510	<0.2	2.2±0.5	2.2±0.5	<330	<10
May	827	1.2±0.2	3.0±0.3	4.2±0.4	<330	<10
June	1232	<0.4	2.4±0.3	2.4±0.3	<330	<10
2nd Qtr. mean ± s.d.		1.2±0.2	2.5±0.4	2.9±1.1	<330	<10
July	TSWU-1782	<0.4	2.8±0.3	2.8±0.3	<330	<10
August	2157	<0.2	2.6±0.3	2.6±0.3	<330	<10
September	2658	<0.2	2.9±0.5	2.9±0.5	<330	<10
3rd Qtr. mean ± s.d.		<0.4	2.8±0.2	2.8±0.2	<330	<10
October	TSWU-3099	<0.4	2.1±0.2	2.1±0.2	<330	<10
November	3491	<0.2	2.3±0.5	2.3±0.5	<330	<10
December	4037	<0.2	2.3±0.5	2.3±0.5	<330	<10
4th Qtr. mean ± s.d.		<0.4	2.2±0.1	2.2±0.1	<330	<10

[a] Analysis was repeated; result of reanalysis, 6.8±0.4 pCi/L; sample very cloudy and very high in sediment content.

Table 27. Untreated surface water samples, monthly composites of weekly samples, analysis for gross beta, tritium, and gamma-emitting isotopes, 1991 (continued)

Collection Period	Lab Code	Gross Beta Activity (pCi/L) Suspended Solids	Dissolved Solids	Total Residue	Activity (pCi/L) H-3	Cs-137
Control						
T-23 (C)						
January	TSWU-9527	<0.2	2.3±0.3	2.3±0.3	<330	<10
February	9814	<0.5	2.7±0.5	2.7±0.5	<330	<10
March	194	0.5±0.1	2.7±0.3	3.2±0.3	<330	<10
1st Qtr. mean ± s.d.		0.5±0.1	2.6±0.2	2.7±0.4	<330	<10
April	TSWU-601	<0.2	1.9±0.5	1.9±0.5	<330	<10
May	986	<0.2	2.2±0.3	2.2±0.3	<330	<10
June	1409	<0.4	2.8±0.5	2.8±0.5	<330	<10
2nd Qtr. mean ± s.d.		<0.4	2.3±0.5	2.3±0.5	<330	<10
July	TSWU-1821	<0.2	1.9±0.3	1.9±0.3	<330	<10
August	2341	<0.3	1.6±0.4	1.6±0.4	<330	<10
September	2722	<0.2	2.4±0.5	2.4±0.5	<330	<10
3rd Qtr. mean ± s.d.		<0.3	2.0±0.4	2.0±0.4	<330	<10
October	TSWU-3228	<0.4	2.1±0.5	2.1±0.5	<330	<10
November	3714	<0.2	3.0±1.0	3.0±1.0	<330	<10
December	4205	<0.2	1.9±0.5	1.9±0.5	<330	<10
4th Qtr. mean ± s.d.		<0.4	2.3±0.6	2.3±0.6	<330	<10

Table 27. Untreated surface water samples, monthly composites of weekly samples, analysis for gross beta, tritium, and gamma-emitting isotopes, 1991 (continued)

Collection Period	Lab Code	Gross Beta Activity (pCi/L) Suspended Solids	Dissolved Solids	Total Residue	Activity (pCi/L) H-3	Cs-137
Indicator						
T-3						
January	TSWU-9387	<0.3	3.3±0.3	3.3±0.3	<330	<10
February	9684	<0.2	3.7±0.3	3.7±0.3	<330	<10
March	22	<0.5	2.9±0.5	2.9±0.5	<330	<10
1st Qtr. mean ± s.d.		<0.5	3.3±0.4	3.3±0.4	<330	<10
April	TSWU-506,7	<0.2	3.6±0.2	3.6±0.2	<330	<10
May	824	<0.3	3.3±0.4	3.3±0.4	<330	<10
June	1229	<0.2	3.0±0.3	3.0±0.3	<330	<10
2nd Qtr. mean ± s.d.		<0.3	3.3±0.3	3.3±0.3	<330	<10
July	TSWU-1778,9	<0.2	2.8±0.2	2.8±0.2	<330	<10
August	2155	0.3±0.1	1.9±0.5	2.2±0.5	424±107[a]	<10
September	2654,5	<0.3	3.0±0.4	3.0±0.4	<330	<10
3rd Qtr. mean ± s.d.		0.3±0.1	2.6±0.6	2.7±0.4	424±107	<10
October	TSWU-3096	<0.4	3.2±0.3	3.2±0.3	<330	<10
November	3488	<0.2	2.7±0.5	2.7±0.5	<330	<10
December	4034	0.6±0.1	2.2±0.6	2.8±0.6	<330	<10
4th Qtr. mean ± s.d.		0.6±0.1	2.7±0.5	2.9±0.3	<330	<10

[a] Analysis was repeated; result of reanalysis 458±99 pCi/L.

Table 27. Untreated surface water samples, monthly composites of weekly samples, analysis for gross beta, tritium, and gamma-emitting isotopes, 1991 (continued)

Collection Period	Lab Code	Gross Beta Activity (pCi/L) Suspended Solids	Dissolved Solids	Total Residue	Activity (pCi/L) H-3	Cs-137
Indicator						
T-28						
January	TSWU-9391	<0.4	3.4±0.3	3.4±0.3	<330	<10
February	9689	<0.2	3.2±0.5	3.2±0.5	<330	<10
March	28	<0.5	2.4±0.6	2.4±0.6	<330	<10
1st Qtr. mean ± s.d.		<0.5	3.0±0.5	3.0±0.5	<330	<10
April	TSWU-512	<0.2	3.0±0.5	3.0±0.5	<330	<10
May	829	<0.2	3.2±0.3	3.2±0.3	<330	<10
June	1234	<0.2	2.3±0.3	2.3±0.3	<330	<10
2nd Qtr. mean ± s.d.		<0.2	2.8±0.5	2.8±0.5	<330	<10
July	TSWU-1784	<0.2	2.3±0.3	2.3±0.3	353±100	<10
August	2159	<0.3	2.0±0.5	2.0±0.5	<330	<10
September	2659	<0.2	2.6±0.5	2.6±0.5	<330	<10
3rd Qtr. mean ± s.d.		<0.3	2.3±0.3	2.3±0.3	353±100	<10
October	TSWU-3100	<0.4	3.0±0.8	3.0±0.8	<330	<10
November	3493	<0.2	2.7±0.5	2.7±0.5	<330	<10
December	4038	<0.2	2.5±0.5	2.5±0.5	<330	<10
4th Qtr. mean ± s.d.		<0.4	2.7±0.2	2.7±0.2	<330	<10

Table 27. Untreated surface water samples, monthly composites of weekly samples, analysis for gross beta, tritium, and gamma-emitting isotopes, 1991 (continued)

Collection Period	Lab Code	Gross Beta Activity (pCi/L) Suspended Solids	Dissolved Solids	Total Residue	Activity (pCi/L) H-3	Cs-137
Indicator						
T-50						
January	TSWU-9392	<0.3	3.2±0.3	[illegible].3	<330	<10
February	9690	<0.2	2.8±0.5	2.8±0.5	<330	<10
March	29	<0.5	2.1±0.6	2.1±0.6	<330	<10
1st Qtr. mean ± s.d.		<0.5	2.7±0.6	2.7±0.6	<330	<10
April	TSWU-513	<0.2	3.2±0.5	3.2±0.5	<330	<10
May	830	<0.2	4.4±0.4	4.4±0.4	<330	<10
June	1235	<0.3	2.1±0.3	2.1±0.3	<330	<10
2nd Qtr. mean ± s.d.		<0.3	3.2±1.2	3.2±1.2	<330	<10
July	TSWU-1785	<0.2	2.0±0.3	2.0±0.3	<330	<10
August	2160	<0.2	2.3±0.6	2.3±0.6	657±115[a]	<10
September	2660	<0.2	2.5±0.5	2.5±0.5	<330	<10
3rd Qtr. mean ± s.d.		<0.2	2.3±0.2	2.3±0.2	657±115	<10
October	TSWU-3101	<0.3	2.4±0.5	2.4±0.5	337±96	<10
November	3494	<0.2	2.9±0.5	2.9±0.5	<330	<10
December	4039,40	<0.2	2.6±0.4	2.6±0.4	<330	<10
4th Qtr. mean ± s.d.		<0.3	2.6±0.2	2.6±0.2	337±96	<10

[a] Analysis was repeated; result of reanalysis 578±103 pCi/L.

Table 28. Untreated surface water samples, monthly composite of weekly samples, analysis for gross beta, tritium, strontium, and gamma-emitting isotopes, 1991.

Sample Description and Activity (pCi/L)				Quarterly Mean±s.d.
T-145 (QC)				
Lab Code	TSWU-9393	TSWU-9691	TSWU-30	
Collection Period	January	February	March	1st Qtr.
Gross Beta				
Suspended Solids	<0.3	<0.2	<0.5	<0.5
Dissolved Solids	4.9±0.4	3.4±0.5	3.0±0.6	3.8±1.0
Total Residue	4.9±0.4	3.4±0.5	3.0±0.6	3.8±1.0
H-3	<330	<330	<330	<330
Sr-89	<0.8	<0.4	<0.6	<0.8
Sr-90	<0.6	<0.4	<0.6	<0.6
Cs-137	<10	<10	<10	<10
Lab Code	TSWU-514	TSWU-831,2	TSWU-1236,7	
Collection Period	April	May	June	2nd Qtr.
Gross Beta				
Suspended Solids	<0.4	0.8±0.2	<0.4	0.8±0.2
Dissolved Solids	2.8±0.5	3.0±0.2	2.2±0.2	2.7±0.4
Total Residue	2.8±0.5	3.8±0.3	2.2±0.2	2.9±0.8
H-3	<330	<330	<330	<330
Sr-89	<0.6	<0.4	<0.5	<0.6
Sr-90	<0.5	<0.5	<0.7	<0.7
Cs-137	<10	<10	<10	<10

Table 28. Untreated surface water samples, monthly composite of weekly samples, analysis for gross beta, tritium, strontium, and gamma-emitting isotopes, 1991 (continued).

Sample Description and Activity (pCi/L)				Quarterly Mean±s.d.
T-145 (QC)				
Lab Code	TSWU-1786	TSWU-2161	TSWU-2661	
Collection Period	July	August	September	3rd Qtr.
Gross Beta				
Suspended Solids	<0.3	<0.2	<0.4	<0.4
Dissolved Solids	2.4±0.3	1.9±0.5	2.0±0.5	2.1±0.3
Total Residue	2.4±0.3	1.9±0.5	2.0±0.5	2.1±0.3
H-3	<330	<330	<330	<330
Sr-89	<0.7	<0.7	<1.0	<1.0
Sr-90	0.8±0.3	<0.4	<0.5	0.8±0.3
Cs-137	<10	<10	<10	<10
Lab Code	TSWU-3104	TSWU-3495	TSWU-4041	
Collection Period	October	November	December	4th Qtr.
Gross Beta				
Suspended Solids	<0.4	<0.2	<0.2	<0.4
Dissolved Solids	3.1±0.3	2.9±0.5	2.0±0.5	2.7±0.6
Total Residue	3.1±0.3	2.9±0.5	2.0±0.5	2.7±0.6
H-3	<330	<330	<330	<330
Sr-89	<1.0	<0.7	<0.7	<1.0
Sr-90	<0.6	0.5±0.3	<0.6	0.5±0.3
Cs-137	<10	<10	<10	<10

Table 29. Untreated surface water samples, quarterly composites of weekly grab samples, analysis for strontium, 1991.

Location	Collection Date	Lab Code	Activity (pCi/L) Sr-89	Sr-90
Control				
T-11	1st Quarter	TSWU-312,3	<0.7	<0.6
	2nd Quarter	1696	<0.8	0.6±0.3
	3rd Quarter	3085	<1.3	<0.5
	4th Quarter	4176	<0.6	0.6±0.3
	Annual mean±s.d.		<1.3	0.6±0.0
T-12	1st Quarter	TSWU-314	<0.8	<0.7
	2nd Quarter	1697	<0.7	<0.4
	3rd Quarter	3086	<1.5	<0.6
	4th Quarter	4177	<0.6	0.9±0.5
	Annual mean±s.d.		<1.5	0.9±0.5
T-23	1st Quarter	TSWU-366	<0.9	<0.7
	2nd Quarter	1756	<1.3	<0.7
	3rd Quarter	3121	<1.9	<0.8
	4th Quarter	4268	<0.6	0.7±0.3
	Annual mean±s.d.		<1.9	0.7±0.3

Table 29. Untreated surface water samples, quarterly composites of weekly grab samples, analysis for strontium, 1991 (continued)

Location	Collection Date	Lab Code	Activity (pCi/L) Sr-89	Sr-90
Indicator				
T-3	1st Quarter	TSWU-311	<0.8	<0.6
	2nd Quarter	1694	<0.9	0.6±0.3
	3rd Quarter	3084	<1.2	0.6±0.3
	4th Quarter	4175	<0.7	<0.6
	Annual mean±s.d.		<1.2	0.6±0.0
T-28	1st Quarter	TSWU-316	<0.7	<0.8
	2nd Quarter	1699	<1.1	<0.6
	3rd Quarter	3087	<1.2	<0.5
	4th Quarter	4178	<0.6	<0.5
	Annual mean±s.d.		<1.2	<0.8
T-50	1st Quarter	TSWU-317	<0.7	<0.7
	2nd Quarter	1700,1	<1.2	<0.7
	3rd Quarter	3088	<1.6	1.2±0.5
	4th Quarter	4179,80	<0.8	<0.7
	Annual mean±s.d.		<1.6	1.2±0.5

Table 30. Untreated surface lake water samples, monthly composites of weekly grab samples, analysis for gross beta, tritium, strontium-89, strontium-90 and gamma-emitting isotopes, collected May through October, 1991.

Location	Period	Lab Code	Gross Beta Activity (pCi/L)			Activity (pCi/L)			
			Suspended Solids	Dissolved Solids	Total Residue	H-3	Sr-89	Sr-90	Cs-137
T-130	(MAY)	TSWU-855	<0.4	2.4±0.6	2.4±0.6	<330	<0.5	<0.4	<10
	(JUN)	1310	0.5±0.2	2.5±0.5	3.0±0.5	<330	<0.7	<0.5	<10
	(JUL)	1884	<0.2	2.4±0.4	2.4±0.4	<330	<0.9	<0.4	<10
	(AUG)	2198	<0.2	2.0±0.6	2.0±0.6	884±113[a]	<0.7	<0.5	<10
	(SEP)	2669	0.4±0.2	2.1±0.5	2.5±0.5	<330	<1.1	<0.6	<10
	(OCT)	3138	<0.8	2.5±0.3	2.5±0.3	<330	<1.4	<0.6	<10
T-131	(MAY)	TSWU-856	<0.4	1.6±0.9	1.6±0.9	<330	<0.9	1.2±0.5	<10
	(JUN)	1311	<0.4	2.5±0.3	2.5±0.3	<330	<1.2	<0.7	<10
	(JUL)	1885	<0.4	2.2±0.5	2.2±0.5	<330	<1.1	<0.5	<10
	(AUG)	2199	<0.2	2.3±0.3	2.3±0.3	<330	<1.0	<0.5	<10
	(SEP)	2670	<0.4	2.6±0.6	2.6±0.6	<330	<1.6	<0.8	<10
	(OCT)	3139	<0.3	2.7±0.5	2.7±0.5	<330	<1.6	<0.6	<10
T-132	(MAY)	TSWU-857	<0.4	2.5±0.6	2.5±0.6	<330	<0.7	<0.4	<10
	(JUN)	1312	<0.2	2.1±0.5	2.1±0.5	<330	<0.6	<0.4	<10
	(JUL)	1886	<0.3	1.7±0.4	1.7±0.4	<330	<0.9	0.6±0.3	<10
	(AUG)	2200	<0.2	2.6±0.6	2.6±0.6	<330	<0.7	<0.4	<10
	(SEP)	2671	<0.4	1.7±0.5	1.7±0.5	<330	<0.9	0.9±0.3	<10
	(OCT)	3140	<0.4	2.2±0.5	2.2±0.5	<330	<1.3	0.6±0.3	<10
T-133	(MAY)	TSWU-858	<0.3	2.0±1.0	2.0±1.0	<330	<0.8	0.6±0.4	<10
	(JUN)	1313,4	<0.7	2.4±0.2	2.4±0.2	<330	<1.0	<0.6	<10
	(JUL)	1887	<0.2	2.0±0.5	2.0±0.5	<330	<1.0	0.7±0.3	<10
	(AUG)	2201	<0.2	2.2±0.3	2.2±0.3	<330	<1.0	<0.7	<10
	(SEP)	2672	<0.3	2.0±0.5	2.0±0.5	<330	<1.1	0.8±0.4	<10
	(OCT)	3141	0.7±0.2	2.4±0.3	3.1±0.4	<330	<1.2	0.6±0.4	<10

[a] Analysis was repeated; result of reanalysis 886±112 pCi/L.

Table 30. Untreated surface lake water samples, monthly composites of weekly grab samples, analysis for gross beta, tritium, strontium-89, strontium-90 and gamma-emitting isotopes, collected May through October, 1991 (continued)

Location	Period	Lab Code	Gross Beta Activity (pCi/L)			Activity (pCi/L)			
			Suspended Solids	Dissolved Solids	Total Residue	H-3	Sr-89	Sr-90	Cs-137
T-134	(MAY)	TSWU-859	<0.4	2.5±0.8	2.5±0.8	<330	<0.8	0.8±0.4	<10
	(JUN)	1315	<0.2	2.3±0.5	2.3±0.5	<330	<0.6	<0.4	<10
	(JUL)	1888	<0.2	2.2±0.4	2.2±0.4	<330	<1.0	0.6±0.3	<10
	(AUG)	2202	<0.2	1.5±0.5	1.5±0.5	<330	<0.8	<0.5	<10
	(SEP)	2673	<0.4	2.6±0.6	2.6±0.6	<330	<1.1	0.6±0.3	<10
	(OCT)	3142	0.6±0.2	2.9±0.5	3.5±0.5	<330	<1.5	<0.6	<10
T-135	(MAY)	TSWU-860	<0.4	2.3±1.0	2.3±1.0	<330	<0.7	0.6±0.3	<10
	(JUN)	1316	<0.2	2.0±0.5	2.0±0.5	<330	<0.5	<0.4	<10
	(JUL)	1889,90	<0.7	2.3±0.2	2.3±0.2	<330	<0.8	0.6±0.2	<10
	(AUG)	2203	<0.2	2.2±0.3	2.2±0.3	<330	<1.0	<0.6	<10
	(SEP)	2674	<0.4	2.2±0.5	2.2±0.5	<330	<1.4	<0.5	<10
	(OCT)	3143	<0.7	2.6±0.5	2.6±0.5	<330	<1.6	<0.7	<10
T-137 (C)	(MAY)	TSWU-861	<0.2	2.6±0.7	2.6±0.7	<330	<0.9	0.6±0.3	<10
	(JUN)	1317	<0.2	2.2±0.5	2.2±0.5	<330	<0.5	0.5±0.3	<10
	(JUL)	1891	<0.2	2.5±0.4	2.5±0.4	<330	<0.9	0.8±0.3	<10
	(AUG)	2204	<0.2	1.8±0.5	1.8±0.5	<330	<0.8	0.6±0.4	<10
	(SEP)	2675	0.4±0.2	2.6±0.5	3.0±0.5	<330	<1.2	0.6±0.4	<10
	(OCT)	3144	<0.7	2.3±0.5	2.3±0.5	<330	<2.3	<0.6	<10
T-138 (C)	(MAY)	TSWU-862	<0.5	1.7±0.7	1.7±0.7	<330	<0.6	1.0±0.4	<10
	(JUN)	1318	<0.2	1.8±0.5	1.8±0.5	<330	<1.3	1.2±0.6	<10
	(JUL)	1892	<0.3	2.1±0.5	2.1±0.5	<330	<0.8	0.7±0.3	<10
	(AUG)	2205	<0.2	2.0±0.5	2.0±0.5	<330	<0.8	0.8±0.4	<10
	(SEP)	2676,7	<0.4	2.4±0.3	2.4±0.3	<330	<1.1	0.6±0.3	<10
	(OCT)	3145	<0.7	2.0±0.5	2.0±0.5	<330	<1.3	1.0±0.4	<10

Table 30. Untreated surface lake water samples, monthly composites of weekly grab samples, analysis for gross beta, tritium, strontium-89, strontium-90 and gamma-emitting isotopes, collected May through October, 1991 (continued)

Location	Period	Lab Code	Gross Beta Activity (pCi/L)			Activity (pCi/L)			
			Suspended Solids	Dissolved Solids	Total Residue	H-3	Sr-89	Sr-90	Cs-137
T-152	(MAY)	TSWU-863	<0.5	3.3±0.7	3.3±0.7	<330	<0.8	<0.4	<10
	(JUN)	1319	0.3±0.1	3.5±0.5	3.8±0.5	<330	<1.0	<0.6	<10
	(JUL)	1893	<0.2	3.3±0.4	3.3±0.4	<330	<1.0	<0.5	<10
	(AUG)	2206	<0.2	2.3±0.6	2.3±0.6	<330	<0.8	0.6±0.3	<10
	(SEP)	2678	<0.3	2.5±0.7	2.5±0.7	<330	<1.2	<0.6	<10
	(OCT)	3146,7	<0.4	3.4±0.4	3.4±0.4	<330	<1.2	6.7±0.4	<10
T-158 (C)	(MAY)	TSWU-864,5	<0.3	2.1±0.7	2.1±0.7	<330	<0.9	<0.9	<10
	(JUN)	1320	<0.3	2.3±0.3	2.3±0.3	<330	<1.4	<0.8	<10
	(JUL)	1894	<0.4	2.6±0.5	2.6±0.5	<330	<0.9	<0.4	<10
	(AUG)	2207	<0.2	2.4±0.6	2.4±0.6	<330	<0.7	<0.5	<10
	(SEP)	2679	<0.3	2.1±0.5	2.1±0.5	<330	<1.3	<0.6	<10
	(OCT)	3148	<0.8	2.7±0.5	2.7±0.5	<330	<1.4	1.4±0.5	<10
T-162 (C)	(MAY)	TSWU-866	<0.4	2.4±1.0	2.4±1.0	<330	<0.9	<0.6	<10
	(JUN)	1321	<0.4	2.1±0.3	2.1±0.3	<330	<1.0	<0.6	<10
	(JUL)	1895	<0.2	2.2±0.4	2.2±0.4	<330	<0.8	<0.4	<10
	(AUG)	2208,9	<0.4	2.2±0.4	2.2±0.4	<330	<0.7	1.0±0.3	<10
	(SEP)	2680	<0.4	2.1±0.5	2.1±0.5	<330	<1.3	<0.7	<10
	(OCT)	3149	<0.7	2.0±0.5	2.0±0.5	<330	<1.4	<0.6	<10
T-164 (C)	(MAY)	TSWU-867	<0.3	1.6±0.9	1.6±0.9	<330	<0.8	0.7±0.4	<10
	(JUN)	1322	<0.4	2.6±0.5	2.6±0.5	<330	<1.5	<0.9	<10
	(JUL)	1896	<0.4	2.0±0.3	2.0±0.3	<330	<1.9	<0.9	<10
	(AUG)	2210	<0.3	1.8±0.5	1.8±0.5	<330	<0.9	<0.5	<10
	(SEP)	2681	<0.4	2.2±0.5	2.2±0.5	<330	<1.2	<0.5	<10
	(OCT)	3150	<0.7	2.2±0.7	2.2±0.7	333±91	<1.2	<0.5	<10

Table 30. Untreated surface lake water samples, monthly composites of weekly grab samples, analysis for gross beta, tritium, strontium-89, strontium-90 and gamma-emitting isotopes, collected May through October, 1991 (continued)

Location	Period	Lab Code	Gross Beta Activity (pCi/L)			Activity (pCi/L)			
			Suspended Solids	Dissolved Solids	Total Residue	H-3	Sr-89	Sr-90	Cs-137
T-167 (C)	(MAY)	TSWU-868	<0.4	2.5±0.7	2.5±0.7	<330	<0.8	<0.5	<10
	(JUN)	1323	<0.3	2.5±0.5	2.5±0.5	<330	<0.9	0.7±0.4	<10
	(JUL)	1897	<0.3	2.0±0.8	2.0±0.8	<330	<0.9	0.7±0.3	<10
	(AUG)	2211	<0.3	2.1±0.5	2.1±0.5	<330	<1.7	0.7±0.4	<10
	(SEP)	2682	<0.3	2.4±0.5	2.4±0.5	<330	<1.2	0.6±0.4	<10
	(OCT)	3151	<0.8	2.2±0.5	2.2±0.5	<330	<1.1	0.8±0.4	<10
T-168 (C)	(MAY)	TSWU-869	<0.5	1.7±0.6	1.7±0.6	<330	<1.2	<0.8	<10
	(JUN)	1324,5	<0.7	2.2±0.2	2.2±0.2	<330	<0.7	<0.5	<10
	(JUL)	1898	<0.4	2.3±0.3	2.3±0.3	<330	<0.9	0.6±0.3	<10
	(AUG)	2212	<0.2	1.7±0.5	1.7±0.5	<330	<0.9	1.0±0.4	<10
	(SEP)	2683	<0.4	2.3±0.5	2.3±0.5	<330	<1.2	<0.6	<10
	(OCT)	3152	<0.7	2.0±0.4	2.0±0.4	<330	<1.2	<0.6	<10

NOTE: Pages 72 through 74 are intentionally left out.

Table 31. Fish samples, analyses for gross beta and gamma-emitting isotopes.
Collection: Semiannually.

Sample Description and Activity (pCi/g wet)						
	Indicator			Control		
Location	T-33 (Lake Erie 1.5 mi NE of Station)			T-35		
Collection Date	05-23-91	05-23-91	05-23-91	05-23-91	05-23-91	05-23-91
Lab Code	TF-1462	TF-1463,4	TF-1465	TF-1466	TF-1467	TF-1468,9
Sample Type	Walleye	White Bass	Carp	Walleye	White Bass	Carp
Gross Beta	2.20±0.07	2.43±0.06	2.66±0.08	3.31±0.10	2.27±0.08	2.69±0.05
K-40	1.90±0.37	2.18±0.22	3.17±0.41	1.93±0.64	1.87±0.34	2.56±0.26
Cs-137	<0.023	0.026±0.018	<0.013	<0.035	<0.020	<0.019[a]

Location	T-33 (Lake Erie 1.5 mi NE of Station)	T-35
Collection Date		
Lab Code		
Sample Type		
Gross Beta		
K-40		
Cs-137		

[a] Corrected result.

Table 32. Shoreline sediment samples, analyses for gamma-emitting isotopes. Collection: Semiannually.

Sample Description and Activity (pCi/g dry)				
Location	T-3	T-4	T-4	T-27 (C)
Date	05-02-91	05-02-91	05-29-91	05-02-91
Lab Code	TBS-938	TBS-939	TBS-961	TBS-941
K-40	14.54±0.89	16.77±1.02	17.80±0.98	11.78±0.079
Mn-54	<0.038	<0.047	<0.061	<0.028
Co-58	<0.035	<0.035	<0.075	<0.032
Co-60	<0.052	<0.056	<0.079	<0.039
Cs-134	<0.031	<0.035	<0.080	<0.026
Cs-137	0.11±0.038	<0.045	<0.062	<0.037

Location	T-132	T-138(C)	T-164(C)
Date	05-29-91	05-29-91	05-29-91
Lab Code	TBS-962	TBS-963	TBS-964
K-40	10.50±0.58	17.82±1.14	9.92±0.54
Mn-54	<0.035	<0.050	<0.036
Co-58	<0.036	<0.053	<0.039
Co-60	<0.043	<0.061	<0.045
Cs-134	<0.034	<0.039	<0.042
Cs-137	<0.030	0.57±0.063	<0.035

Location
Date
Lab Code
K-40
Mn-54
Co-58
Co-60
Cs-134
Cs-137

Table 32. Shoreline sediment samples (continued)

Sample Description and Activity (pCi/g dry)					
Location	T-3	T-4	T-4	T-23	T-27 (C)
Date	10-31-91	10-03-91	10-31-91	10-11-91	10-31-91
Lab Code	TBS-1054	TBS-1014	TBS-1055	TBS-1022	TBS-1057
K-40	10.73±0.37	13.75±0.70	11.80±0.66	11.30±0.51	9.70±0.53
Mn-54	<0.014	<0.034	<0.038	<0.025	<0.028
Co-58	<0.016	<0.042	<0.046	<0.025	<0.035
Co-60	<0.017	<0.039	<0.048	<0.030	<0.037
Cs-134	<0.012	<0.024	<0.047	<0.030	<0.034
Cs-137	<0.016	0.12±0.028	<0.035	0.20±0.020	<0.026

Location	T-132	T-138(C)	T-164(C)
Date	10-03-91	10-03-91	09-27-91
Lab Code	TBS-1018	TBS-1015	TBS-1002
K-40	9.57±0.50	13.10±0.94	10.10±0.45
Mn-54	<0.027	<0.046	<0.013
Co-58	<0.039	<0.050	<0.016
Co-60	<0.034	<0.055	<0.017
Cs-134	<0.029	<0.057	<0.020
Cs-137	<0.022	0.47±0.049	<0.013

Location	
Date	
Lab Code	
K-40	
Mn-54	
Co-58	
Co-60	
Cs-134	
Cs-137	

Table 33. Egg samples, analysis for gamma-emitting isotopes.
Collection: Annually.

	Sample Description and Activity (pCi/g wet)	
Location	T-34	T-197
Date	09-13-91	07-29-91
Lab Code	TE-60	TE-59
K-40	1.33±0.411	1.01±0.17
Nb-95	<0.035	<0.014
Zr-95	<0.047	<0.020
Ru-103	<0.023	<0.012
Ru-106	<0.16	<0.091
Cs-137	<0.018	<0.011
Ce-141	<0.039	<0.016
Ce-144	<0.11	<0.055