ANNUAL ENVIRONMENTAL OPERATING REPORT

JANUARY 1, 1990 - DECEMBER 31, 1990

Radiological Environmental

DAVIS-BESSE NUCLEAR POWER STATION

CENTERIOR ENERGY

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for

DAVIS - BESSE NUCLEAR POWER STATION

January 1, 1990 to December 31, 1990

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

April 1991

Table of Contents

Table of Contents (continued)

Table of Contents (continued)

Table of Contents (continued)

Table of Contents (continued)

Table of Contents (continued)

Table of Contents (continued)

List of Tables

List of Tables (continued)

List of Figures

List of Figures (continued)

List of Figures (continued)

Summary

The Annual Environmental Operating Report is a detailed report on the Environmental Monitoring Programs conducted at the Davis-Besse Nuclear Power Station from January 1 through December 31, 1990. 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. However, the releases must comply with stringent regulations imposed by the Nuclear Regulatory Commission (NRC). Radiological Environmental Monitoring Program (REMP) has been established to monitor the radiological conditions in 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 and radioactivity are monitored around Davis-Besse within a 25 mile radius. The environment around Davis-Besse has been monitored for radiation and radioactivity for approximately 19 years. REMP was established at Davis-Besse about five years before the Station 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 5 miles of the site, and are expected to show any increases or buildup of radioactivity that might occur due to the operation of Davis-Besse. Control locations are farther away from the Station, and are

expected to indicate the presence of only naturally occurring radioactivity. The results obtained from the samples collected from indicator locations are compared with the results from those collected from 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 1990, over 2700 radiological environmental samples were collected, and over 3200 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.

- Samples of air and snow are collected to monitor the atmosphere. The 1990 results are similar to those observed in preoperational and previous operational programs. Only background radioactivity normally present in the environment was detected, and only at normal concentrations.
- Terrestrial monitoring 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 0.39 picocuries per gram dry weight (pCi/g) in 1990, 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 includes the collection and analysis of drinking water, untreated surface water, fish, and shoreline sediments. The 1990 results of these analyses indicate normal background concentrations of radionuclides, and show no increase or buildup in radioactivity due to the operation of Davis-Besse.
- Direct radiation measurements averaged 15.6 mrem/91 days at indicator locations and 16.6 mrem/91 days at control locations, showing that, in 1990, radiation in the area of Davis-Besse was similiar to radiation at locations greater than 5 miles away from the Station.

The 1990 operation of Davis-Besse caused no measurable 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 1990 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. 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. In 1990, the critical pathway changed from the child/vegetation pathway at 980 meters in the west sector to an infant/milk pathway at 4270 meters in the west-southwest sector. The garden at 980 meters in the west was present in 1989, but was not present during the 1990 Land Use Census.

Meteorological Monitoring

The Meteorological Monitoring Program at Davis-Besse is part of a program for evaluating the effects of the routine operation of Davis-Besse 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 (outside air) temperature, differential temperature (air temperature at one height minus air temperature at another height), dew point temperature (air temperature where moisture begins to condense out of air or 100% relative humidity) and precipitation.

Two instrument equipped meteorological towers are used to collect data. Data recovery for 1990 was 90% or greater for all measured parameters. In 1990, 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 manages it as part of the Ottawa National Wildlife Refuge. At Davis-Besse, Environmental Compliance personnel are responsible for inspecting the marsh and reporting on its status monthly.

Special projects conducted in 1990 included song bird, duck, and Canada goose banding, as well as studies of yellow warblers, Canada geese and wood ducks. In 1990, over 8011 individual birds were banded. In addition, unwanted and disruptive plant species, such as purple loosestrife (*Lythrum salicaria*) and the giant reed (*Phragmites australis*), 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 location at the station provides 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 for use here and thoughout the range of the mussel.

Water Treatment

Davis-Besse uses Lake Erie as a source of water for the Water Treatment Plant. The water is treated at the site to provide drinking water for site personnel and to produce high purity water for use in the Station's cooling systems. Notable activities in 1990 included the replacement of domestic flow measurement devices.

Wastewater generated by site personnel is treated onsite 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 to Lake Erie. For 1990, Waste Water Treatment Plant Number 1 was out of service due to damage to an interior tank. The installation of supports have correct the problem and the plant should be back in operation early in 1991. Current plans are to remove Wastewater Treatment Plant Number 2 from service for cleaning and maintenance in 1991.

Chemical Waste Management

The Chemical Waste Management Program at Davis-Besse was developed to ensure that the offsite disposal of nonradioactive chemical, hazardous, and nonhazardous 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 disposing of its chemical wastes in order to protect human health and the environment.

In 1990, as a result of waste minimization efforts, 414 gallons of hazardous waste (used solvents), 19, 640 gallons of waste oil and 129 lead acid battery cells were sent to recycling firms and fuel blenders for thermal energy recovery. In 1990, Davis-Besse generated 26% less hazardous waste (by volume) than in 1989.

As required by SARA, Davis- Besse had ten hazardous products and chemicls on site in sufficient quantities to report to local and state agencies. Two of the chemical were extremely hazardous substances, hydrazine and sulfuric acid.

As part of the program to remove PCB fluid from Davis-Besse, ten PCB transformers were retrofilled the fifth (final) time in 1990. These will be sampled and analyzed in 1991 and possibly re-classified to non-PCB. One of these transformers , BF-4, was re[illegible]ed as non-PCB in 1990.

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 1990 Annual Environmental Operating Report for the Davis-Besse Nuclear Power Station.

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 Davis-Besse Nuclear Power Station to

analyze its REMP samples. The results are then checked by the EPA to ensure consistency with the known values. The results from both the contracted laboratory and the EPA are provided in Appendix B.

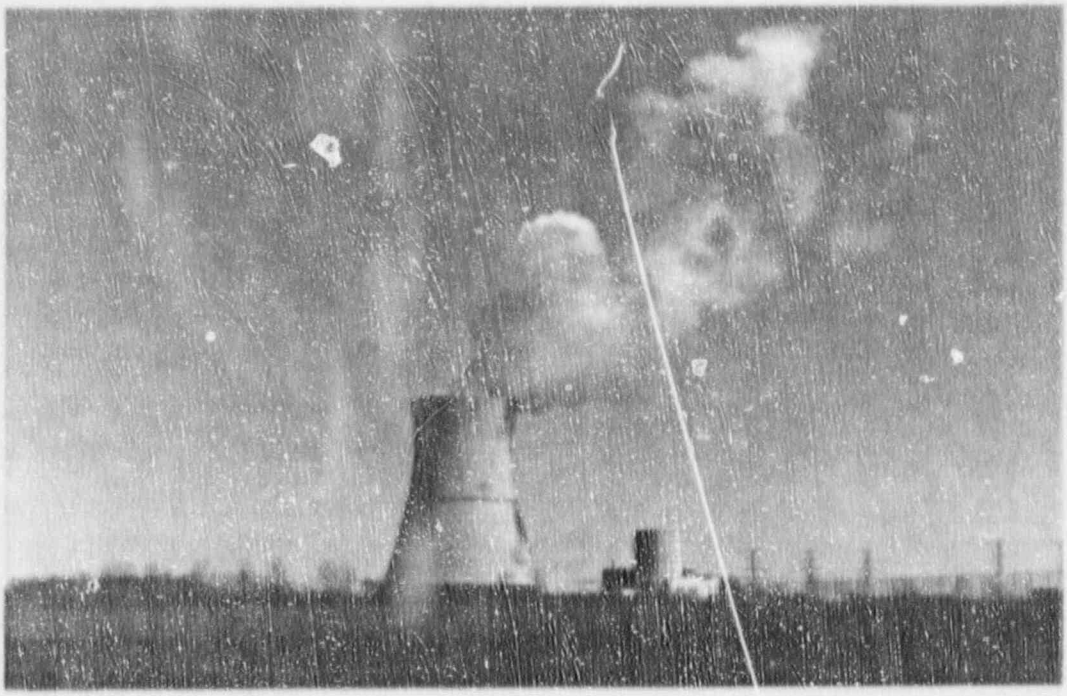
Appendix C contains data reporting conventions used in the REMP at Davis-Besse. The appendix provides an explanation of the format and computational methods used in reporting REMP data. Information on counting uncertainties, and computation of averages and standard deviations is also provided.

Appendix D lists the maximum permissible concentrations of alpha and beta emitting radioisotoes 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 1990.

Appendix E provides a REMP sampling summary for 1990. 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 Attachment 1. This attachment 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. 1991).



Introduction

Introduction

Coal, oil, natural gas, and hydropower have been used to run the 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 make up part of the Ottawa National Wildlife Refuge, the only national refuge in the State of 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 consists 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 of the 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 to hold the atom together.

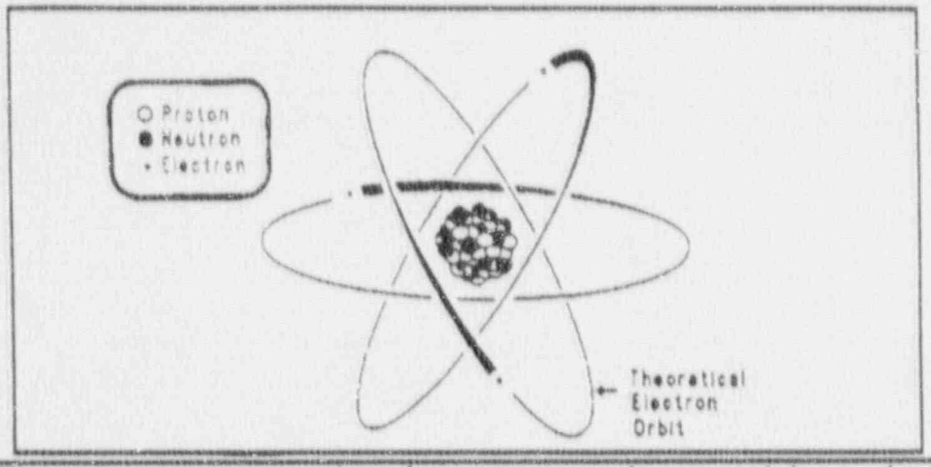


Figure 1-1: An atom consists of two parts: a nucleus containing positively charged protons and electrically neutral neutrons and one or more negatively charged electrons orbiting the nucleus. Protons and neutrons are nearly identical in size and weight, while each is about 2000 times heavier than an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

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

Isotopes

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

Radiation and Radioactivity

Radionuclides

The parts of an atom are normally in a balanced, or **stable** state. If the nucleus of an atom contains an excess of energy, it is called a radioisotope, **radioactive atom** or a **radionuclide**. The excess energy is usually due to an 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	^{235}U	92	143
Uranium-236	^{236}U	92	144
Uranium-237	^{237}U	92	145
Uranium-238	^{238}U	92	146
Uranium-239	^{239}U	92	147
Uranium-240	^{240}U	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 (gamma and X rays) and/or matter (alpha or beta particles, or neutrons) through radioactive decay may transform the atom into a chemically different element. For example, when an atom of uranium-238 decays, it emits an alpha particle and, as a result, 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 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 life, while those which are very active, emitting radiation more frequently, tend to have a comparatively short life. The length of time an atom remains radioactive is defined in terms of **half-lives** (Figure 1-2). Half-life is the amount of time required for a radioactive substance to lose half of 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 electrons as protons. Thus, the number of negative and positive charges cancel, and the atom is electrically neutral. When one or more electrons are removed, an **ion pair** is formed. For example, if an electron is removed from an oxygen atom, the electron (negatively charged) is one half of the ion pair and the rest of the atom (positively charged) is the other half of the ion pair. Ionization is one of the processes which may result in damage to biological systems.

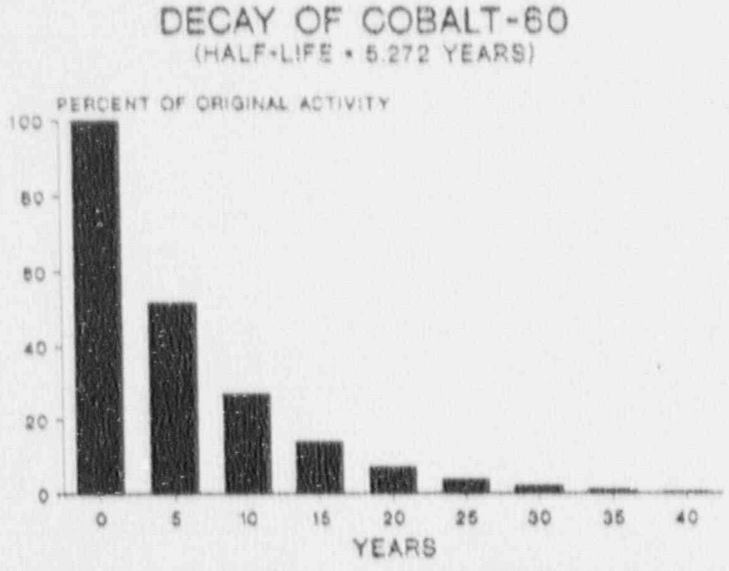


Figure 1-2: Cobalt-60 has a half-life of 5.272 years. After one half-life, about half of the cobalt-60 atoms originally present have decayed and become different elements; after an additional half-life, half of the remaining cobalt-60 atoms, or a total of about 75% of the atoms originally present, have decayed.

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 1-3).

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 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.

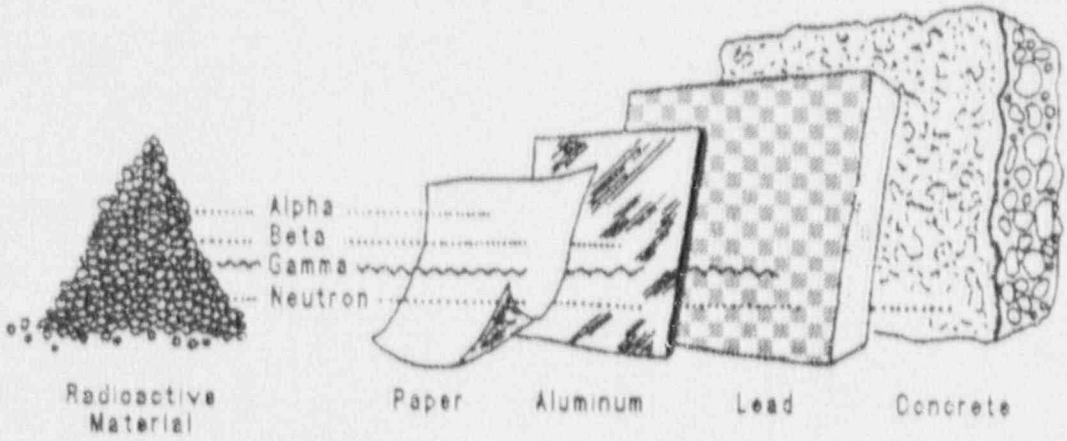


Figure 1-3: As radiation travels, it collides and interacts with other atoms and loses energy. Alpha particles can be stopped by a sheet of paper, and beta particles by a thin sheet of aluminum. Gamma radiation is shielded by highly dense materials such as lead, while hydrogenous materials (those containing hydrogen atoms), such as water and concrete, are used to absorb neutrons.

Gamma rays are pure energy that travel at the speed of light. They have no measurable charge or mass, and generally travel much further than alpha or beta particles before being absorbed. When the gamma ray finally loses all of its energy after repeated interactions, it is gone. The range of a gamma ray in air varies, depending on the ray's energy and its 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 a shielding material for gamma radiation because of its density. Several inches of lead or concrete may be needed to effectively shield gamma rays.

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 (plural of nucleus) 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 much of its energy. At this point, the neutron is mov-

ing 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 thus, 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 lead to slow down the fast neutrons, followed by a 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, lead and concrete are combined to form an effective neutron shield. Concrete is used because it contains water molecules and is can be easily molded around odd shapes. The resulting combination of the lead to slow neutrons and the concrete to further slow and absorb neutrons has proven to be an effective neutron shield at Davis-Besse.

Quantities and Units of Measurement

There are several quantities and units 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) every second. Each time a nucleus disintegrates, radiation is emitted. The **curie** (Ci) is the unit used to describe the

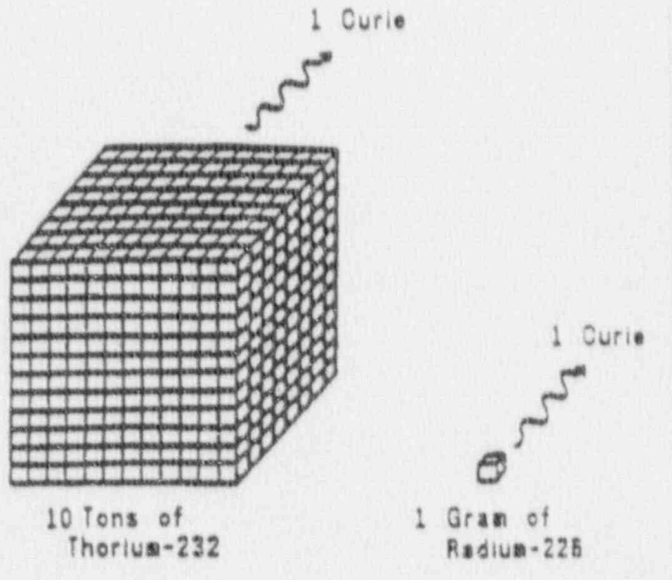


Figure 1-4: One gram of radium-226 and 10 tons of thorium-232 are both approximately equivalent to 1 curie.

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 (Figure 1-4 on previous page).

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 (rad = 100erg/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 radiations.

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 a estimate of the possible biological damage resulting from exposure to a particular type of ionizing radiation. The dose equivalent is measured in **rem (roentgen 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.

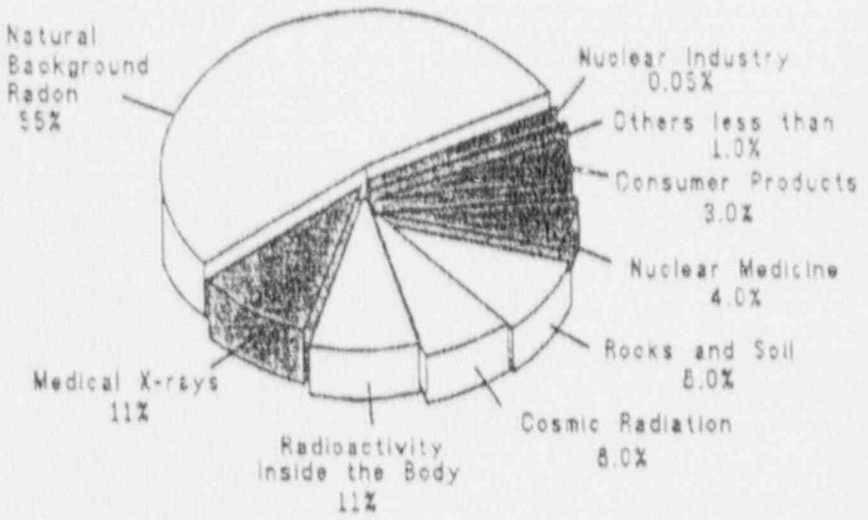
Sources of Radiation

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, radioactivity also exists naturally in the soil, water, air and space. All these common sources of radiation contribute to the natural background radia-

Sources of Exposure to the Public



Note: Shaded portion indicates manmade radiation.

Source: National Council on Radiation Protection and Measurements, NCRP Report No.93.

Figure 1-5: 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.

tion to which everyone is exposed (Figure 1-5).

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 cos-

mic 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.

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 compare the percentage of radioactive carbon to stable carbon present in a fossil or artifact to 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 concrete slabs, cracked slabs,

and those with 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:

- uranium content of the soil
- weather conditions
- construction methods
- presence (or absence) of any cracks or openings in the foundation.

Some weather conditions, such as low pressure systems or increased rainfall, 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, buildings 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, and 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 adsorb 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 detected. 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, and 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:

Radiological Health Program
Ohio Department of Health
1224 Kinnear Road, Suite 120
Columbus, Ohio 43212
(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 1-5, 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 1990 were only 0.22 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 irradiated 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 low level radiation exposure. The effects predicted in this manner have not been actually observed in individuals exposed to low level radiation. However, this assumption provides a highly conservative model of radiation-induced health effects, and most probably overestimates the risks associated with receiving low doses of radiation.

Health Risks

Since the actual effects of exposure to low level 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 wear seatbelts or 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 re-

duced, however, even a parked car is not risk-free. You could choose not to drive, but even pedestrians and bicyclists 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 an essentially 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 the 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 no other 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 associated with ionizing radiation, they do not generate the same degree of concern. 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.

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 the Davis-Besse Nuclear Power Station is significantly less than one millirem (0.0011 millirem in 1990). 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 decision that the 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.

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.

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 1-6). By the end of 1989, however, this number had grown to nineteen percent. At the same time, dependence on oil as an energy source decreased by almost half. By decreasing the nation's 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 its private and business sectors.

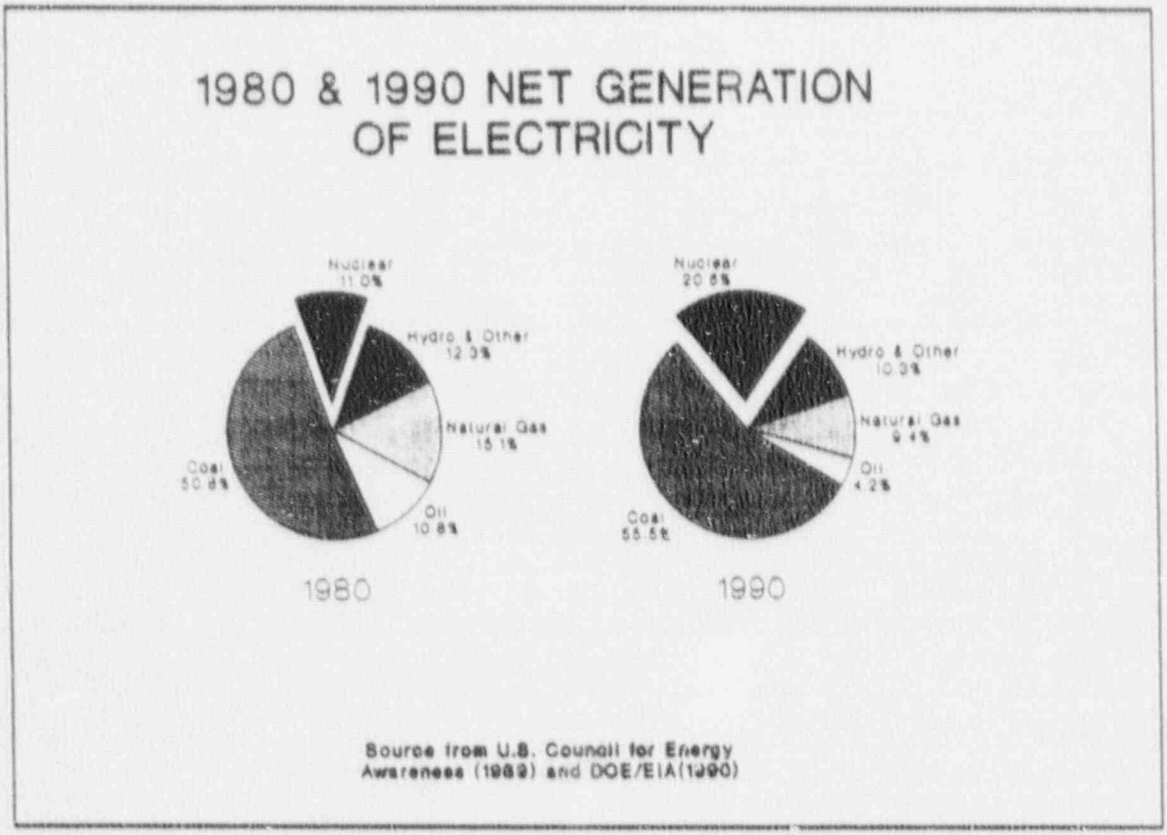


Figure 1-6: During the past decade, the nation's dependence on nuclear power has increased dramatically. This has led to decreased dependence on foreign oil supplies, thus enabling the U.S. to become more self-sufficient in meeting its electricity needs.

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

- nuclear power stations have 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, and
- 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 electrical generation, and on how Davis-Besse uses nuclear fuel and the fission process to produce electricity.

Where Does Electricity Come From?

The flow of electrons through a wire is called an **electric current**, or electricity. **Voltage** is the force that pushes the current along the wire, just as pressure pushes water through pipes. Extra electrons are needed to start and maintain an electric current. One way to add these extra electrons is by using a battery; however, batteries are not an efficient source for large amounts of electricity. Another method of generating electricity is by rotating a magnet inside a coil of wire. Large amounts of high voltage electricity can be produced in this manner. The two ends of a magnet are called **poles**. The power of a magnet extends beyond these poles in invisible **lines of force**. If a loop of wire passes through a magnet's line of force, electrons start racing through the wire.

Figure 1-7 provides a simplified illustration of the basic steps involved in producing an electrical current. Fuel, such as coal, is burned in a **furnace** and heats water in the **boiler** to produce steam. The steam drives the turbine-generator. An electric **generator** is basically a magnet and coils of wire. It has an engine that is called a **turbine**. The turbine converts the **heat energy** of the steam into **mechanical energy**. When steam is forced against the blades of the turbine, the turbine rotates, turning a long shaft. At the end of the shaft is a huge magnet inside the generator. The generator converts mechanical energy into **electrical energy**. As the shaft turns, the magnet spins inside a ring wrapped with a long coil of wire. This starts a current flowing in each section of wire that it passes.

Before the electric current leaves the power station, a **transformer** steps up the voltage so that it can travel long distances to consumers. **Transmission lines**

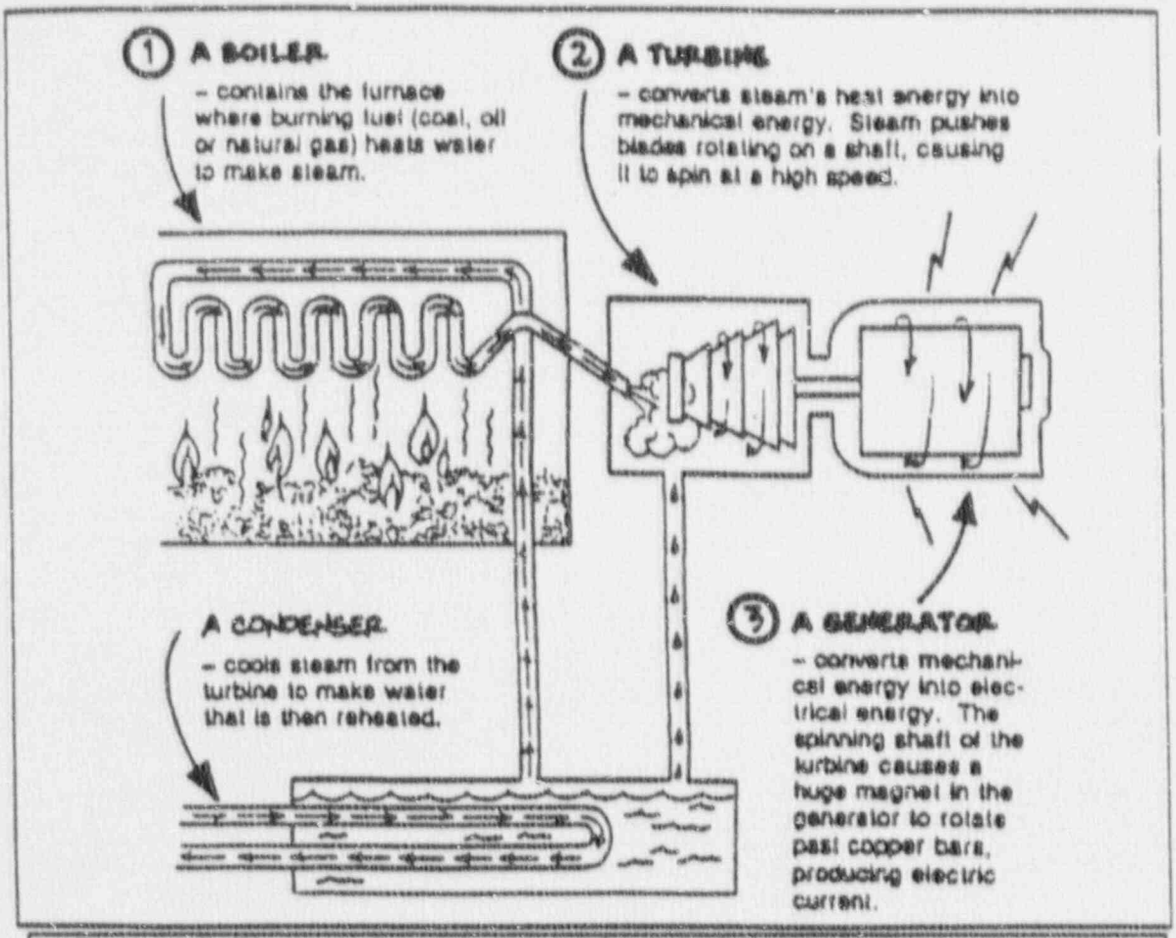


Figure 1-7: Electricity is produced in a fossil-fueled power station much in the way it is produced at Davis-Besse. Steam is forced against the blades of a turbine which turns a magnet inside the generator, and produces an electric current.

carry the current from the power station to other transmission lines many miles away or to local **substations** equipped with transformers that lower the voltage of the current. **Distribution lines** then carry the lower voltage current to **pole transformers** where the voltage is again stepped down for safe use by electrical consumers.

The Use of Steam To Produce Electricity

There are several sources of steam used by power stations to generate electricity, including the burning of fossil fuels such as coal, oil, or natural gas; the earth's natural steam, called geothermal energy; and steam produced inside a nuclear reactor from the heat released when atoms of uranium are split or **fissioned**. Besides steam, water power (hydropower) and wind power can be used to turn turbines to produce electricity.

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. 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 it is weak enough, the nucleus can be split if it is bombarded by a free neutron (Figure 1-8). 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.

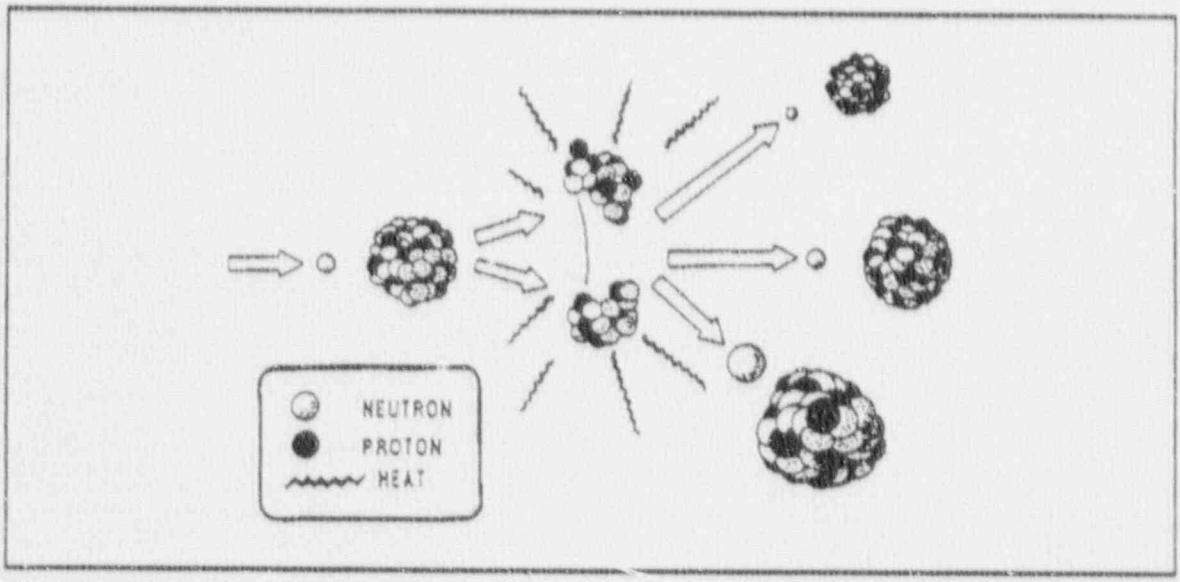


Figure 1-8: When a heavy atom, such as uranium-235 is split, or fissioned, heat, free neutrons, and fission fragments result. The free neutrons can then strike neighboring atoms causing them to fission also. In the proper environment, this process can continue indefinitely in a chain reaction.

Nuclear Fuel

The fissioning of one uranium atom releases approximately 50 million times more energy than 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 minimizes 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 when it is mined. Before it can be economically used in a nuclear reactor, it is **enriched** to approximately three percent U-235 relative 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. Nor could the fuel, as it exists at a power station, be used to make 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** (UF_6), 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 UF_6 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 1-9). Approximately five pounds of these pellets 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 to heat, radiation and corrosion. When the tubes are filled with fuel pellets, they are called **fuel rods**.

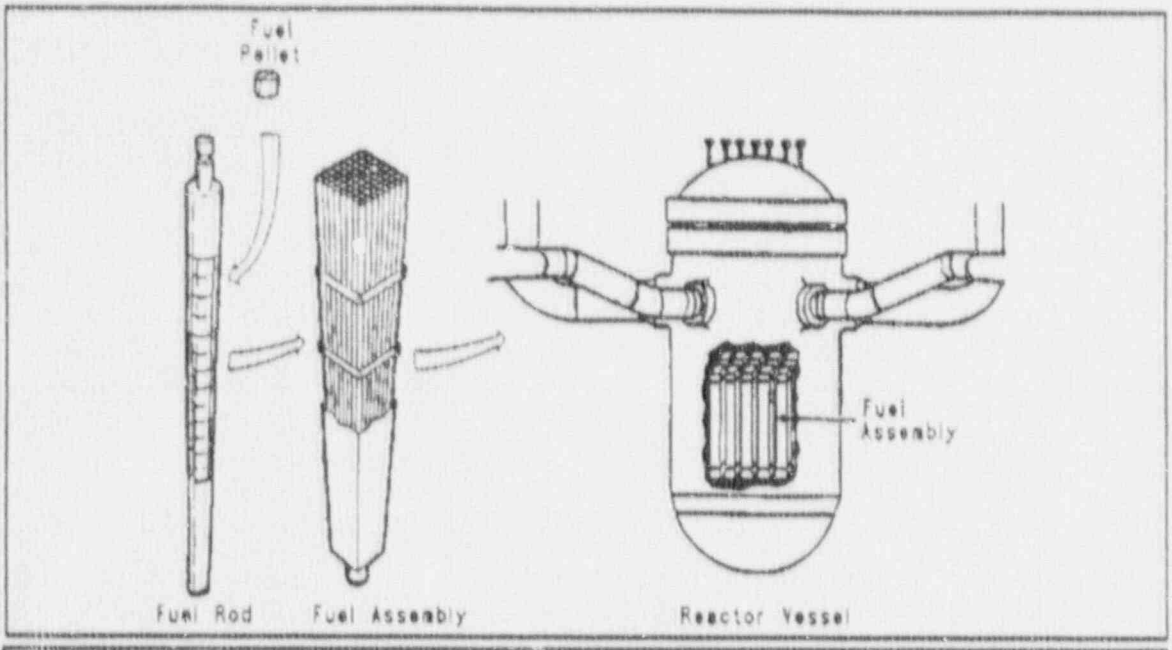


Figure 1-9: The reactor core at Davis-Besse contains 177 fuel assemblies. Each assembly contains 208 fuel rods. Each fuel rod is filled with approximately five pounds of fuel pellets, each pellet approximately 3/8 inch in diameter and 5/8 inch long.

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 core weighs approximately 207,486 pounds, while the reactor vessel itself weighs 838,000 pounds, has a diameter of 14 feet, is 39 feet high, and has 8 1/2 inch thick steel walls.

Fission Control

The fission rate inside the reactor core is controlled by raising or lowering **control rod assemblies** into the reactor core. Each assembly consists of 16 "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 cool-

ant 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 nonradioactive lithium-7 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 reactors are called **heavy water reactors**, or **HWRs**.

In BWRs, made by the General Electric Company, water boils to steam directly in the reactor vessel. In PWRs, made by the Babcock & Wilcox Company, Combustion Engineering, Inc., and the Westinghouse Electric Corporation, the reactor water or coolant is pressurized to prevent it from boiling. Instead, the hot water is pumped to a **steam generator**, where its heat is transferred to a separate supply of water. The water inside the steam generator boils into steam. 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.

Station Systems

The following paragraphs describe the various systems illustrated in Figure 1-10 on page 1-25. 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)

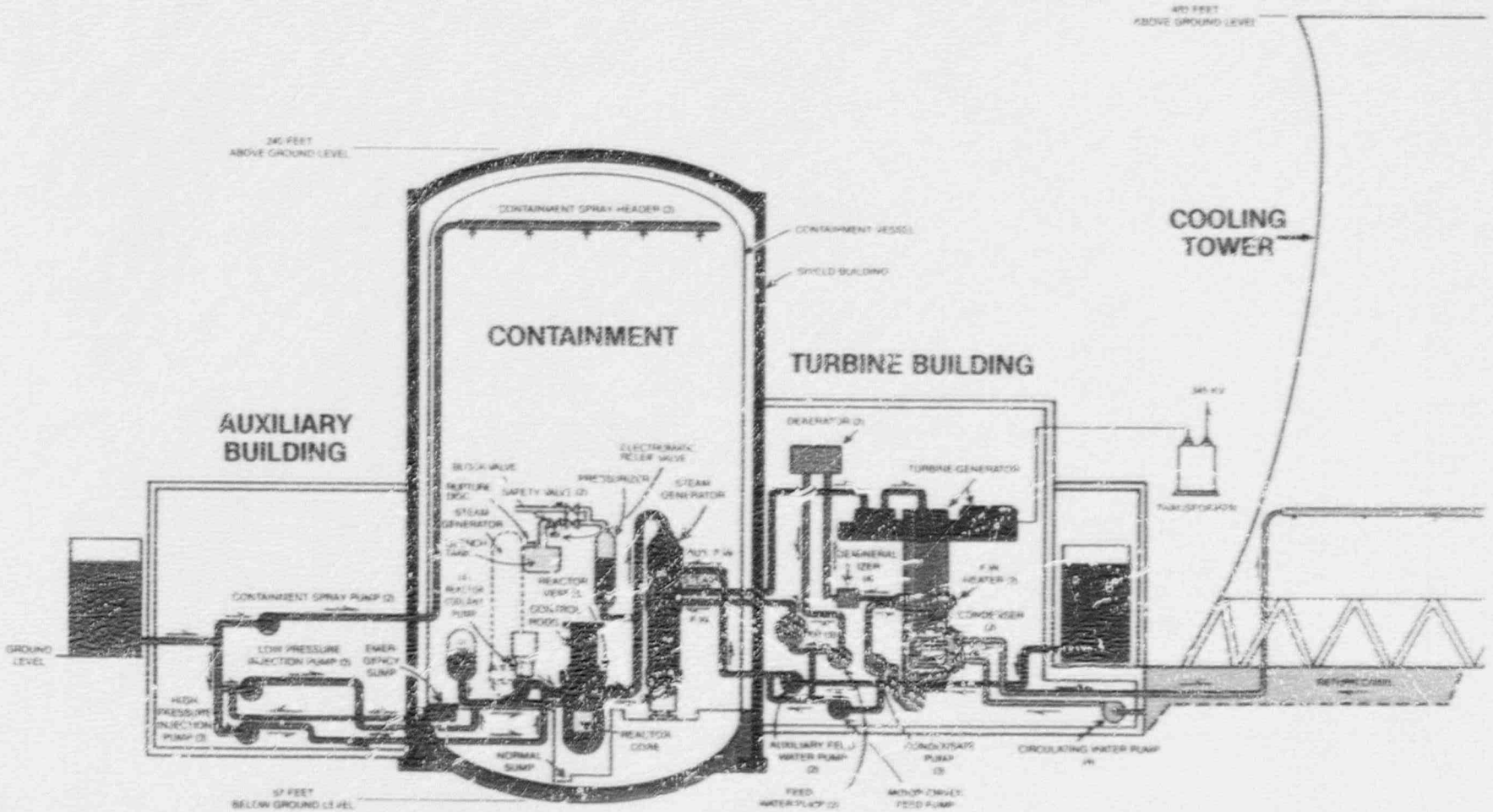
GOLD - Emergency Core Cooling System

SCARLET - Auxiliary 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** (refer to

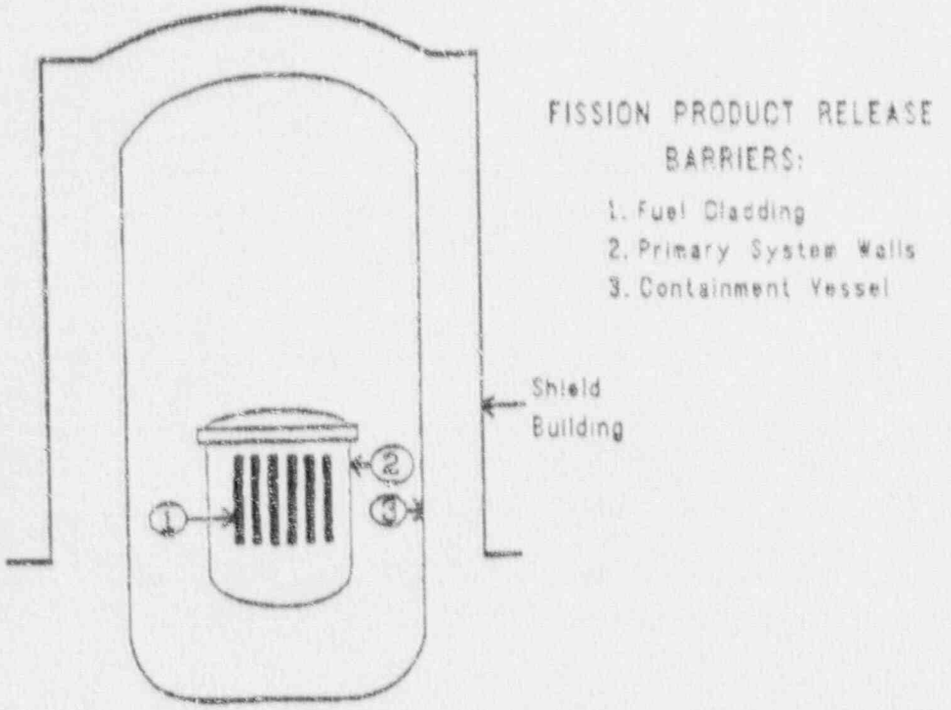


Figure 1-11: There are three isolation barriers that would prevent the release of fission products to the environment in the event of an accident at Davis-Besse. In addition to these barriers, a negative pressure boundary maintained between the containment vessel and concrete shield building is designed to contain airborne radioactive contaminants.

Figure 1-11) 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 606^0F, 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 558^0F to be circulated back into the reactor where it is again heated to 606^0F 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 400^0F 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) from the **cooling tower** passes 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 with 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 power facility, to 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 often 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 water to the

tower are 9 feet in diameter. They circulate 480,000 gallons of water per minute; 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 circ water has warmed to approximately 100^0F. In order to cool the water back down to around 70^0F, the circ 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 circ water is discharged back to Lake Erie at essentially the same temperature it was withdrawn earlier. In 1990, the average difference between the intake and discharge water temperatures was only 3.8° F. The slightly warmer discharge water had no adverse environmental impact on the area of the 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 additon, 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 **Auxiliary 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 **Auxiliary Feedwater System**, a key safety system in the 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 (such as the Auxiliary Feedwater System) 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. The Davis-Besse Station, 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 preceding pages should provide basics on electrical generation, and more specifically, how the Davis-Besse Nuclear Power Station 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 1-12).

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 settlment and farming. During the nineteenth century, the land was cleared and drained, and has been farmed

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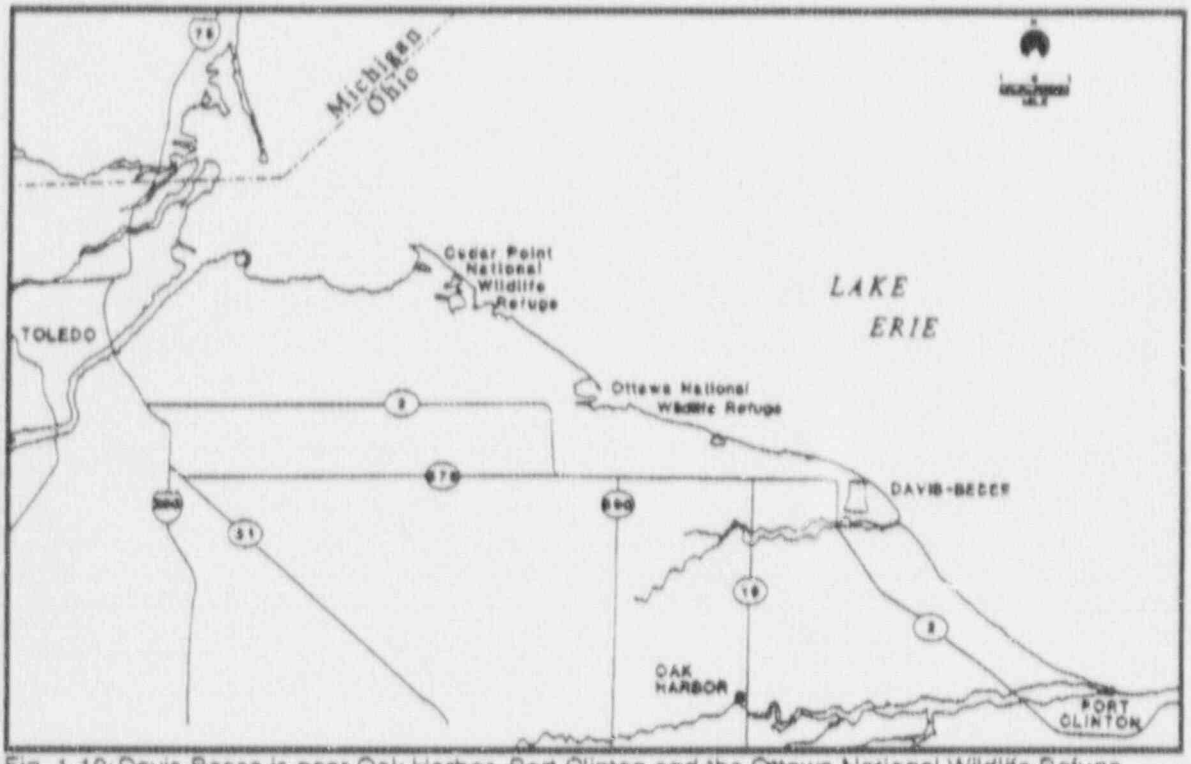

Fig. 1-10: Davis-Besse is near Oak Harbor, Port Clinton and the Ottawa National Wildlife Refuge.

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.

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 the 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 from 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, Sandusky, and the Bass Islands.

The immediate area near Davis-Besse is sparsely populated; Ottawa County had a population of only 40,076 in the 1980 census. The nearest incorporated communities are:

- Port Clinton - 10 miles southeast, population 7,223
- Oak Harbor - 7 miles south, population 2,678
- Rocky Ridge - 7 miles west southwest, population 457
- Toledo (the nearest major city) - 25 miles west, population 354,650.

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 1990 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 objectives in the control of radiation exposure are to ensure that any necessary exposures are kept **as low as is reasonably achievable (ALARA)**. The ALARA principles in a practical sense, means redcing and maintaining exposure to radiation and radioactive materials both to the individual working at Davis-Besse and the general public. This is based on sound economic decisions and operating practices. By practicing ALARA, Davis-Besse and Centerior Energy minimizes the health risk and environmental detriment and ensures 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 place restrictions on 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	
	less than or equal to 3 mrem/year to the whole body less than or equal to 10 mrem/year to any organ
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/year to any organ

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 of 40CFR190, the EPA established environmental radiation protection standards for nuclear power operations. The 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
- 25 mrem/year to any other organ.

Sources

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. Many of these particles are removed through **demineralizers** in a processing system.

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 system 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 radionuclides 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 1990, approximately 1090 curies of noble gases were released. The calculated offsite gamma and beta air doses due to the release of this activity were 0.024 mrad and 0.068 mrad, respectively and are less than 1.0% of their respective Technical Specifications limits. Additional dose information is provided in Table 1-4 on page 1-42.

Iodine and Particulates

Annual releases of radioisotopes of iodine and radioactive 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 principal radioactive particulates released are radioactive fission products (cesium-134 and cesium-137) and activation products (cobalt-58 and cobalt-60). During 1990, the amount of radioactive iodine and particulates (excluding tritium) released was approximately 3.82E-3 curie in gaseous effluents and 0.14 curie in liquid effluents. These releases were well below all applicable regulatory limits. Additional dose information is provided in Table 1-4 on page 1-42.

Tritium

Tritium, a radioactive isotope of hydrogen, is the predominant radionuclide in liquid effluents, and 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. The amount of tritium released in 1990 was approximately 28.9 curies in gaseous effluents and 127 curies in liquid effluents. The associated doses were well below all regulatory limits, and additional dose information is provided in Table 1-4, page 1-42.

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. All wastes are sampled prior to release and an offsite dose evaluation is performed to assure that the dose from the release will be as low as reasonably achievable (ALARA).

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 set points are low to ensure the limits will not be exceeded. If a monitor alarms, a release from a tank is automatically stopped.

Additionally, effluent samples are collected and analyzed in a laboratory to identify the specific concentrations of radionuclides being released. Sampling and analysis provides 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 a computer which records 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 conjunction 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. This provides information on the water flow, wind speed and wind direction at the time of a gaseous or liquid release. This information is used to evaluate how the radionuclides will be distributed in the area. The most 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 Figure 1-11 and 1-12. The release of radioactivity in gaseous effluents involves pathways such as direct radiation, deposition on plants, deposition on soil, inhalation by animals destined for human consumption, and inhalation by humans. The release of radioactivity in liquid effluents involves pathways such as drinking water, fish consumption, and direct exposure from the lake, both shoreline and immersion in the lake (swimming).

Although radionuclides can reach humans by many different pathways, some are more important than others. The pathway of concern is termed the **critical pathway**. 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**.

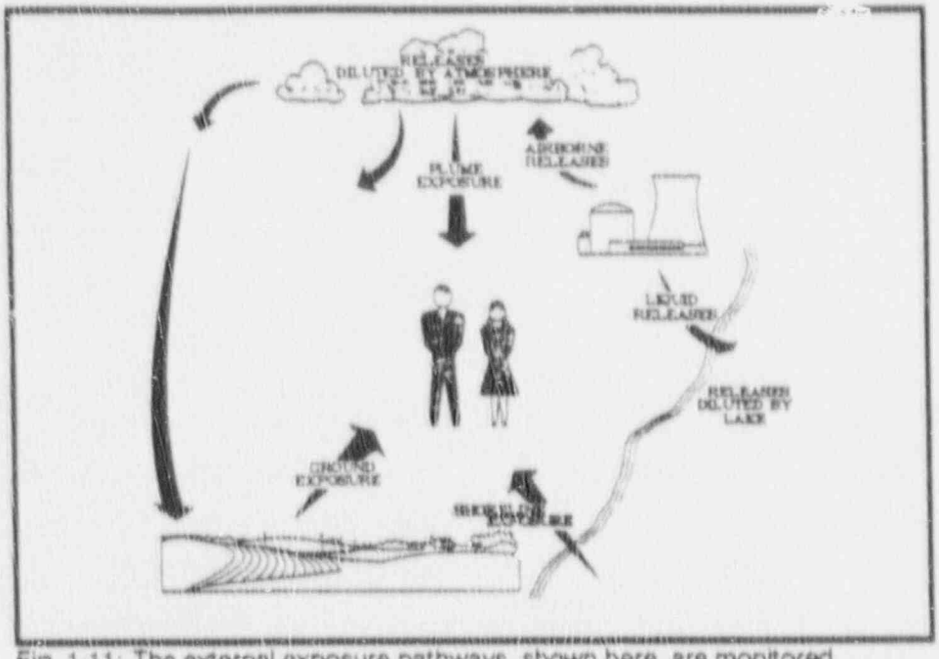

Fig. 1-11: The external exposure pathways, shown here, are monitored through the Radiological Environmental Monitoring Program (REMP), and are considered when calculating doses to the public.

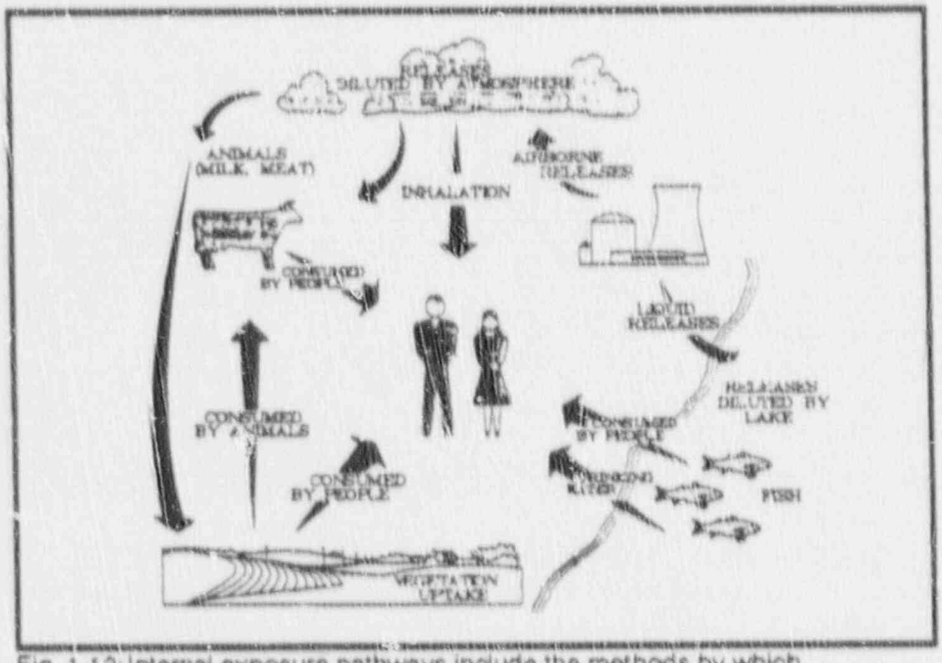

Fig. 1-12: Internal exposure pathways include the methods by which radioactivity could reach people around the Station via the foods they eat, the milk they drink, and the air they breathe.

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 (breathing) or ingestion (eating, drinking). When they do, they are usually not distributed evenly. For example, radioactive iodine selectively concentrates in the thyroid gland, while radioactive cesium collects in muscle and liver tissue, and radioactive strontium collects in bone tissue.

The total dose to organs from a given radionuclide depends on the 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 our bodies 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 present at the time of the release, the locations of important 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 amount of radioactivity released, the total volume of radioactive liquid, the total volume of dilution water, near field dilution, and useage 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 Effluent and Waste Disposal Report. For 1990, 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 7.3% 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 0.4% of the annual Technical Specifications limits. Table 1-4 summarizes the dose due to radioactivity released in effluents in 1990.

Table 1-4: 1990 Offsite Doses to the Public due to Radioactivity Released in Gaseous and Liquid Effluents

	1990 Dose	Annual Limit	Percent of Limi
Liquid Effluents			
Whole Body	0.22 mrem	3 mrem	7.3%
Organ (liver)	0.31 mrem	10 mrem	3.1%
Gaseous Effluents			
Noble Gas			
Gamma (air dose)	0.024 mrad	10 mrad	0.24%
Beta (air dose)	0.068 mrad	20 mrad	0.34%
Iodine-131, tritium and particulates with half-lives greater than 8 days	0.053 mrem	15 mrem	0.36%

Prior to January 1, 1990, a small leak appeared in one of the steam generators which allowed a small fraction of the radioactivity present in the primary coolant to be transferred to the secondary loop. Although the steam generator leak has contributed to the radioactivity released in effluents and to the dose to the public during 1990, the offsite doses have remained less than 8% of the annual Technical Specifications dose limits.

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Radiological Environmental Monitoring Program

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 at Davis-Besse has been a part of the radiological programs conducted at the Station for approximately 19 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 the operation of Davis-Besse. 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 13 years now.

A wide variety of environmental samples are collected as part of the REMP at Davis-Besse. 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 environment.

A description of the Radiological Environmental Monitoring Program at Davis-Besse 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 1990, 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 program 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 sort of insurance that any radiological impact the operation of Davis-Besse has had on the surrounding environment, since its design conception through its productive years to its eventual shutdown, 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 Station's 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 **Quality Assurance (QA)**. 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 analysis 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 couterpart.

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, airborne radioiodine, and snow,
- **terrestrial** -- including samples of milk, groundwater, broad leaf vegetation and fruits, animal/wildlife feed, soil, and wild and domestic meat,
- **aquatic** -- including samples of treated and untreated surface water, fish, and shoreline sediments, and
- **direct radiation** -- measured by thermoluminescent dosimeters.

All environmental samples are labled 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
Thermoluninescent Dosimeter	TLD	Quarterly, Annually
Snow	SNO	When Available
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

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. Typically, these are more than five miles away from the Station. 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, including nuclear 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.

Beginning on page 2-8 through 2-11, Figures 2-1 through 2-4 identify the REMP sampling locations on the Davis-Besse site, within a five mile radius, within a ten mile radius, and in Lake Erie, respectively. Table 2-2 provides a more detailed listing of the locations of all sampling sites and the types of samples collected at each site.

DAVIS – BESSE NUCLEAR POWER STATION
RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
SAMPLING LOCATIONS – SITE AREA

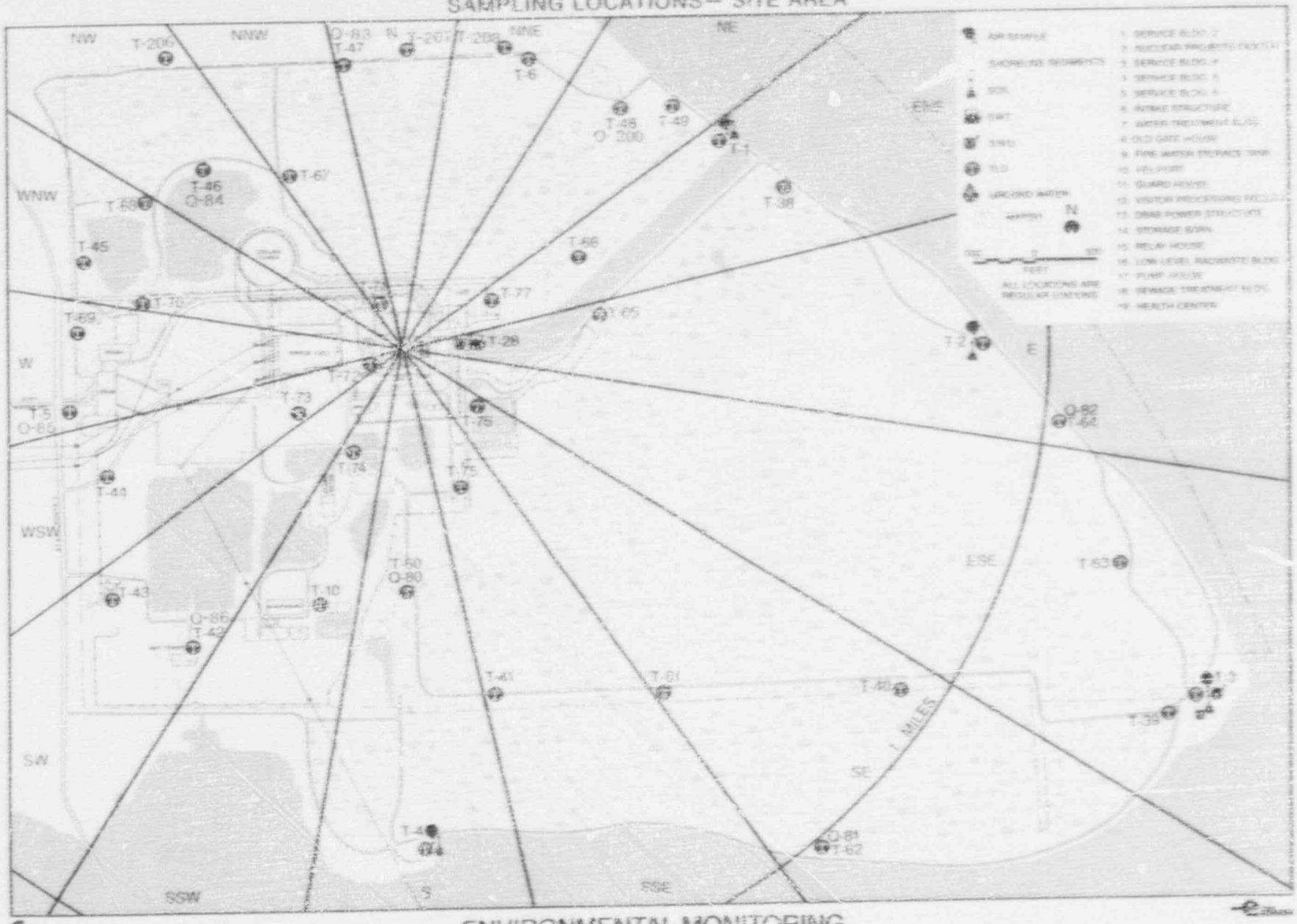
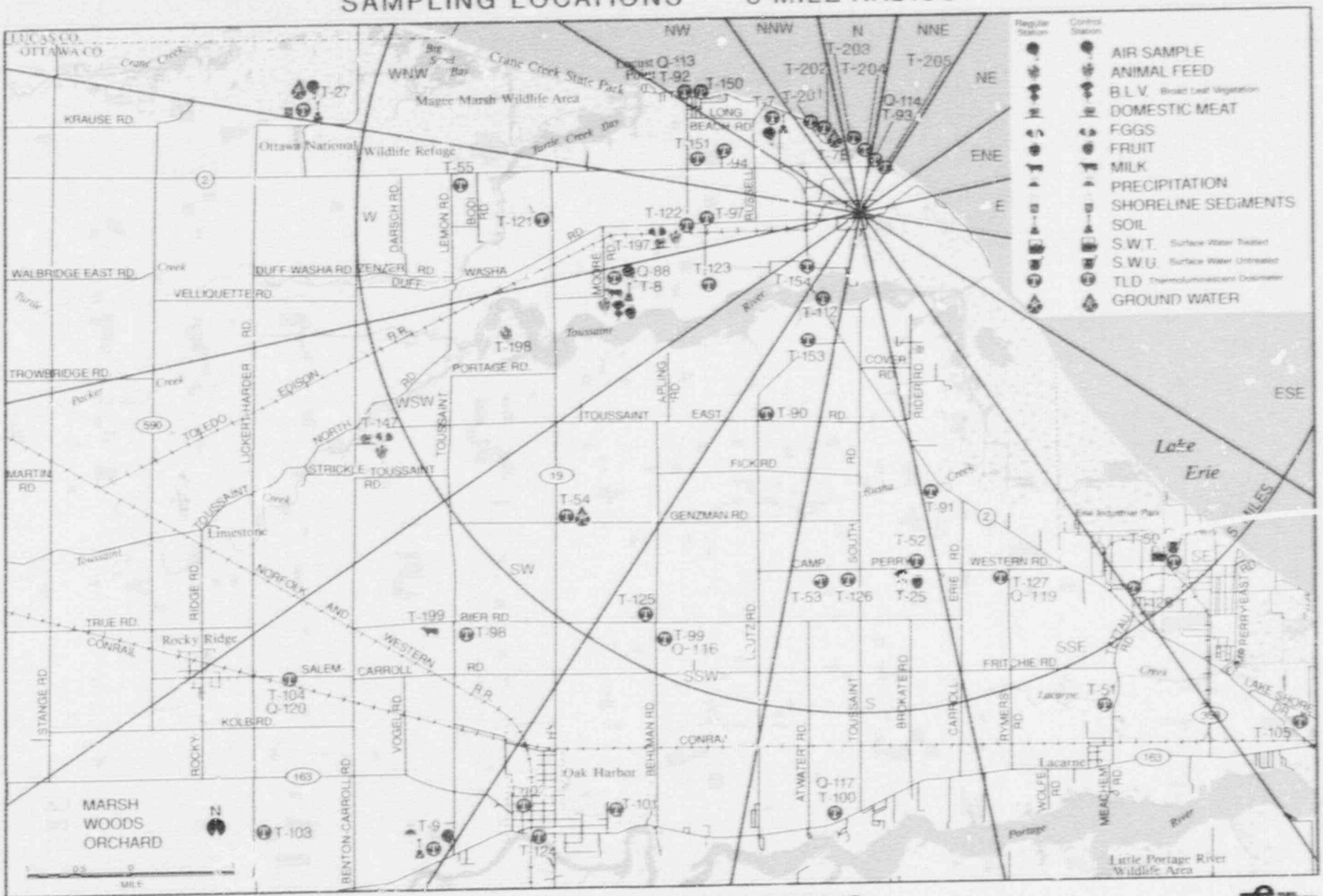


Figure 2-1

DAVIS-BESSE NUCLEAR POWER STATION
RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
SAMPLING LOCATIONS -- 5 MILE RADIUS



ENVIRONMENTAL MONITORING

Figure 2-2

DAVIS-BESSE NUCLEAR POWER STATION
RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
SAMPLING LOCATIONS – 10 MILE RADIUS

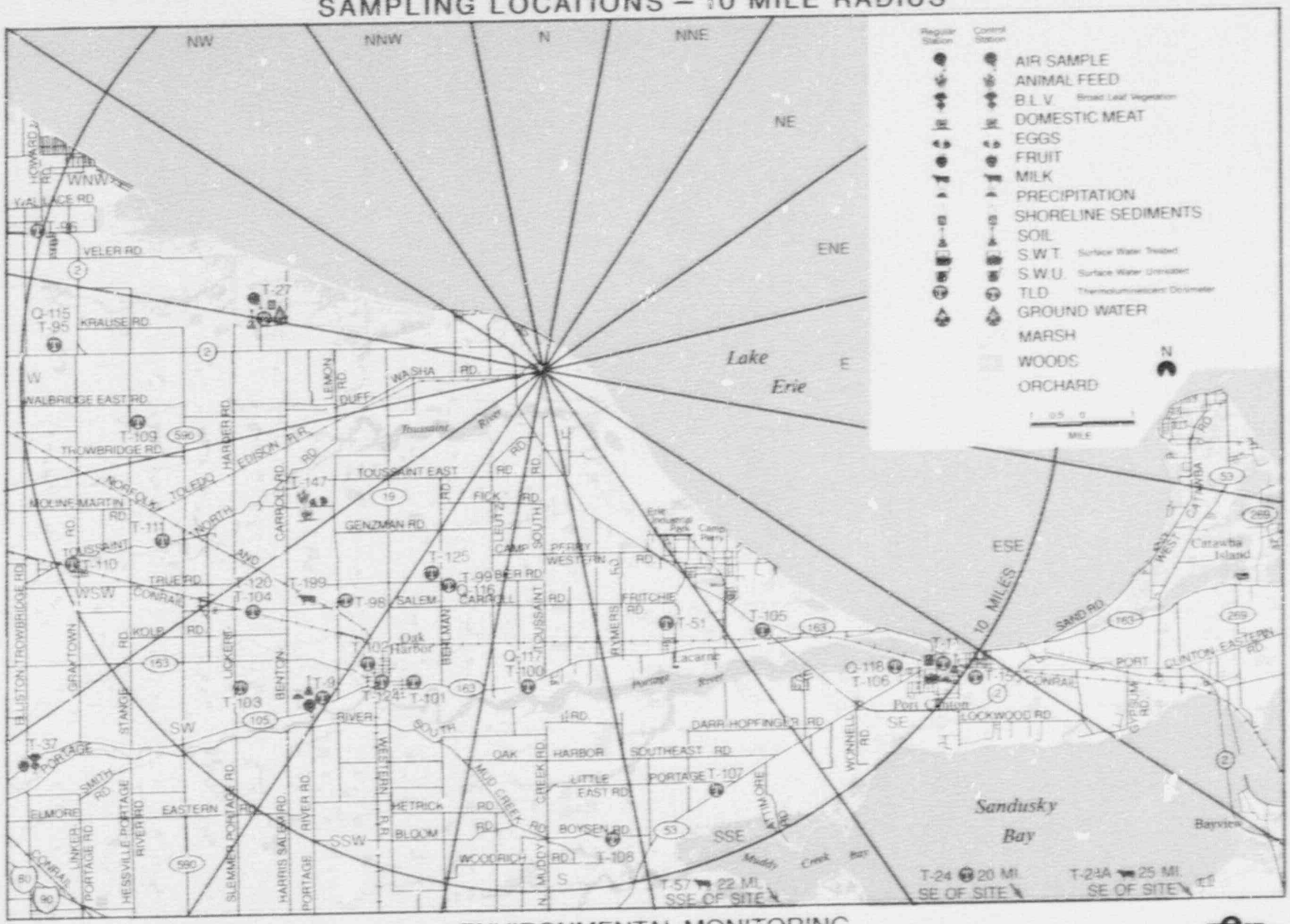


Figure 2-3

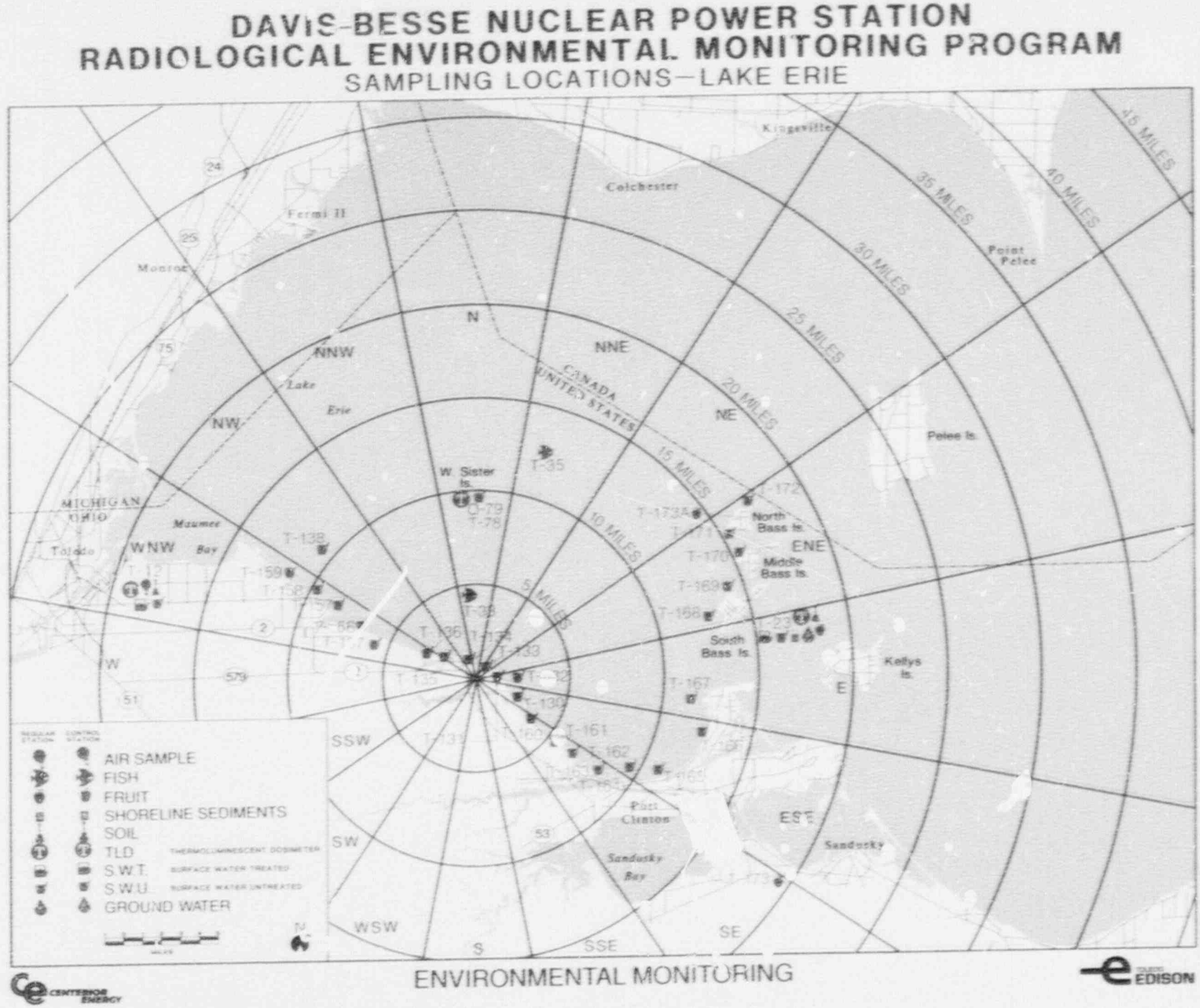

DAVIS-BESSE NUCLEAR POWER STATION
RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
SAMPLING LOCATIONS—LAKE ERIE
N
NNE
NE
ENE
E
ESE
SE
SSE
S
SSW
SW
WSW
W
WNW
NW
NNW
5 MILES
10 MILES
15 MILES
20 MILES
25 MILES
30 MILES
35 MILES
40 MILES
45 MILES
CANADA
UNITED STATES
Lake Erie
Fermi II
Monroe
Toledo
Maumee Bay
MICHIGAN
OHIO
Colchester
Kingsville
Point Pelee
Pelee Is.
W. Sister Is.
North Bass Is.
Middle Bass Is.
South Bass Is.
Kelleys Is.
Port Clinton
Sandusky
Sandusky Bay
AIR SAMPLE
FISH
FRUIT
SHORELINE SEDIMENTS
SOIL
TLD THERMOLUMINESCENT DOSIMETER
S.W.T. SURFACE WATER TREATED
S.W.U. SURFACE WATER UNTREATED
GROUND WATER
ENVIRONMENTAL MONITORING
CENTERIOR ENERGY
EDISON

Figure 2-4

Table 2-2: Description of REMP Sampling Locations and Types of Samples Collected at Each

Site Number	Type of Location (I,C or QC)*	Location Description	Type(s) of Samples**
T-1	I	Site boundary, 0.6 mile ENE of Station.	AI, AP,TLD SOI, SNO
T-2	I	Site boundary, 0.9 mile E of Station.	AI, AP, TLD, SOI
T-3	I	Site boundary, 1.4 miles ESE of Station.	AI, AP, TLD, SOI, SWU, SED
T-4	I	Site boundary, 0.8 mile S of Station.	AI, AP, TLD, SOI, SED, SNO
T-5	I	Site boundary, 0.5 mile W ofTLD Station.	TLD
T-6	I	Site boundary, 0.5 mile NNE of Station.	TLD
T-7	I	Sand Beach, main entrance, 0.9 mile NW of Station.	AI, AP, TLD, SOI, GW
T-8	I	Farm, 2.7 miles WSW of Station.	AI, AP, TLD, MIL, SOI, AF, BLV, FRU, SNO

* I = Indicator C = Control QC = Quality Control

**Refer to Sample Codes in Table 2-1, page 2-6.

Table 2-2: Description of REMP Sampling Locations and Types of Samples Collected at Each

Site Number	Type of Location (I,C or QC)*	Location Description	Type(s) of Samples**
T-9	C	Oak Harbor Substation, 6.8 miles miles SW of Station.	AI, AP, TLD, SOI, SNO
T-10	I	Site boundary, 0.5 mile SSW of Station.	TLD
T-11	C	Port Clinton Water Treatment Plant 9.5 miles SE of Station.	AI, AP, TLD, SOI, SNO SWT, SWU
T-12	C	Toledo Water Treatment Plant. AI, AP, TLD, and SOI collected 23.5 miles WNW of Station, SWU and SWT samples taken from Intake Crib 11.25 miles NW of Station.	AI, AP, TLD, SOI, SWU, SWT
T-23	C	South Bass Island, 14.3 miles ENE of Station.	TLD, SOI, SED SWU, SWT, GW FRU
T-24	C	Sandusky, 21.0 miles SE of Station.	TLD, MIL
T-25	I	Farm, 3.7 miles S of Station.	BLV, FRU

* I = Indicator C = Control QC = Quality Control

**Refer to Sample Codes in Table 2-1, page 2-6.

Table 2-2: Description of REMP Sampling Locations and Types of Samples Collected at Each

Site Number	Type of Location (I,C or QC)*	Location Description	Type(s) of Samples**
T-27	C	Crane Creek State Park, 5.3 miles WNW of Station.	AI, AP, TLD, SOI, GW, SED
T-28	I	Treated and untreated water supply, at the Davis-Besse site.	SWU, SWT
T-31	I	Onsite roving location.	Me(W), AF
T-33	I	Lake Erie, within 5 mile radius of Station.	FIS
T-34	C	Offsite roving location, land greater. than 10 mile radius of Station.	Me(W), AF
T-35	C	Lake Erie, greater than 10 mile radius of Station.	FIS
T-37	C	Farm, 13.0 miles SW of Station.	BLV, FRU
T-38	I	Site boundary, 0.6 mile ENE of Station.	TLD
T-39	I	Site boundary, 1.2 miles ESE of Station.	TLD

* I = Indicator C = Control QC = Quality Control

**Refer to Sample Codes in Table 2-1, page 2-6.

Table 2-2: Description of REMP Sampling Locations and Types of Samples Collected at Each

Site Number	Type of Location (I,C or QC)*	Location Description	Type(s) of Samples**
T-40	I	Site boundary, 0.7 mile SE of Station.	TLD
T-41	I	Site boundary, 0.6 mile SSE of Station.	TLD
T-42	I	Site boundary, 0.8 mile SW of Station.	TLD
T-43	I	Site boundary, 0.5 mile SW of Station.	TLD
T-44	I	Site boundary, 0.5 mile WSW of Station.	TLD
T-45	I	Site boundary, 0.5 mile WNW of Station.	TLD
T-46	I	Site boundary, 0.5 mile NW of Station.	TLD
T-47	I	Site boundary, 0.5 mile N of Station.	TLD
T-48	I	Site boundary, 0.5 mile NE of Station.	TLD
T-49	I	Site boundary, 0.5 mile NE Of Station.	TLD

* I = Indicator C = Control QC = Quality Control

**Refer to Sample Codes in Table 2-1, page 2-6.

Table 2-2: Description of REMP Sampling Locations and Types of Samples Collected at Each

Site Number	Type of Location (I,C or QC)*	Location Description	Type(s) of Samples**
T-50	I	Erie Industrial Park, Port Clinton, 4.5 miles SE of Station.	TLD, SWU, SWT
T-51	C	Farm, 5.5 miles SSE of Station.	TLD
T-52	I	Farm, 3.7 miles S of Station.	TLD
T-53	I	Farm, 4.5 miles S of Station.	TLD
T-54	I	Farm, 4.8 miles SW of Station.	TLD, GW
T-55	I	Farm, 5.0 miles W of Station.	TLD
T-57	C	Farm, 22.0 miles SSE of Station.	MIL,AF
T-60	I	Site boundary, 0.3 mile S of Station.	TLD
T-61	I	Site boundary, 0.6 mile SE of Station.	TLD
T-62	I	Site boundary, 1.0 mile SE of Station.	TLD
T-63	I	Site boundary, 1.1 miles ESE of Station.	TLD
T-64	I	Site boundary, 0.9 mile E of Station.	TLD

* I = Indicator C = Control QC = Quality Control

**Refer to Sample Codes in Table 2-1, page 2-6.

Table 2-2: Description of REMP Sampling Locations and Types of Samples Collected at Each

Site Number	Type of Location (I,C or QC)*	Location Description	Type(s) of Samples**
T-65	I	Site boundary, 0.3 mile E of Station.	TLD
T-66	I	Site boundary, 0.3 mile ENE of Station.	TLD
T-67	I	Site boundary, 0.3 mile NNW of Station.	TLD
T-68	I	Site boundary, 0.5 mile WNW of Station.	TLD
T-69	I	Site boundary, 0.4 mile W of Station.	TLD
T-70	I	Site boundary, 0.3 mile NNW of Station.	TLD
T-71	I	Site boundary, 0.1 mile NNW of Station.	TLD
T-73	I	Site boundary, 0.1 mile WSW of Station.	TLD
T-74	I	Site boundary, 0.1 mile SSW of Station.	TLD
T-75	I	Site boundary, 0.2 mile SSE of Station.	TLD
T-76	I	Site boundary, 0.1 mile SE of Station.	TLD
T-77	I	Site boundary, 0.1 mile ENE of Station.	TLD

* I = Indicator C = Control QC = Quality Control

**Refer to Sample Codes in Table 2-1, page 2-6.

Table 2-2: Description of REMP Sampling Locations and Types of Samples Collected at Each

Site Number	Type of Location (I,C or QC)*	Location Description	Type(s) of Samples**
T-78	C	West Sister Island, 10.0 miles N of Station.	TLD, SWU
T-79	QC	Quality Control site.	TLD
T-80	QC	Quality Control site.	TLD
T-82	QC	Quality Control site.	TLD
T-83	QC	Quality Control site.	TLD
T-84	QC	Quality Control site.	TLD
T-85	QC	Quality Control site.	TLD
T-86	QC	Quality Control site.	TLD
T-88	QC	Quality Control site.	TLD
T-89	QC	Quality Control site.	TLD
T-90	I	Toussaint East and Leutz Roads, 2.0 miles SSW of Station.	TLD

* I = Indicator C = Control QC = Quality Control

**Refer to Sample Codes in Table 2-1, page 2-6.

Table 2-2: Description of REMP Sampling Locations and Types of Samples Collected at Each

Site Number	Type of Location (I,C or QC)*	Location Description	Type(s) of Samples**
T-91	I	State Route 2 and Rankie Road, 2.5 miles SSE of Station.	TLD
T-92	I	Locust Point Road, 2.7 miles WNW of Station.	TLD
T-93	I	Twelfth Street, Sand Beach, 0.6 mile NNE of Station.	TLD
T-94	I	State Route 2, 1.8 miles WNW of Station.	TLD
T-95	C	State Route 579, 9.3 miles W of Station.	TLD
T-96	C	State Route 2 and Howard Road, 10.5 miles WNW of Station.	TLD
T-97	I	Duff Washa and Zetzer Road, 1.5 miles W of Station.	TLD
T-98	C	Toussaint-Portage and Bier Road, 6.0 miles SW of Station.	TLD
T-99	I	Behlman Road, 4.7 miles SSW of Station.	TLD

* I = Indicator C = Control QC = Quality Control

**Refer to Sample Codes in Table 2-1, page 2-6.

Table 2-2: Description of REMP Sampling Locations and Types of Samples Collected at Each

Site Number	Type of Location (I,C or QC)*	Location Description	Type(s) of Samples**
T-100	C	Ottawa County Highway Garage, Oak, Harbor, 6.0 miles S of Station.	TLD
T-101	C	Finke Street, Oak Harbor, 6.5 miles of Station.	TLD
T-102	C	Oak Street, Oak Harbor, 6.5 miles SSW of Station.	TLD
T-103	C	Lickert-Harder Road, 8.5 miles SW of Station.	TLD
T-104	C	Salem-Carroll Road, 7.3 miles SW of Station.	TLD
T-105	C	Lake Shore Drive, Port Clinton, 6.0 miles SE of Station.	TLD
T-106	C	Third Street, Port Clinton, 8.9 miles SE of Station.	TLD
T-107	C	Little Portage East Road, 8.5 miles SSE of Station.	TLD
T-108	C	Boysen Road, 9.0 miles S of Station.	TLD

* I = Indicator C = Control QC = Quality Control

**Refer to Sample Codes in Table 2-1, page 2-6.

Table 2-2: Description of REMP Sampling Locations and Types of Samples Collected at Each

Site Number	Type of Location (I,C or QC)*	Location Description	Type(s) of Samples**
T-109	C	Stange Road, 6.0 miles W of Station.	TLD
T-110	C	Toussaint North and Graytown Road, 10.0 miles WSW of Station.	TLD
T-111	C	Toussaint North Road, 8.3 miles WSW of Station.	TLD
T-112	I	Thompson Road, 1.5 miles SSW of Station.	TLD
T-113	QC	Quality Control site.	TLD
T-114	QC	Quality Control site.	TLD
T-115	QC	Quality Control site.	TLD
T-116	QC	Quality Control site.	TLD
T-117	QC	Quality Control site.	TLD
T-118	QC	Quality Control site.	TLD
T-119	QC	Quality Control site.	TLD

* I = Indicator C = Control QC = Quality Control

**Refer to Sample Codes in Table 2-1, page 2-6.

Table 2-2: Description of REMP Sampling Locations and Types of Samples Collected at Each

Site Number	Type of Location (I,C or QC)*	Location Description	Type(s) of Samples**
T-120	QC	Quality Control site.	TLD
T-121	I	State Route 19, 2.0 miles W of Station.	TLD
T-122	I	Duff Washa and Humphrey Road, 1.7 miles W of Station.	TLD
T-123	I	Zetzer Road, 1.6 miles WSW of Station.	TLD
T-124	C	Church and Walnut Street, Oak Harbor, 6.5 miles SSW of Station.	TLD
T-125	I	Behlman and Bier Roads, 4.4 miles SSW of Station.	TLD
T-126	I	Camp Perry Western and Toussaint South Road, 3.7 miles S of Station.	TLD
T-127	I	Camp Perry Western and Rymers Road, 4.0 miles SSE of Station.	TLD
T-128	I	Erie Industrial Park, Port Clinton, 4.0 miles SE of Station.	TLD

* I = Indicator C = Control QC = Quality Control

**Refer to Sample Codes in Table 2-1, page 2-6.

Table 2-2: Description of REMP Sampling Locations and Types of Samples Collected at Each

Site Number	Type of Location (I,C or QC)*	Location Description	Type(s) of Samples**
T-130	I	Lake Erie, 1.7 miles ESE of Station.	SWU
T-131	I	Lake Erie, 0.8 mile NE Of Station.	SWU
T-132	I	Lake Erie, 1.0 mile E of Station.	SWU
T-133	I	Lake Erie, 0.8 mile N of Station.	SWU
T-134	I	Lake Erie, 1.4 miles NW of Station.	SWU
T-135	I	Lake Erie, 2.5 miles WNW of Station.	SWU
T-136	I	Lake Erie, 3.8 miles WNW of Station.	SWU
T-137	C	Lake Erie, 7.0 miles WNW of Station.	SWU
T-138	C	Lake Erie, 11.0 miles NW of Station.	SWU
T-141	QC	Quality Control site.	GW

* I = Indicator C = Control QC = Quality Control

**Refer to Sample Codes in Table 2-1, page 2-6.

Table 2-2: Description of REMP Sampling Locations and Types of Samples Collected at Each

Site Number	Type of Location (I,C or QC)*	Location Description	Type(s) of Samples**
T-143	QC	Quality Control site.	SWT
T-144	I	Green Cove Condominiums, 0.9 mile NNW of Station.	SWT
T-145	QC	Quality Control site.	SWU
T-147	C	Farm, 5.7 miles WSW of Station.	Me(D), AF
T-150	I	Humphrey and Hollywood Road, 2.1 miles NW of Station.	TLD
T-151	I	State Route 2 and Humphrey Road, 1.8 miles WNW of Station.	TLD
T-153	I	Leutz Road, 1.4 miles SSW of Station.	TLD
T-154	I	State Route 2, 0.7 mile SW of Station.	TLD
T-155	C	Fourth and Madison Street, Port Clinton, 9.5 miles SE of Station.	TLD
T-156	C	Lake Erie, 8.0 miles WNW of Station.	SWU

* I = Indicator C = Control QC = Quality Control

**Refer to Sample Codes in Table 2-1, page 2-6.

Table 2-2: Description of REMP Sampling Locations and Types of Samples Collected at Each

Site Number	Type of Location (I,C or QC)*	Location Description	Type(s) of Samples**
T-157	C	Lake Erie, 8.9 miles WNW of Station.	SWU
T-158	C	Lake Erie, 10.0 miles WNW of Station.	SWU
T-159	C	Lake Erie, 10.2 miles WNW of Station.	SWU
T-160	I	Lake Erie, 3.5 miles ESE of Station.	SWU
T-161	I	Lake Erie, 4.7 miles SE of Station.	SWU
T-162	C	Lake Erie, 5.4 miles SE of Station.	SWU
T-163	C	Lake Erie, 8.5 miles SE of Station.	SWU
T-164	C	Lake Erie, 9.5 miles ESE of Station.	SWU
T-165	C	Lake Erie, 10.2 miles ESE of Station.	SWU
T-166	C	Lake Erie, 12.0 miles ESE of Station.	SWU
T-167	C	Lake Erie, 11.5 milmes E of Station.	SWU
T-168	C	Lake Erie, 12.5 miles ENE of Station.	SWU

* I = Indicator C = Control QC = Quality Control

**Refer to Sample Codes in Table 2-1, page 2-6.

Table 2-2: Description of REMP Sampling Locations and Types of Samples Collected at Each

Site Number	Type of Location (I,C or QC)*	Location Description	Type(s) of Samples**
T-169	C	Lake Erie, 14.0 miles ENE of Station.	SWU
T-170	C	Lake Erie, 15.0 miles ENE of Station.	SWU
T-171	C	Lake Erie, 15.5 miles ENE of Station.	SWU
T-172	C	Lake Erie, 17.0 miles ENE of Station.	SWU
T-173	C	Firelands Winery, Sandusky, 20.0 miles SE of Station.	FRU
T-173A	C	Firelands Vineyard, North Bass Island, 16.3 miles ENE of Station.	FRU
T-197	I	Farm, 1.7 miles W of Station.	Me(D), AF
T-198	I	Toussaint Creek Wildlife Area, 4.0 miles WSW of Station.	AF
T-199	C	Farm, 8.5 miles SW of Station.	MIL
T-200	QC	Quality Control site.	TLD
T-201	I	Sand Beach, 1.1 miles NNW of Station.	TLD

* I = Indicator C = Control QC = Quality Control

**Refer to Sample Codes in Table 2-1, page 2-6.

Table 2-2: Description of REMP Sampling Locations and Types of Samples Collected at Each

Site Number	Type of Location (I,C or QC)*	Location Description	Type(s) of Samples**
T-202	I	Sand Beach, 0.8 miles NNW of Station.	TLD
T-203	I	Sand Beach, 0.7 miles N of Station.	TLD
T-204	I	Sand Beach, 0.7 miles N of Station.	TLD
T-205	I	Sand Beach, 0.5 miles NNE of Station.	TLD
T-206	I	Site boundary, 0.6 miles NW of Station.	TLD
T-207	I	Site boundary, 0.5 miles N of Station.	TLD
T-208	I	Site boundary, 0.5 miles NNE of Station.	TLD

* I = Indicator C = Control QC = Quality Control

**Refer to Sample Codes in Table 2-1, page 2-6.

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. No two radionuclides emit the same energy gamma rays. Therefore, 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 a natural or man-made 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 envi-

ronment 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 determined by a special laboratory procedure that is more thoroughly discussed on page 2-55.

Table 2-3 provides a listing of the type(s) 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 that will give a net count for which there is confidence, at a predetermined level, that radioactivity is present. When a measurement of radioactivity is reported as less than the 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 analyses 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 1990 is provided in the following section.

Table 2-3: 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
Snow	Gross Beta Gamma Spectral Tritium
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 2-3: Radiochemical Analyses Performed on REMP Samples (continued)

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.

- Snow:

  Only normal background and fallout radioactivity from nuclear weapons testing have been detected.

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 has 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 has been detected.

- Soil:

  Only natural background radioactivity and radioactivity from nuclear weapons testing and the 1986 nuclear accident at Chernobyl has been detected.

- Animal/Wildlife Feed:

  Only natural background radioactivity and radioactivity from weapons testing has 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 above 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. However, the results at T-7 were more than 39 times lower than 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)(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 subsequent 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 has been detected.

- Shoreline Sediments:

  Only natural background radioactivity and radioactivity from nuclear testing and the 1986 nuclear accident at Chernobyl has been detected.

Direct Radiation Monitoring:

- Thermoluminescent Dosimeters (TLDs):

  The annual average gamma dose rates recorded by TLDs have ranged from 49 to 87 millirem per year at control locations, and between 44 and 63 millirem per year at indicator locations. No increase above natural background radiation attributable to the operation of Davis-Besse has been observed.

1990 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, snow, groundwater, milk, 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 2-4). 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 during 1987 and 1988. 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 effort, 1990 REMP included over 1700 more samples than required by the Technical Specifications. During 1990, only 29% of the samples collected for REMP were required to satisfy regulatory requirements. In addition, of the 138 sampling locations utilized in 1990, 23 of these, or 16% of the total were quality control locations.

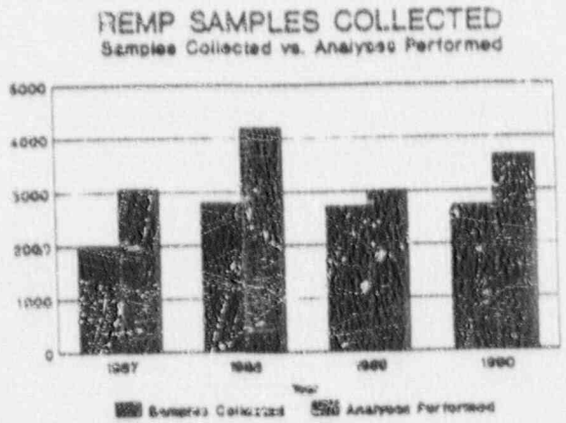


Figure 2-5 : In 1987, the number of samples collected and analyses performed were selectively increased. Since 1988, the number of samples collected have only increased slightly. The number of analyses performed varied because of the types of samples missed and the analyses varied with each sample type.

Table 2-4: 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	2***
Airborne Radioiodine	C/W	10	520	2***
Snow	G/AQ	5	5	0
TERRESTRIAL				
Milk (May-Oct.)	G/SM	4	46	3
(Nov-Apr.)	G/M	4	20	3
Groundwater	G/Q	4	20	0
Edible Meat				
a.wild	G/A	1	3	0
b.domestic	G/A	2	1	1****
Broad Leaf Vegetation/Fruit				
(July-Sep.)	G/M	5	20	0
Soil	G/S	11	22	0
Animal/Wildlife feed	G/A	6	5	1****
AQUATIC				
Treated Surface Water	G/WM	7	327	2****
Untreated Surface Water	G/WM	29	436	3****
	Comp/WM	5	208	2****
Fish (3 species)	G/SA	2	11	1****
Shoreline Sediments	G/SA	4	9	0
DIRECT RADIATION				
Thermoluminescent	C/M	0	0	0
Dosimeters	C/Q	115	445	15****
	C/A	115	109	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;
/AQ = When available composited Quarterly.

*** **Airborne particulate and radioiodine samples** were collected but declared invalid due to low volume during sampling period.

**** The reasons for missed samples is discussed on pages 2-36 and 2-37.

1990 Program Deviations

Provided below is a description and explanation of all environmental samples which were not collected in 1990.

- Untr. .ed surface water from T-3 was unavailable the weeks of January 2, 8, and 15 because the Toussaint River was frozen.
- Milk was not collected from the dairy cow at T-199 the weeks of January 8, February 12, March 13, April 9, July 24, and August 13, 1990 because of low milk production from the cow.
- Airborne radioiodine and particulate sample from T-11 (Port Clinton) for week of January 22, 1990 were considered invalid samples because of low sample volume caused by a pump malfunction. The LLD for this airborne radioiodine sample was < 0.24 pCi/m^3 instead of < 0.07 pCi/m^3.
- A composite sample of untreated surface water at T-28 was unavailable for the weeks of February 5 and 13, 1990 because the water compositor malfunctioned.
- Treated water sample was not collected at T-144 the week of February 26, 1990 due to frozen faucet. .
- There were no TLD data for locations T-122 and T-203 for first quarter 1990, because TLDs were lost due to vandalism.
- There were no TLD data for location T-78 and T-79 for 1990 because TLDs are located on an island in Lake Erie and lake conditions did not permit collection.
- There were no TLD data for location T-109, T-93, T-114, and T-202 during second quarter 1990, because TLDs were lost due to vandalism.
- A composite untreated surface water sample at T-12 for week of September 4, 1990 was not available, from personnel contracted to collect the sample. A grab sample was collected as a substitute.
- A chicken, eggs and animal feed samples were not collected during 1990 at T-147 because the person no longer raised chickens.
- A treated surface water sample was unavailable at T-23 from February through September 1990 due to policy changes at the Water Treatment Facility. Therefore, a new contract was written. A suitable substitute was unavailable.
- The February 1990 composite of untreated surface water for T-23 was lost in transit to the analytical laboratory.

- A carp sample was unavailable at T-33 during November because this species was not in the nets at the time of collection.
- The airborne iodine and particulate sample at T-7 collected on September 10, 1990 was considered an invalid sample because of low sample volume. The LLD for the airborne iodine (I-131) sample was < 0.34 pCi/m^3 instead of < 0.07 pCi/m^3.
- There was no TLD data for location T-150 during fourth quarter of 1990, because TLD was lost due to vandalism
- There were no TLD data for locations T-114, T-122, T-202, and T-203 for the Annual 1990 TLD sites because TLDs were lost due to vandalism.

In 1990, the major deviation from the REMP scheduled activities were losses of TLDs due to vandalism and not being able to collect milk sample because low milk production of the dairy cow. A summary of the major deviation is provided in the following paragraphs.

Every year, a small percentage of the TLDs placed in the field by REMP personnel are vandalized. However, the lost data can usually be estimated from calculations using data from other nearby locations or from other TLDs (quality control, quarterly, annual) at the same site. The increased number of sampling locations brought on by the REMP Enhancement Program has provided greater TLD coverage over the area monitored by the REMP, and has helped to reduce the impact of lost TLDs on the REMP database. In 1990, 3% of all TLDs in the field were lost, however, these lost data did not have a significant effect on the quality of the 1990 REMP.

The second major program deviation experienced in 1990 was the loss of milk samples at T-199. The sample could not be obtained because the cow's daily milk production was too low. The low milk production was a result of the cow being pregnant and the newborn calf consuming all the milk.

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 Davis-Besse 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, 52 weeks a year.

Airborne particulate samples are collected on 47 mm diameter membrane filters which are carefully handled so as not to disturb or lose any deposited particulates. Charcoal cartridges are installed downstream of the particulate filters to sample for the presence of airborne radioiodine. The airborne particulate and airborne radioiodine samples are sent to an offsite 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 (T-1, T-2, T-3, and T-4), one at Sand Beach (T-7), and another at a local farm (T-8). There are four control locations, Oak Harbor (T-9), Port Clinton (T-11), Toledo (T-12) and Magee Marsh (T-27).

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 yielded an annual average of .019 pCi/m3 at both control and indicator location for 1990. Evidence of

Average Concentration of Beta Emitting Radionuclides in Airborne Particulate Sample

Year - Concentration	Year - Concentration
1972 - 0.041 pCi/m3	1981 - 0.090 pCi/m3*
1973 - 0.035 pCi/m3	1982 - 0.023 pCi/m3
1974 - 0.198 pCi/m3*	1983 - 0.021 pCi/m3
1975 - 0.096 pCi/m3*	1984 - 0.025 pCi/m3
1976 - 0.089 pCi/m3*	1985 - 0.023 pCi/m3
1977 - 0.166 pCi/m3*	1986 - 0.033 pCi/m3
1978 - 0.096 pCi/m3*	1987 - 0.022 pCi/m3
1979 - 0.038 pCi/m3	1988 - 0.031 pCi/m3
1980 - 0.030 pCi/m3	1989 - 0.024 pCi/m3
	1990 - 0.019 pCi/m3

*Averages were influenced by nuclear fallout from weapons testing.

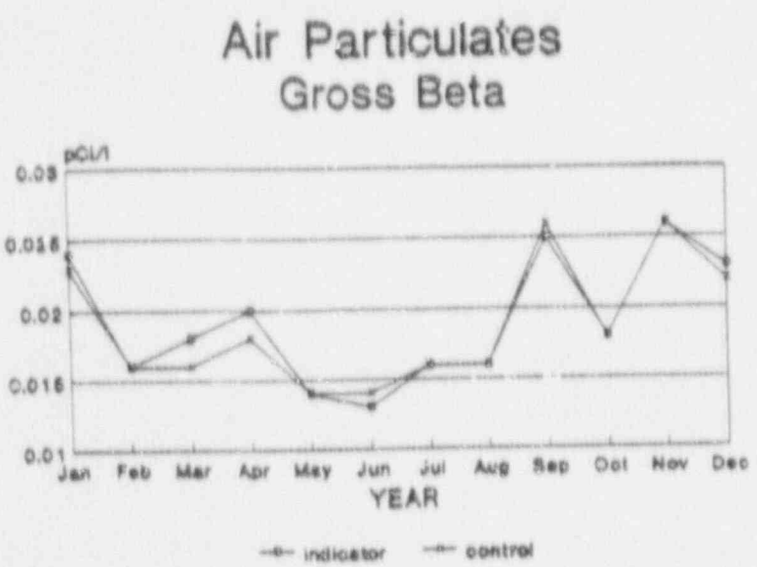


Figure 2-6: Concentrations of beta emitting radionuclides in airborne particulate samples were almost identical at indicator and control locations.

the similarity of the results of the control and indicator locations may be seen in similarity of the average monthly results shown in Fig 2-6 (pg 2-39). The highest annual average (.020 pCi/m3) was detected at T-1, T-8, and T-12. The 1990 annual average is in good agreement with previous years. The results of the past 18 years are shown on page 2-38.

Beryliium-7 was the only gamma emitting radionuclide detected by the gamma spectroscopic analysis of the quarterly composites. Beryllium-7 is a naturally occurring radionuclide produced in the upper atmosphere by cosmic radiation. The average concentration of beryllium-7 was 0.051 pCi/m3 for indicator locations and 0.050 pCi/m3 for control locations. These values are similar to those observed in the previous preoperational and operational years. No other radionuclides were detected above their respective LLDs.

Airborne Iodine-131

Airborne iodine-131 samples are collected at the same ten locations and with the same samplers as the airborne particulates. Charcoal cartridges are installed downstream of the 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 sample collected in 1990, there was no detectable iodine-131 above the LLD of 0.07 pCi/m3. In two samples, the LLD of 0.07 pCi/m3 could not be reached due to

low sample volume caused by the loss of power to the pumps. These samples indicated less than the LLD of 0.24 and 0.34 pCi/m3 of iodine-131.

Snow

Snow provides a mechanism to sample for radionuclide deposition from the atmosphere. Since snow is solid, it provides a surface which airborne radionuclides can be deposited. The radionuclides may be man-made (from nuclear weapons test fallout or nuclear power plant operation) or naturally occurring.

Following a fresh snowfall, approximately 10 pounds of snow are collected from the surface and packed into a container. Once the snow melts, it is transferred to a one gallon container. At the end of the quarter, a one gallon composite is made for each sampling location.

During 1990, snow samples were collected when available from three indicator locations (T-1, T-4 and T-8) and 2 control locations (T-9 and T-11). The samples were analyzed for beta emitting radionuclides, tritium, and gamma emitting radionuclides.

In all snow samples collected in 1990, there were no detectable beta emitting radionuclides above the LLD of 0.6 pCi/l in suspended solids. The concentration of dissolved solids averaged 0.8 pCi/l at indicator locations and 1.4 pCi/l at control locations. Tritium was not detected above the LLD of 330 pCi/l in all samples. There was no detectable cesium-137 above the LLD of 10 pCi/l in any of the samples.

TERRESTRIAL MONITORING

The collection and analysis 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 normally present are:

- **tritium**, present as a result of the interaction of cosmic radiation with the upper atmosphere.
- **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, and
- **fallout radionuclides** from nuclear weapons testing, including strontium-89, strontium-90, cesium-134, cerium-141, cerium-144, ruthenium-103 and ruthenium-106. 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 the Davis-Besse Station. The contribution of radionuclides from the operation of Davis-Besse 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.

Davis-Besse monitors the terrestrial environment through the collection and analysis of samples of groundwater, milk, meat, broad leaf vegetation, fruits, animal feed, and soil.

Milk Samples

Milk sampling is very important in environmental surveillance because it provides a direct basis for assessing the buildup of radionuclides in the environment that may be ingested by humans. 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 can 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 (T-8) and three control locations (T-24, T-57, and T-199).

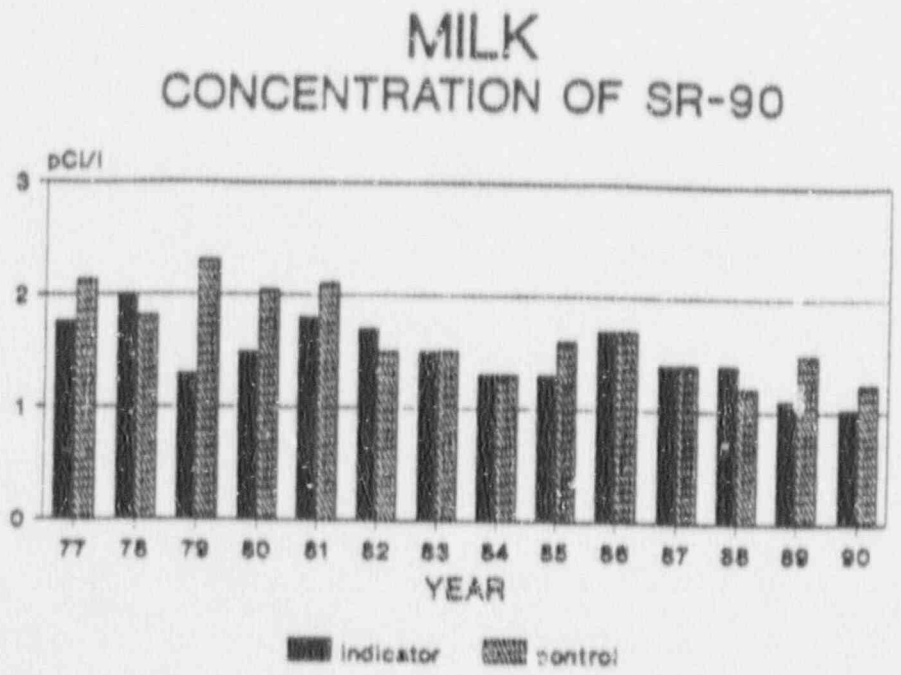


Figure 2-7: Strontium-90 is normally detected in milk samples from both control and indicator locaations. The 1990 average concentrations of strontium-90 in milk samples were similiar at control and indicator locations, a trend exhibited in previous years.

The milk samples are analyzed for strontium-89, strontium-90, iodine-131 and other gamma emitting radionuclides, stable calcium and potassium. A total of 66 milk samples were collected in 1990. The results obtained were similar to those of the previous years.

Strontium-89 was not detected above the LLD of 2.1 pCi/l in any of the samples. Strontium-90 activity was detected in 64 of the 66 samples collected and ranged from 0.6 to 3.1 pCi/l. The annual average concentration of strontium-90 was 1.02 pCi/l at the indicator locations and 1.25 pCi/l at the control locations. The location with the highest annual average concentration was indicator location T-199 with an average of 1.81 pCi/l. For all sample sites, the annual average concentrations were similar to those measured in the previous years (Fig 2-7).

A total of 66 analyses for iodine-131 in milk were performed during 1990. Iodine-131 was not detected in milk samples above the LLD of 0 .5 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 (1229 and 1225 pCi/l, respectively).

Since the chemistries of calcium and strontium, and potassium and cesium are similar, organisms tend to deposit cesium radioisotopes in muscle tissue, and strontium radioisotopes in bones. In order to detect the potential environmental accumulation of these radionuclides, the ratio of the strontium radioisotopes radioactivity (pCi/l) to the concentration of calcium (g/l), and cesium radioisotpes 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 the milk samples collected in 1990 indicate no effect due to the operation of Davis-Besse.

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, REMP personnel sample local wells on a quarterly basis to measure the detection of any adverse impact on the local groundwater supplies due to Station operation. The four wells sampled include two indicator locations (T-7, T-54), and two control locations (T-23 and T-27). 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 radionuclide concentrations in suspended solids were not detected above the LLD of 0.4 pCi/l in any samples. In dissolved solids, the concentrations averaged 3.1 pCi/l at indicator locations and 2.1 pCi/l at control locations. The location with the highest annual average was T-54, a control location. The concentration of beta emitting radionuclides at T-54 averaged 3.6 pCi/l.

Tritium was not detected in any sample above the LLD of 330 pCi/l. Also, Strontium-89 was not detected above the LLD of 1.6 pCi/l. Strontium-90 was detected at T-7. The average concentration of Strontium-90 was 0.6 pCi/l which is similar to concentrations observed in past years. Additionally, no gamma emitting radionuclides were detected in any of the samples collected.

Wild and Domestic Meat Samples

Sampling of meat, both domestic and wild, provides information on environmental nuclide concentrations 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.

Wild animals commonly consumed by residents in the vicinity of Davis-Besse include waterfowl, deer, and muskrat. The REMP generally collects wild meat samples and domestic meat samples(chickens) and eggs on an annual basis. Analyses from animals whose meat is eaten by humans provides general information on radionuclide concentrations in the food chain. When evaluating the results from analyses performed on meat animals, it is important to consider the age, diet, and relative mobility of the animal before drawing conclusions on radionuclide concentrations in the local environment or in the species as a whole. For instance, a meat sample taken from a deer killed by an automobile near Davis-Besse might not provide as much information as a meat sample taken from a muskrat living in the Navarre Marsh, because the deer probably foraged in areas well beyond those that could be affected by Station operation.

Both wild and domestic meat sample and eggs were sampled in 1990 as follows:

- Wild Meat:

  One Canada goose was collected from on site
  One woodchuck was obtained on site
  Four muskrats were collected from the marsh on site

- Domestic Meat:

  A Domestic Meat sample (chicken) was collected at one indicator (T-197) in July. The Domestic Meat sample at control site T-147 was unavailable. All meat samples were analyzed for gamma emitting radionuclides.

- Eggs:

  Eggs were collected at T-197 in July. The sample was analyzed for gamma emitting radionuclides.

In the edible meat samples, the mean potassium-40 concentration was 2.47 pCi/g wet weight for the indicator locations. No edible meat sample was available during 1990 for the control location. This value is well within the range of the preoperational and operational values. Potassium-40 is a naturally occurring radionuclide and is not produced by nuclear power stations. Cesium-137 was not detected in meat samples above the LLD of 0.025 pCi/g.

In the eggs, the only detectable gamma emitting radionuclide was potassium-40 which was detected at a concentration of 0.97 pCi/g weight. This is similar to concentrations observed in previous years.

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 from nuclear facilities) or from 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), broad-leaved edible vegetation such as cabbage or lettuce, and fruits, are collected from farms in the vicinity of Davis-Besse.

In 1990 broad leaf vegetation samples were collected at two indicator locations (T-8 and T-25) and one control location (T-37). Fruit samples were collected

from two indicator (T-8 and T-25) and three control (T-23, T-37, and T-173) locations. Samples were collected once a month during the growing/harvest season, from July through September. All samples were analyzed for gamma emitting radionuclides, strontium-89, strontium-90, and iodine-131.

In all the samples, strontium-89 was not detected above the LLD of 0.028 pCi/g wet weight. Strontium-90 was detected at one indicator site in a broad leaf vegetation sample at a concentration of 0.007 pCi/g wet weight. This is well within the normal range.

Broad leaf vegetation (cabbage, squash leaves, Kohlrabi leaves, Swiss chard, lettuce and horseradish leaves) and fruit (apples, pears, and grapes) collected during the growing season were analyzed for I-131 by gamma spectral analysis. Broad leaf vegetation is an excellent source for accessing the deposition of radionuclides from atmosphere on the leaves. Iodine-131 was not detected above the LLD of 0.043 pCi/g wet weight.

No gamma emitting radionuclides, except naturally occuring potassium-40 were detected. In fruits, the average potassium-40 concentrations were 1.01 pCi/g wet weight and 1.93 pCi/g wet weight for indicator and control locations, respectively. In vegatation, the concentrations of potassium-40 were 4.35 pCi/g wet weight for indicator locations and 1.53 pCi/g wet weight for control locations.

Although the average concentration of potassium-40 at indicator locations was approximately twice that at control locations in 1990, this radionuclide is not produced by nuclear power stations, and, thus could not be attributable to the operation of Davis-Besse. The disparity between control and indicator potassium-40 averages may be due to the fact that different types of vegetation (e.g., cabbage versus squash leaves) were sampled at control and indicator locations, and different types of plants accumulate different concentrations of potassium-40.

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 an indication of airborne radionuclides deposited in the vicinity of the Station. Analyses from animal/wildlife feed samples also provide data for determining radionuclide concentrations in the food chain. Domestic animal feed samples are collected annually at both 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 at two indicator (T-8 and T-197) and one control (T-57) locations. The feed collected consisted of hay, silage, corn, and chicken feed. The samples were analyzed for gamma emitting radionuclides.

- Wildlife Feed:

  Wildlife feed was collected at 2 sites (T-31 and T-198 Toussaint Wildlife Area) and consisted of cattails, coontail, millets and smartweed. The samples were analyzed for gamma emitting radionuclides.

In cattle feed, chicken feed, and wildlife feed, the only gamma emitting radionuclides detected were beryllium-7 and potassium-40: both are naturally occurring radionuclides not produced at nuclear plants. Beryllium-7 was detected in two indicator locations at an average concentration of 0.50 pCi/g wet weight. The annual average potassium-40 concentration for control location was 1.48 pCi/g wet weight compared to the average value of 5.39 pCi/g for the indicator locations.

The type of plants collected for animal feed will influence the potassium-40 concentrations found. For instance, hay samples collect more potassium than other crops or wild feed. Also, crops that are fertilized possess more potassium because it is readily available in fertilizer and therefore, more available for the plants to absorb it.

The normal range of berryllium-7 concentrations is 0.15 to 1.61 pCi/g wet weight. The normal range for potassium-40 is 1.17 to 14.4 pCi/g wet weight. Thus, the concentrations of these radionuclides measured in 1990 were typical for the types of feed sampled. In addition to being analyzed for gamma emitting radionuclides, all grass amples were analyzed for iodine-131; however, iodine-131 was not detected in any of these samples. No other radionuclides were detected.

Soil Samples

Soil samples are generally collected twice a year at all sites equipped with air samplers. Only the top layer of soil is sampled in an effort to identify possible trends in the local environmental nuclide concentrations caused by atmospheric deposition of fallout and Station-released radionuclides. Generally, the sites selected 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 the analyses. Approximately five pounds of soil are taken from the top two inches at each site. Many naturally occurring radionuclides (e.g., berryllium-7, potassium-40) and fallout radionuclides from nuclear weapons testing are usually detected. Fallout radionuclides which are often detected include strontium-90, cesium-137, cerium-141, cerium-144, and ruthenium-106.

During 1990 soil was collected at 11 sites in June and October. The indicator locations included T-1, T-2, T-3, T-4, T-7, and T-8. The control locations included: T-9, T-11, T-12, T-23, and T-27.

The predominant activity was attributable to the presence of potassium-40 which had an average concentration of 11.93 pCi/g dry weight at the indicator locations and 15.59 pCi/g dry weight at control locations. Potassium-40 is part of the natural environment and is expected to be found in soil. The typical potassium-40 concentrations for the locations range from 9.70 pCi/g dry weight to 25.82 pCi/g dry weight.

Cesium-137 is a man-made radionuclide that is normally present in top few inches of soil as a result of fallout from nuclear weapons testing. Cesium-137 was detected at both indicator and control locations. The average concentration for the indicator locations was 0.40 pCi/g dry weight and 0.38 pCi/g dry weight at control locations. The concentrations and distribution patterns were similar to those observed in previous years. No other radionuclides were detected above the respective LLDs.

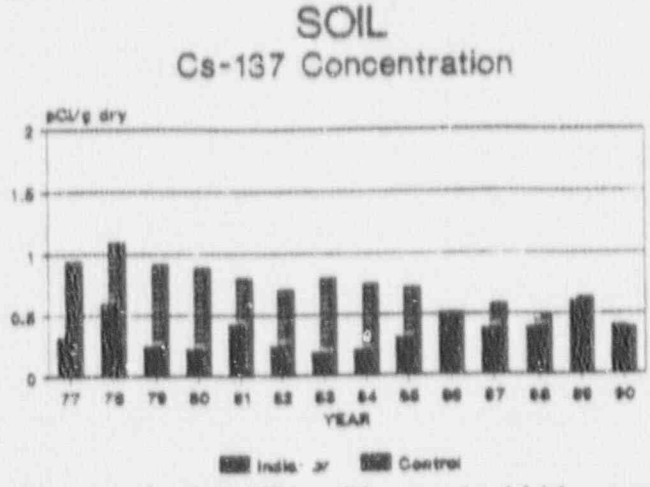


Figure 2-8: The concentration of cesium-137 in soil has remained fairly constant over the years the REMP has conducted sampling. The peak observed in 1978 was due to fallout from nuclear weapons testing.

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 from the immersion (swimming) in the water. Internal exposure can occur from ingestion of radionuclides, either directly from drinking water, or as a results of the transfer of radionuclides through aquatic food chain with eventual consumption of aquatic organism, such as fish. To monitor these pathways, Davis-Besse samples treated surface water (drinking water), untreated surface water (lake or river water), fish and shoreline sediments.

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 from three indicator (T-28, T-50, and T-144) and three control locations (T-11, T-12, and T-23). 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 into a quarterly sample and analyzed for strontium-89, strontium-90, gamma emitting radionuclides and tritium. One QC sample was collected from a routine location which was changed each month.

In treated water samples, beta emitting radionuclides were detected at one site (T-11) in suspended solids at a concentration of 0.7 pCi/l. The average concentration was similar in dissolved solids for indicator and control (2.2 and 2.1 pCi/l, respectively). The annual average beta emitting radionuclides was similar to concentration observed in previous years (Fig. 2-9).

All tritium analysis results were less than the LLD of 330 pCi/l. All strontium-89 and strontium-90 analysis results were less than their respective LLDs of 2.4 pCi/l and 1.0 pCi/l. Additionally, all cesium-137 results were less than the LLD of 10.0 pCi/l. These results are similar to those of previous years and indicate no measurable effect resulting from the operation of Davis-Besse.

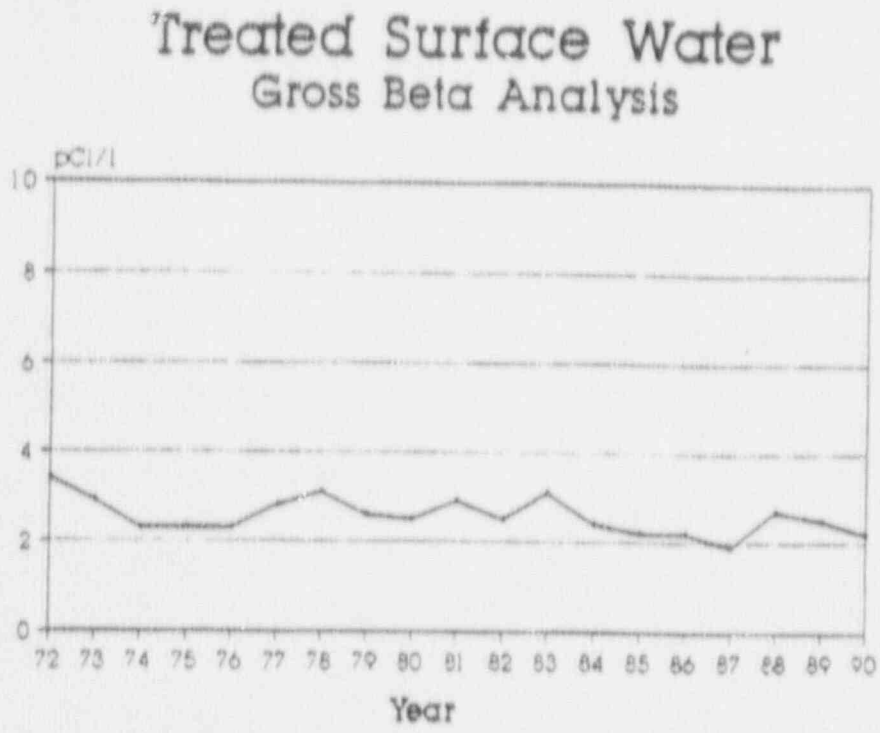


Figure 2-9: The average concentration of beta emitting radionuclides in treated surface water samples collected during 1990 was similiar to concentrations detected in previous years.

A quality control sample (T-143) was collected from a routine sample site each week and composited each month, and the location was varied on a monthly basis. The results of the analyses were consistent with the results obtained at the routine sampling locations.

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 (see Figure 2-10).

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.

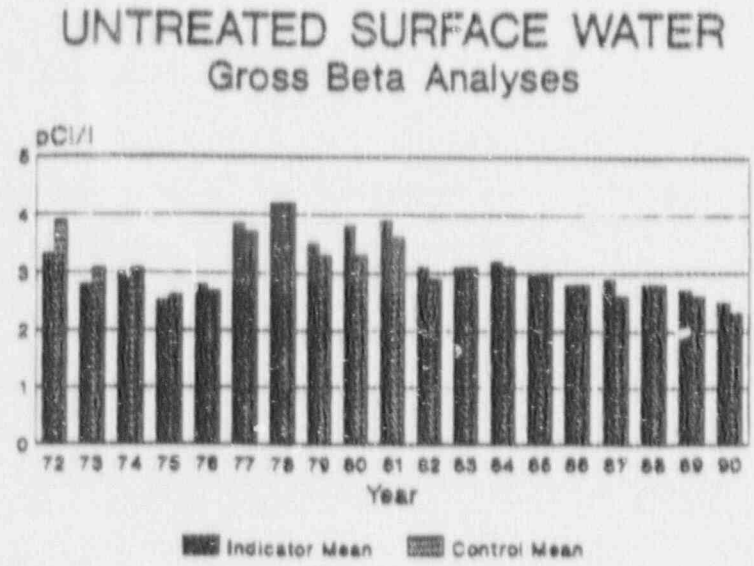


Figure 2-10: Over the past 19 years, the annual average concentrations of beta emitting radionuclides in untreated surface water samples collected from indicator locations have been consistent with those concentraions in samples collected from control locations. This shows that Davis-Besse has had no measurable radiological impact on the surrounding surface water.

In untreated water samples, beta emitting radionuclides in suspended solids were detected at an average concentration of 0.5 pCi/l for indicator and 0.4 pCi/l at control location. In dissolved solids, the average concentrations were 2.5 pCi/l and 2.3 pCi/l for indicator and control sites.

Of the 208 tritium analyses performed on untreated surface water, 206 results were less than the LLD of 330 pCi/l. The concentrations in these two samples with tritium results greater than LLD were 437 pCi/l and 768 pCi/l. It is suspected that these two samples may have been cross-contaminated with non-environmental sample when the sample was composited or analyzed at the laboratory. No other samples collected at the same time from nearby locations showed elevated tritium results, and all other samle collected from T-134 and T-162 during 1990 showed tritium results less than the LLD.

Cesium-137 and strontium-89 were not detected in samples of untreated water above their LLDs of 10 pCi/l and 2.3 pCi/l, respectively. Strontium-90 was detected at both indicator and control and an average concentration of 0.7 pCi/l and 0.8 pCi/l, respectively. These concentrations are similar to concentrations observed in previous years.

Each month, weekly quality control samples were collected at different locations. 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 are provided below:

T - 12 - 2.62 pCi/l	vs.	T - 138 - 2.44 pCi/l
T - 3 - 3.00 pCi/l	vs.	T - 130 - 2.62 pCi/l
T - 11 - 2.30 pCi/l	vs.	T - 164 - 2.60 pCi/l
T - 23 - 1.92 pCi/l	vs.	T - 168 - 2.25 pCi/l
T - 28 - 2.22 pCi/l	vs.	T - 131 - 2.60 pCi/l

Fish Samples

Fish are analyzed primarily to quantify the dietary radionuclide intake by humans, and secondarily to serve as indicators of radioactivity in the aquatic ecosystem. The principal 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 a local commercial fisherman, 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. Only one carp sample could be obtained at T-33 during 1990. The edible portions of fish were analyzed for beta and gamma emitting radionuclides.

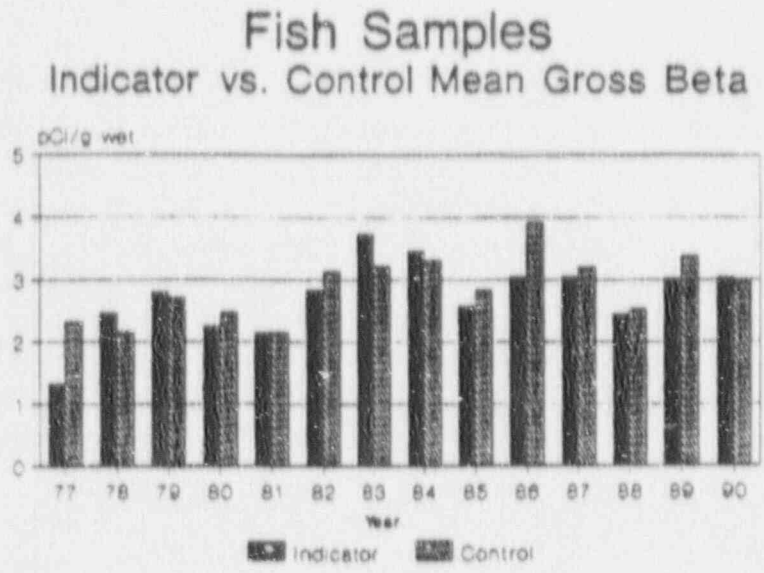


Figure 2-11: Average concentrations of beta emitting radionuclides in fish samples were similiar at indicator and control locations and were within the range of results from previous years.

Fig.2-11 shows that the average concentration of beta emitting radionuclides in fish muscle was similar for indicator and control locations (3.04 and 2.98 pci/g wet weight,respectively). The predominant gamma emitting radionuclide detected was the naturally occurring potassium-40. The average concentration at the indicator location was 2.77 pCi/g wet weight and 2.80 pCi/g wet weight for control locations. Cesium-137 was detected in one indicator location (T-33, walleye sample), at a concentration of 0.13 pCi/g wet weight. All the sample analysis results were within normal ranges compared to previous years.

Shoreline Sediments

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

Samples of deposited sediments in water were collected in May and October from two indicator locations (T-3 and T-4) and two control locations (T-23 and T-27). The samples were analyzed for gamma emitting radionuclides.

Naturally occurring potassium-40 averaged 12.8 and 11.6 pCi/g dry weight at indicator and control locations. Cesium-137 was detected at one control location T-23 at a concentration of 0.49 pCi/g dry weight.

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 (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.

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. Davis-Besse measures direct radiation at 95 locations. These locations include indicator and control locations. Additionally, there are 20 duplicate or QC sites.

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 95 TLD locations (71 indicator and 24 control) which are collected and replaced on a quarterly and annual basis. Twenty QC TLDs are also collected on a quarterly and annual basis or at any given time. There are a total

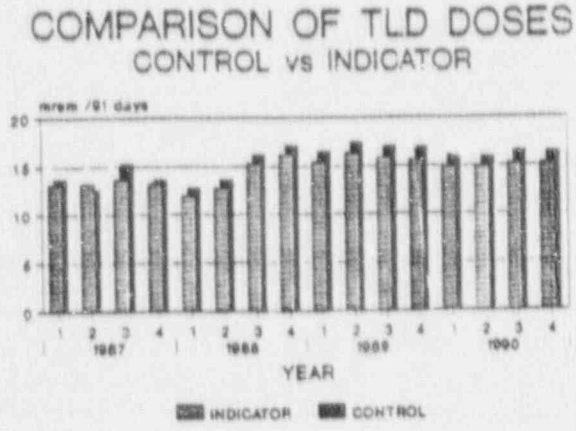


Figure 2-12: The similiarity of the indicator and control results demonstrate that the operation of Davis-Besse has not caused any abnormal gamma dose.

of 230 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 1990, the annual average value for all indicator locations was 15.1 mR/91 days, and for all control locations was 16.2 mR/91 days. The annual average value for all TLDs in 1990 was 15.4 mrem/91 days. This average value is slightly lower than 1989 and within normal range of the previous years as shown below:

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

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 same 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 at the routine TLDs averaged 14.3 mrem while the quality control TLDs yielded an average dose of 15.3 mrem. 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 the Panasonic Model UD801 TLD, which has 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 16.4 mrem/91 days for the Davis-Besse TLDs and 16.5 mrem/91 days for the NRC TLDs (data from first and third quarters only). The variance in these measurements is most likely due to the differences in the TLD materials.

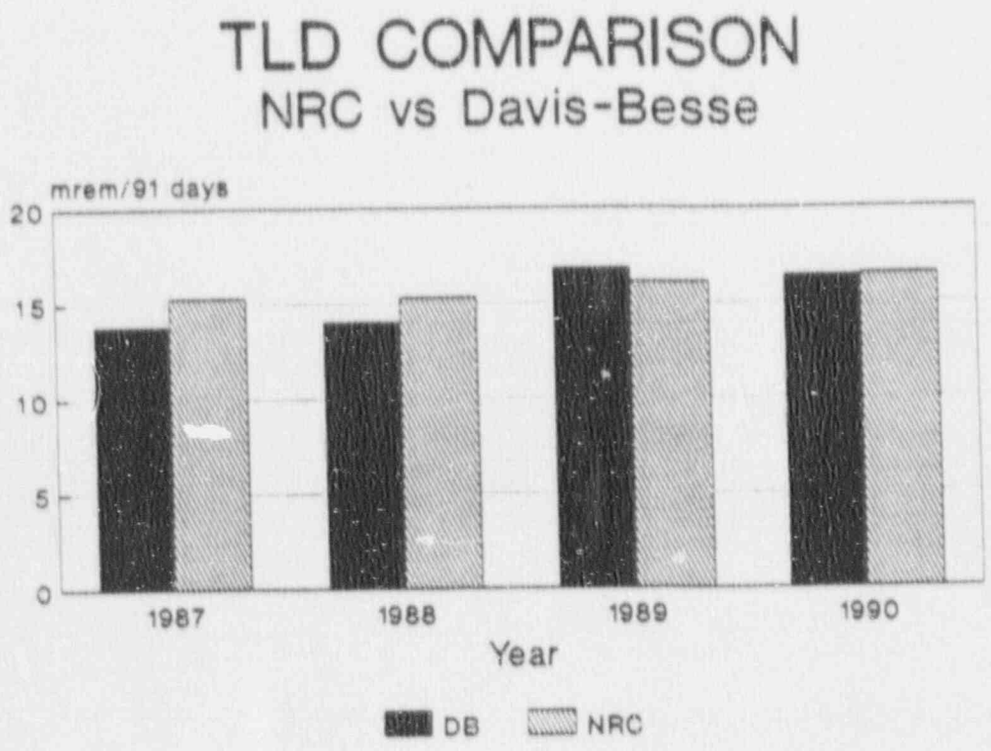


Figure 2-13 compares NRC and Davis-Besse's TLDs for the last four years.

CONCLUSION

The Radiological Environmental Monitoring Program at Davis-Besse is conducted to determine the radiological impact the Station's operation on the environment. Radionuclide concentrations measured at control locations, in previous operational studies and in the preoperational surveillance program. These comparisons indicate normal concentrations of radioactivity in all environmetnal samples collected in 1990. No adverse effects attributable to the operation of Davis-Besse were detected in any of the sampling media collected and analyzed during 1990. In fact, the dose to local residents 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 1990 are summarized in Appendix E of this report.

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Land Use Census

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 Regulations, 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 1990 Land Use Census was performed during the month of July. In order to gather as much information as possible, the locations 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 1990 census:

- **SSE Sector** - A milk goat deleted at 3467 meter. The residence and vegetation pathways at 2030 and 2830 meters were changed to 2010 and 2900 meters. These changes were due to an increased accuracy in measurement.

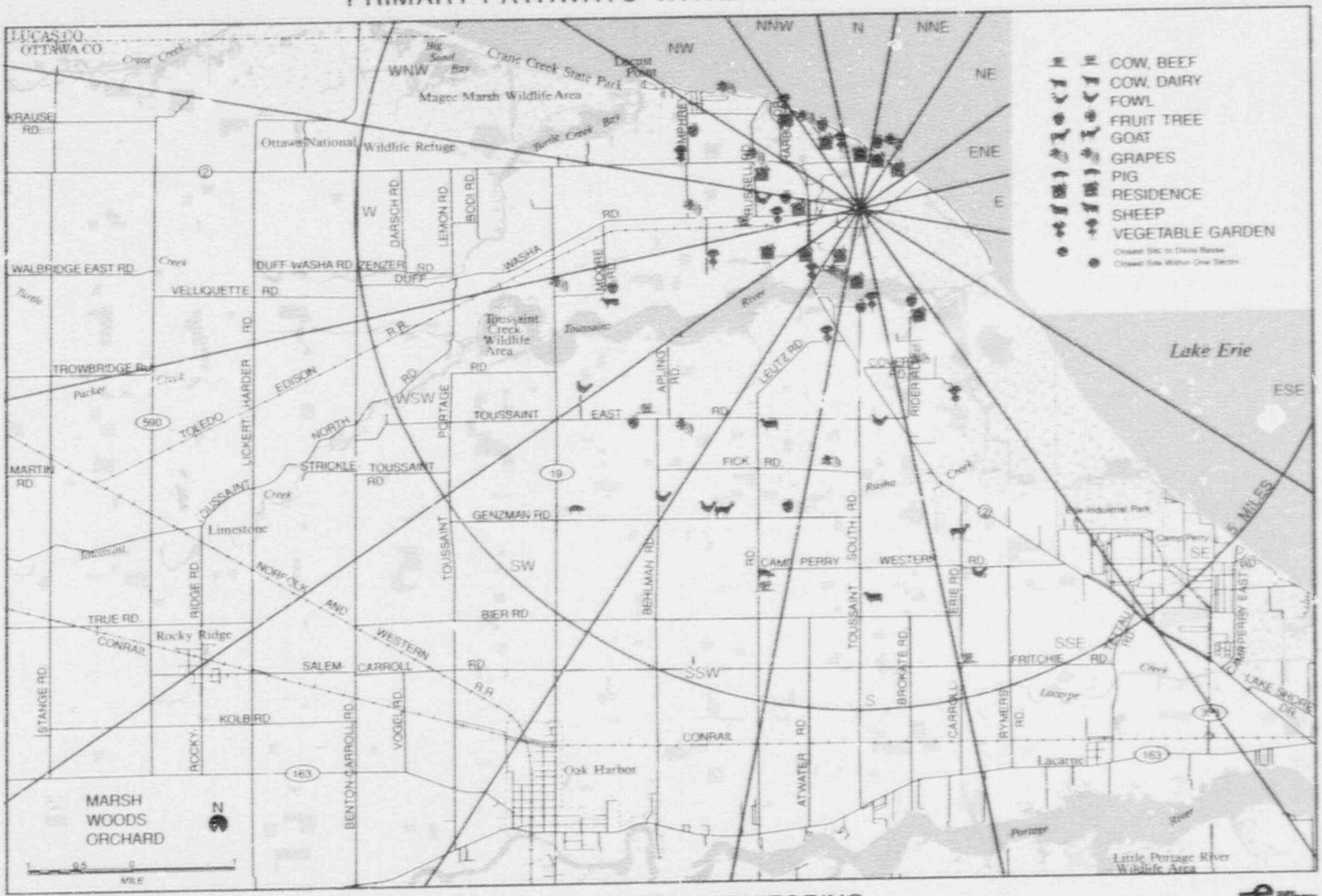
- **S Sector**-The vegetation pathway at 2560 meters was deleted in favor of a closer garden at 1450 meters. The residence at 1090 meters is changed to 1070 meters. The actual location of residence is the same as 1989 census.
- **SSW Sector**- The residence and garden located at 960 and 980 meters changed to 980 and 2180 meters. The residence was changed due to measurement improvement and the garden at 980 meters was not present in 1990.
- **SW Sector**-A garden at 1340 meters was added. The garden at 1220 meters was not present in 1990.
- **WSW Sector**- The residence, garden and milk cow changed to 1620, 2640, and 4270 meters. The changes are due to improvement in measuring accuracy. The actual ground locations remained the same.
- **W Sector** - The garden at 1050 meters was added because the garden at 980 meters was not present in 1990.
- **WNW Sector** - The residence and vegetation pathway at 1310 and 2900 meters, respectively, were changed to 1730 and 3290 meters, respectively.
- **NW Sector** - The residence and vegetation pathway at 1730 and 2290 meters, respectively, were changed to 1980 and 2040 meters, respectively.
- **NNW Sector**- The residence and vegetation pathway at 1250 and 1490 meters were deleted in favor of a closer location at 1210 meters.
- **Critical Pathway** - The critical pathway for 1989 was west sector at 980 meters for child/vegetation. The critical pathway for 1990 changed to WSW at 4270 meters for infant/milk pathway.

The detailed pathway 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.

There were a number of changes in the 1990 Annual Land Use Census. The majority of these changes were due to improvements in measuring the distance from the station vent. The actual ground location in these sectors were the same as last year only the distance measured changed (see Table 3-1).

Table 3-2 provided information on the 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 Calculation 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
LAND USE CENSUS 1990
PRIMARY PATHWAYS WITHIN 5 MILE RADIUS



ENVIRONMENTAL MONITORING

Figure 3-1

Table 3-1: Closest Exposure Pathways Present in 1990

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

*Changes since 1989.

Table 3-1: Closest Exposure Pathways Present in 1990
(continued)

Sector	Distance from Station (meters)	Closest Pathways
*SSW	980	Inhalation Ground Exposure Plume Exposure
*SSW	2180	Inhalation Ground Exposure Plume Exposure Vegetation
SW	1050	Inhalation Ground Exposure Plume Exposure
*SW	1340	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 1989.

Table 3-1: Closest Exposure Pathways Present in 1990
(continued)

Sector	Distance from Station (meters)	Closest Pathways
*W	1050	Inhalation Ground Exposure Plume Exposure Vegetation
*WNW	1730	Inhalation Ground Exposure Plume Exposure
*WNW	3290	Inhalation Ground Exposure Plume Exposure Vegetation
*NW	1980	Inhalation Ground Exposure Plume Exposure
*NW	2040	Inhalation Ground Exposure Plume Exposure Vegetation
*NNW	1210	Inhalation Ground Exposure Plume Exposure Vegetation

*Changes since 1989.

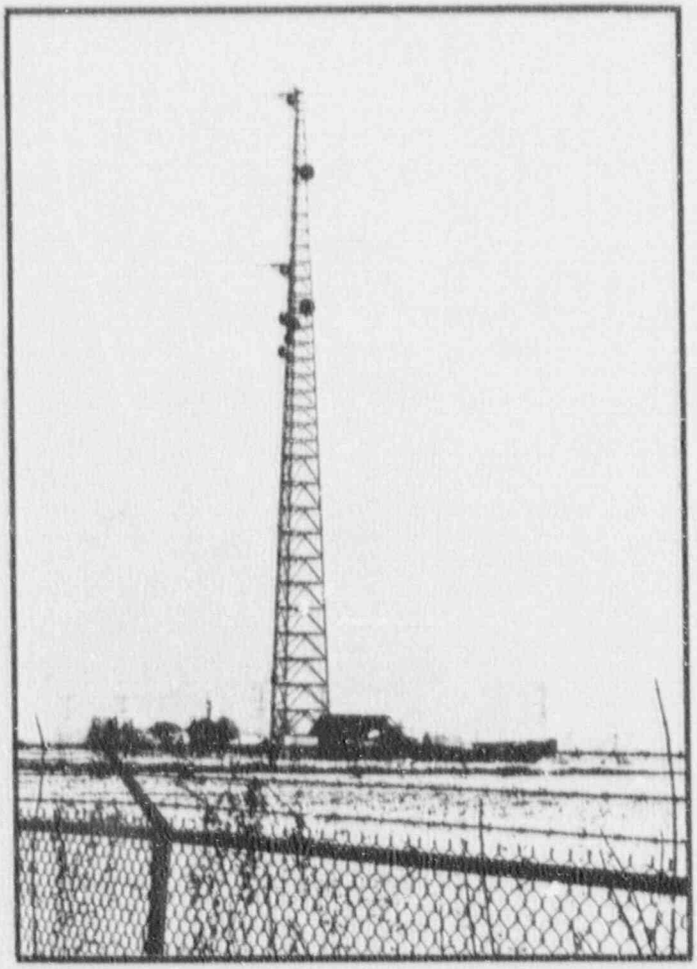
Table 3 - 2: Pathway Locations and Corresponding Atmospheric Dispersion(X/Q) and Deposition(D/Q) Parameters

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**	2180	vegetation	child	6.45E-08	1.19E-09
SW**	1340	vegetation	child	2.10E-07	3.94E-09
WSW***	4270	cow/milk	infant	5.71E-08	5.31E-10
W**	1050	vegetation	child	5.72E-07	8.87E-09
WNW**	3290	vegetation	child	6.28E-08	5.18E-10
NW**	2040	vegetation	child	8.25E-08	7.28E-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 1989.

***Changes in measurement but not actual ground location.



Meteorological Monitoring

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 Davis-Besse began in October 1968. The Meteorological Monitoring Program at Davis-Besse has provided data, with very little data loss, since the Station began operation in 1977. This has provided an extensive record of meteorological information that can be used by many programs at Davis-Besse. 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 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, as well as local residents. Onsite meteorological data would also be a valuable tool in the unlikely event of an emergency at Davis-Besse. 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 at Davis-Besse, 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** (air temperature at 100 or 75 m minus air temperature 10 m), **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 this data.

Meteorological Instrumentation

The meteorological system consists of one monitoring site located at a grade level of 577 feet above mean sea level. A 340 ft (100 m) free-standing tower located about 3000 feet SSW of the cooling tower, and an auxiliary 35 ft (10m) foot tower located 100 feet west of the 340 ft tower, are used to gather the meteorological data. The 340 ft tower is instrumented for wind speed and wind direction at 340 ft (100 m) and 250 ft (75 m). The 35 ft (10 meter) tower is instrumented for wind speed and wind direction. The 350 ft tower also measures two **differential temperatures (delta T's)** : 340-35 ft and 250-35 ft (100-10 m and 75-10 m, respectively). 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 35 ft (10 m) tower. According to the Davis-Besse Nuclear Power Station, Operating License, Appendix A, Technical Specifications, 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 (refer to Figure 4-2): to an ADAC System-1000 computer (PDP 11/03) located in the meteorological shelter, to a computer in the Control Room, and to four Esterline-Angus strip chart recorders located in the meteorological shelter which are used if the PDP 11/03 and Control Room data are not available. The PDP 11/03 also communicates data to a PDP 11/34 computer located

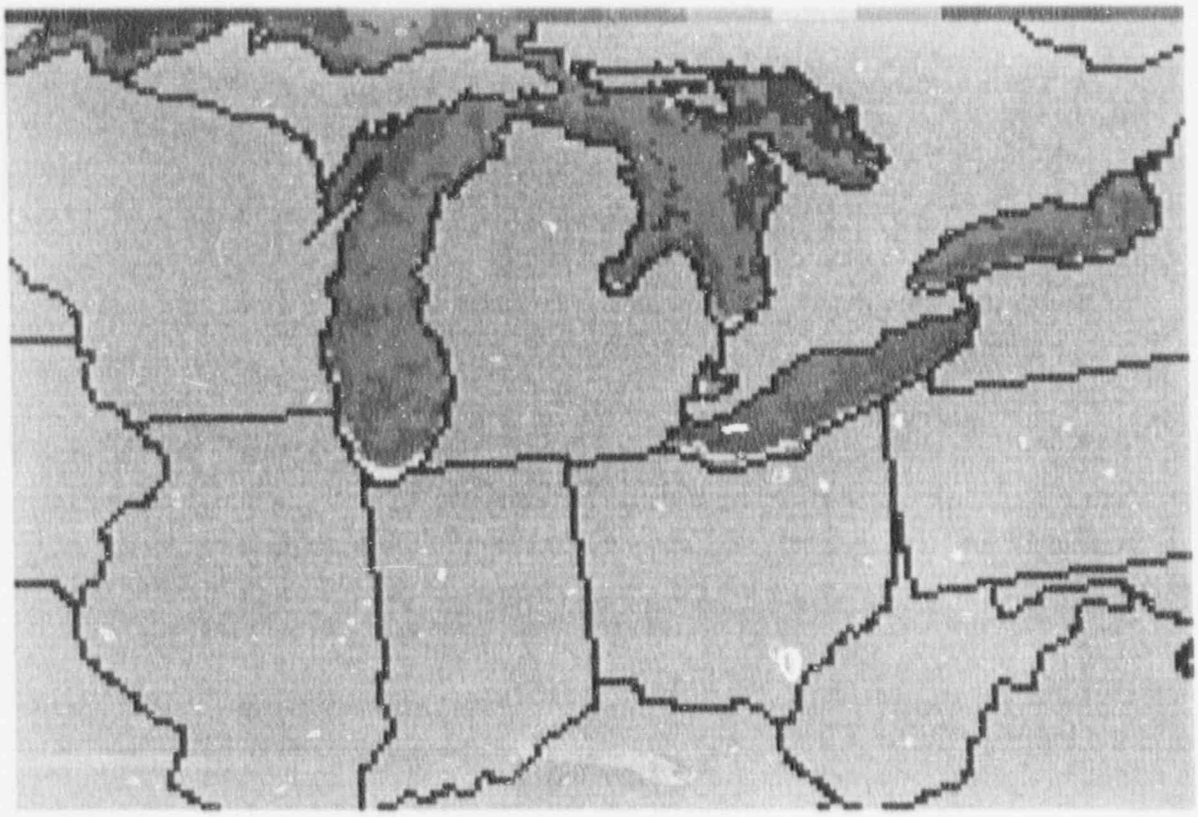
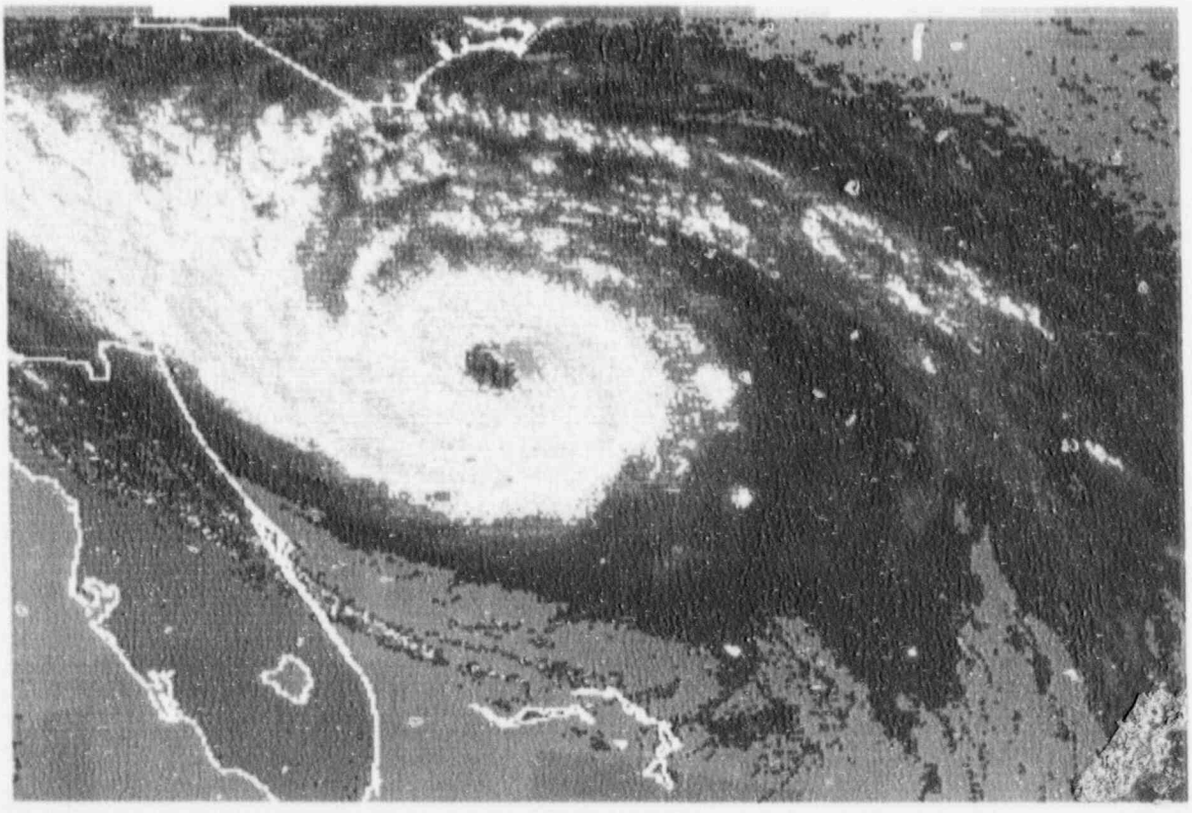


Figure 4-1(Above) Great Lakes water temperature are monitored through infrared satelite imagery.

Figure 4-2:(Below) Geostationary Operational Environmental System (GOES) imagery 22,000 miles (3500km) above the earth detailing weather characteristic globally. This information can be accessed to aid in identifying major storm systems which could impact Stations operations. Source: Weather Incorportated System (1989).



Additional data losses during the year were as follows:

- January: Ice stom freezes 340 foot(100meter) 250 foot (75meter sensors temporary sensor failure). High winds break 35 foot (10m) windspeed sensor.
- February: Ice storm freezes all sensors temporarily.
- August: Lightning strike, temporary computer failure.

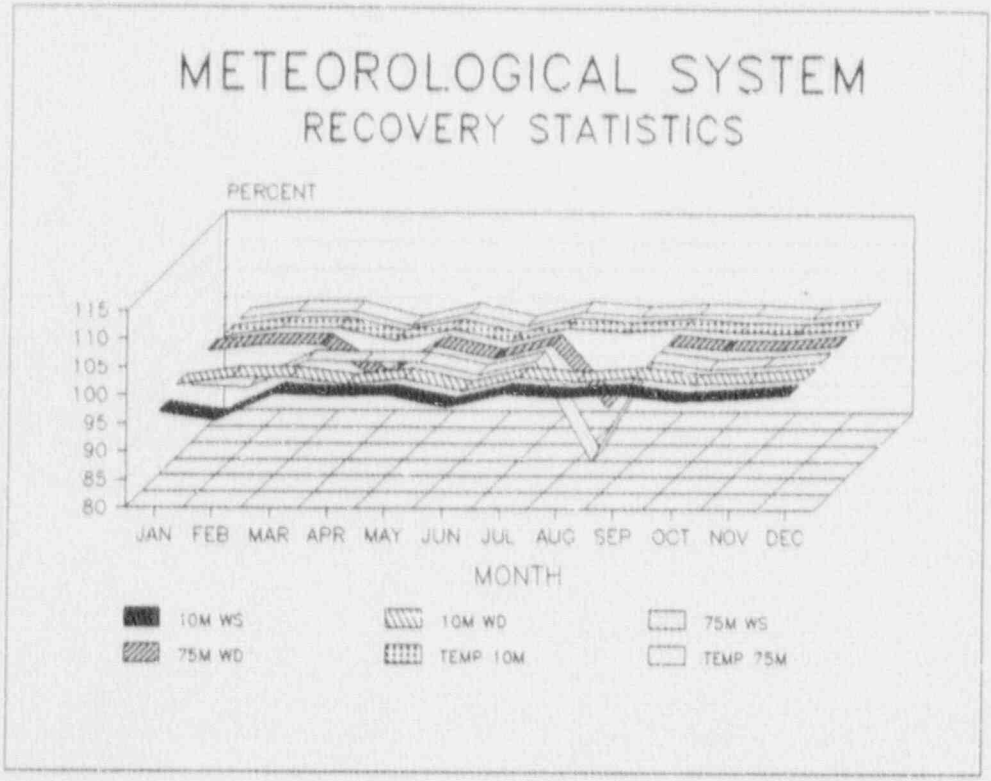


Fig. 4-4: Davis- Besse Technical Specification requires six sensors to be to be operable on site during plant operation. Data loss from these six sensors were minimal resulting in a data recovery of greater than 90% for 1990. See table 4-1.

Meteorological Data Summaries

This section presents summaries of the meteorological data collected from the onsite monitoring program at Davis-Besse during 1990. Tables 4-2 through 4-7, discused in this section, can be found on pages 4-27 through 4-34. Table 4-2 sum-

In the area surrounding Davis-Besse, the lake breezes are deflected clockwise 12 degrees each hour until about midnight. As the land cools, a land breeze from late evening to mid-morning develops, resulting in winds from the SSW and WSW. In general, lake/land breezes occur at Davis-Besse from April through September, with a peak in May.

Current and reliable information on local weather patterns (such as the lake/land breeze effect) and global weather patterns is crucial for Davis-Besse personnel responsible for monitoring atmospheric dispersion characteristics in the unlikely event of a radiological emergency at the Station.

Wind Speed and Wind Direction

The maximum hourly average wind speeds for 1990 were 54.49 mph for the 100m level on January 25, 50.6 mph for the 75m level on January 25, and 37.14 mph for the 10m level on January 25.

Figure 4-5 gives an annual and monthly **wind rose** of average wind speed and percent frequency by direction measured at the 100 m level in 1990. Wind roses get their name because the circular pattern of each graph resembles a flowering rose. Each wind sector has two radial bars, the darker bar represents the percent of time the wind blew from that direction. The hatched bar represents the average speed of the wind from that direction. Wind direction sectors are classified using Pasquill Stabilities (Table 4-3, page 4-31). Calms (less than or equal to 1.0 mph) are shown in percent in the middle of the wind rose. The 75 m wind rose is given in Figure 4-6 and the 10 m wind rose in Figure 4-7.

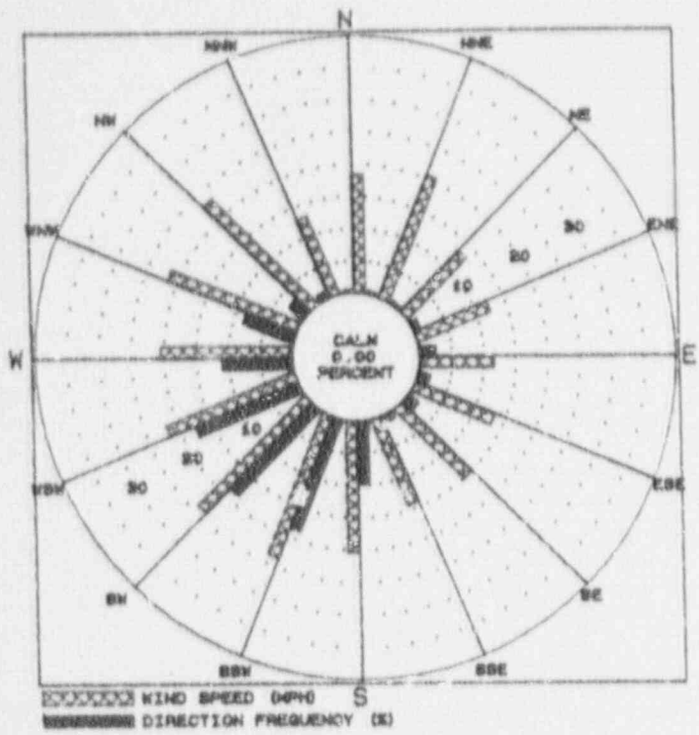
Ambient Temperature

Monthly minimum and maximum temperatures for 1990 are given in Table 4-2. These data are measured at the 10m level. The maximum monthly average temperature was 72.3^{0}F(22.4^{0}C) for July. The extreme maximum was 97.9^{0}F(36.6^{o}C) on July 4, and the extreme minimum was 4.43^{0}F(-15.4^o C) on December 24.

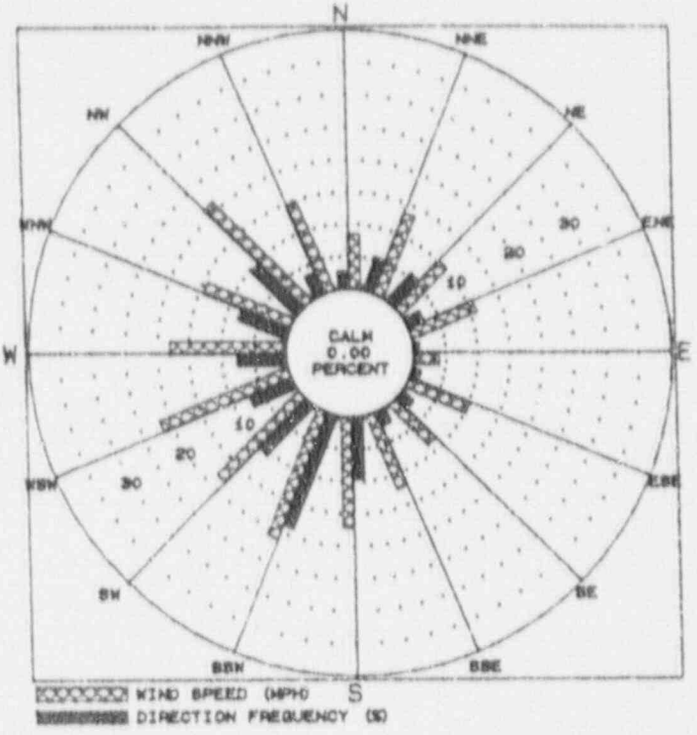
Dew Point Temperature

Monthly average and extreme dew point temperatures for 1990 are also provided in Table 4-2. These data are measured at the 10m level. The maximum daily average dew point temperature was 63.0^{0}F(17.2^o C) for August. The extreme maximum was 75.5^{0}F(24.2^o C) on August 27, and the extreme minimum was -6.7^{0}F(-21.5^{o}C)on Februrary 25.

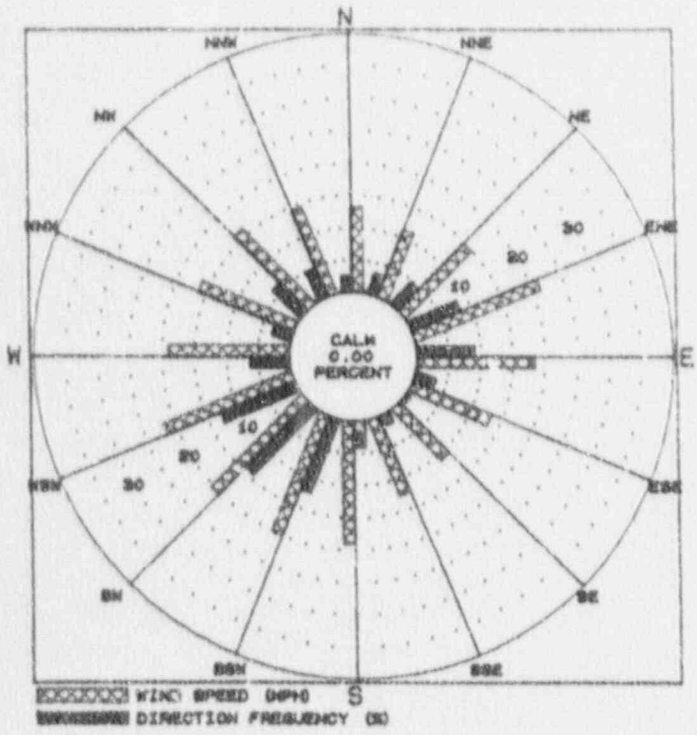
Fig. 4-4: 100 Meter Wind Rose for January through December 1990.



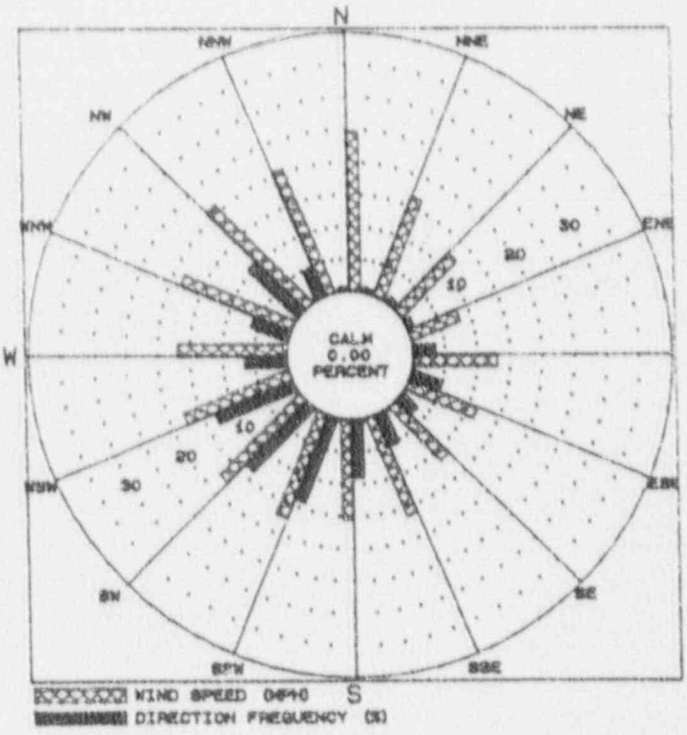
DAVIS-BESSE
JANUARY 1990
100M LEVEL



DAVIS-BESSE
FEBRUARY 1990
100M LEVEL

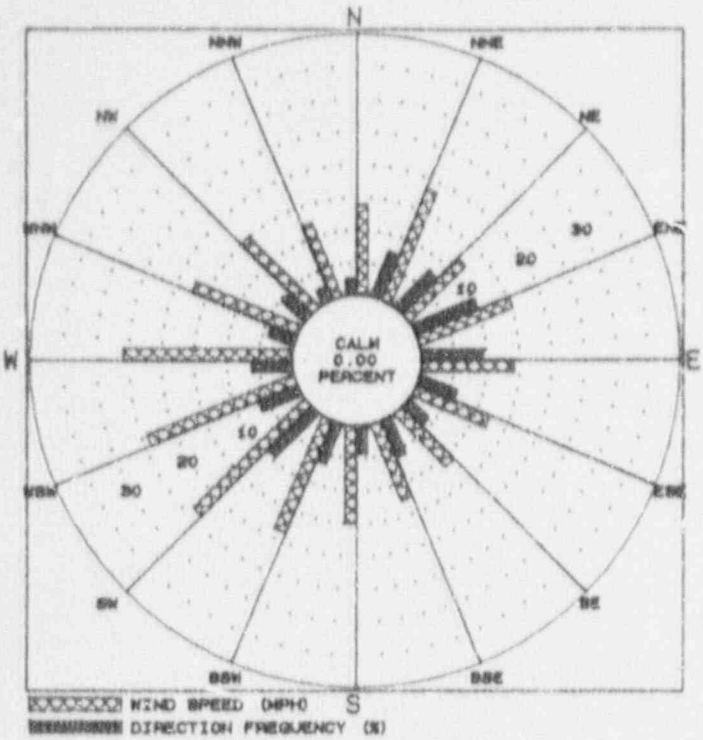


DAVIS-BESSE
MARCH 1990
100M LEVEL

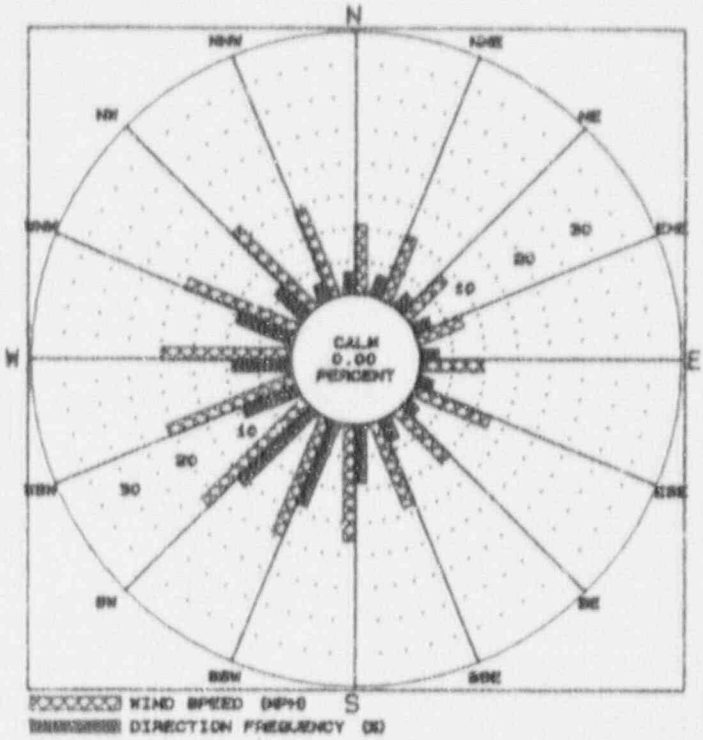


DAVIS-BESSE
APRIL 1990
100M LEVEL

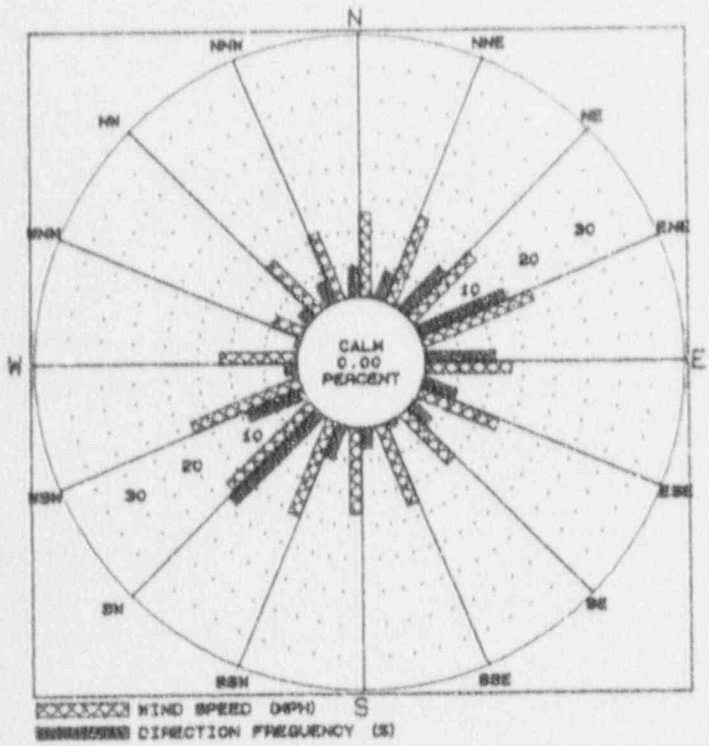
Fig. 4-4 (continued): 100 Meter Wind Rose for January through December 1990.



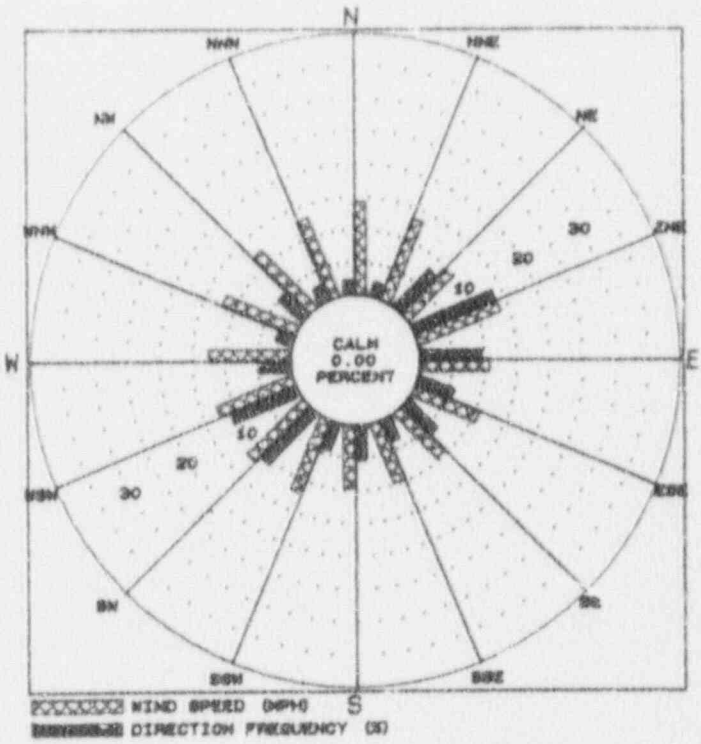
DAVIS-BESSE
MAY 1990
100M LEVEL



DAVIS-BESSE
JUNE 1990
100M LEVEL

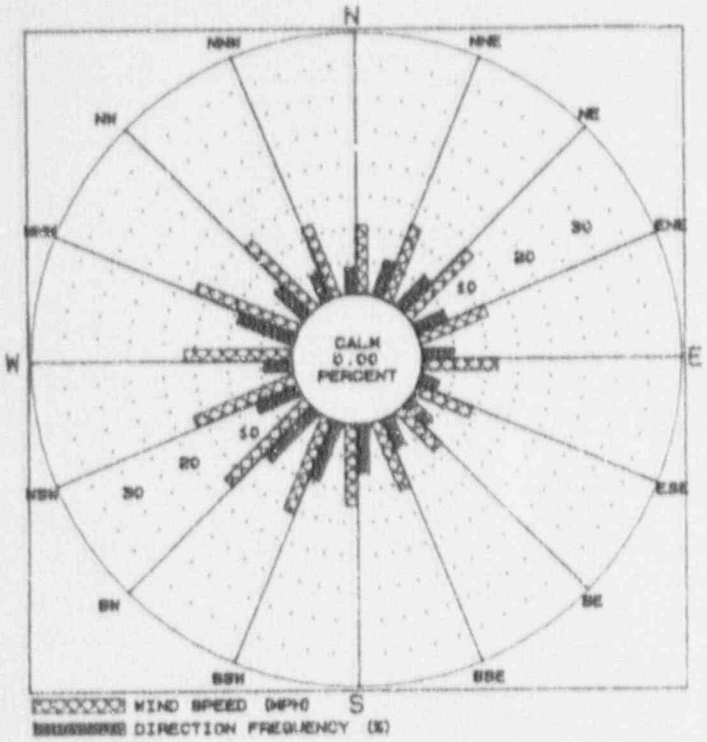


DAVIS-BESSE
JULY 1990
100M LEVEL

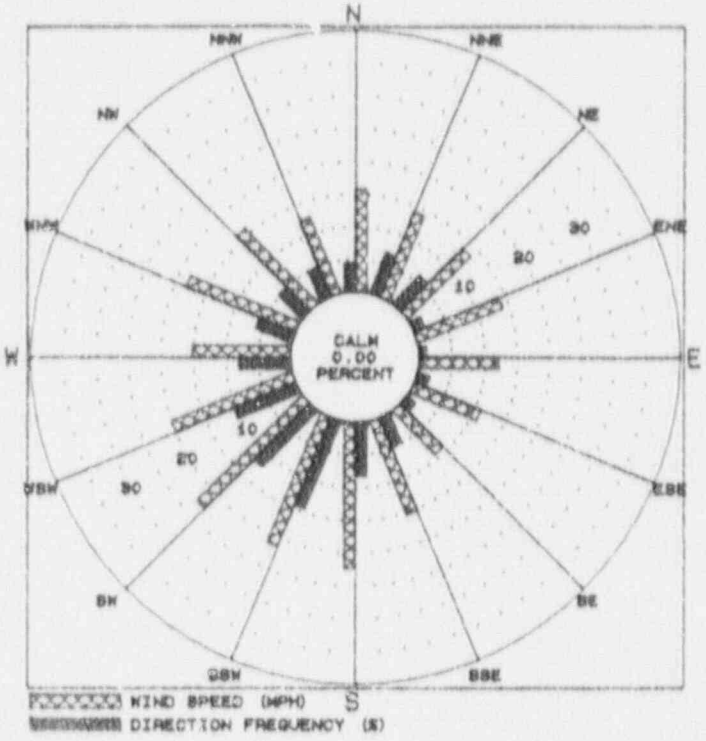


DAVIS-BESSE
AUGUST 1990
100M LEVEL

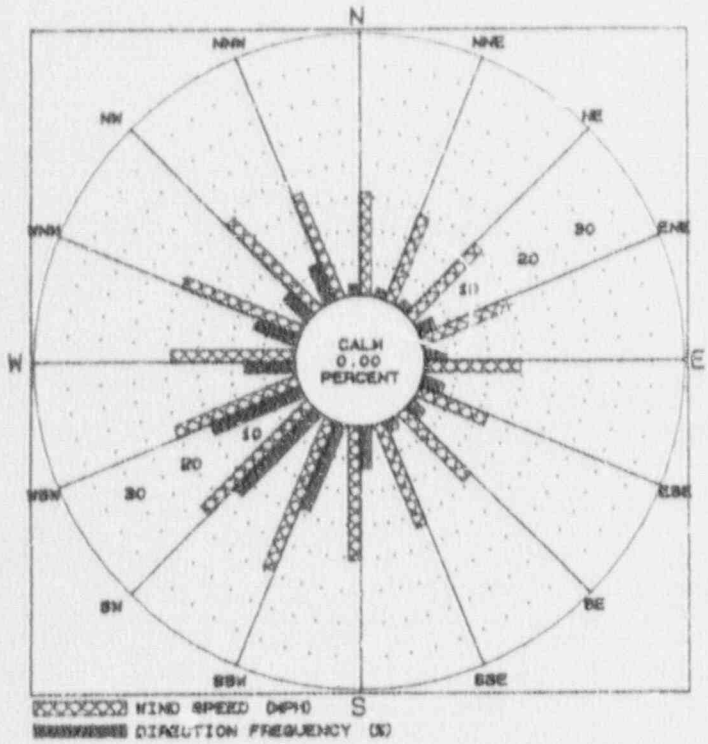
Fig. 4-4 (continued): 100 Meter Wind Rose for January through December 1990.



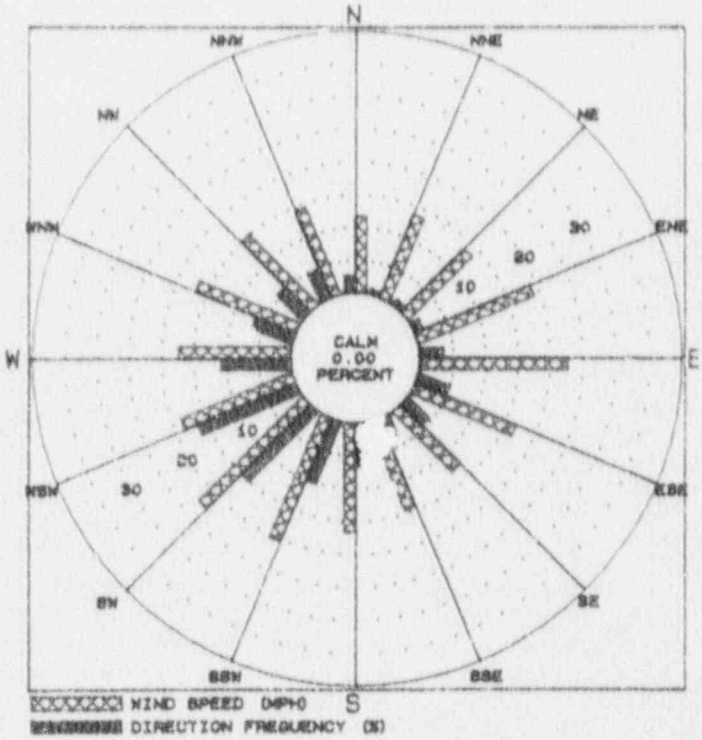
DAVIS-BESSE
SEPTEMBER 1990
100M LEVEL



DAVIS-BESSE
OCTOBER 1990
100M LEVEL

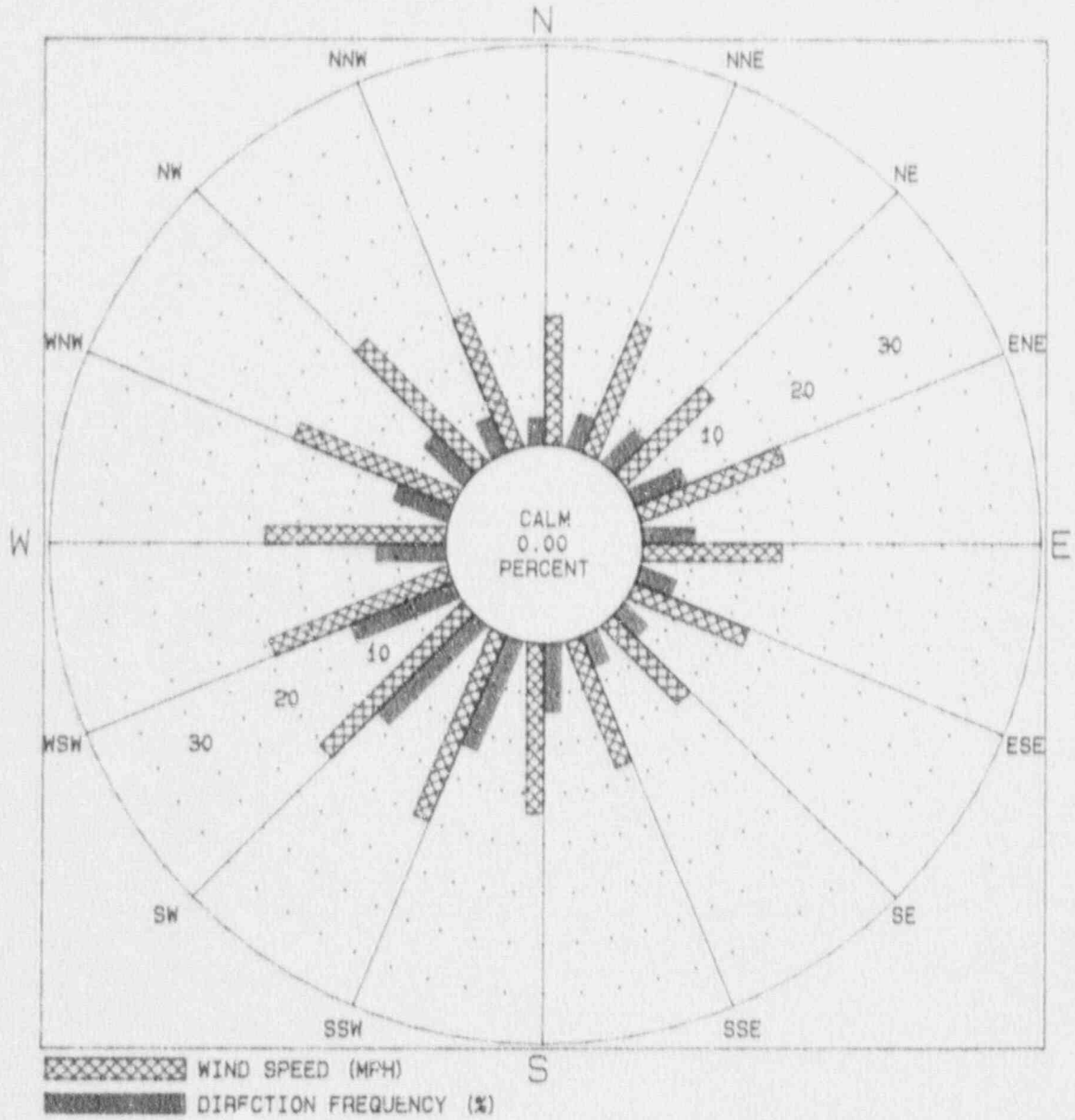


DAVIS-BESSE
NOVEMBER 1990
100M LEVEL



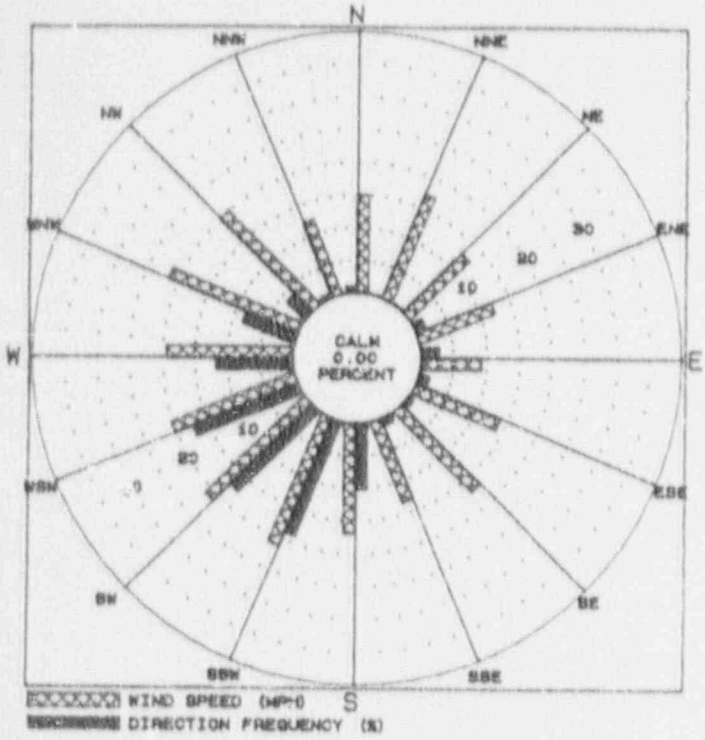
DAVIS-BESSE
DECEMBER 1990
100M LEVEL

Fig. 4-4 (continued): 100 Meter Wind Rose for January through December 1990.

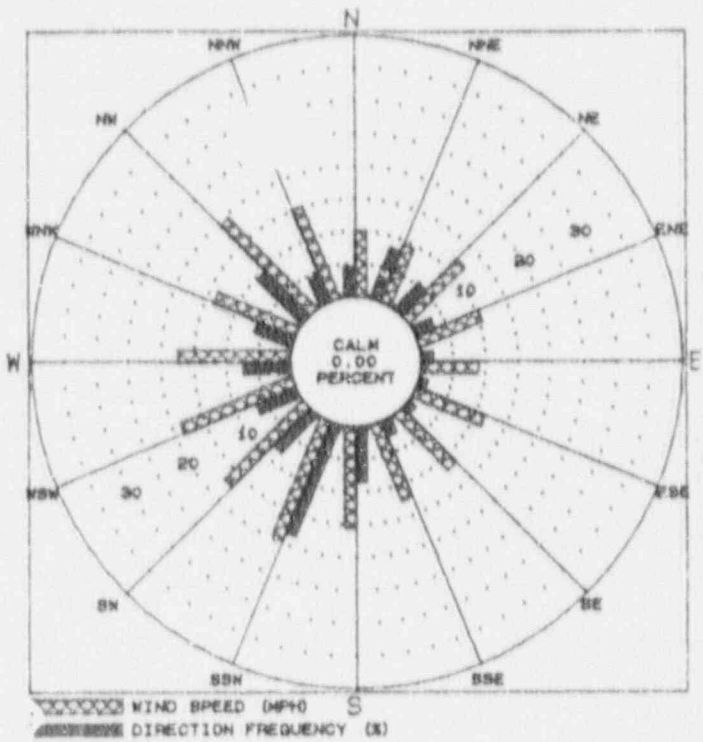


DAVIS-BESSE
ANNUAL 1990
100M LEVEL

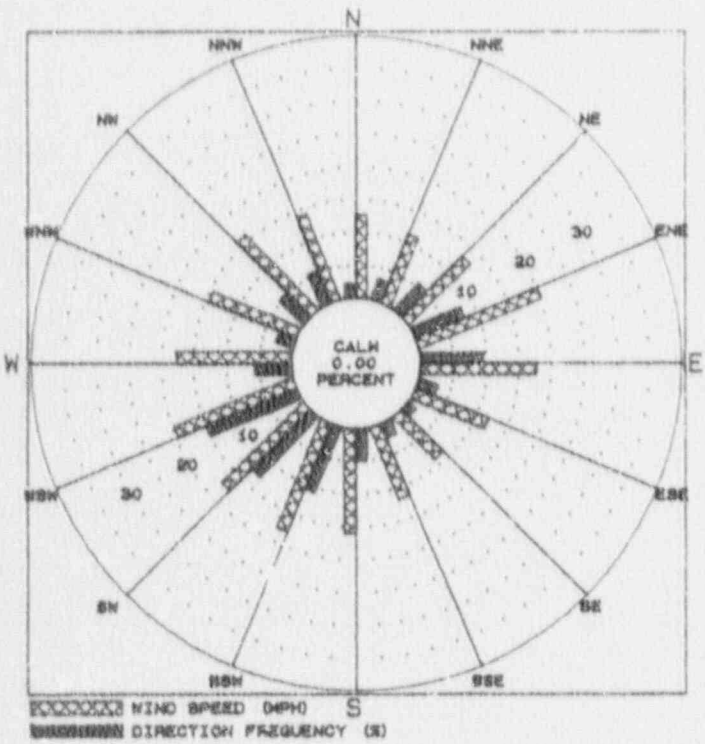
Fig. 4-5: 75 Meter Wind Rose for January through December 1990.



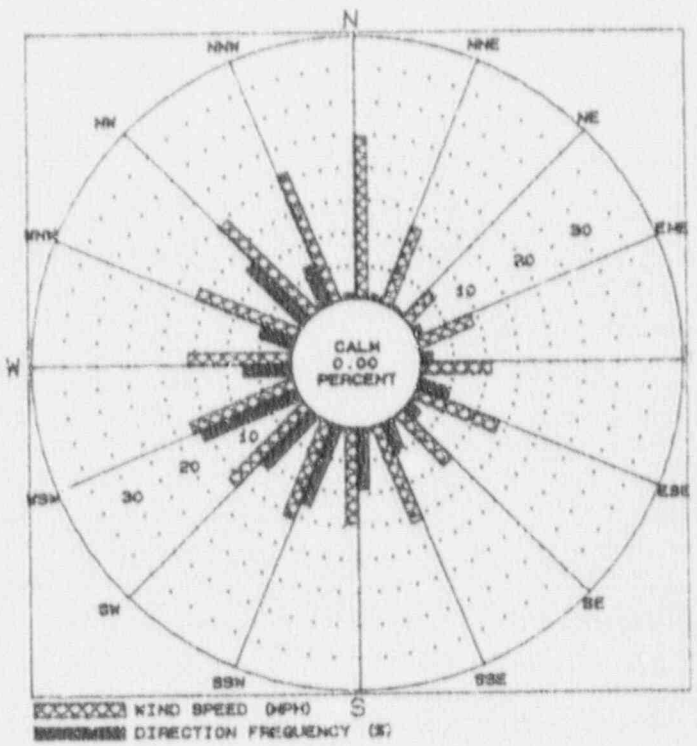
DAVIS-BESSE
JANUARY 1990
75M LEVEL



DAVIS-BESSE
FEBRUARY 1990
75M LEVEL

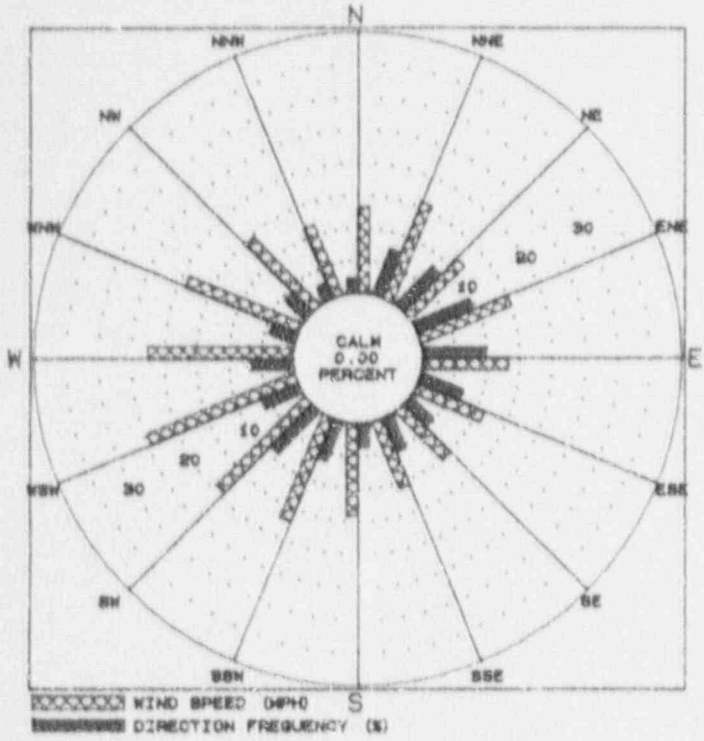


DAVIS-BESSE
MARCH 1990
75M LEVEL

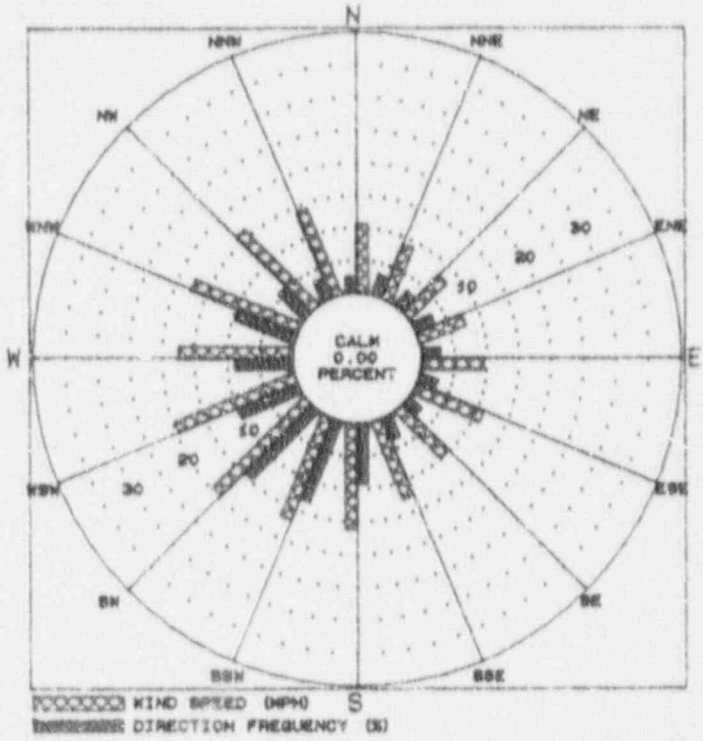


DAVIS-BESSE
APRIL 1990
75M LEVEL

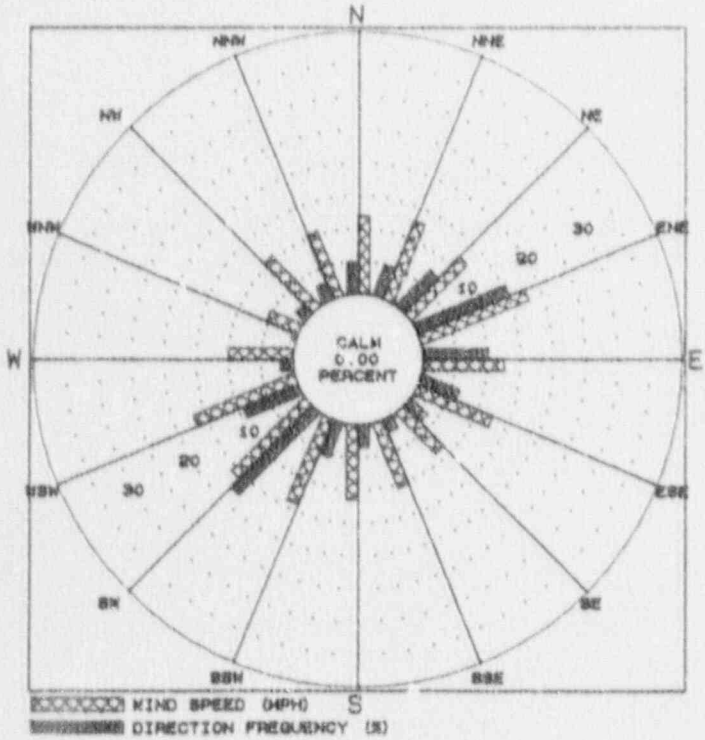
Fig 4-5 (continued): 75 Meter Wind Rose for January through December 1990.



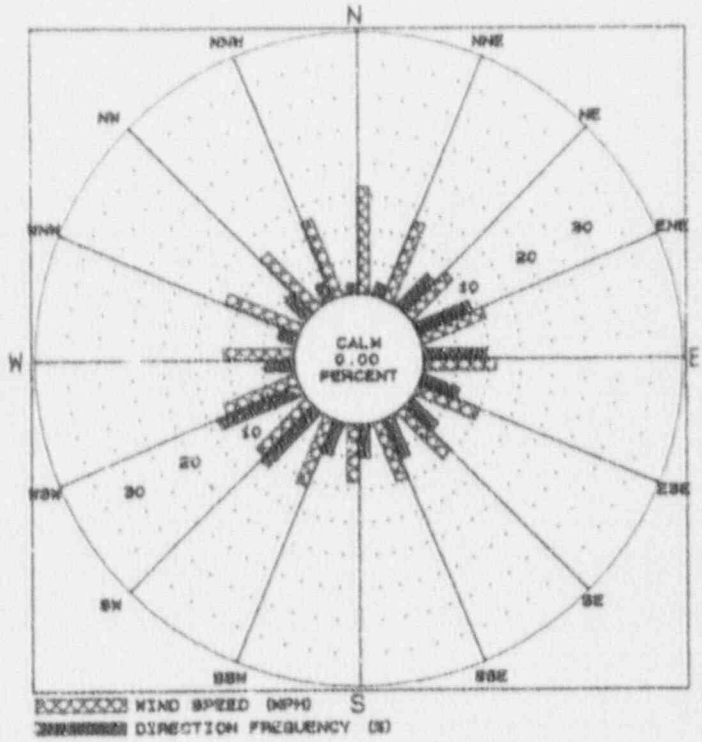
DAVIS-BESSE
MAY 1990
75M LEVEL



DAVIS-BESSE
JUNE 1990
75M LEVEL

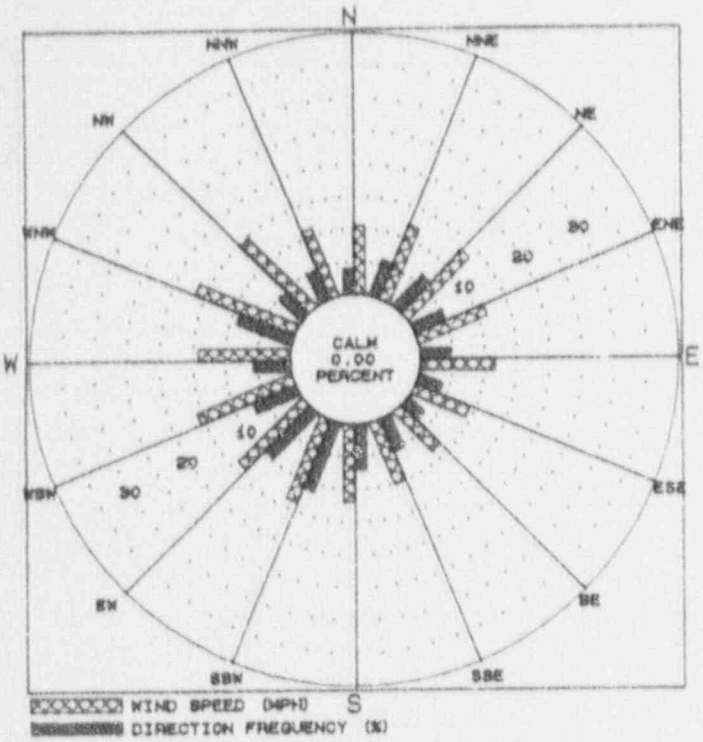


DAVIS-BESSE
JULY 1990
75M LEVEL

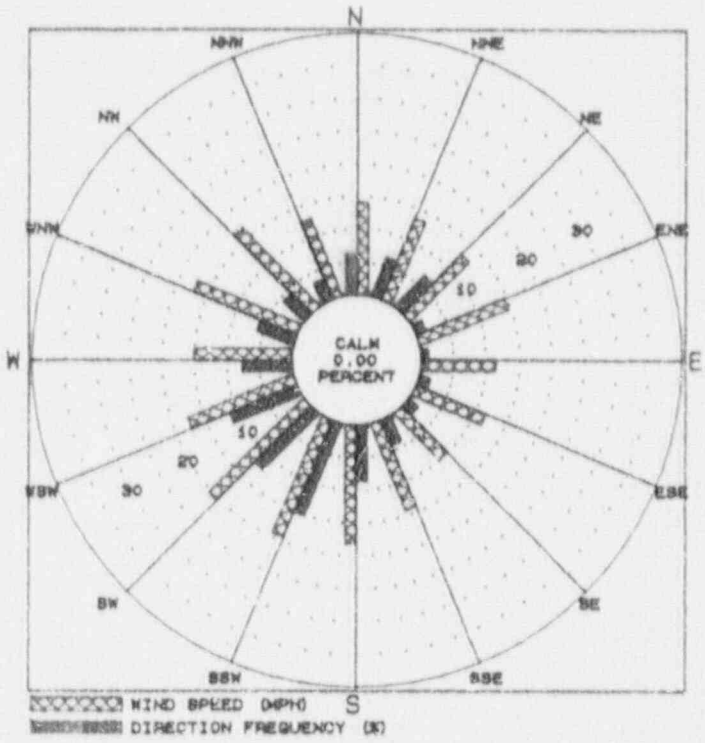


DAVIS-BESSE
AUGUST 1990
75M LEVEL

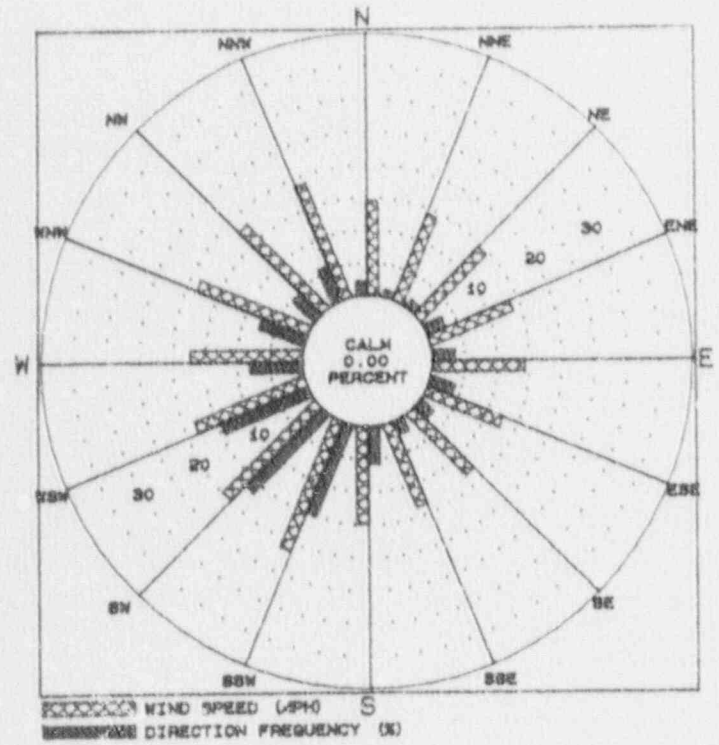
Fig. 4-5 (continued): 75 Meter Wind Rose for January through December 1990.



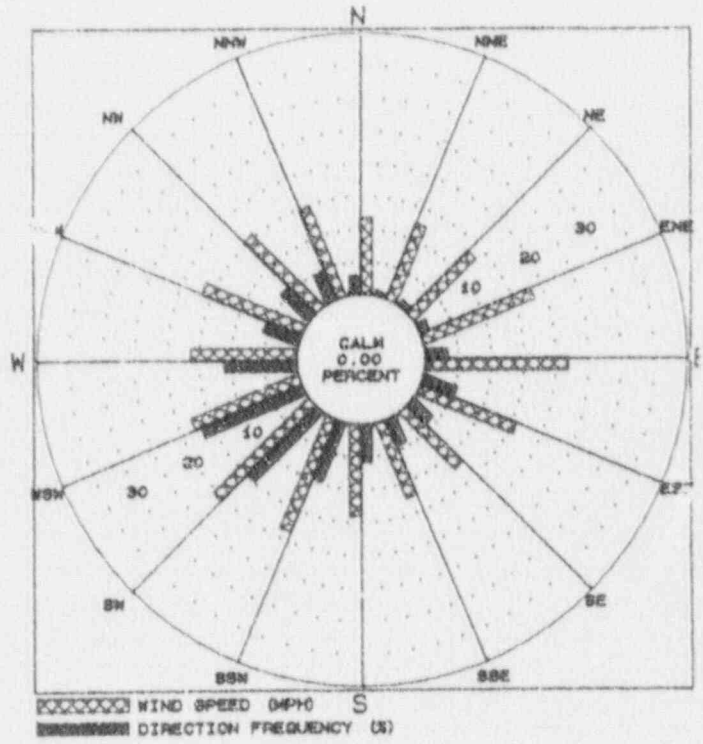
DAVIS-BESSE
SEPTEMBER 1990
75M LEVEL



DAVIS-BESSE
OCTOBER 1990
75M LEVEL

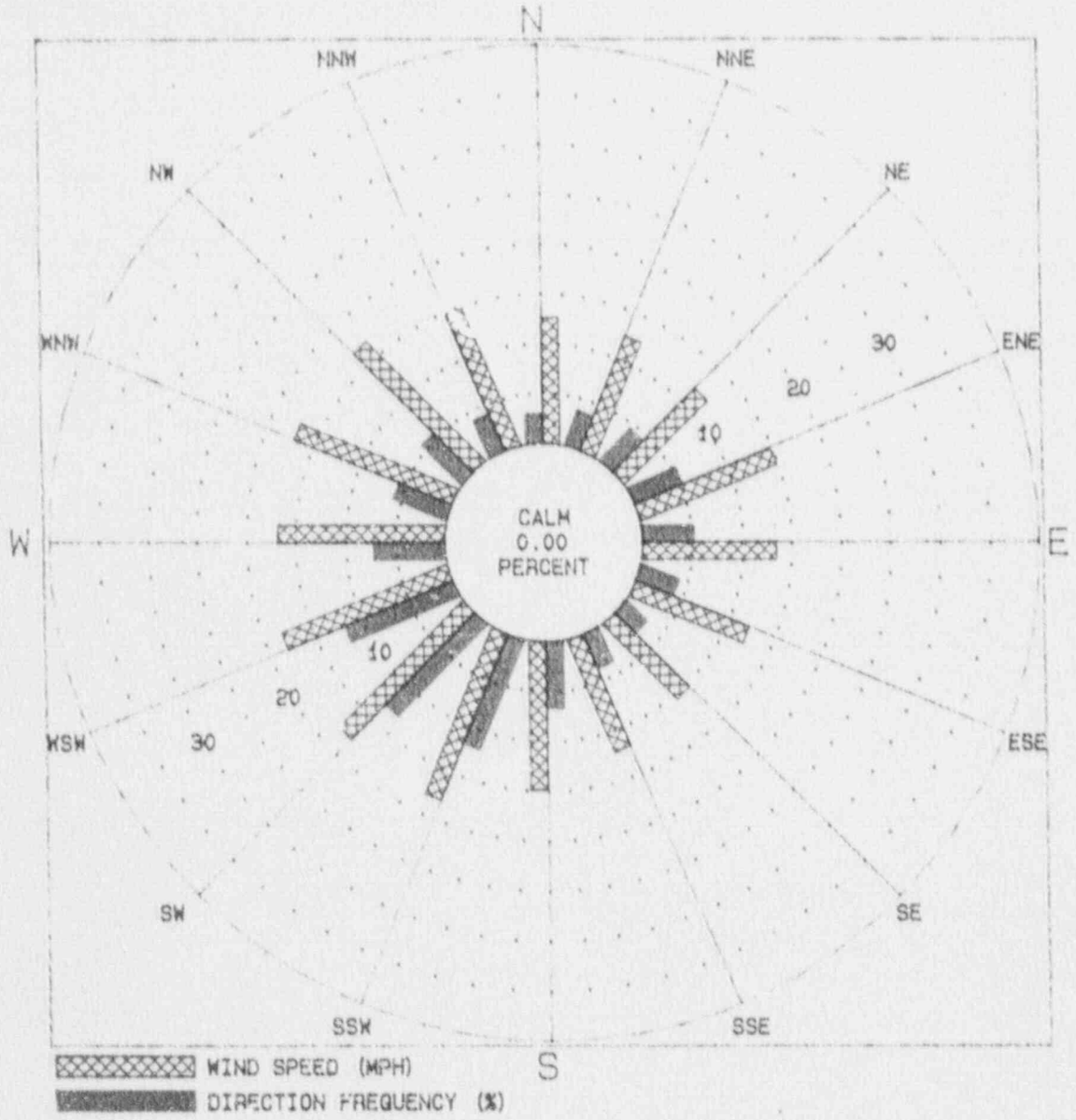


DAVIS-BESSE
NOVEMBER 1990
75M LEVEL



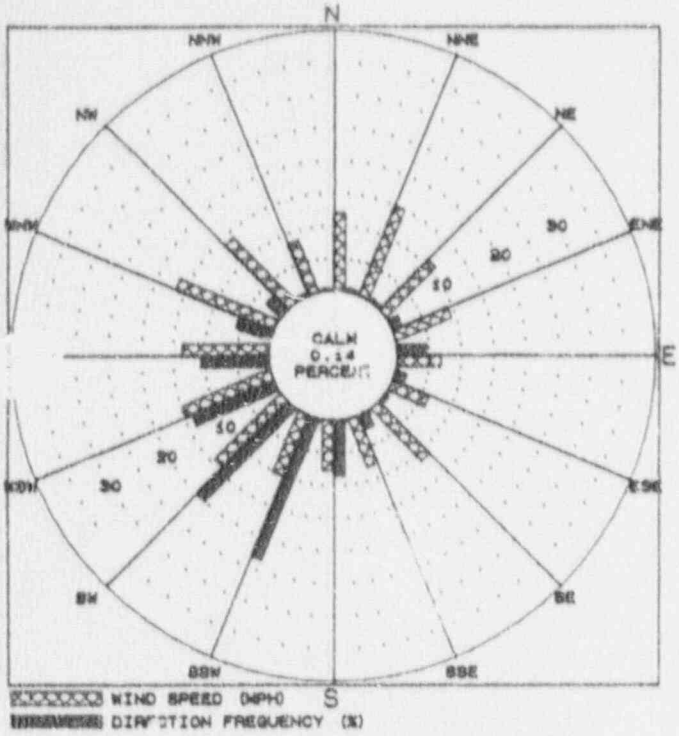
DAVIS-BESSE
DECEMBER 1990
75M LEVEL

Fig. 4-5 (continued): 75 Meter Wind Rose for January through December 1990.

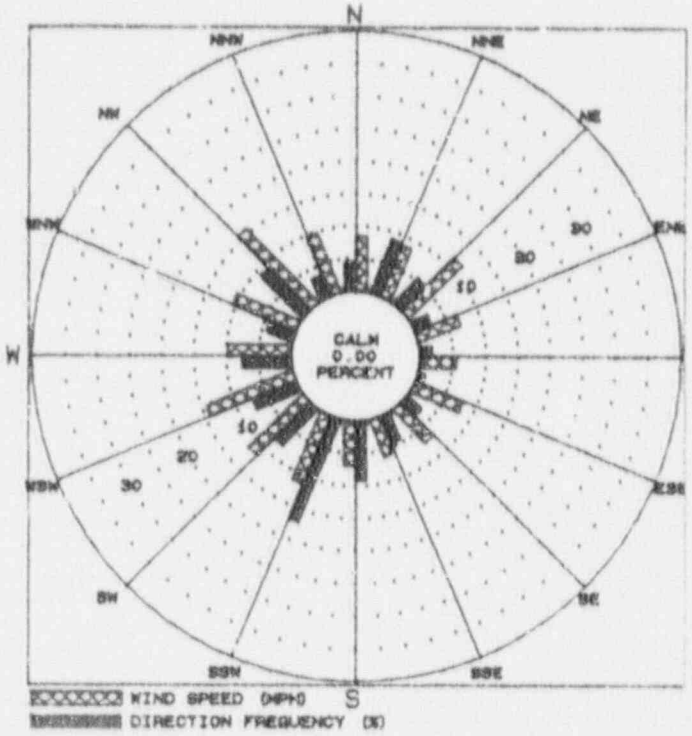


DAVIS-BESSE
ANNUAL 1990
75M LEVEL

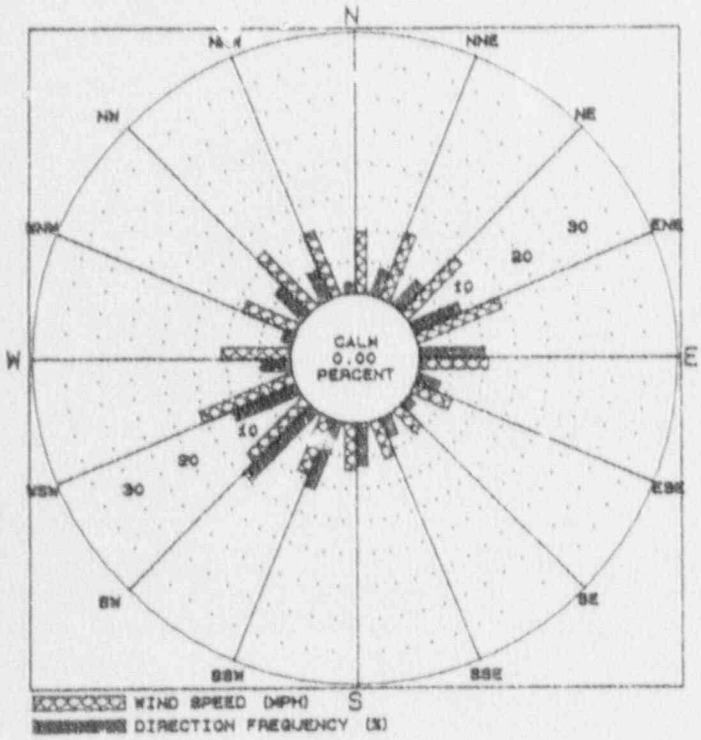
FIG. 4-6: 10 Meter Wind Rose for January through December 1990.



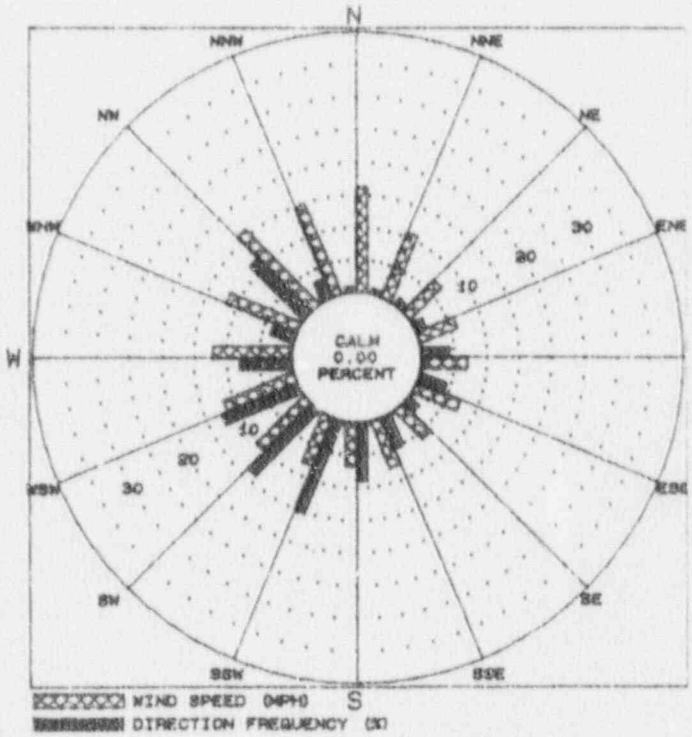
DAVIS-BESSE
JANUARY 1990
10M LEVEL



DAVIS-BESSE
FEBRUARY 1990
10M LEVEL

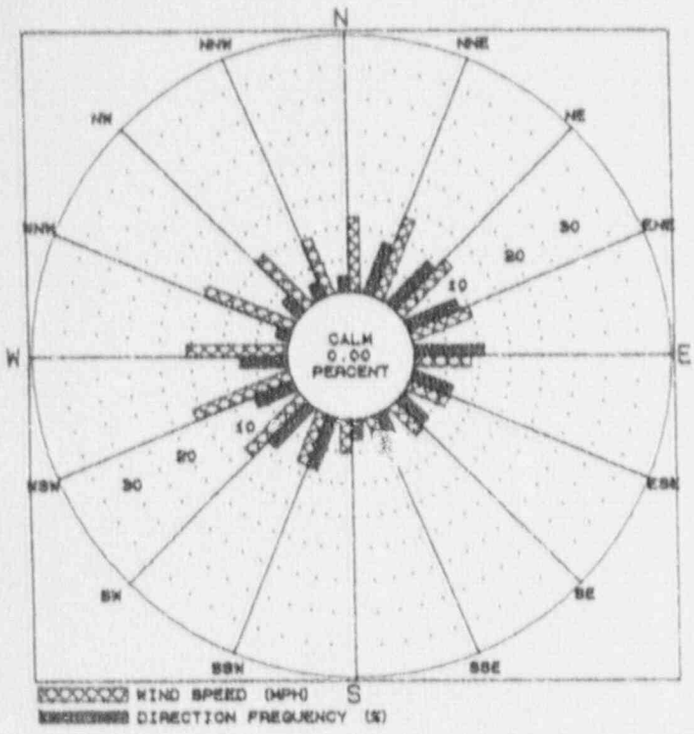


DAVIS-BESSE
MARCH 1990
10M LEVEL

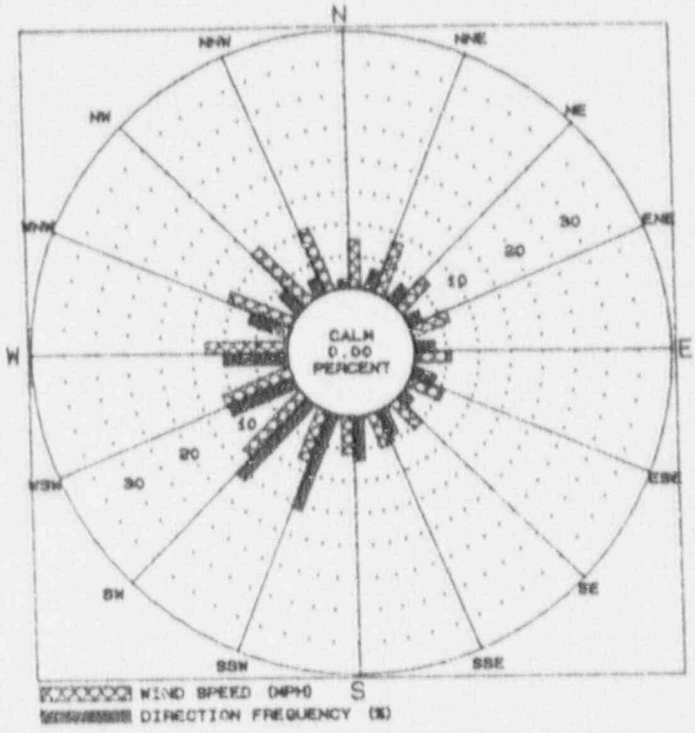


DAVIS-BESSE
APRIL 1990
10M LEVEL

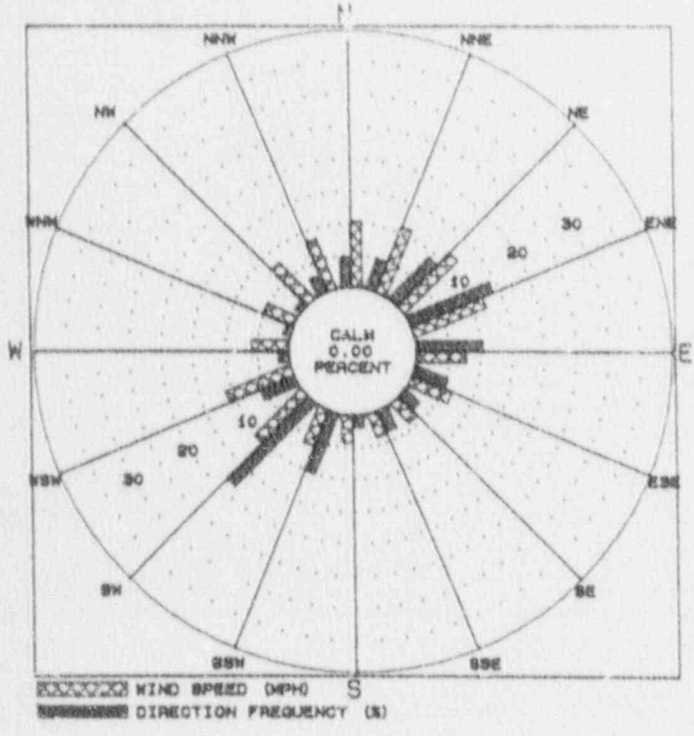
Fig. 4-6 (continued): 10 Meter Wind Rose for January through December 1990.



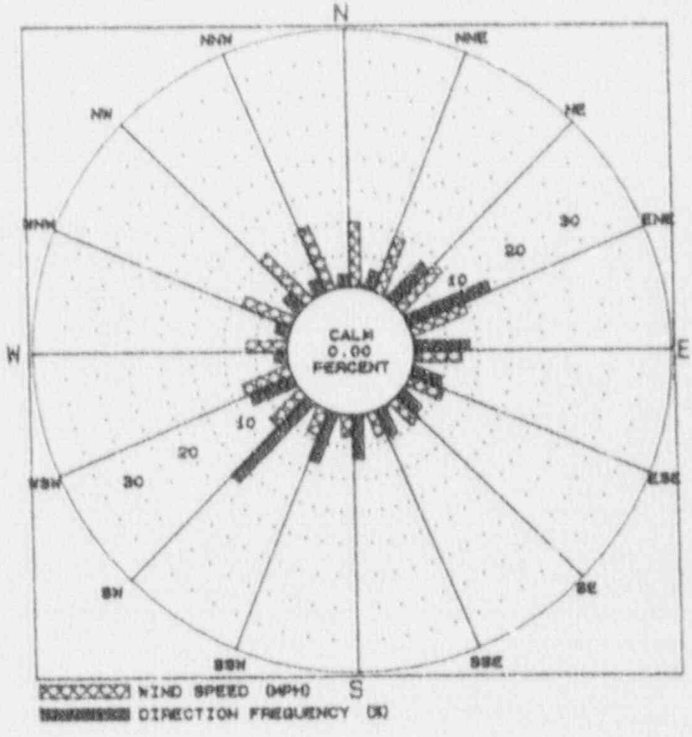
DAVIS-BESSE
MAY 1990
10M LEVEL



DAVIS-BESSE
JUNE 1990
10M LEVEL

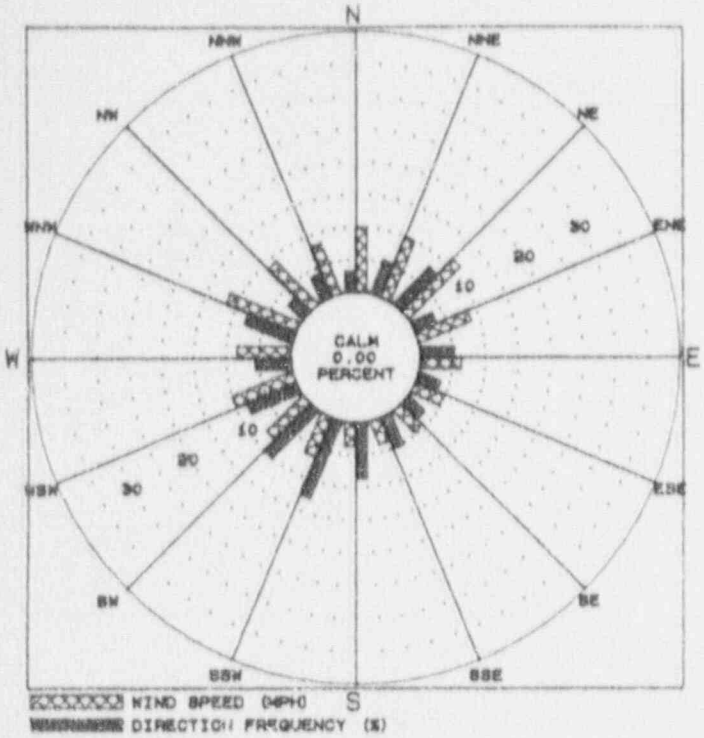


DAVIS-BESSE
JULY 1990
10M LEVEL

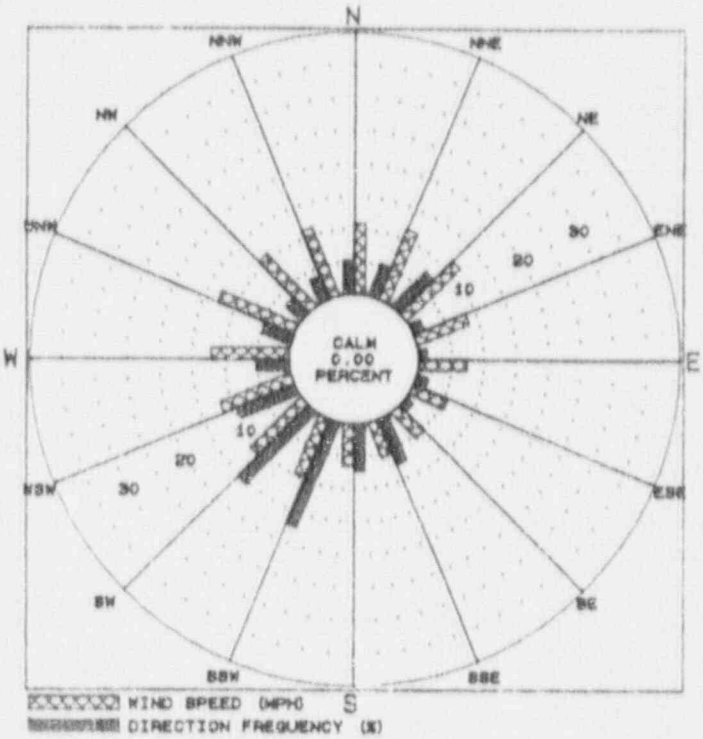


DAVIS-BESSE
AUGUST 1990
10M LEVEL

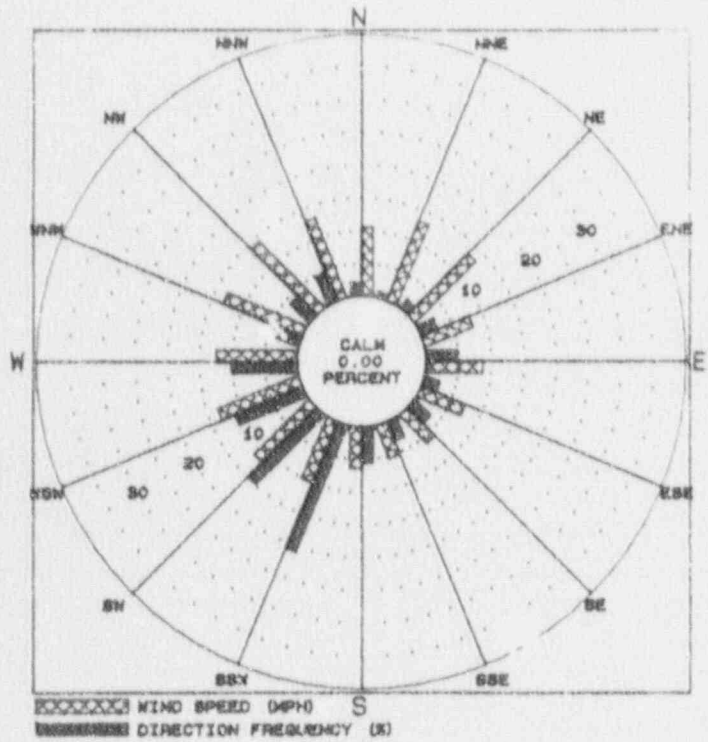
Fig. 4-6 (continued): 10 Meter Wind Rose for January through December 1990.



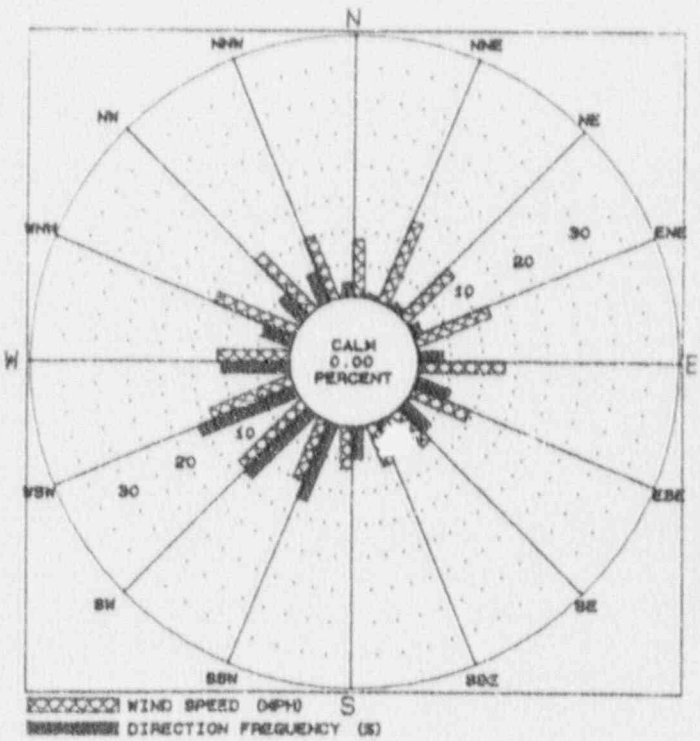
DAVIS-BESSE
SEPTEMBER 1990
10M LEVEL



DAVIS-BESSE
OCTOBER 1990
10M LEVEL

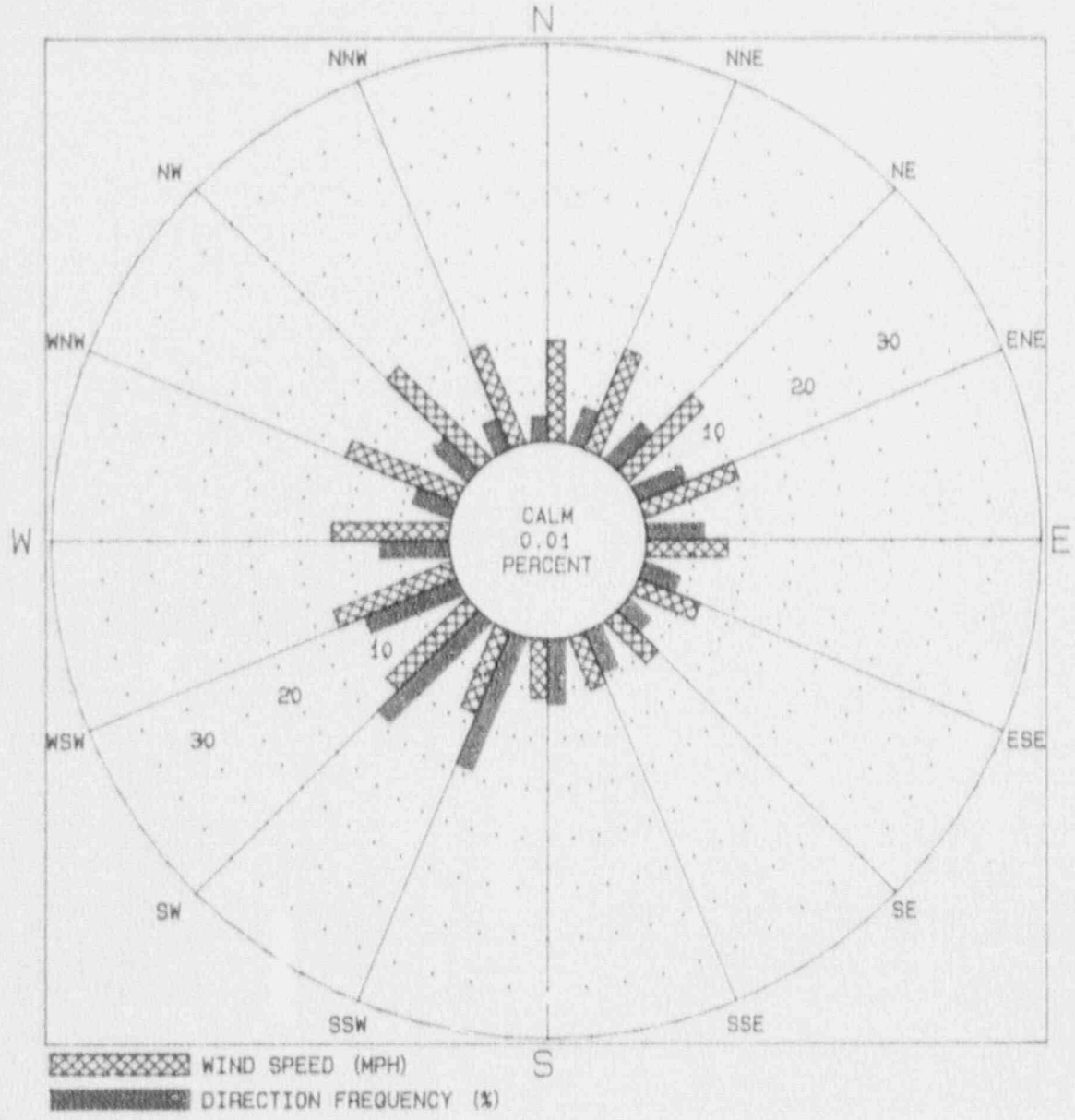


DAVIS-BESSE
NOVEMBER 1990
10M LEVEL

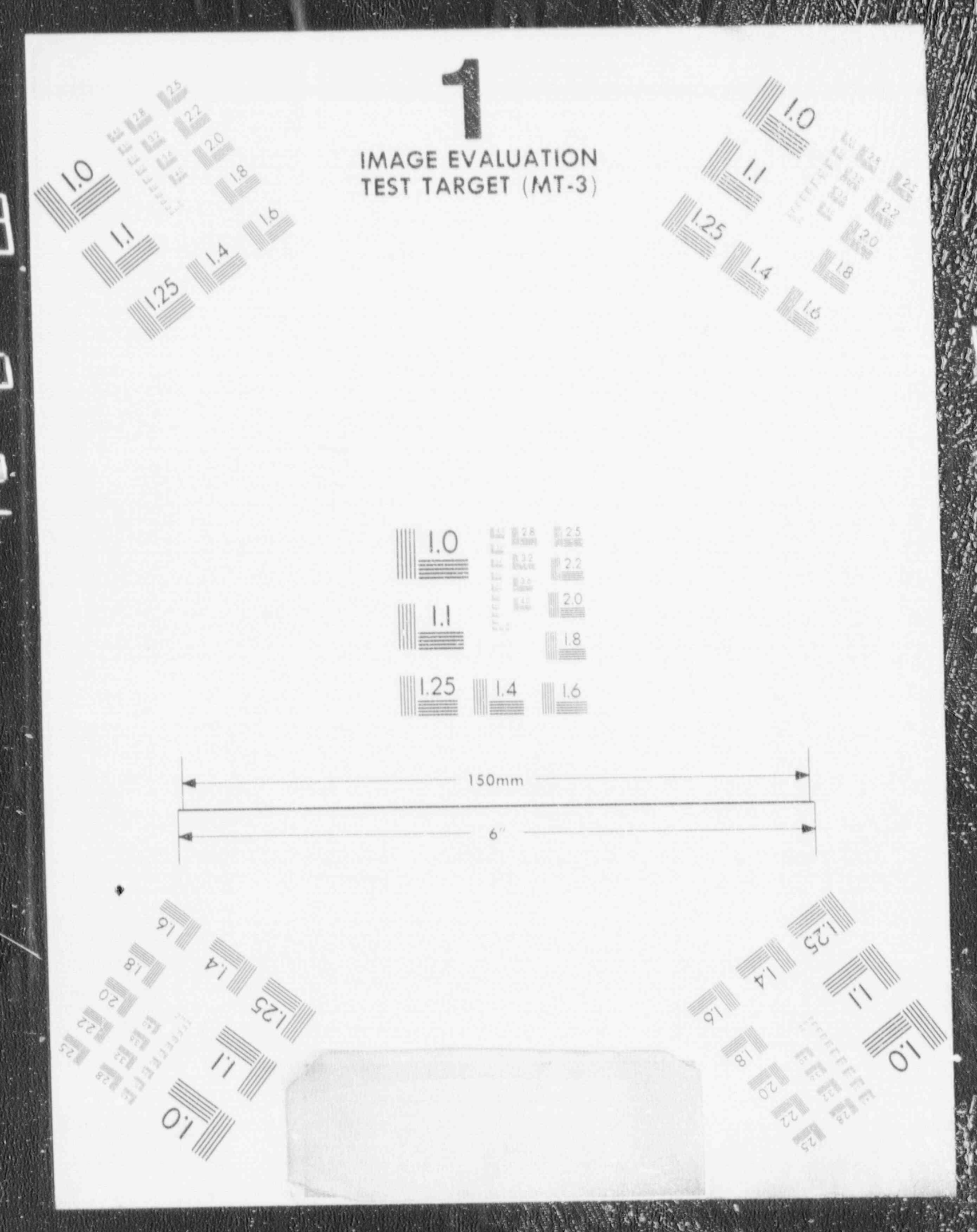


DAVIS-BESSE
DECEMBER 1990
10M LEVEL

Fig. 4-6 (continued): 10 Meter Wind Rose for January through December 1990.

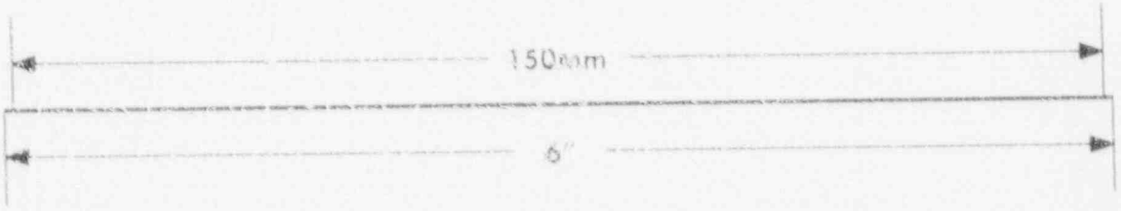


DAVIS-BESSE
ANNUAL 1990
10M LEVEL


1
IMAGE EVALUATION
TEST TARGET (MT-3)
1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
150mm
6"

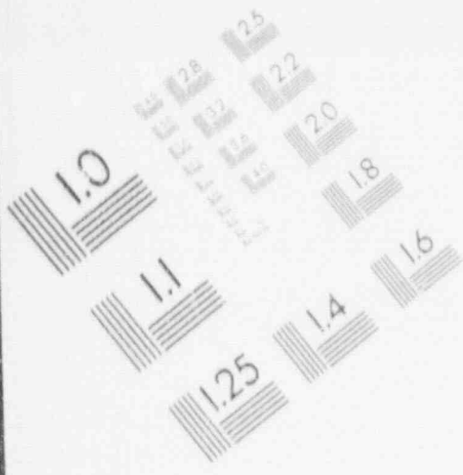
1

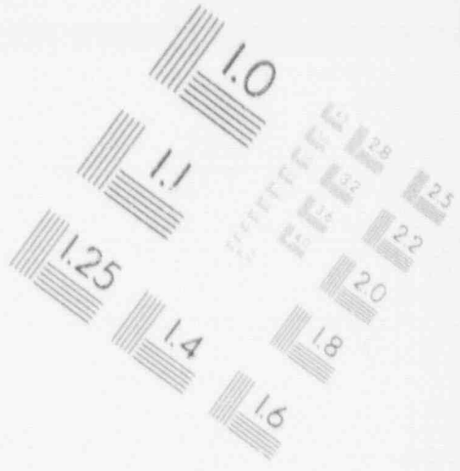
IMAGE EVALUATION
TEST TARGET (MT-3)

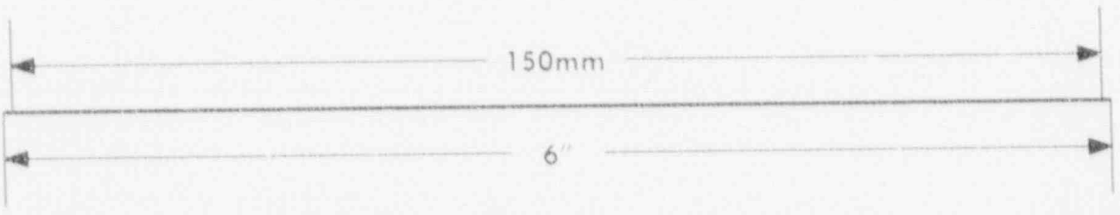


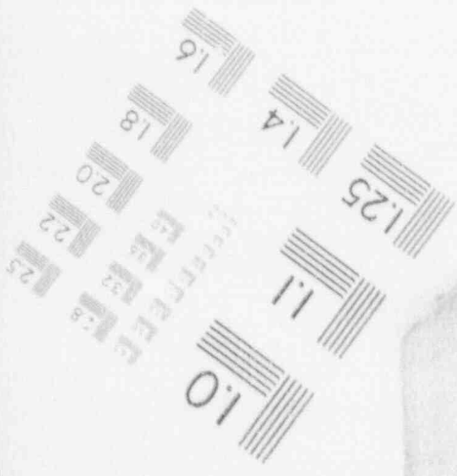
1

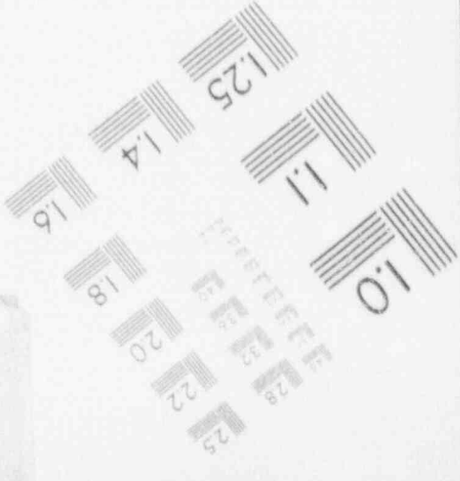
IMAGE EVALUATION TEST TARGET (MT-3)











Precipitation

Monthly totals and extremes of precipitation at Davis-Besse for 1990 are given in Table 4-2. Total precipitation for the year was 36.76 inches (93.37 cm). The maximum monthly precipitation total was 5.50 inches (13.97 cm) in December. It is likely that precipitation totals recorded in colder months are somewhat less than the actual amounts received at the site due to periods of freezing precipitation coupled with strong winds.

Atmospheric Stability

The **atmospheric stability** is categorized by delta T (100m - 10m) and delta T (75m - 10m) using the information provided in Table 4-3 (page 4-18). Unstable conditions (classes A-C) mix and disperse effluents better than stable conditions (classes E-G). Table 4-4 (page 4-19) gives the monthly and annual stability class frequency distributions for 1990, based on delta T (100m - 10m). The table shows that neutral and slightly stable conditions (classes D and E) were the most common during the year.

For comparison purposes, the delta T (75m - 10m) stability class frequency distribution is given in Table 4-5 (page 4-20). The delta T (75m - 10m) shows an increase of extreme classes (A and G), and a decrease of neutral class D relative to the delta T (100m - 10m) distribution. This was expected due to the small height separation.

Tables 4-6 and 4-7 (pages 4-21 and 4-22, respectively) give the distributions of stability classes by hour of day for delta T (100m - 10m) and delta T (75m - 10m), respectively, for 1990. They show, as expected, that unstable classes occurred primarily during the daytime hours and stable classes generally occurred at night. The neutral class occurred throughout the day and night, but showed a peak frequency for morning and afternoon transition periods.

Local Wind Patterns

Heating and cooling cycles that develop from solar heating of the atmosphere can create a variety of localized wind systems. One example common in areas bordering the Great Lakes is sometimes referred to as the "lake/land breeze effect." Unfortunately, this term is also used in other parts of the country to describe localized wind systems not at all related to the wind patterns in the Lake Erie area. For purposes of this report, the term "lake/land breeze effect" will be used to describe the harmless wind patterns that occur over areas adjacent to Lake Erie, including the Davis-Besse site. These wind patterns arise because of

the different thermal characteristics of land and water, a difference that is magnified when the body of water has a large surface area, such as Lake Erie. The large surface area of Lake Erie causes the temperature of the air over the water to be quite different from the air temperature over the land. This difference in temperature is not seen over smaller bodies of water such as man-made reservoirs. Lake Erie acts as a giant "heat sink"; i.e., it takes a long time for water temperatures to rise in the spring, but once the lake has warmed, it also takes a long time to cool back down in the autumn. In contrast, landforms experience significant temperature changes over short periods of time.

In the case of the lake/land breeze effect along the Lake Erie shoreline, during the daytime, the land surface heats up faster than the water, and therefore reaches higher temperatures than the water. The warmer air above the land rises faster because it is less dense than the cooler air over the lake. This leads to rising air currents over the land with descending denser air over the lake. This starts a wind circulation which draws air from the water to the land during the daytime, creating a "**lake breeze**" effect (Figure 4-7). At night time, this process is reversed. The water retains its heat as the land cools rapidly. This results in warmer, less dense air over the lake, with colder air over the land. This causes the local winds to shift from the land to the water, creating a "**land breeze**" effect (Figure 4-8).

The lake/land breeze circulation at Davis-Besse is generally not present during the late fall, winter, early spring, or when skies are cloudy. At these times, there is no significant solar heating of the land. The lake/land breeze is also not present when the difference between the lake temperature and land temperature is too small, or when wind speeds become faster than 12 mph (19.2 km/L). Such wind speeds tend to minimize the effect of local wind circulation patterns and allow large scale weather features (e.g., fronts, lows, highs, etc.) to dominate.

If conditions are such that a lake breeze develops in the area around Davis-Besse, the winds usually start out from the SSW and the WSW during midmorning. As the land becomes warmer during the day, the lake breeze develops and the wind shifts to the NNE and NE. Once the lake breeze develops, the Coriolis Force begins to act on the wind direction. The Coriolis Force develops due to the earth's rotation. When any mass travels above the earth's surface in an apparently linear path (as viewed from its point of origin), its path is actually deflected to the right or left, depending upon the object's position relative to the equator. This deflection is easily observed from the earth's surface at some point in the initial trajectory of the mass. However, when viewed from some fixed point in outer space, or from the initial point of origin, the mass appears to travel a straight path. The deflection seen by earthbound observers arises from the fact

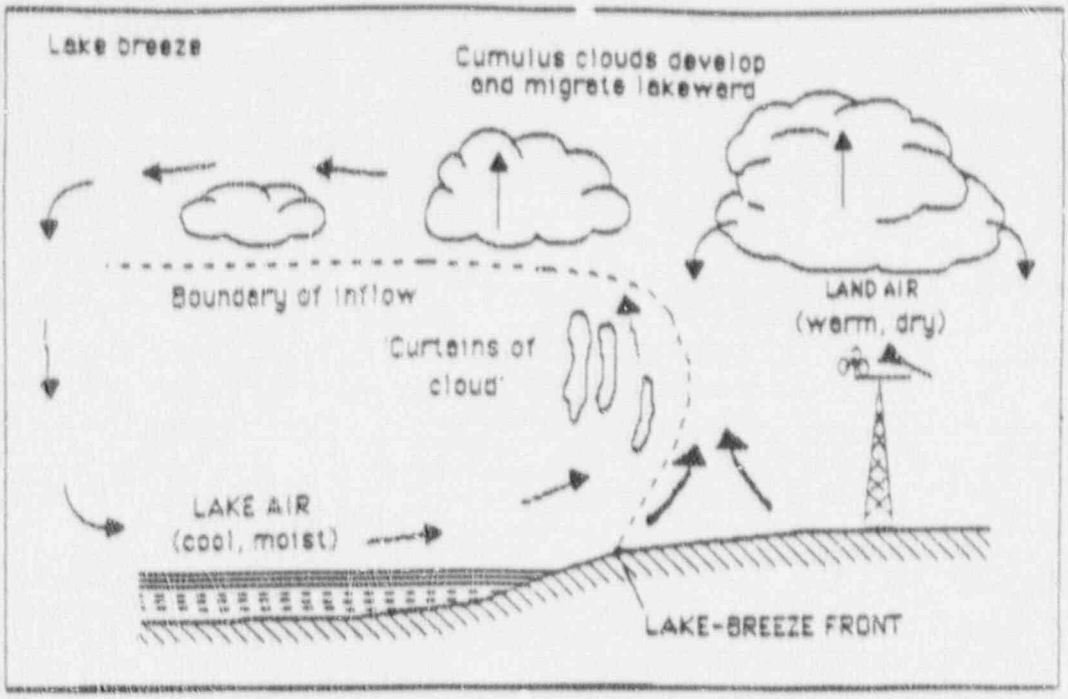


Figure 4-7: During the daytime, warmer air over the land rises faster than the dense cool air over Lake Erie. The resulting "lake breeze " draws cool air from the lake towards the land.

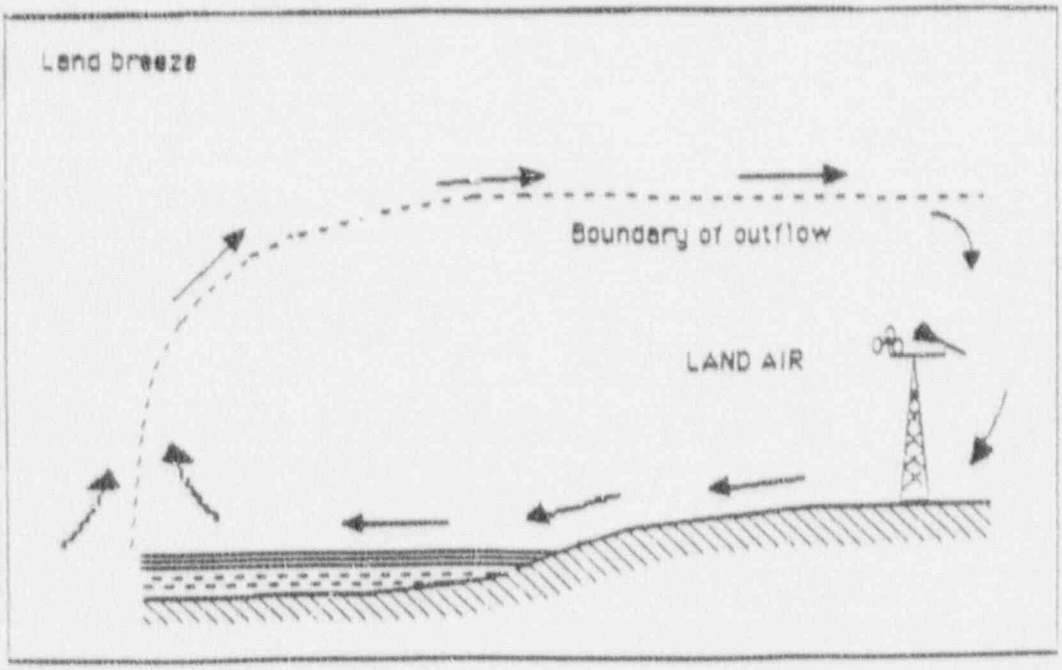


Figure 4-8: During the nighttime, landforms cool more rapidly than the lake. This results in a "land breeze" circulation pattern that blows the cool air away from land and over the lake.

that their frame of reference changes as the mass travels along its path due to the earth's rotation beneath the mass. In essence, the earth actually "moves out" from under the traveling mass. In the Northern Hemisphere, objects (or air masses) are deflected to the right of their path of motion; in the Southern Hemisphere, they are defleced to the left.

In the area surrounding Davis-Besse, the lake breezes are deflected clockwise 12 degrees each hour until about midnight. As the land cools, a land breeze from late evening to mid-morning develops, resulting in winds from the SSW and WSW. In general, lake/land breezes occur at Davis-Besse from April through September, with a peak in May.

Current and reliable information on local weather patterns (such as the lake/land breeze effect) and global weather patterns is crucial for Davis-Besse personnel responsible for monitoring atmospheric dispersion characteristics in the unlikely event of a radiological emergency at the Station. The Meteorological Monitoring Program at Davis-Besse has provided such information, with very little data loss, since the Station began operation in 1977.

Lake Level Monitoring

Lake and forebay levels are monitored at Davis-Besse to observe, evaluate, predict and disseminate high or low lake level information. Long-term Lake Erie water levels are controlled by the amount of precipitation and evaporation in the Great Lakes drainage basin. As well as diversion of water for irrigation. Industry and domestic use, short-term changes are controlled by the current meterological conditions daily. Davis-Besse personnel gather national weather service information and satellite imagery data to evaluate Lake Erie fluctuations. Figure 4-9 shows lake level data for Lake Erie during 1980 to 1990 from four sites: Toledo, Davis-Besse, Cleveland, and Buffalo. As expected, all four sites track each other for the ten year period.

The increase or decrease in lake level is sometimes due to high winds creating a seiche. Specifically, a seiche is an oscillation in water level from one end of a lake to the other due to rapid changes in winds and atmospheric pressure. The seiche may last as long as thirty six hours and cause flooding at one end of the lake and anti-flooding at the other. Close monitoring of these events allow time to prepare for low or high water events and take appropriate action.

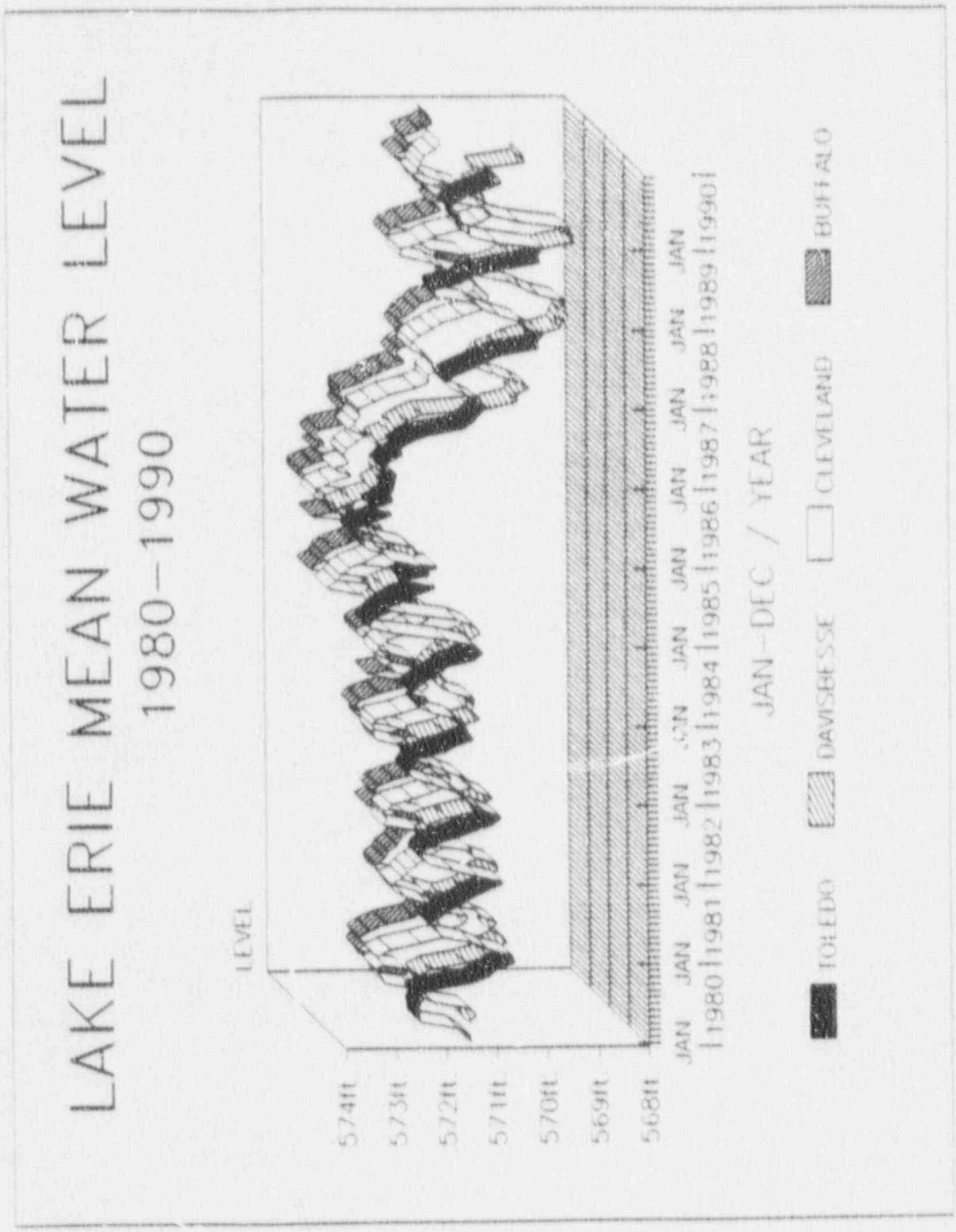


Figure 4-10 shows lake level data for Lake Erie during 1980 to 1990 four sites: Toledo, Davis-Besse, Cleveland, and Buffalo. As expected, all four sites track each other for the ten year period.

Forebay Temperature Monitoring

Forebay temperature at Davi -Besse are monitored and compared with Lake Erie temperatures. Figure 4-10 show Forebay temperature averages for 1989, 1990 and the ten year average.

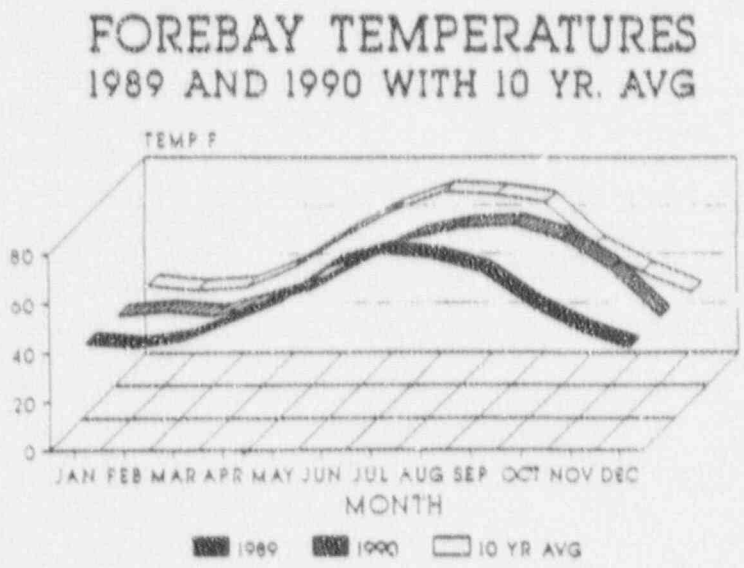


Fig. 4-11: Forebay Temperature ar monitored to aid in determining evaporation.

REMOTE SENSING

Remote sensing is the scanning of the earth from remote observation stations; manned or unmanned. Satellite imagery can provide information on temperatures of the earth and its atmosphere, snowfall and rainfall, geologic activity, land use and vegetation cover. Radar is also used for detecting precipitation and geographic features. Aerial photography is used for land use, mapping, water use and vegetation cover.

Satellite, radar imagery and aerial photography are used by meteorological personnel on a daily basis to monitor global and local weather systems, lunar-tidal gravitational effects, seismic activity, solar radiation fluctuations and magnetic fields and land use. All of these have an impact on the weather. Monitoring these events allow for careful analysis of weather conditions that could impact the operation of Davis-Besse and surrouding area. Figures 4-12 and 4-13 shows sample applications of remote sensing.

Figure 4-12 (above) and 4-13 (below) shows application of remote sensing, such as monitoring water temperatures and weather pattern globally.

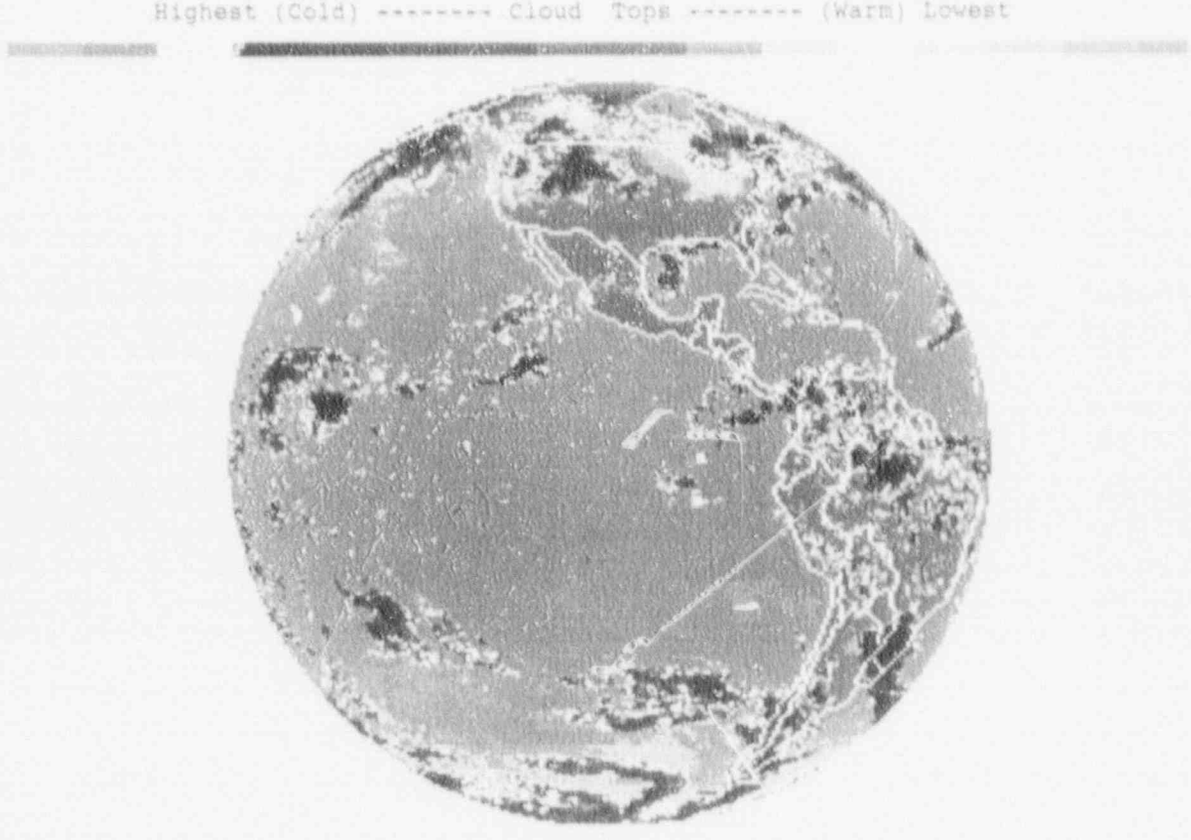


Table 4-1
Summary of Meteorological Instrumentation used at Davis-Besse Nuclear Power Station

Site	Parameter	Levels (meters)	Instrument (A)	Threshold (m/d)	Accuracy (m/s)
Main and Aux	Wind Speed	100 and 75 (main) 10 (aux)	Climet model 011-1, transmitter Climet model 025-2, translator (Esterline Angus Recorder, model E1102R)	0.6 mph	±1% or 0.15 mph which ever is greater
Main and Aux	Wind Direction	100 and 75 (main) 10 (aux)	Climet model 012-10, transmitter Climet model -025-2, translator (Esterline Angus Recorder, model E1102R)	0.75 mph	±3.0°
Main	Temperature	100, 75 and 10	Teledyne Geotech Aspirated Thermal Radiation Shield, model 327 with Platinum RTB (T-200) (Esterline Angus Multipoint Recorder, model E1124D)	N/A	±0.9°F
Main	Differential Temperature	100-10 75-10	Teledyne Geotech Platinum RTB T/ delta T processor, model 21.35 (Esterline Angus Multipoint Recorder model E1124E)	N/A	±0.18°F
Main	Dew Point Temperature	100, 10	Cambridge model 110S-M (Esterline Angus Multipoint Recorder model E1124E)	N/A	±0.5°F
Aux	Precipitation	1	Belfort tipping Bucket Rain Gauge Cat. No. 5-405H Teledyne Geotech Processor, model 21.52	N/A	±1% at a in/hr cm/hr ±4% at 3 in/hr ±6% at 6 in/hr

NOTE: Main = 340 foot tower, Aux = 35 foot tower, (A) Recording equipment indicated in parentheses

Table 4-1
Summary of Meteorological Data Recovery (expressed in percentages of operable time)* for the Davis-Besse Nuclear Power Station January 1, 1990 through December 31, 1990

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
100m Wind Speed	94.35	95.09	99.87	99.72	99.73	97.50	100.00	99.33	100.00	98.66	99.17	100.00	98.64
100m Wind Direction	98.79	99.85	99.87	84.72	99.73	97.50	100.00	99.19	100.00	99.19	99.17	100.00	98.18
75m Wind Speed	95.56	95.09	99.87	99.72	99.73	97.50	100.00	82.12	100.00	98.66	99.17	100.00	97.28
75m Wind Direction	98.79	99.85	99.87	93.61	99.73	95.50	100.00	88.84	100.00	99.19	99.17	100.00	98.04
10m Wind Speed	96.64	95.09	99.87	99.44	99.73	97.50	100.00	99.33	100.00	98.66	99.17	100.00	98.81
10m Wind Direction	98.39	99.85	99.87	98.61	99.73	97.50	100.00	99.19	100.00	98.92	99.17	100.00	99.27
10m Ambient Temperature	99.39	99.85	99.87	97.78	99.73	95.50	100.00	99.33	100.00	99.33	99.17	100.00	99.25
10m Dew Point Temperature	81.59	99.85	99.87	99.17	99.73	97.50	100.00	99.06	100.00	99.19	98.89	100.00	97.88
Delta T (100m - 10m)	97.72	99.85	99.87	97.22	99.73	97.50	100.00	99.33	99.72	99.60	99.17	100.00	99.14
Delta T (75m - 10m)	98.52	99.85	99.87	97.36	99.73	97.50	100.00	99.33	99.72	99.60	99.17	100.00	99.22
Precipitation	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Joint 100m winds and Delta T (100m - 10m)	93.41	95.09	99.87	82.50	99.73	97.50	100.00	99.19	99.72	98.52	99.17	100.00	97.10
Joint 75m winds and Delta T (100m-10m)	94.62	95.09	99.87	91.53	99.73	97.50	100.00	81.85	99.72	98.52	99.17	100.00	96.47
Joint 75m winds and Delta T (75m - 10m)	94.62	95.09	99.87	91.67	99.73	97.50	100.00	81.85	99.72	98.52	99.17	100.00	96.48
Joint 10m winds and Delta T (75m - 10m)	95.56	95.09	99.87	96.39	99.73	97.50	100.00	99.19	99.72	98.25	99.17	100.00	98.40

* Values for individual MONTHS = percent of time instrument was operable during the month, divided by the number of hours in that month that the instrument was 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
For January 1, 1990 through December 31, 1990

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
100m WIND	21.4	17.0	18.4	17.5	16.9	17.3	15.1	11.7	13.4	17.9	19.9	17.9
Max. Speed (mph)	54.49	52.79	40.93	35.79	46.24	43.9	34.76	28.18	30.46	42.13	44.10	47.78
Date of Max. Speed	25	24	17	5	10	3	12	28	25	18	5	3
Min. Speed (mph)	3.60	1.56	2.09	2.18	1.13	2.39	1.70	1.70	2.15	1.56	1.60	2.24
Date of Min. Speed	31	4	31	1	23	14	20	10	13	23	18	27
75m WIND	19.4	15.6	16.8	16.2	15.6	15.8	14.1	10.9	13.0	16.5	17.8	16.9
Max. Speed (mph)	50.60	49.74	38.59	34.44	44.82	40.70	33.06	26.45	30.01	40.02	41.47	45.23
Date of Max. Speed	25	24	17	10	10	3	12	28	15	18	5	3
Min. Speed (mph)	3.30	1.75	1.85	2.43	1.17	1.98	2.12	1.96	2.89	2.11	1.55	3.04
Date of Min. Speed	31	4	31	1	23	14	20	10	26	23	18	19
10m WIND	12.1	10.3	11.1	10.3	10.6	9.7	9.2	7.2	7.9	10.1	10.9	11.1
Max. Speed (mph)	37.14	36.87	30.88	30.04	35.47	31.0	22.62	18.59	21.89	31.23	32.88	31.91
Date of Max. Speed	25	24	17	12	10	26	12	28	16	18	5	4
Min. Speed (mph)	.88	1.70	1.55	1.85	1.02	1.74	1.35	1.33	1.33	1.94	1.02	1.47
Date of Min. Speed	27	11	11	23	22	12	25	2	26	24	19	27
10m Ambient Temp.	35	33.1	40.8	50.2	57.1	68.8	72.3	70.8	64.2	53.4	45.2	43.4
Max. (°F)	56.39	63.19	76.05	85.90	76.85	91.32	97.91	89.68	90.58	92.03	72.43	57.56
Date of Max.	17	13	14	25	8	17	4	28	6	3	1	3
Min (°F)	16.55	8.72	21.67	23.70	40.73	45.01	60.79	54.51	41.34	34.21	26.79	4.37
Date of Min.	30	26	4	3	11	5	7	8	24	29	30	24

Table 4-2
Summary of Meteorological Data Measured at Davis-Besse Nuclear Power Station
For January 1, 1990 through December 31, 1990
(Continued)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
10m DEW POINT TEMPERATURE												
Mean (°F)	28.3	24.5	31.8	37.3	46.6	57.7	61.3	63.0	56.3	43.4	36.0	28.0
Max. (°F)	53.5	51.8	61.2	61.6	63.3	72.5	74.7	75.5	74.6	63.3	62.2	54.8
Date of Max.	17	22	11	25	15	18	5	27	6	4	27	3
Min. (°F)	10.6	-6.7	2.56	10.6	20.1	38.7	44.6	46.1	32.6	24.0	18.8	-2.3
Date of Min.	30	25	6	7	11	5	6	1	17	26	8	24
PRECIPITAITON												
Total (inches)	2.53	3.87	1.61	2.00	4.76	1.92	2.50	4.73	2.44	3.05	1.85	5.50
Max. in One Day	1.00	.36	.15	.11	.57	.41	.31	.65	.40	.38	.12	.23
Date	23	15	10	10	16	13	22	19	14	4	5	23

Table 4-3
Classification of Meteorological Data

Wind Direction

Wind Sector	Wind Direction (Degrees)		
N	348.75	TO	11.25
NNE	11.25	TO	33.75
NE	33.75	TO	56.25
ENE	56.25	TO	78.75
E	78.75	TO	101.25
ESE	101.25	TO	123.75
SE	123.75	TO	146.25
SSE	146.25	TO	168.75
S	168.75	TO	191.25
SSW	191.25	TO	213.75
SW	213.75	TO	236.25
WSW	236.25	TO	258.75
W	258.75	TO	281.25
WNW	281.25	TO	303.75
NW	303.75	TO	326.25
NNW	326.25	TO	348.75

Pasquill Stability

(340 ft - 35 ft) Stability Class	Delta T (100m - 10m) 340ft -35 ft °F (°C)	Delta T (75m - 10m) 250 ft - 35 ft °F (°C)
A (extremely unstable)	T < -3.13	T < -2.18
B (moderately unstable)	-3.13 < =T < -2.80	-2.18 < =T < -1.95
C (slightly unstable)	-2.80 < =T < -2.47	-1.95 < =T < -1.72
D (neutral)	-2.47 < =T < -0.82	-1.72 < =T < -0.57
E (slightly stable)	-0.82 < =T < 2.47	-0.57 < =T < 1.72
F (moderately stable)	2.47 < =T < 6.59	1.72 < =T < 4.59
G (extremely stable)	6.59 < =T	4.59 < =T

Table 4-4
Monthly and Annual Stability Class Frequency Distributions
Based On Delta T 340FT - 35FT (100m - 10m)
For January 1, 1990 Through December 31, 1990 (in percent)

100m-10m	A	B	C	D	E	F	G
JAN	0.00	0.00	0.00	54.9	37.1	6.10	1.90
FEB	0.90	1.20	3.30	60.8	29.4	4.20	0.30
MAR	0.00	0.80	2.70	61.9	27.2	5.40	2.00
APR	0.40	1.10	4.60	49.0	28.7	12.40	3.70
MAY	0.50	2.40	4.70	57.8	26.3	7.70	0.50
JUN	0.10	0.60	1.90	56.3	33.2	6.40	1.60
JUL	1.20	0.80	2.00	60.5	27.8	7.10	0.50
AUG	0.10	0.30	3.00	58.3	20.2	15.0	3.10
SEP	0.00	0.40	1.00	52.8	29.7	13.1	3.10
OCT	0.10	0.40	4.00	52.9	25.1	15.0	2.40
NOV	0.00	0.70	0.70	48.2	37.3	10.9	2.20
DEC	0.90	0.30	0.30	58.6	34.8	5.10	0.00
	0						
ANNUAL	0.40	0.70	2.30	56.0	29.7	9.10	1.80

Table 4-5
Monthly and Annual Stability Class Frequency Distributions
Based on Delta T 250FT - 35FT (75m - 10m)
For January 1, 1990 Through December 31, 1990 (in percent)

75m-10m	A	B	C	D	E	F	G
JAN	0.00	0.00	0.80	51.8	39.0	6.40	1.90
FEB	0.40	1.90	5.20	56.5	31.3	4.30	0.30
MAR	0.40	1.70	3.50	58.5	27.2	5.90	2.70
APR	1.30	2.00	7.60	44.2	26.4	14.4	4.10
MAY	1.20	1.50	4.90	58.5	25.5	6.50	2.00
JUN	0.60	1.00	6.10	50.3	34.8	5.40	1.90
JUL	0.10	1.90	8.20	53.2	28.5	7.10	0.90
AUG	0.10	1.50	8.90	52.0	18.8	12.2	6.50
SEP	0.30	1.00	5.70	47.4	28.6	13.4	3.80
OCT	0.70	2.30	4.20	49.9	25.4	14.0	3.50
NOV	0.80	0.40	1.70	40.8	42.4	11.2	2.70
DEC	0.00	0.00	0.50	57.7	36.4	5.10	0.30
ANNUAL	0.50	1.30	4.80	51.8	30.3	8.80	2.60

Table 4-6
Davis-Besse Nuclear Power Station
Stability Classes by Hour of Day for 1990, Based on 340FT- 35FT (100m-10m) Delta T

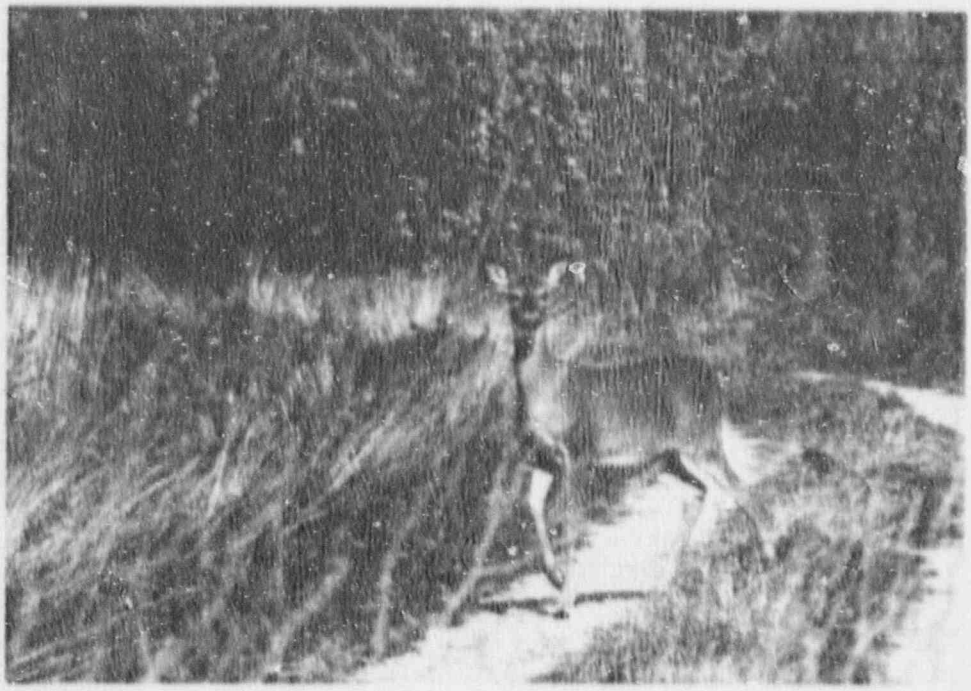
Stability Index

Hour of Day	A	B	C	D	E	F	G	TOTAL	FG	EFG
1	0	1	0	125	162	64	12	364	76	238
2	0	0	0	129	157	66	13	365	79	236
3	0	1	1	127	152	66	18	365	84	236
4	1	0	2	130	146	70	16	365	86	232
5	1	3	1	144	131	62	20	362	82	213
6	2	2	3	141	137	59	20	364	79	216
7	4	1	2	153	137	58	10	365	68	205
8	5	2	1	179	139	28	6	360	34	173
9	3	1	5	251	89	11	1	361	12	101
10	3	2	13	298	35	6	1	358	7	42
11	3	4	23	205	17	3	1	356	4	21
12	3	7	29	299	20	0	1	359	1	21
13	2	10	39	293	12	0	1	357	1	13
14	2	11	35	297	14	1	1	361	2	16
15	0	8	26	302	22	3	0	361	3	25
16	1	5	13	305	33	4	1	362	5	38
17	0	2	5	290	57	6	2	362	8	65
18	0	1	2	249	101	9	1	363	10	111
19	0	2	1	202	138	18	2	363	20	158
20	1	0	1	141	185	32	3	363	35	220
21	1	0	0	122	191	42	5	361	47	238
22	0	1	0	122	179	55	5	362	60	239
23	0	1	0	130	165	61	6	363	67	232
24	0	0	1	132	159	62	9	363	71	230
Total	32	65	203	4866	2578	786	155	8685	941	3519
Percent	9.4	0.7	2.3	56.0	29.7	9.1	1.8	100.00	10.8	40.5

Table 4-7
Davis-Besse Nuclear Power Station
Stability Classes by Hour of Day for 1990, Based on 250FT-35FT (75m-10m) Delta T

Stability Index

Hour of Day	A	B	C	D	E	F	G	TOTAL	FG	EFG
1	0	0	1	117	166	64	17	365	81	247
2	0	0	2	120	159	56	28	365	84	243
3	0	1	0	124	155	55	30	365	85	240
4	0	0	2	125	149	61	28	365	89	238
5	0	0	0	135	145	56	26	362	82	227
6	0	0	1	145	139	56	23	364	79	218
7	0	0	1	158	144	51	11	365	62	206
8	1	0	2	205	122	28	2	360	30	152
9	0	0	6	264	82	7	2	361	9	91
10	0	1	32	278	42	4	1	358	5	47
11	5	10	58	256	24	3	1	357	4	28
12	8	19	73	238	20	0	1	359	1	21
13	11	27	68	232	18	0	1	357	1	19
14	7	25	69	236	22	1	1	361	2	24
15	4	17	54	260	23	2	1	361	3	24
16	3	8	26	288	32	4	1	362	5	37
17	2	2	13	276	58	9	2	362	11	69
18	1	0	3	247	101	9	2	363	11	112
19	0	0	1	191	148	21	2	363	23	171
20	1	0	0	138	181	40	4	364	44	225
21	0	0	1	116	188	50	7	362	57	245
22	0	0	0	114	176	67	6	363	73	249
23	0	0	0	119	170	63	12	364	75	245
24	0	0	1	119	170	61	13	364	74	244
Total	43	110	414	4501	2634	768	222	8692	990	3624
Percent	0.5	1.3	4.8	51.8	30.3	8.8	2.6	100.00	11.4	41.8



Marsh Management

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 which is leased to the U.S. Fish and Wildlife Service (USFWS), who manage 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 such as purple loosestrife. 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 (refer to Figure 5-1) and a revetment(Figure5-2) 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. A dike generally consists of rock laid over a clay base at a slope of approximately a one-to-one or a two-to-one ratio. 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 Navare 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 that serve no useful purpose (e.g.,purple loosestrife.)

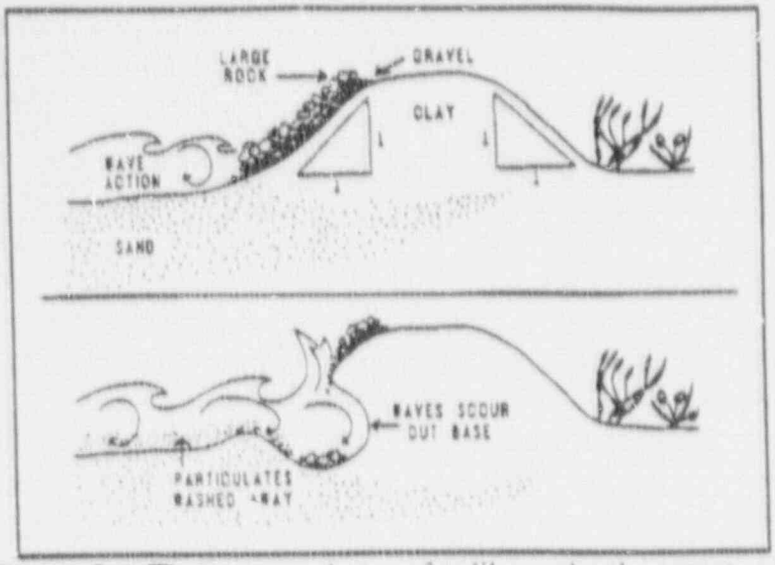


Figure 5-1: The steeper slopes of a dike make the structure vulnerable to wave action and erosion. For this reason, dikes are only suitable for flood control in relatively quiet waters, such as an inland marsh.

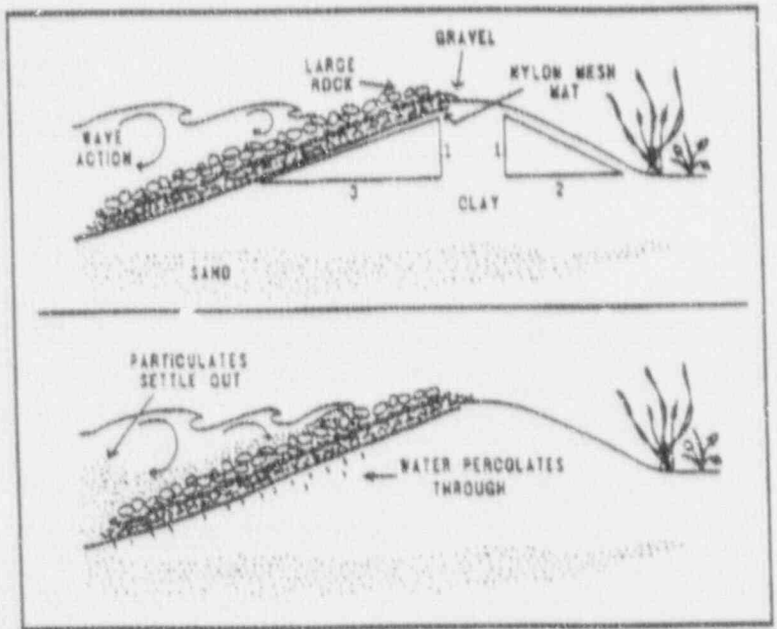


Figure 5-2: The gently sloping sides of a revetment actually encourage beach formation by dissipating wave energy and allowing particulate matter to settle out at the base of the structure. Revetments are an ideal method of flood control for areas subject to a great deal of wave action, such as the Lake Erie shoreline.

A **revetment** is also a retaining structure designed to hold back water for purposes of erosion control and/or to encourage beach fromation. Unlike a dike, a revetment consists of rocks laid over a nylon mesh mat atop a clay base. Revetments are also 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. At the same time, the underlying mat allows the water to percolate through slowly. This helps maintain the integrity of the clay base beneath the mat. Because a revetment extends well out into the water, it actually encourages beach formation by this passive deposition of particulate matter.

Particularly along the southern shores of Lake Erie, where wave action has literaly eroded away large areas of shoreline, a revetment is a logical choice to both protect the inland areas and to encourage beach formation. Due to the steeper slopes of dikes, when waves strike, they are deflected **laterally** down the shoreline. This tends to scour out the base of the dike and will eventually cause the dike to slump or collapse, allowing flooding. In contrast, when waves strike the gently sloping sides of a revetment, they are deflected **up** and their energy is dissipated. As the water slowly passes back down the revetment, any silt or sediment drops out, gradually forming a beach along the base of the revetment. Beaches themselves provide a natural form of flood control, and are therefore desirable in areas with a great deal of wave action (such as Lake Erie).

Marshes are generally found in low-lying flat areas, and are chacterized by a wide divesity of plant life as the elevation changes. In the Navarre Marsh , elevations throughout rarely differ by more than two feet (refer to Figure5-3). As one travels to higher elevations and the land gets dryer, woody plants such as shrubs and trees replace the plants more commonly associated with wetlands. The Navarre Marsh has a varied landscape with different plants found in each. 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 area 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 treed, frequently occupied by birds of prey such as bald eagles. Extending out from the beach is a sandbar which formed over the last few 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

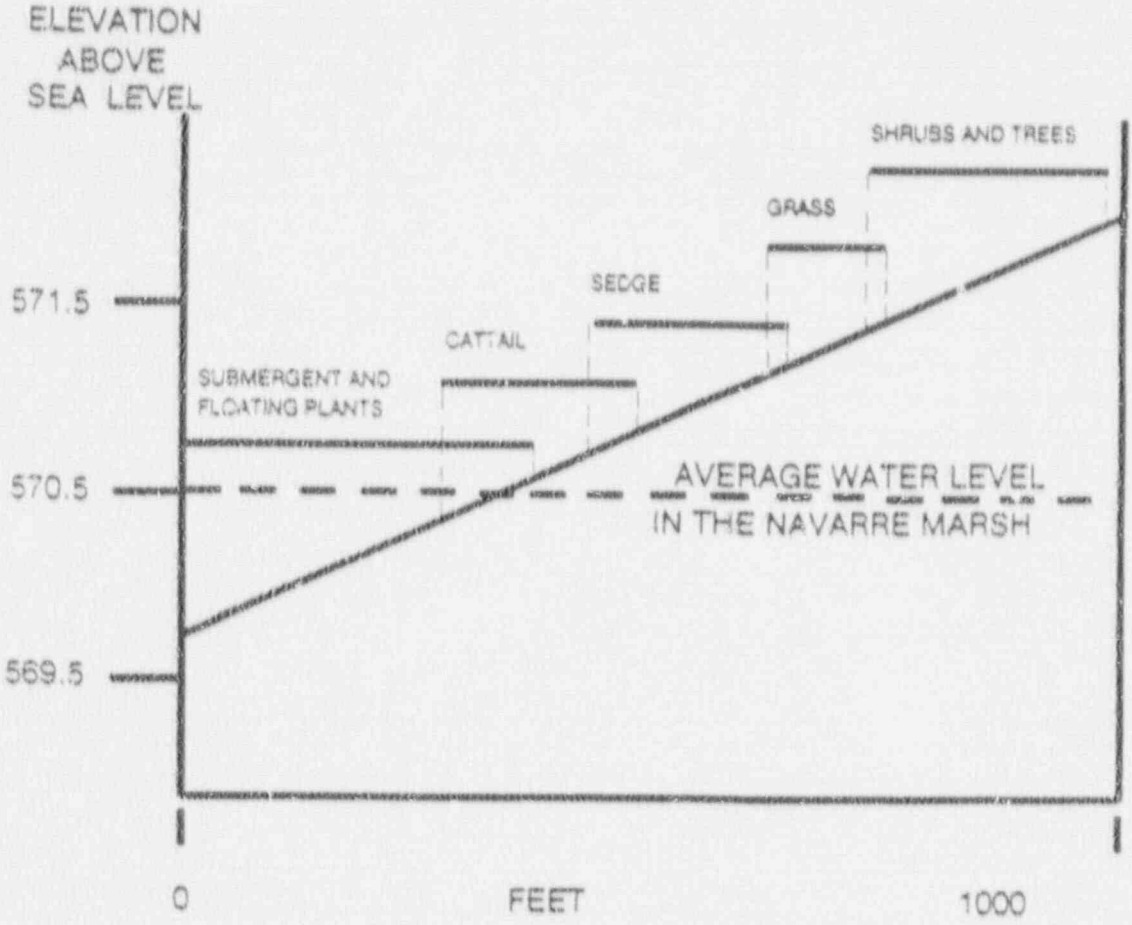


Figure 5-3: If one travels 1,000 feet in any direction in the Navarre Marsh, elevations will rarely differ by more than two feet. As elevation increases, the ground gets dryer and plant communities change.

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. Shore birds and waterfowl are often seen resting and feeding in this area. Figure 5-4, taken in early 1990, shows the beach that has formed within the last year after the revetment was completed in 1988. Lower lake levels in 1989 also exposed shorelines that were underwater during previous years. These lower levels also contributed to the beach at the base of the revetment pictured in Figure 5-4.

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

Figure 5-4: The revetment encouraged this beach to form within the first two years. While encouraging beach formation, the revetment also provides a means of flood control and protects the marsh against the wave action of Lake Erie.

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 and 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 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 nesting 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 Station site. Besides natural nesting site, several artificial nesting areas, such as wood duck boxes and goose tubs, are provided. The boxes and tubs represent a collective effort of both 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 bariety 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 1990

Toledo Edison and Davis-Besse are committed to protecting the Navarre Marsh and have 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 1990, these special projects included controlling undesirable plant species, songbird banding, Canada goose banding and nesting surveys, and 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 March 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 the 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 stands 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 April through August 1990. The project involved capturing and banding songbirds migrating through the area. From April through June, 8,011 individual birds were banded. The **yellow warbler**, a resident species of the Navarre Marsh during the summer months, was studied in further detail from June through August. The study provided information on nesting and feeding habits of the yellow warbler. The data collected during the banding project provides and extensive database so that the migratory movements of the warblers may be better understood, and to aid in tracking the population levels of the different warbler species over time.

A Canada goose nest survey was performed in the Navarre Marsh and in the surrounding marsh area in 1990 by the ODNR. The survey was performed using a helicopter from the ODNR. This allowed the nests to be located more quickly and easily. Sixty-five goose nest were identified in Navarre Marsh. This was the highest concentration of Canada goose nest in this area.

Environmental Compliance students assisted the ODNR in capturing and banding ducks at Ottawwa National Wildlife Refuge in December. Mallards and black ducks were aged, sexed, and banded. Six of the black ducks were fitted with radio collars for tracking.

Prior to the 1990 nesting season, 19 wood duck boxes were installed at several locations throughout the Navarre Marsh. These boxes will be examined for use and reconditioned with fresh sawdust prior to the 1991 breeding season.

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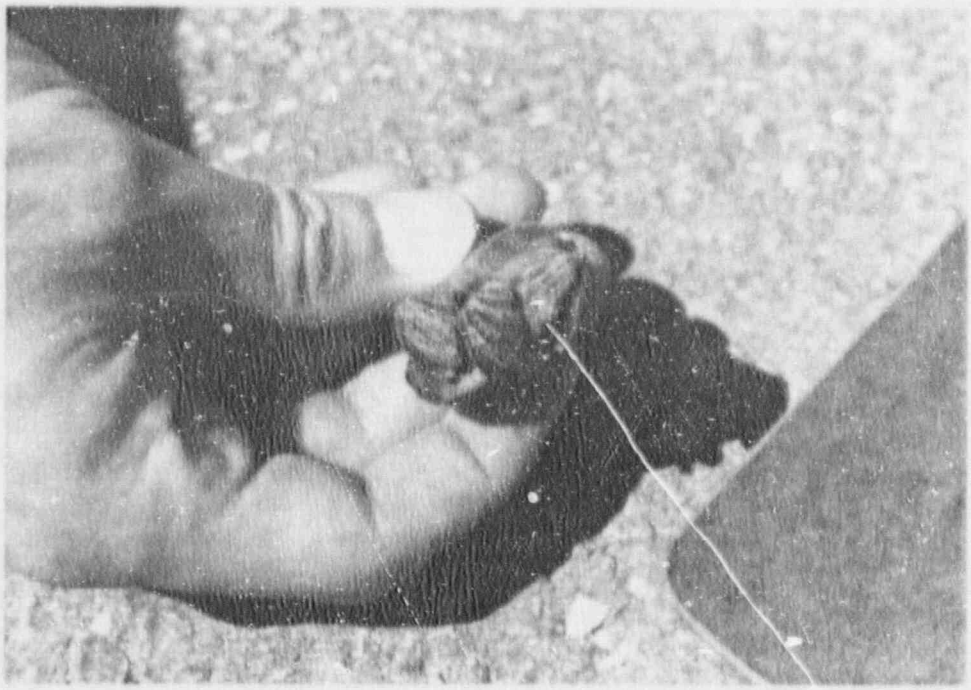


Zebra Mussel Control Program

ZEBRA MUSSEL CONTROL

Introduction

Dreissena polymorpha, more commonly known as the zebra mussel because of its striated shell, is a native European bivalve that was accidentally introducted 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 any 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 mussels were removed from the crib with high pressure water which destroys the mussels as well.

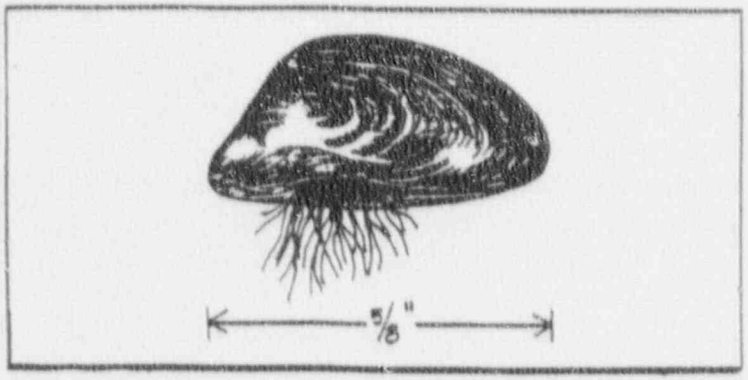


Fig. 6-1 : Named after its distinctive black striping, the zebra mussel (*Dreissena polymorpha*) is equipped with a tuft of fibers that protrude through the hinged area of its shell. These, known as byssal threads, attach to hard surfaces with an adhesive secretion which anchors the mussel firmly in place.

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 or 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 temperature at which spawning may occur. At temperatures above 18°C, when spawning conditions are most favorable, more frequent samples are taken.

The most frequent sample type is the raw water sample collected daily from the water treatment plant. Other water samples are taken weekly from the Toussaint River and semi-weekly from two different locations along the forebay (the canal that provides lake water for plant intake). 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 by using the sample volume and the number of veligers observed to determine the average number of veligers per liter. The average number of veligers per liter is determined so that a standard comparison may be made from water samples of different volumes.

One other type of sample is collected, but it is observed for the presence of adult mussels rather than the veliger stage. 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 (an Eckman Dredge) which 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.

Another method used by the Environmental Compliance Unit to monitor adult mussels is the observation of mussels that attach to objects placed in the forebay. These objects include a cement block and a "veliger tree" (two levels of crossed boards separted by a metal support), which has large graduated slides that allow attached mussels to be counted easily. Once a week the block and the tree are pulled out of the forebay and the mussels are counted.

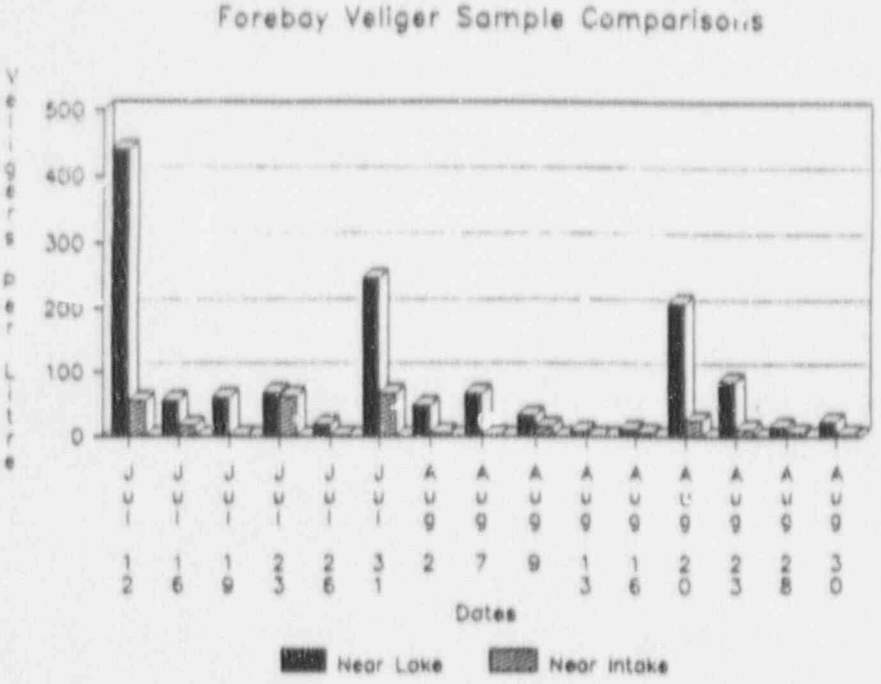


Fig. 6-2: The graph (above) shows the peaks in veliger population during July and August 1990 and that the veliger population is less dense in the intake near the station compared to the veligers near the lake.

The date, time, location, and number of adult mussels or veligers are recorded for every sample or observation. Weather data and water temperatures are also recorded to determine their effects on veliger/mussel population.

Research

The Environmental Compliance Unit is involved with the Electric Power Research Institute (EPRI) in studying the effects of water velocity and chemicals on zebra mussels. The purpose of the study is to determine what may influence mussel mortality and/or detachment. An apparatus, Fig. 6-3, designed by EPRI to roughly simulate an in-plant water system was constructed for use at Davis-Besse. The apparatus 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 results of the first chemical study are inconclusive due to the low temperatures that occurred during the experiment. Research has been halted but will resume once water temperatures increase with the coming of Spring.

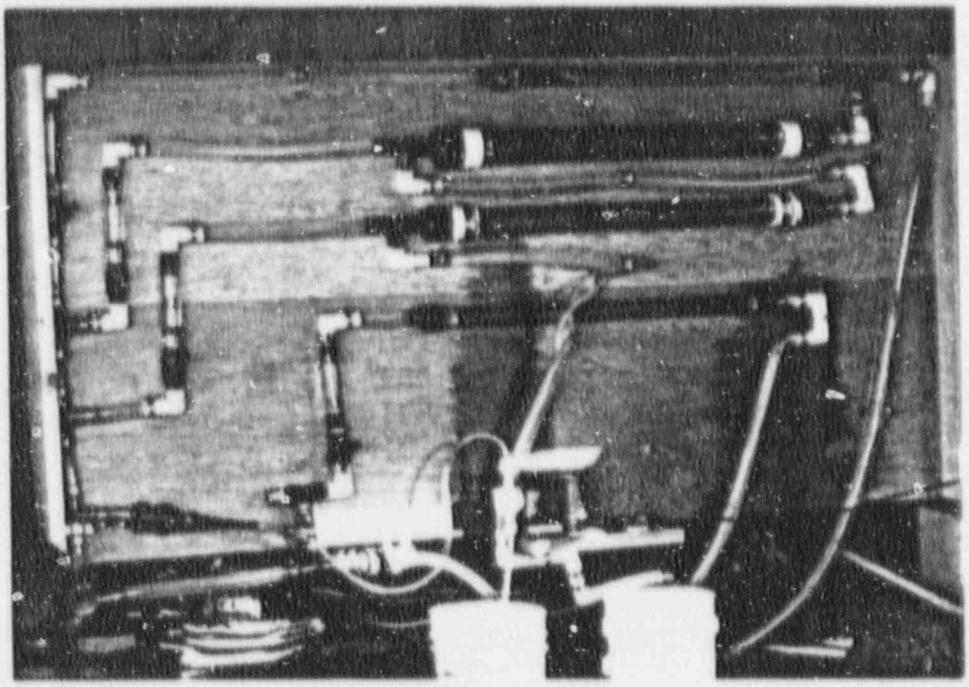
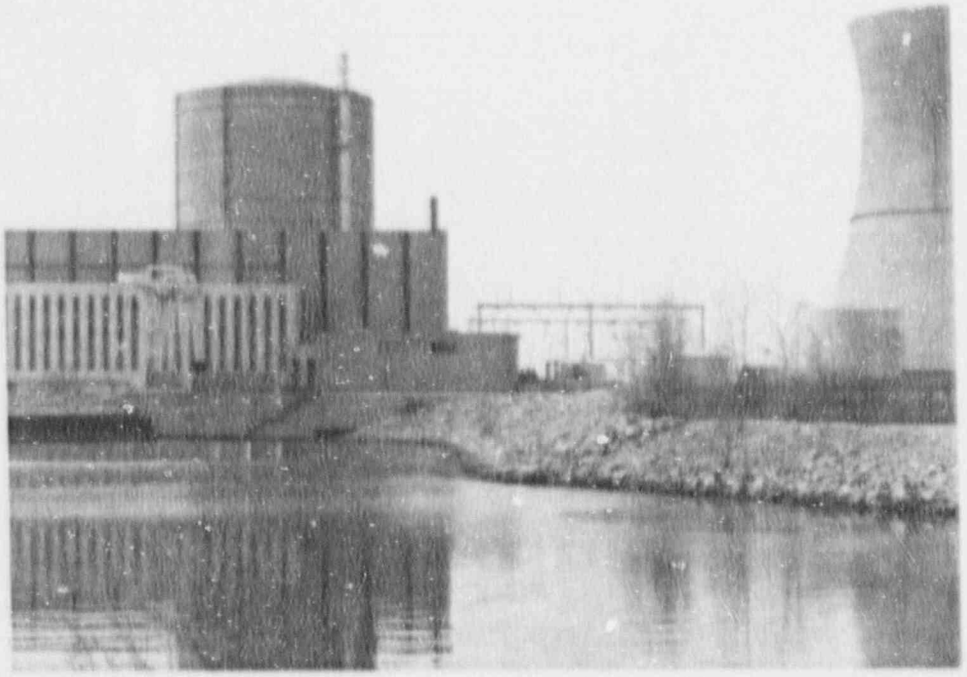


Fig. 6-3: The apparatus designed by EPRI that is used for zebra mussel experimentation.



Water Treatment

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 a coagulant aid to make the water clean and safe for consumption. This water may also be further treated by a demineralization 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 certified operation, 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 by Toledo Edison personnel and submitted to the agency. These reports are submitted monthly, and 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, aresenic, 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 inspections 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 **clarifer**. 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 1990, precipitator number two was operational while precipitator number one was taken out of service for cleaning and maintenance.

Flow Measurement

The OEPA requires daily domestic water production flow measurement for the Drinking Water Operation Report. This flow is normally recorded from the Domestic Water integrator in the water treatment plant, however, this integrator was out of service throughout the year. As a result, flow values had to be calculated using precipitator and secondary demineralizer flow measurements. In December 1990, the integrator was replaced by a new flow measuring device making plant production flow values more accurate and easily obtainable.

Wastewater Treatment Plant Operation

The wastewater (sewage) treatment plant 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 accomodate a flow of 38,000 gallons per day (gpd). This facility (Figure 7-1) consists of two units, and the second is a 23,000 gpd plant, WWTP Number 2. 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 is 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 contains the organisms necessary for continued treatment, and is pumped back to the front of

Figure 7-2: Environmental Compliance personnel run tests daily on the Wastewater plant processes.

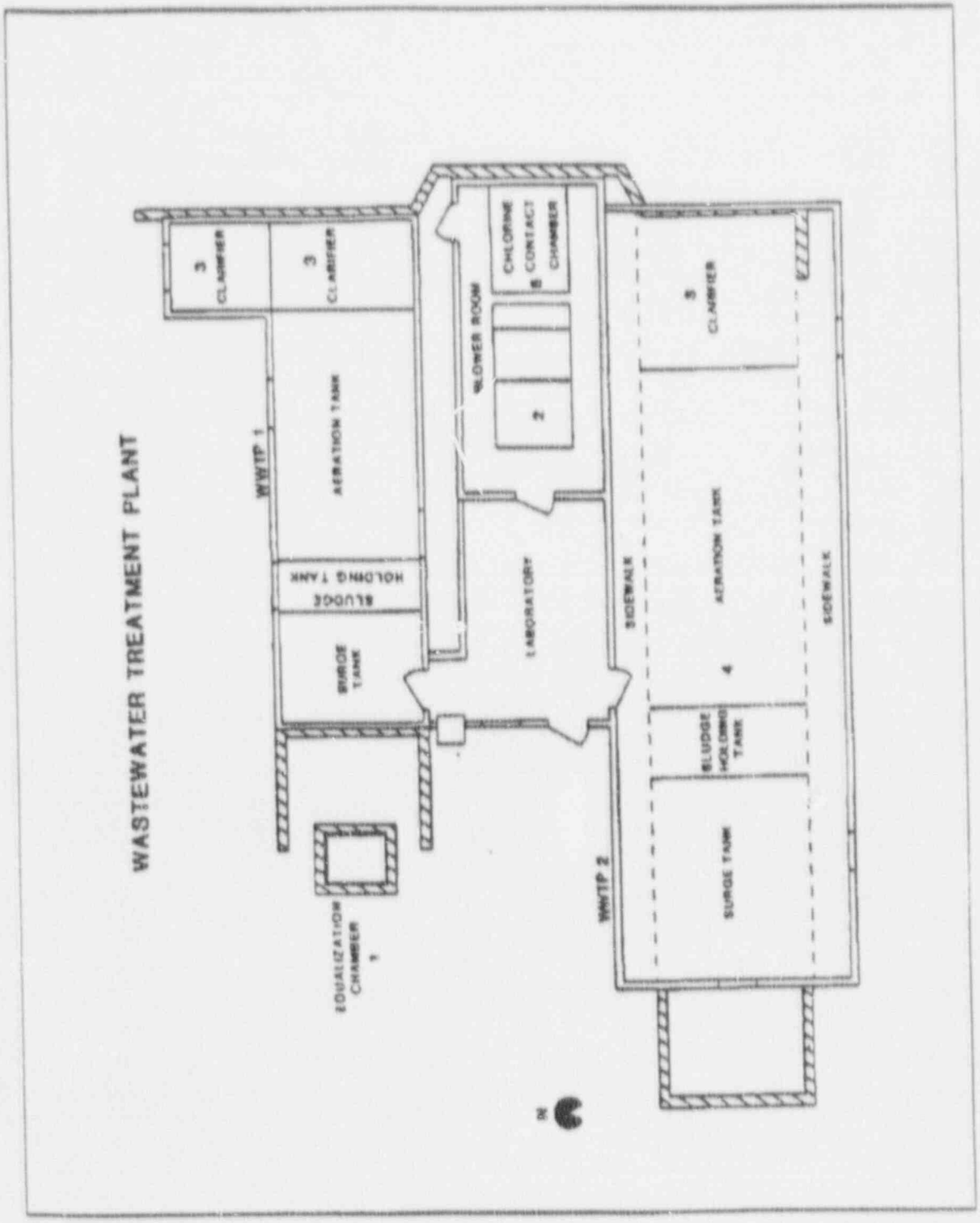


Figure 7-1: A diagram of the Wastewater Treatment Plant.

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 the **Biochemical Oxygen Demand** (BOD) takes place.

To provide for optimun wastewater treatment, Environmental Compliance added a laboratory to the wastewater treatment facility in 1988. The laboratory is used to run daily tests (refer to Figure 7-2) on the plant processes including pH, total suspended solids, dissolved solids, percent settleability, chlorine and dissolved oxygen tests. By analyzing the test results, an operator may make adjustments to treat the wastes more effecively.

SUMMARY OF 1990 WASTEWATER TREATMENT PLANT OPERATIONS

WWTP Number 1 was taken out of service in early May 1989 after operators obse ved that the wall separating two of the plant's treatment tanks was bowing several inches. The plant was completely drained and suupports were installed to alleviate this problem. Current plans are to place the Number one WWTP back into service early in 1991. Later that year WWTP2 will be removed from service for cleaning and maintenance in 1991.

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 1990, water entering the treatment system had an average BOD of 230mg/L, while water leaving the system averaged only 5 mg/L. This represents a total BOD reduction of 98%.

National Pollutant Discharge Elimination System (NPDES) Reporting

The OEPA has established limits on the amount of pollutants the Davis-Besse may discharge to the environment. These limits are regulated through the Station's **National Pollutant Discharge Elimination System** (NPDES) permit, number 21B0011*ED. Parameters such as chlorine, suspended solids, and pH are monitored under the NPDES permit. In June 1990, the NPDES permit was renewed, with Ohio EPA issuing a new permit with some new requirements. For example, the permit was expanded to include increased sampling frequencies for suspended solids and BOD at the wastewater basin.

Davis-Besse personnel prepare and submit the Monthly Ohio EPA NPDES Reports. These reports are complied, typed, reviewed, approved, and submitted 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 blowdown 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, condensate pit sumps, turbine building drains, boiler 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.
Source of Wastes: Water treatment residues, condensate polishing resins (sample collected at overflow number 2 basin).

Sampling Point 801

Intake Temperature: Intake water prior to cooling operation (values obtained computer point at east end of forebay).

1990 NPDES Summary

Outfall 001

The Davis-Besse NPDS permit limits the amount of chlorine that can be discharged to Lake Erie, in order to protect the lake's diverse aquatic life. Chlorine discharge is restrictd to only two hours per day for this purpose. On two occasions, in 1990 this requirement was not met. The first incident occured on August 31 as a result of an equipment malfunction. The second took place on October 4. It was attributed to design and equipment deficiencies. Neither occurance resulted resulted in an exceedance of the 0.5 mg/l free available chlorine (FAC) daily maximum concentration limitation , and no impact to the lake was observed.

Outfall 002

Various conditions resulted in the isolation of Outfal 002 for much of 1990. In February of 1990, the discharge gate was closed due to feedwater drainage into the Training Center pond via the station stormwater system. The discharge of the pond (Outfall 002) was again isolated in May 1990 as a result of condensate drainage in the station which contained small quantities of a treatment chemical; hydrazine. The gate remained closed throughout the summer as evaporation eliminated the need to discharge stormwater. The gate was opened in November 1990, 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 signifigant problems occured at this outfall in 1990.

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 cleanup,

excessive numbers can adversely impact effluent quality. Algae concentrations in 1990 were suprisingly moderate. A single algicide treatment and cool temperatures stabilized the basin. The established limits for Outfall 601 were not exceeded in 1990.

Outfall 602

The established limits for Outfall 602 were not exceeded in 1990. No signigicant problems occured at this outfall in 1990.

Sampling Point 801

The intake temperature is obtained from a computer point and is monitored continuously. Temperature variations between intake and discharge temperatures can range as high as 15^0 F was recorded for the year. An average differentiation of 3.8^0 F was recorded for the year.

MANAGEMENT PROGRAM
CHEMICAL WASTE

Chemical Waste Management Program

Chemical Waste Management Program

The Chemical Waste Management Program for chemical, hazardous and nonhazardous wastes generated at the Davis Besse Nuclear Power Station was developed to ensure wastes are disposed of offsite in accordance with all applicable state and federal regulations. Chemical wastes which are transported from Davis-Besse are regulated primarily by two federal agencies, the United States Environmental Protection Agency (USEPA) and the United States Department of Transportation (DOT). The State of Ohio also regulates chemical wastes, but in general, State regulations duplicate the federal regulations.

Regulations Governing Chemical Materials

The Chemical Waste Management Program is regulated by the 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)**; and the **Toxic Substance Control Act (TSCA)**. The waste transported from Davis-Besse is also regulated by DOT under the **Transportation Safety Act**. A brief description of these programs is provided in the following paragraphs.

Resource Conservation and Recovery Act (RCRA)

The Resource Conservation and Recovery Act (RCRA) of 1976 is the federal law which regulates solid hazardous waste. **Solid waste** is defined as any 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.

Under RCRA, there are essentially three categories of waste generators:

- Large Quantity Generator - A facility which generates 1000 kilograms/month (2200 lbs/month) or more.
- Small Quantity Generator - A facility which generates less than 1000 kilograms/month (2200 lbs/month).
- Conditionally Exempt Small Quantity Generator - A facility which generates 100 kilograms/month (220 lbs/month).

Hazardous and Solid Waste Amendment (HSWA)

The Hazardous and Solid Waste Amendment of 1984 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 the next few years. 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 such as 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.

Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)

The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA, sometimes refered to as Superfund) became law in 1980. The primary reason for the establishment of this law was to create a federal authority and source of funding for responding to spills and other releases of hazardous materials, pollutants, or contaminants into the environment. **Superfund** established "reportable quantities" for several hundred hazardous materials, thus, spills exceeding this quantity for a specific material must be reported to the EPA. Superfund also regulates the cleanup of abandoned hazardous waste disposal sites.

Superfund Amendment and Reauthorization Act (SARA)

Superfund was amended in October 1986 to establish new programs for dealing with emergency prepardness and community right-to-know. As part of this program, CERCLA would be enhanced by ensuring 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)**, about 400 chemicals, and to establish **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 commitees to aid in the implementation of emergency response plans.

Toxic Substances Control Act (TSCA)

The Toxic Substances Control Act (TSCA) was enacted in 1976 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 similiar to the hazardous waste management system established under RCRA.

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, flammable materials, oxidizing materials, irritants, corrosive materials, radioactive materials, and hazardous wastes.

Clean Air Act

Passed in 1970, the Clean Air Act identified several substances which are considered hazardous air pollutants. Of particular significance is asbestos removal from renovation and demolition projects for which the US EPA 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. Re-

moval teams must meet medical surveillance, respirator fit tests, and training requirements prior to removing asbestos-containing material.

Compliance With Chemical Materials Regulations

Compliance with RCRA and HWSA

Davis-Besse Nuclear Power Station has been designated by the USEPA, according to RCRA, 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, a spill control plan and an accident contingency plan, all of which are part of the Chemical Management Program at Davis-Besse. The following is completed as part of the hazardous waste management program to ensure compliance with the RCRA regulations:

- **Weekly Inspections of Chemical Waste Storage and Accumulation Areas**

Chemical waste storage and accumulation areas are designated throughout the site to ensure proper handling and disposal of chemical waste. The chemical waste accumulation and storage areas are routinely patrolled by security person-

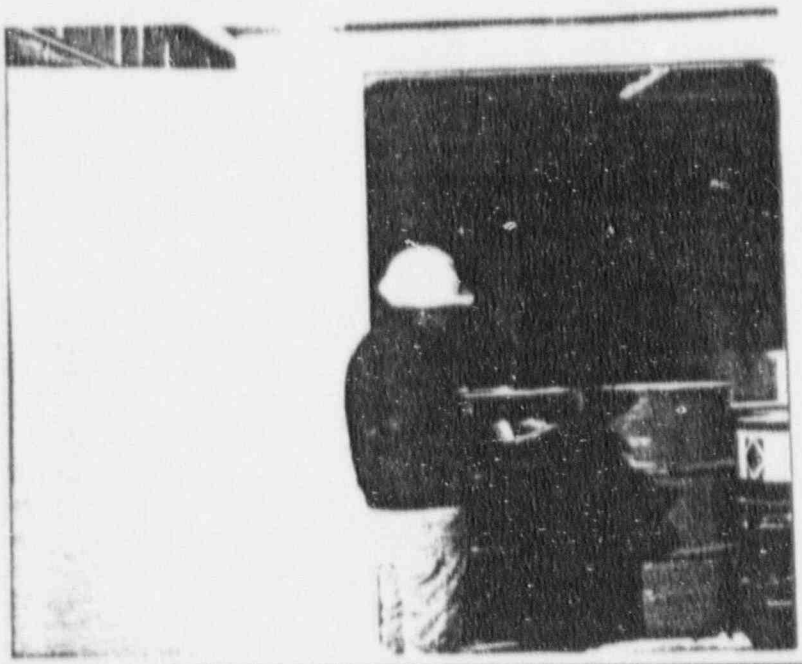


Figure 8-1: EC personnel inspect chemical waste storage areas weekly to ensure wastes are not stored in unapproved areas.

nel, and are also inspected weekly by Environmental Compliance personnel (Figure 8-1). Inspection log sheets, inspection reports and maintenance work requests are completed as needed after each inspection. The log sheets and inspection 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. In addition to the storage and accumulation areas, EC personnel inspect areas throughout the Station and site to ensure wastes are not stored in unapproved areas.

- **Identification of Unknown Chemicals**

The Chemical Waste Storage Area (CWSA) is divided into three sections: Hazardous Waste, Nonhazardous Waste, and Chemical Identification. During the weekly inspection of the CWSA, the Chemical Identification Section is also inspected, and all additions of unmarked waste containers are identified, sampled, and analyzed according to USEPA methods to ensure proper disposal. Once the container's contents are identified, the waste container is immediately labeled and moved to the appropriate waste section. For example, a drum of golden brown fluid is added to this section. The drum is assigned a number and sampled for laboratory analysis. The lab results state that the sample is oil. A nonhazardous waste label is then applied to the drum, and the drum is subsequently moved to the Nonhazardous Waste Section of the Chemical Waste Storage Area.

- **Written Inspection Reports**

All inspections of the chemical waste storage and accumulation areas, as well as any follow-up action items, are reported to upper management in inspection reports. All inspection items (deficiencies) of immediate concern are completed and delivered on the day of the inspection.

- **Waste Minimization**

In 1990, 1465 gallons of hazardous waste were transported off site for disposal. This is 26% less hazardous waste than was generated in 1989. An additional 365 gallons and 200 cubic yards of nonhazardous waste and 5523 gallons of PCB waste were disposed of in 1990.

Davis-Besse reduced the volume of waste sent to disposal facilities in 1990 by sending 414 gallons of hazardous waste (used solvents), 19,640 gallons of waste oil and 129 lead acid battery cells to recycling firms and fuel blenders for thermal energy recovery purposes.

As another measure in waste minimization, 4000 pounds of polystyrene resins were returned to a plastic manufacturer for reuse. Recycling this material represents about 74 cubic feet of space which was not used in today's dwindling landfill space.

Compliance With CERCLA and SARA

Davis-Besse conducted 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 1990, the following list was generated:

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

Two of these chemicals, hydrazine and sulfuric acid, are extremely hazardous substances (EHS). These chemicals are found onsite in quantities greater than or equal to 500 pounds. The other reported chemicals are in quantities greater than or equal to 10,000 pounds. Any new chemicals found to be present in these quantities (10,000 lbs. or 500 lbs.) or at threshold planning quantities (TPQ) prior to the next reporting year (1991), 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 1990, the required reporting quantity was the same pound limits as in 1989. Annual SARA reports are submitted by March 1 for the preceding calendar year.

Compliance With TSCA

Although TSCA requires inspections every three months, PCB transformers at Davis-Besse are inspected on a weekly basis to ensure effective management of PCBs. Visual inspections of the transformers are conducted to detect leakage

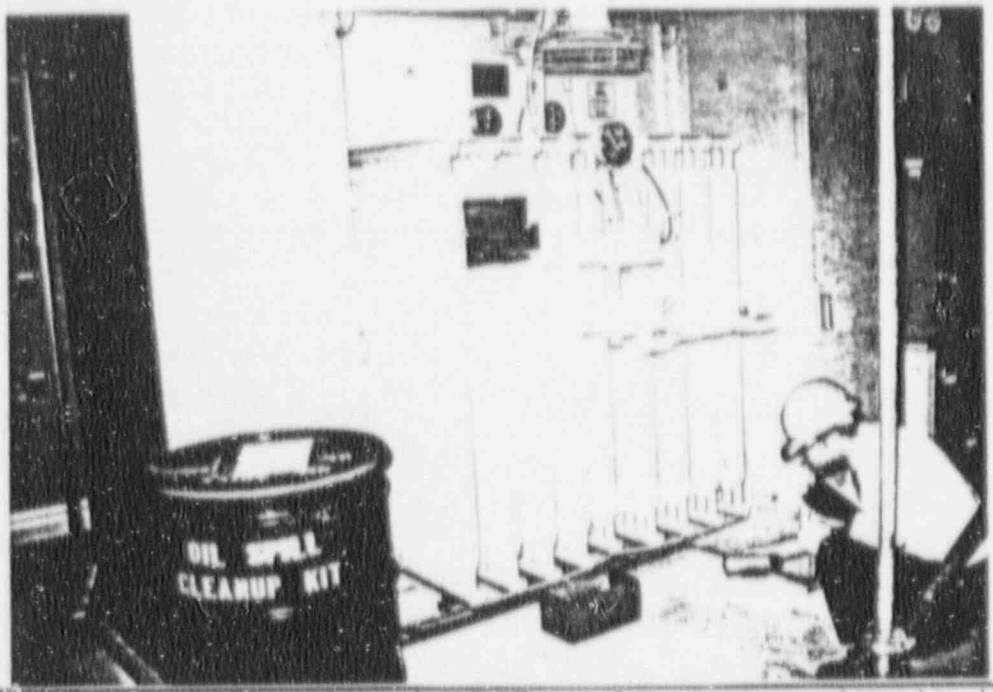


Figure 8-2: Visual inspections of all PCB transformers are conducted to detect leakage and avoid potential problems which may arise.

and avoid potential problems which may arise. There are eleven PCB transformers located in the Auxiliary Building, Water Treatment Plant, near Service Building 2 and the Personnel Processing Facility. Environmental Compliance personnel are currently sampling all fluid-filled transformers at Davis-Besse and submitting the samples to an offsite lab for analysis to ensure that there are no other PCB or PCB-contaminated transformers onsite.

The eventual phase out and elimination of PCBs is recommended due to the high cost of PCB spill cleanup. Although no time limit has been set on this plan, in 1990, Davis-Besse continued an aggressive program of reducing the number of PCB transformers onsite.

Ten PCB transformers underwent the fifth and final retrofill cycle during 1990. A retrofill cycle involves flushing the PCB fluid out of the transformer, refilling it with a PCB-leaching solvent, and allowing the solvent to circulate in the trans-

former during operation. For the entire retrofill process, the transformers are retrofilled three times with a leaching solvent and twice with silicone fluid. The entire process will take two to three years and will extract almost all of the PCBs. The transformers will be tested in 1991 for PCB levels, and if less than 50 parts per million (ppm), the transformers can be reclassified as non-PCB. One transformer, BF-4, was reclassified as non-PCB in 1990.

Compliance With the Transportation Safety Act

Before any wastes are transported offsite, Davis-Besse must ensure that the wastes are identified, labeled and marked according to DOT regulations. Also, the transportation vehicle is checked to ensure DOT placards are on all sides and it is in good operating condition (for example, brake lights and turn signals function properly).

Hazardous wastes are transported for disposal within 90 days from the date accumulation and storage began, as required by the USEPA waste generator permit issued to Davis-Besse. 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. If the TSDF does not return a signed copy of the manifest within 35 days, Davis-Besse personnel contact the facility to determine the status of the waste. In 1990, all manifests were returned from the TSDF to Davis-Besse within the required 35 days.

Compliance With the Clean Air Act

In 1990, 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 (amount) of nonfriable asbestos cement board was removed and replaced with a non-asbestos cement board. 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.

Audits and Inspections

The above programs, as well as Davis-Besse's commitments to various regulatory agencies, are audited and inspected by various groups and individuals including the following:

- Davis-Besse Quality Assurance Department
- Nuclear Regulatory Commission
- Institute of Nuclear Power Operations

- Environmental Protection Agency
- Private Consultants

These inspections and audits are performed to ensure Davis-Besse maintains the commitment to meet the requirements of local, state and federal regulations.

As a measure to ensure compliance with applicable regulations, Environmental Compliance and Quality Assurance personnel have been conducting surveys of all the vendors utilized for disposal of Davis-Besse chemical wastes. This includes the analytical laboratories, transporters, and TSDFs. The surveys include a checklist of applicable federal RCRA, HSWA, and DOT regulations. If the vendor or TSDF has a deficiency in complying with an item of the regulation or program enhancement, a Recommendation or Observation, respectively, is issued to the vendor or TSDF. For an Observation, the facility is requested to respond within thirty days with corrective actions. A Recommendation is issued to suggest a good business practice and does not require the facility to respond with any corrective actions. Only three Recommendations were issued to the one facility surveyed in 1990.

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 provide protection from tank contents leaking and causing damage to the environment. An UST includes the tank system and its piping. It must have 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. UST regulations also provide the following timeline for revamping tank systems:

- By January 31,1992 all tanks must have permit renewals completed and submitted.
- Tank tightness testing capable of detecting a 0.1 gal/hr leak rate or monthly tank gauging with inventories within 13 gallons must be conducted on the 2,000 gallon waste oil tank by December 22, 1993.
- Line tightness tests must be performed every three years by December 22, 1996.

- There must be corrosion protection, monthly release detection, and overfill prevention for the 2,000 gallon waste oil tank by December 22, 1998.

In 1990, the two 40,000 gallon and the 8,000 gallon diesel fuel storage tanks became exempt from these regulations by virtue of being part of an emergency generating system at a nuclear power station. However, there are regulations that do apply for responding to a tank or piping leak greater than 25 gallons and for corrective action to clean up such a spill.

Fuel Storage Tanks At Service Building #4

Permanent gasoline storage tanks were constructed at Service Building #4. Mobile Central at Service Building #4 provides vehicle repair and service. Having a fuel supply at this location eliminates the inconveniences of the previous temporary fuel storage facility at the station warehouse.

The gasoline storage tanks are constructed inside a diked concrete structure to collect any spilled fuels and to reduce any environmental impact should a spill occur.

100,000 Gallon Diesel Fuel Oil Storage Tank

A spill control dike was constructed in front of the pump house for the 100,000 gallon diesel fuel oil storage tank. This dike was constructed to ensure containment of drips, leaks and small spills during refueling operations.

Fire Training Area Modification

In response to an independent Chemical Risk Assessment Audit performed at the Davis-Besse site, Environmental Compliance recommended that the fire protection training area be upgraded to reduce the potential of adverse environmental impact due to training activities or potential spills.

Environmental Compliance recommended that a diked concrete pad with a catch basin be installed. The catch basin would collect wastes preventing contamination of surrounding soils and possibly groundwater supplies. Wastes are periodically pumped out of the catch basin and properly disposed of. When the training area is not in use, a waterproof cover prevents accumulation of rain/snow thereby minimizing the amount of contaminated wastes.

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 onsite for training em-

ployees 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.

Spill Control Kits

Fifty-five gallon drums containing protective equipment and spill control equipment are maintained throughout the Station at chemical storage areas. 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 to allow for fast and easy response in the event of a chemical or oil spill.

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 determine that it is nonhazardous. Waste oil that contains less than 1000 parts per million of halogens and has a flash point above 140^{0}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 Inventory Forms

Inventory forms placed on waste accumulation drums 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 increasing the volume and number of containers of hazardous waste and increasing disposal costs.

Chemical Approval

The **Controlled Materials Program** at Davis-Besse was developed to review and approve chemicals and products before they are put to use at the Station. Chemicals and products that cannot be disposed of easily are either deleted or replaced with a less hazardous substitute to eliminate the problem of waste disposal at a later date.

Appendix

APPENDIX A - GLOSSARY

Glossary

A

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

activation products — Radioactivity that is created when stable substances are bombarded by 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. It is identical to a helium nucleus, and has a mass number of 4 and a charge of +2. It has low penetrating power and short range. Alpha particles are easily stopped by a thin layer of paper or fabric, or the dead outer layer of skin cells.

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. An atom has a nucleus, composed of positively charged protons and electrically neutral neutrons, around which orbit negatively charged electrons.

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. For example, a carbon atom has 6 neutrons and 6 protons, so its atomic weight is 12.

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. In the United States, most people receive 100 to 250 millirem of background radiation per year. Common sources of man-made background radiation include consumer products such as color televisions, radium dials on watches or clocks, smoke detectors, coast-to-coast jet flights, construction materials, and certain foods.

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 structure from overpressurization by condensing any steam released through any leaks in 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, such as the anemometer used to measure wind speed, 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 fissions, 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. (e.g., four weekly water samples combined to make one monthly composite sample).

containment vessel A steel liner inside the concrete shield building. Designed to isolate the primary system from the environment and other station systems.

continuous sample A continuous sample is one that collects samples non-stop and is used to evaluate conditions over a specific period of time. The typical continuous samples collected at Davis-Besse include TLDs and air samples.

control location A sample collection location generally more than 5 miles away from Davis-Besse. Analyses of samples collected at control locations provide information on

	normally-occurring background radiation and radioactivity.
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	Essentially a chimney, designed to create a natural draft. Cool air enters the base of the tower, is drawn upward through the hollow tower interior and exits the top. At the same time, warm water used to cool the turbine is showered on to a series of baffles inside the cooling tower. As the water strikes the baffles, it is cooled by the process of evaporation.
coriolis force	An apparent deflective force that develops due to the earth's rotation. When any mass travels above the earth's surface, the coriolis force appears to deflect the mass to the right in the Northern Hemisphere and to the left in the Southern Hemisphere.
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. In the case of radium-226, there are 10 successive daughter products, ending in the stable isotope lead-206.

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.

decommissioning — The process of dismantling a nuclear power station, decontaminating any radioactive parts, and storing or disposing of these parts. This process will begin at the end of the reactors' useful life, normally after 40 years of operation.

differential temperature — Air temperature at one level, minus air temperature at another level. Also called delta T.

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. An example of a dissolved solid is a small amount of table salt dissolved in a glass of water.

dose — A quantity (total or accumulated) of ionizing radiation received.

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. Effluents discharged from the Davis-Besse Nuclear Power Station include liquid and gaseous media containing extremely small concentrations of radionuclides. The concentrations released are well below the limits established by the NRC.

electromagnetic radiation — A travelling wave motion resulting from changing electric or magnetic fields. Familiar electromagnetic radiations range from X-rays (and gamma rays) of short wavelength, through the ultraviolet, visible, and infrared regions, to radar and radiowaves of relatively long wavelength.

electron — An elementary particle with a negative charge and a mass 1/1837 that of the proton. Electrons orbit arround the positively charged nucleus. In an electrically neutral atom, the negative charges of the electrons are balanced by the positive charges of the protons.

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.

enrichment — The process of increasing the concentration of the fissionable isotope uranium-235 relative to concentrations present in natural uranium ore. Enriched fuel is more capable of sustaining a chain reaction, and is therefore a more economical fuel source for a nuclear power station. The uranium fuel used at Davis-Besse has been enriched approximately 3%. In comparison, the uranium fuel used in nuclear weaponry has been enriched over 90%.

exposure — The absorption of radiation or ingestion of a radionuclide. Acute exposure is generally accepted to be a large exposure received over a short

period of time. Chronic exposure is low level exposure received during a lifetime or over a long period of time.

external radiation — Exposure to ionizing radiation when the radiation source is located outside of 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 gases — Those fission products that exist in the gaseous state. Primarily the noble gases (krypton, xenon, radon, etc.).

fission products — The nuclei (fission fragments) formed by the fission of heavy elements, plus the nuclides formed by the fragments' radioactive decay.

fuel assembly — A cluster of fuel rods. Also called a fuel element. Many fuel assemblies make up a reactor core. The reactor core at the Davis-Besse Station contains 177 fuel assemblies, each assembly containing 208 fuel rods. The combined weight of the reactor core is 207,486 pounds.

fuel pellet — A small ceramic capsule containing fissionable material, generally powdered uranium dioxide (UO_2).

fuel rod — Contains approximately five pounds of nuclear fuel pellets stacked inside a thin-walled tube (cladding) of zirconium alloy.

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 similiar to X-rays, but are usually more energetic.

grab samples — A grab sample represents a single sample collected in 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. Analyses from samples collected at indicator locations provide information on the radiological impact, if any, Davis-Besse has 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 one or more electrons to, or removing one or more electrons 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. For example, alpha and beta particles, gamma and X-rays, neutrons, and ultraviolet light.

isotope — One of two or more atoms with the same number of protons, but different numbers of neutrons in their nuclei. Thus, carbon-12, carbon-13, and carbon-14 are isotopes of the element carbon; the numbers denoting their approximate atomic weights. Isotopes have the same chemical properties, but often different physical properties (for example, carbon-12 and carbon-13 are stable, while carbon-14 is radioactive).

J K L

lower limit of detection (LLD) — 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. The LLD is actually a measure of the ability of an individual analysis to detect extremely minute amounts of radioactivity in a sample.

M

mean — Arithmetic average. In a series of 3 or more numbers, the mean is calculated by the equation:

$$x = \frac{x1 + x2 + \ldots xn}{n}$$

where n is the number of observations in a data set,and x1, x2, ... xn are the various observations.

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

microcurie — One-millionth of a curie.

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

millirem — One-thousandth of a rem.

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.

picocurie — One-trillionth of a curie.

primary loop — A closed system of piping which provides cooling water to the reactor and transfers heat energy to a second closed system, the secondary loop.

proton — An elementary particle that carries a positive charge and has a mass of 1.67×10^{-24} gram.

Q R

quality assurance (QA) — All the planned and systematic actions that are necessary to provide adequate confidence in the results of an activity.

quality control (QC) — The field check or verification of work while it is being performed to assure that the task is properly done.

quality factor — The factor by which the absorbed dose is multiplied to obtain a quantity that expresses, on a common scale for all ionizing radiation (rem), the potential for biological damage to exposed 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 measureable 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), or airborne.
radioactive decay	The decrease in the amount of radioactivity with the passage of time due to the spontaneous emission of particulate or gamma radiation from the atomic nuclei.
radioactivity	The spontaneous emission of radiation from the nucleus of an unstable isotope. Radioactivity is a process and radiation is the product.
radioiodine	A radioactive isotope of iodine. The radioisotopes of iodine are among the most abundant of the fission products. All told, 27 isotopes of iodine are known to exist, but only the naturally-occurring iodine-127 is stable. Of the remaining 26 radioisotopes, 12 are produced during fission and these have half-lives ranging from 1.5 seconds to 16 million years.
radioisotope	The term "radioisotope" is used to specifically describe the relationship between an element and a radioactive isotope of that element. For instance, in describing Cs-137, one could state that Cs-137 is a radioisotope of cesium (stable).
radionuclide	A radioactive isotope.
reaction	Any process involving a chemical or nuclear change.
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, 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. Inherent in the design -- a layer of rocks, concrete blocks, etc., laid over a nylon mesh mat to form a gradual slope that extends well into the water -- revetments actually encourage beach formation by passive deposition of particulate matter along the base of the structure.

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 meter of dry air at standard temperature and pressure.

S

secondary loop — A closed piping system that absorbs heat from water in the primary loop via convection through the steam generator tubes. As water in the secondary loop heats, it boils and becomes the steam used to spin the turbines to produce an electric current.

shield building — A specially designed concrete building which surrounds the containment vessel. Its purpose is to protect the containment vessel from environmental extremes, and to provide a negative pressure boundary between the containment vessel and the environment.

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.

spiked sample — A sample that has been intentionally contaminated with a known concentration of some radionuclide. Subsequent testing of the sample should indicate concentrations at least as high as the introduced concentration. Spiked sample analyses provide a quality control check on the validity of the analyses performed at the laboratory.

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. This design permits heat exchange with little or no contamination of the secondary system equipment.

suspended solids — Solids capable of removal through a filter such as a screen. An example of a suspended solid is silt present in lake or river water that gives the water a cloudy appearance. The silt is easily removed by passing the water through a filter.

T

Technical Specifications (Tech Specs) — A part of the operating license for any nuclear facility issued by the Nuclear Regulatory Commission (NRC), the Tech Specs delineate the requirements the facility must meet in order to maintain its operating license. For example, the Tech Specs for Davis-Besse provide detailed information on the types, collection sites, frequencies, and analyses to be performed on samples collected as part of the Radiological Environmental Monitoring Program.

terrestrial radiation — The portion of natural radiation (background) that is emitted by naturally occurring radioactive materials in the earth.

tertiary loop — The steam in the secondary loop used to drive the turbine-generator is condensed, i.e., cooled to a liquid form, by transferring its heat to a third loop system, the

tertiary loop. Also called the circulating water system, the nonradioactive water in this system carries heat from the condenser to the cooling tower; the heat is lost to the atmosphere via evaporative cooling.

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

wind rose — A graph representing the percent of time that the wind blew from a particular direction and the average speed of the wind from that direction.

whole-body exposure — An exposure of the body to radiation, in which the entire body rather than an isolated part is irradiated. Where a radioisotope is uniformly distributed throughout the body tissues, rather than being concentrated in certain parts, the irradiation can be considered as a whole-body exposure.

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 Nazleton 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 concentrations 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 1986 through December, 1990. 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 1985-1986 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, 1986 through 1990.[a]

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L[b] TIML Result ±2σ[c]	EPA Result[d] 1s, N=1	EPA Result[d] Control Limits
STF-447	Food	Jan 1986	Sr-89	24.3±2.5	25.0±5.0	16.3-33.7
			Sr-90	17.3±0.6	10.0±1.5	7.4-12.6
			I-131	22.7±2.3	20.0±0.6	9.6-30.4
			Cs-137	16.3±0.6	15.0±5.0	6.3-23.7
			K	927±46	950±144	701-1199
STW-448	Water	Feb 1986	Cr-51	45.0±3.6	38.0±5.0	29.3-46.7
			Co-60	19.7±1.5	18.0±5.0	9.3-26.7
			Zn-65	44.0±3.5	40.0±5.0	31.3-48.7
			Ru-106	<9.0	0.0±5.0	0.0-8.7
			Cs-134	28.3±2.3	30.0±5.0	21.3-38.7
			Cs-137	23.7±0.6	22.0±5.0	13.3-30.7
STW-449	Water	Feb 1986	H-3	5176±48	5227±525	4317-6137
STW-450	Water	Feb 1986	U total	8.0±0.0	9.0±6.0	0.0-19.4
STM-451	Milk	Feb 1986	I-131	7.0±0.0	9.0±6.0	0.0-19.4
STW-452	Water	Mar 1986	Ra-226	3.8±0.1	4.1±0.6	3.0-5.2
			Ra-228	11.0±0.5	12.4±1.8	9.2-15.5
STW-453	Water	Mar 1986	Gr. alpha	6.7±0.6	15.0±5.0	6.3-23.7
			Gr. beta	7.3±0.6	8.0±5.0	0.0-16.7
STW-454	Water	Apr 1986	I-131	7.0±0.0	9.0±6.0	0.0-19.4
STW-455 . 456	Water (Blind)	Apr 1986				
	Sample A		Gr. alpha	15.0±1.0	17.0±5.0	8.3-25.7
			Ra-226	3.1±0.1	2.9±0.4	2.1-3.7
			Ra-228	1.5±0.2	2.0±0.3	1.6-2.5
			Uranium	4.7±0.6	5.0±6.0	0.0-15.4
	Sample B		Gr. beta	28.7±1.2	35.0±5.0	26.3-43.7
			Sr-89	5.7±0.6	7.0±5.0	0.0-15.7
			Sr-90	7.0±0.0	7.0±1.5	4.4-9.6
			Co-60	10.7±1.5	10.0±5.0	1.3-18.7
			Cs-134	4.0±1.7	5.0±5.0	0.0-13.7
			Cs-137	5.3±0.6	5.0±5.0	0.0-13.7

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	EPA Result[d] Control Limits
STAF-457	Air Filter	Apr 1986	Gr. alpha	13.7±0.6	15.0±5.0	6.3-23.7
			Gr. beta	46.3±0.6	47.0±5.0	38.3-55.7
			Sr-90	14.7±0.6	18.0±1.5	15.4-20.6
			Cs-137	10.7±0.6	10.0±5.0	1.3-18.7
STU-458	Urine	Apr 1986	Tritium	4313±70	4423±189	4096-4750
STW-459	Water	May 1986	Sr-89	4.3±0.6	5.0±5.0	0.0-13.7
			Sr-90	5.0±0.0	5.0±1.5	2.4-7.6
STW-460	Water	May 1986	Gr. alpha	5.3±0.6	8.0±5.0	0.0-16.7
			Gr. beta	11.3±1.2	15.0±5.0	6.3-23.7
STW-461	Water	Jun 1986	Cr-51	<9.0	0.0±5.0	0.0-8.7
			Co-60	66.0±1.0	66.0±5.0	57.3-74.7
			Zn-65	87.3±1.5	85.0±5.0	77.3-94.7
			Ru-106	39.7±2.5	50.0±5.0	41.3-58.7
			Cs-134	49.3±2.5	49.0±5.0	40.3-57.7
			Cs-137	10.3±1.5	10.0±5.0	1.3-18.7
STW-462	Water	Jun 1986	Tritium	3427±25	3125±361	2499-3751
STM-464	Milk	Jun 1986	Sr-89	<1.0	0.0±5.0	0.0-8.7
			Sr-90	15.3±0.6	16.0±1.5	13.4-18.6
			I-131	48.3±2.3	41.0±6.0	30.6-51.4
			Cs-137	43.7±1.5	31.0±5.0	22.3-39.7
			K	1567±114	1600±80	1461-1739
STW-465	Water	Jul 1986	Gr. alpha	4.7±0.6	6.0±5.0	0.0-14.7
			Gr. beta	18.7±1.2	18.0±5.0	9.3-26.7
STW-467	Water	Aug 1986	I-131	30.3±0.6	45.0±6.0	34.4-55.4
STW-468	Water	Aug 1986	Pu-239	11.3±0.6	10.1±1.0	8.3-11.9
STW-469	Water	Aug 1986	Uranium	4.0±0.0	4.0±6.0	0.0-14.4
STAF-470 471 472	Air Filter	Sep 1986	Gr. alpha	19.3±1.5	22.0±5.0	13.3-30.7
			Gr. beta	64.0±2.6	66.0±5.0	57.3-74.7
			Sr-90	22.0±1.0	22.0±5.0	19.4-24.6
			Cs-137	25.7±1.5	22.0±5.0	13.3-30.7
STW-473	Water	Sep 1986	Ra-226	6.0±0.1	6.1±0.9	4.5-7.7
			Ra-228	8.7±1.1	9.1±1.4	6.7-11.5

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	EPA Result[d] Control Limits
STW-474	Water	Sep 1986	Gr. alpha	16.3±3.2	15.0±5.0	6.3-23.7
			Gr. beta	9.0±1.0	8.0±5.0	0.0-16.7
STW-475	Water	Oct 1986	Cr-51	63.3±5.5	59.0±5.0	50.3-67.7
			Co-60	31.0±2.0	31.0±5.0	22.3-39.7
			Zn-657	87.3±5.3	85.0±5.0	76.3-93.7
			Ru-106	74.7±7.4	74.0±5.0	65.3-82.7
			Cs-134	25.7±0.6	28.0±5.0	19.3-36.7
			Cs-137	46.3±1.5	44.0±5.0	35.3-52.7
STW-476	Water	Oct 1986	H-3	5918±60	5973±597	4938-7008
SPW-477	Water (Blind)	Oct 1986				
	Sample A		Gr. alpha	34.0±6.0	40.0±5.0	31.3-48.7
			Ra-226	5.8±0.2	6.0±0.9	4.4-7.6
			Ra-228	2.7±1.0	5.0±0.8	3.7-6.3
			Uranium	11.0±0.0	10.0±6.0	0.0-20.4
	Sample B		Gr. beta	38.7±1.2	51.0±5.0	42.3-59.7
			Sr-89	5.0±0.0	10.0±5.0	1.3-18.7
			Sr-90	3.0±0.0	4.0±1.5	1.4-6.6
			Co-60	24.7±1.2	24.0±5.0	15.3-32.7
			Cs-134	11.0±2.0	12.0±5.0	3.3-20.7
			Cs-137	9.3±1.2	8.0±5.0	0.0-20.4
STM-479	Milk	Nov 1986	Sr-89	7.7±1.2	9.0±5.0	0.3-17.7
			Sr-90	1.0±0.0	0.0±1.5	0.0-2.6
			I-131	52.3±3.1	49.0±6.0	38.6-59.4
			Cs-137	45.7±3.1	39.0±5.0	30.3-47.7
			K	1489±104	1565±78	1430-1700
STU-480	Urine	Nov 1986	H-3	5540±26	5257±912	4345-6169
STW-481	Water	Nov 1986	Gr. alpha	12.0±4.0	20.0±5.0	11.3-28.7
			Gr. beta	20.0±3.5	20.0±5.0	11.3-28.7
STW-482	Water	Dec 1986	Ra-226	6.7±0.2	6.8±1.0	5.0-8.6
			Ra-228	5.2±0.2	11.1±1.7	8.2-14.0
STW-483	Water	Jan 1987	Sr-89	19.7±5.0	25.0±5.0	16.3-33.7
			Sr-90	21.0±2.0	25.0±1.5	22.4-27.6

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	EPA Result[d] Control Limits
STW-484	Water	Jan 1987	Pu-239	17.0±2.3	16.7±1.7	13.8-19.6
STF-486	Food	Jan 1987	Sr-90	36.0±4.0	49.0±10.0	31.7-66.3
			I-131	78.0±3.4	78.0±8.0	64.1-91.9
			Cs-137	89.7±3.0	84.0±5.0	75.3-92.7
			K	942±56	980±49	895-1065
STF-487	Food (Blank)	Jan 1987	Sr-90	2.0±0.0	---	
			I-131	<3	---	
			Cs-137	<2	---	
			K	993±102	---	
STW-488	Water	Feb 1987	Co-60	49.0±0.0	50.0±5.0	41.3-58.7
			Zn-65	96.0±7.2	91.0±5.0	82.3-99.7
			Ru-106	92.0±20.2	100.0±5.0	91.3-108.7
			Cs-134	53.0±3.4	59.0±5.0	50.3-67.7
			Cs-137	89.3±4.6	87.0±5.0	78.3-95.7
STW-489	Water	Feb 1987	H-3	4130±140	4209±420	3479-4939
STW-490	Water	Feb 1987	Uranium	8.3±1.2	8.0±6.0	0.0-18 ^
STM-491	Milk	Feb 1987	I-131	10.0±0.0	9.0±0.9	7.4-10.6
STW-492	Water	Mar 1987	Gr. alpha	3.7±1.2	3.0±5.0	0.0-11.7
			Gr. beta	11.3±1.2	13.0±5.0	4.3-21.7
STW-493	Water	Mar 1987	Ra-226	7.0±0.1	7.3±1.1	5.4-9.2
			Ra-228	7.1±2.3	7.5±1.1	5.5-9.5
STW-494	Water	Apr 1987	I-131	8.0±0.0	7.0±0.7	5.8-8.2
STAF-495	Air Filter	Apr 1987	Gr. alpha	15.0±0.0	14.0±5.0	5.3-22.7
			Gr. beta	41.0±2.0	43.0±5.0	34.3-51.7
			Sr-90	16.3±1.2	17.0±1.5	14.4-19.6
			Cs-137	7.0±0.0	8.0±5.0	0.0-16.7
STW-496 497	Water (Blind)	Apr 1987				
	Sample A		Gr. alpha	30.7±1.2	30.0±8.0	16.1-43.9
			Ra-226	3.9±0.2	3.9±0.6	2.9-4.9
			Ra-228	4.9±0.9	4.0±0.6	3.0-5.0
			Uranium	5.0±0.0	5.0±6.0	0.0-15.4

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	EPA Result[d] Control Limits
STW-496 497	Water (Blind)	Apr 1987				
	Sample B		Gr. beta	69.3±9.4	66.0±5.0	57.3-74.7
			Sr-89	16.3±3.0	19.0±5.0	10.3-27.7
			Sr-90	10.0±0.0	10.0±1.5	7.4-12.6
			Co-60	8.3±3.0	8.0±5.0	0.0-16.7
			Cs-134	19.0±2.0	20.0±5.0	11.3-28.7
			Cs-137	14.7±1.2	15.0±5.0	6.3-23.7
STU-498	Urine	Apr 1987	H-3	6017±494	5620±795	4647-6593
STW-499	Water	May 1987	Sr-89	38.0±6.0	41.0±5.0	32.3-49.7
			Sr-90	21.0±2.0	20.0±1.5	17.4-22.6
STW-500	Water	May 1987	Gr. alpha	9.0±3.4	11.0±5.0	2.3-19.7
			Gr. beta	10.3±1.2	7.0±5.0	0.0-15.7
STW-501	Water	Jun 1987	Cr-51	40.0±8.0	41.0±5.0	32.3-49.7
			Co-60	60.3±3.0	64.0±5.0	55.3-72.7
			Zn-65	11.3±5.0	10.0±5.0	1.3-18.7
			Ru-106	78.3±6.4	75.0±5.0	66.3-83.7
			Cs-134	36.7±3.0	40.0±5.0	31.3-48.7
			Cs-137	80.3±4.2	80.0±5.0	71.3-88.7
STW-502	Water	Jun 1987	H-3	2906±86	2895±357	2277-3513
STW-503	Water	Jun 1987	Ra-226	6.9±0.1	7.3±1.1	5.4-9.2
			Ra-228	13.3±1.0	15.2±2.3	11.2-19.2
STM-504	Milk	Jun 1987	Sr-89	57.0±4.3	69.0±5.0	60.3-77.7
			Sr-90	32.0±1.0	35.0±5.0	32.4-37.6
			I-131	64.0±2.0	59.0±6.0	48.6-69.4
			Cs-137	77.7±0.6	74.0±5.0	65.3-82.7
			K	1383±17	1525±76	1393-1657
STW-505	Water	Jul 1987	Gr. alpha	2.3±0.7	5.0±5.0	0.0-13.7
			Gr. beta	4.0±1.0	5.0±5.0	0.0-13.7
STF-506	Food	Jul 1987	I-131	82.7±4.6	80.0±8.0	66.1-93.9
			Cs-137	53.7±3.0	50.0±5.0	41.3-58.7
			K	1548±57	1680±84	1534-1826
STW-507	Water	Aug 1987	I-131	45.7±4.2	48.0±6.0	37.6-58.4

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	EPA Result[d] Control Limits
STW-508	Water	Aug 1987	Pu-239	5.8±0.2	5.3±0.5	4.4-6.2
STW-509	Water	Aug 1987	Uranium	13.3±0.3	13.0±6.0	2.6-23.4
STAF-510	Air Filter	Aug 1987	Gr. alpha	9.7±0.4	10.0±5.0	1.3-18.7
			Gr. beta	28.3±0.6	30.0±5.0	21.3-38.7
			Sr-90	10.0±0.9	10.0±1.5	7.4-12.6
			Cs-137	10.0±1.0	10.0±5.0	1.3-18.7
STW-511	Water	Sep 1987	Ra-226	9.9±0.1	9.7±1.5	7.2-12.2
			Ra-228	8.1±1.4	6.3±1.0	4.6-8.0
STW-512	Water	Sep 1987	Gr. alpha	2.0±0.6	4.0±5.0	0.0-12.7
			Gr. beta	11.3±1.3	12.0±5.0	3.3-20.7
STW-513	Water	Sep 1987	H-3	4473±100	4492±449	3714-5270
STW-514	Water (Blind)	Oct 1987				
	Sample A		Gr. alpha	29.3±2.6	28.0±7.0	15.9-40.1
			Ra-226	4.9±0.1	4.8±0.7	3.6-6.1
			Ra-228	4.2±1.0	3.6±0.5	2.7-4.5
			Uranium	3.0±0.1	3.0±6.0	0.0-13.4
	Sample B		Sr-89	14.3±1.3	16.0±5.0	7.3-24.7
			Sr-90	9.7±0.4	10.0±1.5	7.4-12.6
			Co-60	16.7±3.0	16.0±5.0	7.3-24.7
			Cs-134	16.7±2.3	16.0±5.0	7.3-24.7
			Cs-137	24.3±3.3	24.0±5.0	15.3-32.7
STW-516	Water	Oct 1987	Cr-51	80.3±17.5	70.0±5.0	61.3-78.7
			Co-60	16.0±2.3	15.0±5.0	6.3-23.7
	Sample A		Zn-65	46.3±5.6	46.0±5.0	37.3-54.7
			Ru-106	57.3±15.4	61.0±5.0	52.3-69.7
			Cs-134	23.7±2.5	25.0±5.0	16.3-33.7
			Cs-137	51.7±3.2	51.0±5.0	42.3-59.7
STU-517	Urine	Nov 1987	H-3	7267±100	7432±743	6145-8719
STW-518	Water	Nov 1987	Gr. alpha	3.0±2.0	7.0±5.0	0.0-15.7
			Gr. beta	15.7±2.3	19.0±5.0	10.3-27.7
STW-519	Water	Dec 1987	I-131	26.0±3.0	25.0±6.0	15.6-36.4

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	EPA Result[d] Control Limits
STW-520	Water	Dec 1987	Ra-226	5.1±0.8	4.8±0.7	3.6-6.0
			Ra-228	3.4±0.1	5.3±0.8	3.9-6.7
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
STF-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
STM-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	EPA Result[d] 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±0.0	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	321.7±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
STM-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	EPA Result[d] 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	6.3-2[illegible]
STW-551	Water	Oct 1988	H-3	2333±127	2316±350	1710
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	EPA Result[d] 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	24.4-27.6
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
STW-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	EPA Result[d] 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
STW-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-5719	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	EPA Result[d] 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±0.09	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	EPA Result[d] 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
STW-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	EPA Result[d] 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
STW-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
STM-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	90.9-129.1
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	EPA Result[d] 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

[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 the 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 the lab.

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

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

Lab Code	TLD Type	Measurement	mR: Teledyne Result ±2σ[a]	mR: Known Value[c]	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	43.0±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
		Lab 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 Intercomparison[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 (continued)

Lab Code	TLD Type	Measurement	mR: Teledyne Result ±2σ[a]	mR: Known Value[c]	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±5.4	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	32.3±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	mR: Teledyne Result ±2σ[a]	mR: Known Value[c]	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	--

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 (GASL), 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 Dosimeter 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.

Table B-3 In-house spiked samples.

Lab Code	Sample Type	Date Collected	Analysis	Concentration (pCi/L) TIML Result n=3	Known Activity	Expected Precision 1s, n=3[a]
QC-MI-6	Milk	Feb 1986	Sr-89	6.0±1.9	6.4±3.0	8.7
			Sr-90	14.2±1.7	12.9±2.0	5.2
			I-131	34.2±3.8	35.2±3.5	10.4
			Cs-134	32.0±1.8	27.3±5.0	8.7
			Cs-137	35.8±2.1	35.0±5.0	8.7
QC-W-14	Water	Mar 1986	Sr-89	1.6±0.4	1.6±1.0	7.1
			Sr-90	2.4±0.2	2.4±2.0	4.2
QC-W-15	Water	Apr 1986	I-131	44.9±2.4	41.5±7.0	10.6
			Co-60	10.6±1.7	12.1±5.0	7.1[b]
			Cs-134	30.2±2.4	25.8±8.0	7.1[b]
			Cs-137	21.9±1.9	19.9±5.0	7.1[b]
QC-MI-7	Milk	Apr 1986	I-131	39.7±3.3	41.5±7.0	10.4
			Cs-134	28.7±2.8	25.8±8.0	8.7
			Cs-137	21.2±2.8	19.9±5.0	8.7
SPW-1	Water	May 1986	Gr. alpha	15.8±1.8	18.0±5.0	5[c]
QC-W-16	Water	Jun 1986	Gr. alpha	16.2±0.7	16.9±2.5	8.7
			Gr. beta	38.4±3.5	30.2±5.0	8.7
QC-MI-9	Milk	Jun 1986	Sr-89	<1.0	0.0	7.1[b]
			Sr-90	12.6±1.8	13.3±3.0	4.2[b]
			I-131	38.9±7.0	34.8±7.0	10.4
			Cs-134	33.0±3.4	36.1±5.0	8.7
			Cs-137	38.5±2.8	39.0±5.0	8.7
SPW-2	Water	Jun 1986	Gr. alpha	16.8±1.8	18.0±5.0	5[c]
SPW-3	Water	Jun 1986	Gr. alpha	17.7±0.8	18.0±5.0	5[c]
QC-W-18	Water	Sep 1986	Cs-134	34.7±5.6	31.3±5.0	8.7
			Cs-137	51.1±7.0	43.3±8.0	8.7
QC-W-19	Water	Sep 1986	Sr-89	13.6±4.1	15.6±3.5	7.1[b]
			Sr-90	6.4±1.6	6.2±2.0	4.2[b]

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

Lab Code	Sample Type	Date Collected	Analysis	Concentration (pCi/L) TIML Result n=3	Known Activity	Expected Precision 1s, n=3[a]
QC-W-21	Water	Oct 1986	Co-60	19.2±2.2	18.5±3.0	8.7
			Cs-134	31.7±5.2	25.6±8.0	8.7
			Cs-137	23.8±1.0	21.6±5.0	8.7
QC-MI-11	Milk	Oct 1986	Sr-89	12.3±1.8	14.3±3.0	8.7
QC-W-20	Water	Nov 1986	H-3	3855±180	3960±350	520[b]
QC-W-22	Water	Dec 1986	Gr. alpha	9.8±1.4	11.2±4.0	8.7
			Gr. beta	21.7±2.0	23.8±5.0	8.7
QC-W-23	Water	Jan 1987	I-131	29.8±2.5	27.9±3.0	10.4
QC-MI-12	Milk	Jan 1987	I-131	36.5±1.3	32.6±5.0	10.4
			Cs-137	32.6±4.2	27.4±8.0	8.7
QC-MI-13	Milk	Jan 1987	Sr-89	10.4±2.1	12.2±4.0	8.7
			Sr-90	14.6±1.6	12.6±3.0	5.2
			I-131	49.5±1.2	54.9±8.0	10.4
			Cs-134	<1.6	0.0	8.7
			Cs-137	33.3±0.6	27.4±8.0	8.7
QC-W-24	Water	Mar 1987	Sr-89	24.7±3.6	25.9±5.0	8.7
			Sr-90	23.9±3.8	22.8±8.0	5.2
QC-W-25	Water	Apr 1987	I-131	28.0±1.9	29.3±5.0	10.6
QC-MI-14	Milk	Apr 1987	I-131	25.0±2.2	23.9±5.0	10.4
			Cs-134	<2.1	0.0	8.7
			Cs-137	34.2±2.0	27.2±7.0	8.7
QC-W-26	Water	Jun 1987	H-3	3422±100	3362±300	520
			Co-60	24.8±1.4	26.5±7.0	8.7
			Cs-134	<2.0	0.0	8.7
			Cs-137	21.2±0.5	21.6±7.0	8.7
QC-W-27	Water	Jun 1987	Gr. alpha	8.5±1.9	10.1±4.0	8.7
			Gr. beta	22.6±1.9	21.2±5.0	8.7
QC-W-28	Water	Jun 1987	Gr. alpha	8.7±1.3	10.1±4.0	8.7
			Gr. beta	12.2±5.2	9.4±3.0	8.7

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

Lab Code	Sample Type	Date Collected	Analysis	Concentration (pCi/L) TIML Result n=3	Known Activity	Expected Precision 1s, n=3[a]
QC-W-29	Water	Jun 1987	Gr. alpha	16.4±1.3	18.9±5.0	8.7
			Gr. beta	15.9±4.0	11.8±4.0	8.7
QC-MI-15	Milk	Jul 1987	Sr-90	19.4±1.6	18.8±3.5	5.2
			I-131	43.5±0.7	45.3±7.0	10.4
			Cs-134	17.9±2.2	16.0±5.3	8.7
			Cs-137	25.4±1.8	22.7±5.0	8.7
QC-W-30	Water	Sep 1987	Sr-89	17.5±3.0	14.3±5.0	8.7
			Sr-90	18.4±2.2	17.5±2.2	5.2
QC-W-31	Water	Oct 1987	H-3	2053±939	2059±306	520
QC-W-32	Water	Dec 1987	Gr. alpha	8.6±1.0	10.1±5.0	8.7
			Gr. beta	15.2±0.1	1±3.0	8.7
QC-W-33	Water	Dec 1987	Gr. alpha	7.7±1.4	10.1±5.0	8.7
			Gr. beta	10.9±1.0	7.9±3.0	8.7
QC-W-34	Water	Dec 1987	Gr. alpha	4.0±0.9	5.1±3.0	8.7
			Gr. beta	9.4±0.9	7.9±3.0	8.7
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	Feb 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

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

Lab Code	Sample Type	Date Collected	Analysis	Concentration (pCi/L) TIML Result n=3	Known Activity	Expected Precision 1s, n=3a
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
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

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

Lab Code	Sample Type	Date Collected	Analysis	Concentration (pCi/L) TIML Result n=3	Known Activity	Expected Precision 1s, n=3[a]
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
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

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

Lab Code	Sample Type	Date Collected	Analysis	Concentration (pCi/L) TIML Result n=3	Known Activity	Expected Precision 1s, n=3[a]
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	10.0±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	18.3±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
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

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

Lab Code	Sample Type	Date Collected	Analysis	Concentration (pCi/L) TIML Result n=3	Known Activity	Expected Precision 1s, n=3[a]
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	51.8±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

[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)
BL-1	D.I. Water	Nov 1985	Gross alpha	<0.1	<1
			Gross beta	<0.4	<4
BL-2	D.I. Water	Nov 1985	Cs-137 (gamma)	<1.9	<10
BL-3	D.I. Water	Nov 1985	Sr-89	<0.5	<5
			Sr-90	<0.6	<1
BL-5	D.I. Water	Nov 1985	Ra-226	<0.4	<1
			Ra-228	<0.4	<1
SPW-2265	D.I. Water	Apr 1985	Gross alpha	<0.6	<1
			Gross beta	<2.2	<4
			Sr-89	<0.2	<5
			Sr-90	<0.4	<1
			I-131	<0.2	<1
			Cs-137 (gamma)	<7.4	<10
BL-6	D.I. Water	Apr 1986	Gross alpha	<0.4	<1
BL-7	D.I. Water	Apr 1986	Gross alpha	<0.4	<1
BL-8	D.I. Water	Jun 1986	Gross alpha	<0.4	<1
BL-9	D.I. Water	Jun 1986	Gross alpha	<0.3	<1
SPW-3185	D.I. Water	Jan 1987	Ra-226	<0.1	<1
			Ra-228	<0.9	<1
SPS-3292	Milk	Jan 1987	I-131	<0.1	<1
			Cs-134	<6.2	<10
			Cs-137	<5.4	<10
SPW-3554	D.I. Water	Feb 1987	H-3	<180	<300
			Gross beta	<2.6	<4
SPS-3555	Milk	Feb 1987	Sr-89	<0.5	<5
			Sr-90	1.9±0.4[a]	<1
SPS-3731	Milk	Mar 1987	Cs-134	<2.2	<10
			Cs-137	<2.5	<10

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-3732	D.I. Water	Mar 1987	Sr-89	<0.9	<5
			Sr-90	<0.8	<1
			I-131	<0.3	<1
			Co-60	<2.3	<10
			Cs-134	<2.2	<10
			Cs-137	<2.4	<10
			Ra-226	<0.1	<1
			Ra-228	<1.0	<1
			Np-237	<0.04	<1
			Th-230	<0.05	<0.1
			Th-232	<0.02	<0.1
			U-234	<0.05	<0.1
			U-235	<0.03	<0.1
			U-238	<0.03	<0.1
SPS-4023	Milk	May 1987	I-131	<0.1	<1
SPS-4203	D.I. Water	May 1987	Gross alpha	<0.7	<1
			Gross beta	<1.7	<4
SPS-4204	Milk	May 1987	Sr-89	<0.5	<5
			Sr-90	2.4±0.6[a]	<1
SPS-4390	Milk	Jun 1987	Cs-134	<4.7	<10
			Cs-137	<5.2	<10
SPS-4391	D.I. Water	Jun 1987	Sr-89	<0.4	<5
			Sr-90	<0.4	<1
			I-121	<0.1	<1
			Co-60	<3.8	<10
			Cs-137	<5.7	<10
			Ra-226	<0.1	<1
			Ra-228	<0.9	<1
SPW-4627	D.I. Water	Aug 1987	Gross alpha	<0.6	<1
			Gross beta	<1.4	<4
			Tritium	<150	<300
SPS-4628	Milk	Aug 1987	Sr-89	<0.6	<5
			Sr-90	2.4±0.6[a]	<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)
SPS-4847	Milk	Sep 1987	Cs-134	<4.4	<10
			Cs-137	<5.3	<10
SPS-4848	D.I. Water	Sep 1987	I-131	<0.2	<1
SPW-4849	D.I. Water	Sep 1987	Co-60	<4.1	<10
			Cs-134	<4.8	<10
			Cs-137	<4.0	<10
			Sr-89	<0.7	<5
			Sr-90	<0.7	<1
SPW-4850	D.I. Water	Sep 1987	Th-228	<0.04	<1
			Th-232	<0.8	<1
			U-234	<0.03	<1
			U-235	<0.03	<1
			U-238	<0.02	<1
			Am-241	<0.06	<1
			Cm-242	<0.04	<1
			Ra-226	<0.1	<1
			Ra-228	<1.0	<2
SPW-4859	D.I. Water	Oct 1987	Fe-55	<0.5	<1
SPS-5348	Milk	Dec 1987	Cs-134	<2.3	<10
			Cs-137	<2.5	<10
SPW-5384	D.I. Water	Dec 1987	Co-60	<2.8	<10
			Cs-134	<2.6	<10
			Cs-137	<2.8	<10
			I-131	<0.2	<1
			Ra-226	<0.1	<1
			Ra-228	<1.2	<2
			Sr-89	<0.5	<1
			Sr-90	<0.4	<1
SPW-5385	D.I. Water	Nov 1987	Gross alpha	<0.4	<1
			Gross beta	<2.2	<4
			Fe-55	<0.3	<1
SPS-5386	Milk	Jan 1988	I-131	<0.1	<1
SPW-5448	"Dead" Water	Jan 1988	H-3	<177	<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-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-242	<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
SPW-6625	Water	Dec 1988	Gross alpha	<0.7	<1
			Gross beta	<1.9	<4

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-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	<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-7558	Water	Jun 1989	Gross alpha	<0.2	<1
			Gross 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	Gross alpha	<0.4	<1
			Gross 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	<1
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	Gross alpha	<0.3	<1
			Gross 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-89	<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
SPM-107	Milk	Oct 1990	I-131	<0.4	<1
			Cs-134	<3.3	<5
			Cs-137	<4.3	<5
SPW-[illegible]70	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	Gross alpha	<0.3	<1
			Gross 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 of 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 x (known).0933
	>4,000 pCi/liter	10% of known value
Radium-226, Radium-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-63[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 Comparison Program starting January 1987.

Lab Code	Analysis	TIML Result (pCi/L)[a]	EPA Control Limit (pCi/L)[a]	Explanation
STM-504	Sr-89 Sr-90	57.0±4.3 32.0±1.0	60.3-77.7 32.4-37.6	Milk had high fat content which made analyses difficult. Addition of errors to TIML result would put values within EPA control limits. EPA also had the same problem in analyzing its own sample.
STW-511	Ra-228	8.1±1.4	4.6-8.0	TIML results are usually within EPA control limits. Analysis of the next sample was within EPA control limits. No further action is planned.
STW-516	Cr-51	80.3±17.5	61.3-78.7	Results in the past have been within EPA control limits and TIML will monitor the situation in the future.
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.

[a] Reported in pCi/L unless otherwise noted.
[b] Concentrations are reported in mg/kg.

Lab Code	Analysis	TIML Result (pCi/L)[a]	EPA Control Limit (pCi/L)[a]	Explanation
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 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 in the 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 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 crosscheck results were within the control limits. No further action is planned.
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.

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

Lab Code	Analysis	TIML Result (pCi/L)[a]	EPA Control Limit (pCi/L)[a]	Explanation
STW-589	Sr-90	17.3±1.2	17.4-22.6	Sample was reanalyzed in triplicate; results of reanalyses 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, 1421.7±95.3 mg/L. The cause of low results is unknown.
STW-601	Gross Alpha	11.0±2.0	11.6-32.4	Sample was reanalyzed in triplicate. Results of reanalyses, 13.4±1.0 pCi/L.

[a] Reported in pCi/L unless otherwise noted.
[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 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 x 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 1990

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[f]	0.019 (310/312) (0.006-0.038)	T-1, Site Boundary 0.6 mi ENE	0.020 (52/52) (0.009-0.035)	0.019 (206/208) (0.007-0.042)	0
				T-8, Farm 2.7 mi WSW	0.020 (52/52) (0.010-0.035)		
				T-12, Toledo Water Treatment Plant 23.5 mi WNW	0.020 (51/52) (0.008-0.034)		
	Sr-89 40	0.0010	<LLD	-	-	<LLD	0
	Sr-90 40	0.0010	<LLD	-	-	<LLD	0
	GS 40						
	9e-7	0.015	0.051 (24/24) (0.038-0.067)	T-1, Site boundary 0.6 mi EDE	0.053 (4/4) (0.045-0.067)	0.050 (16/16) (0.029-0.063)	0
				T-2, Site boundary 0.9 mi E	0.053 (4/4) (0.045-0.064)		
	K-40	0.027	<LLD	-	-	<LLD	0
	Nb-95	0.0024	<LLD	-	-	<LLD	0
	Zr-95	0.0038	<LLD	-	-	<LLD	0
	Ru-103	0.0012	<LLD	-	-	<LLD	0
	Ru-106	0.01[illegible]	<LLD	-	-	<LLD	0
	Cs-134	0.0016	<LLD	-	-	<LLD	0
	Cs-137	0.0017	<LLD	-	-	<LLD	0
	Ce-141	0.0030	<LLD	-	-	<LLD	0
	Ce-144	0.0095	<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 Jannnry - Decemoer 1990

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/m^3)	I-131 520	0.079	<LLD	-	-	<LLD	0
Snow (pCi/L)	GB (SS) 5	0.6	<LLD	-	-	<LLD	0
	GB (DS) 5	0.6	0.8 (3/3) (0.7-0.9)	T-11, Port Clinton 9.5 mi SE	1.6 (1/1) -	1.4 (2/2) (1.2-1.6)	0
	GB (TR) 5	0.6	0.8 (3/3) (0.7-0.9)	T-11, Port Clinton 9.5 mi SE	1.6 (1/1) -	1.4 (2/2) (1.2-1.6)	0
	H-3 5	330	<LLD	-	-	<LLD	0
	GS 5						
	Cs-137	10	<LLD	-	-	<LLD	0
TLD (Quarterly) (mR/91 days)	Gamma 370	1.0	15.1 (279/279) (8.6-23.1)	T-66, Site boundary 0.3 mi ENE	22.0 (4/4) (20.9-23.0)	16.2 (91/91) (10.8-20.8)	0
TLD (Annual) (mR/365 days)	Gamma 89	1.0	60.2 (67/67) (30.8-88.5)	T-153 Leutz Road 1.4 mi SSW	88.5 (1/1) -	58.4 (22/22) (43.7-84.8)	0
Milk (pCi/L)	I-131 66	0.5	<LLD	-	-	<LLD	0
	Sr-89 66	2.1	<LLD	-	-	<LLD	0
	Sr-90 66	0.5[h]	1.0 (16/18) (0.7-1.4)	T-199, Farm 8.5 mi SW	1.8 (12/12) (1.3-3.1)	1.2 (48/48, (0.6-3.1)	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 1990

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]		
Milk (pCi/L) (continued)	GS 66						
	K-40	100	1230 (18/18) (1060-1390)	T-8, Farm 2.7 mi WSW	1230 (18/18) (1060-1390)	1230 (48/48) (1010-1540)	0
				T-24, Sandusky 21.0 mi SE	1230 (18/18) (1010-1400)		
				T-199, Farm 8.5 mi SW	1230 (12/12) (1030-1540)		
	Cs-137	10	<LLD	-	-	<LLD	0
	Ba-140	10	<LLD	-	-	<LLD	0
	Ca-66 66	0.50	0.83 (18/18) (0.64-1.06)	T-199, Farm 8.5 mi SW	1.00 (12/12) (0.60-1.35)	0.86 (48/48) (0.60-1.35)	0
	K (stable) 66	0.04	1.42 (18/18) (1.22-1.61)	T-8, Farm 2.7 mi WSW	1.42 (18/18) (1.22-1.61)	1.42 (48/48) (1.17-1.78)	0
				T-24, Sandusky 21.0 mi SE	1.42 (18/18) (1.17-1.62)		
				T-199, Farm 8.5 mi SW	1.42 (12/12) (1.19-1.78)		
	Sr-90/Ca 66	0.94[f]	1.29 (13/18) (0.96-1.75)	T-199, Farm 8.5 mi SW	1.85 (12/12) (1.22-3.60)	1.53 (43/48) (0.94-3.60)	0
	Cs-137/K 66	8.55	<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 1990

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) 16	1.0	<LLD	-	-	<LLD	0
	GB (DS) 16	2.0	3.4 (7/8) (2.0-4.7)	T-54, Farm 4.8 mi SW	3.6 (4/4) (2.0-4.7)	2.4 (5/8) (2.0-2.8)	0
	GB (TR) 16	2.0	3.4 (7/8) (2.0-4.7)	T-54, Farm 4.8 mi SW	3.6 (4/4) (2.0-4.7)	2.4 (5/8) (2.0-2.8)	0
	H-3 16	330	<LLD	-	-	<LLD	0
	Sr-89 16	1.6	<LLD	-	-	<LLD	0
	Sr-90 16	1.0	<LLD	-	-	<LLD	0
	GS 16						
	Cs-137	10.0	<LLD	-	-	<LLD	0
Edible Meat (pCi/g wet)	GS 4						
	K-40	0.1	2.47 (4/4) (2.30-2.57)	T-31, Onsite roving location	2.52 (3/3) (2.48-2.57)	None	0
	Cs-137	0.025	<LLD	-	-	None	0
Fruits and Vegetables (pCi/g wet)	Sr-89 7	0.017	<LLD	-	-	<LLD	0
	Sr-90 7	0.011	<LLD	-	-	<LLD	0
	I-131 7	0.022	<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 1990

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 7						
	K-40	0.50	1.04 (4/4) (0.90-1.31)	T-173, Firelands Winery, Sandusky 20.0 mi SE	2.55 (1/1) -	1.94 (3/3) (0.83-1.55)	0
	Nb-95	0.019	<LLD	-	-	<LLD	0
	Zr-95	0.034	<LLD	-	-	<LLD	0
	Cs-137	0.019	<LLD	-	-	<LLD	0
	Ce-141	0.025	<LLD	-	-	<LLD	0
	Ce-144	0.10	<LLD	-	-	<LLD	0
Broad Leaf Vegetation (pCi/g wet)	Sr-89 13	0.028	<LLD	-	-	<LLD	0
	Sr-90 13	0.015	<LLD	-	-	<LLD	0
	I-131 13	0.043	<LLD	-	-	<LLD	0
	GS 13						
	K-40	0.1	4.35 (10/10) (3.35-4.98)	1-8, Farm 2.7 mi WSW	4.43 (6/6) (3.35-4.98)	1.53 (3/3) (1.41-1.64)	0
	Nb-95	0.024	<LLD	-	-	<LLD	0
	Zr-95	0.044	<LLD	-	-	<LLD	0
	Cs-137	0.028	<LLD	-	-	<LLD	0
	Ce-141	0.040	<LLD	-	-	<LLD	0
	Ce-144	0.16	<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 1990

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 1						
	K-40	0.01	0.97 (1/1)	I-197, Farm 1.7 mi W	0.97 (1/1)	None	0
	Nb-95	0.017	<LLD	-	-	None	0
	Zr-95	0.030	<LLD	-	-	None	0
	Ru-103	0.014	<LLD	-	-	None	0
	Ru-106	0.11	<LLD	-	-	None	0
	Cs-137	0.012	<LLD	-	-	None	0
	Ce-141	0.017	<LLD	-	-	None	0
	Ce-144	0.048	<LLD	-	-	None	0
Animal - Wildlife Feed (pCi/g wet)	GS 5						
	Be-7	0.16	0.50 (2/4) (0.37-0.62)	I-198, Toussaint Creek, 4.0 mi WSW	0.62 (1/1)	0.37 (1/1)	0
	K-40	0.1	5.39 (4/4) (1.44-10.60)	I-8, Farm 2.7 mi WSW	10.60 (1/1)	1.48 (1/1)	0
	Nb-95	0.031	<LLD	-	-	<LLD	0
	Zr-95	0.048	<LLD	-	-	<LLD	0
	Ru-103	0.028	<LLD	-	-	<LLD	0
	Ru-106	0.20	<LLD	-	-	<LLD	0
	Cs-137	0.022	<LLD	-	-	<LLD	0
	Ce-141	0.037	<LLD	-	-	<LLD	0
	Ce-144	0.16	<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 1990

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	1.07	<LLD	-	-	<LLD	0
	K-40	1.0	11.93 (12/12) (3.87-20.87)	T-8, Farm 2.7 mi WSW	19.70 (2/2) (19.55-19.86)	15.59 (10/10) (11.34-19.51)	0
	Zr-95	0.22	<LLD	-	-	<LLD	0
	Nb-95	0.28	<LLD	-	-	<LLD	0
	Ru-103	0.15	<LLD	-	-	<LLD	0
	Ru-106	0.81	<LLD	-	-	<LLD	0
	Cs-137	0.14	0.48 (7/12) (0.16-1.56)	T-8, Farm 2.7 mi WSW	1.15 (2/2) (0.74-1.56)	0.38 (10/10) (0.19-0.70)	0
	Ce-141	0.28	<LLD	-	-	<LLD	0
	Ce-144	1.30	<LLD	-	-	<LLD	0
Treated Surface Water (pCi/L)	GB (SS) 64	0.8	<LLD	-	-	<LLD	0
	GB (DS) 64	1.0	2.2 (36/36) (1.3-3.2)	T-144, Green Cove Cond., 0.9 mi NNW	2.5 (12/12) (1.9-3.2)	2.1 (28/28) (1.6-3.3)	0
	GB (TR) 64	1.0	2.2 (36/36) (1.3-3.2)	T-144, Green Cove Cond., 0.9 mi NNW	2.5 (12/12) (1.9-3.2)	2.2 (28/28) (1.6-3.3)	0
	H-3 22	330	<LLD	-	-	<LLD	0
	Sr-89 22	2.4	<LLD	-	-	<LLD	0
	Sr-90 22	1.0	<LLD	-	-	<LLD	0
	GS 22						
	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 1990

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) 207	0.9	<LLD	-	-	<LLD	0
	GB (DS) 207	1.0	2.5 (81/81) (1.4-4.1)	T-3, Site boundary 1.4 mi ESE	3.7 (12/12) (2.1-4.1)	2.3 (126/126) (1.1-4.7)	0
	GB (IR) 207	1.0	2.5 (81/81) (1.4-4.1)	T-3, Site boundary 1.4 mi ESE	3.8 (12/12) (2.1-4.1)	2.4 (126/126) (1.1-4.7)	0
	H-3 207	330	718 (1/81) -	T-134, Lake Erie 1.4 mi NW	718 (1/5) -	437 (1/126) -	0
	Sr-89 160	2.3	<LLD	-	-	<LLD	0
	Sr-90 160	1.4	<LLD	-	-	<LLD	0
	GS 160						
	Cs-137	10	<LLD	-	-	<LLD	0
Fish	GB 11	0.1	3.04 (5/5) (2.03-3.96)	T-33, Lake Erie 1.5 mi NE	3.04 (5/5) (2.03-3.96)	2.98 (6/6) (2.13-3.86)	0
	GS 11						
	K-40	0.1	2.77 (5/5) (1.96-3.16)	T-35, Lake Erie >10 mi radium	2.80 (6/6) (2.09-3.26)	2.80 (6/6) (2.09-3.26)	0
	Cs-137	0.033	0.13 (1/5) -	T-33, Lake Erie 1.5 mi NE	0.13 (1/5) -	<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 1990

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 10						
	K-40	0.1	11.04 (6/6) (4.0-15.1)	T-23, S. Bass Island 14.3 mi ENE	11.95 (2/2) (11.9-12.0)	11.58 (4/4) (10.0-12.4)	0
	Cs-137	0.038	0.82 (1/6) -	T-23, S. Bass Island 14.3 mi ENE	0.49 (1/2) -	0.49 (1/4) -	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 (<0.031 pCi/m^3) was exclused in the determination of the LLD of gross beta in air particulates. The elevated LLD resulted from low volume due to pump malfunction.

[g] Two results (<0.24 and <0.34 pCi/m^3) were excluded in the determination of the LLD of airborne iodine-131. The elevated LLDs resulted from low volume due to pumps malfunctions.

[h] One result (<1.5 pCi/l) was excluded in the determination of iodine-131 in milk. The elevated LLD resulted from low carrier recovery.

[i] One result (<1.88 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.

FOR MORE INFORMATION, CALL OR WRITE:

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