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Revision 1

DESCRIPTION OF THE PERRY NUCLEAR POWER PLANT EMERGENCY OFFSITE DOSE CALCULATIONS

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1.0 INTRODUCTION

This revised report is issued (1) to reflect the installation of the selected dose assessment model at Perry and (2) to respond to the NRC's review comments (NRC letter, Youngblood to Edelman, August 22, 1984: NRC Contractor Evaluation Findings of Use of Meteorology in Emergency Response at Perry Nuclear Power Plant (Units 1 and 2)). Accordingly, Section 3 has been totally revised, as well as references in Section 5. The cross-references in Section 6 have been modified to correspond to the revised Section 3 and to correspond to NRC recommendations. Change bars are added to all sections except Section 3 that is completely new.

The Cleveland Electric Illuminating Company (CEI) will adopt for use at the Perry Nuclear Power Plant (PNPP) two methods for determining offsite doses during an emergency: a computerized method and a hand-calculated method. In this document the methods of making these emergency offsite dose calculations will be discussed in the context of the Perry Emergency Response Facilities (ERFs) that are described separately (CEI, 1983). The MONICORE computer system incorporates a meteorological information and dose assessment system (MIDAS) that will run in conjunction with the Emergency Response Information System (ERIS) computer. MIDAS incorporates (1) a straight-line Gaussian approach as well as (2) a plume segment approach that is able to simulate the lake breeze meteorology of this coastal location.

MIDAS is the dose projection methodology of choice because it provides rapid dose assessments based on up-to-the-minute meteorological and radiological data. Provisions, however, are being made for dose projections in the event that MIDAS is inoperable or unavailable. In the event that MIDAS is inoperable or unavailable, dose projections will be calculated by hand. Hand calculations do not account for such things as lake breeze effects and time-varying source terms.

This document provides CEI's response on the technical bases of the dose calculational methodology used to assess the impact of an accidental airborne release. While the bases of both the automated and backup manual methods are generally described in Section 7.3.11 of the Emergency Plan, details are provided here

of the assumptions, models, and technical bases used in developing these calculational procedures.

The remainder of this document is organized into five sections that involve the following:

- Hand-calculated emergency offsite doses
- Automated emergency offsite dose calculations
- A summary
- A list of references that were cited in the text
- A cross-reference of sections of this document that respond to NRC comments.

2.0 HAND-CALCULATED EMERGENCY OFFSITE DOSES

Dose projections will only be calculated by hand in one or both of the following situations:

- o MIDAS is non-functional
- o The Technical Support Center (TSC) or Emergency Operations Facility (EOF) have not yet been activated.

In the second situation, dose projections are carried out in the Control Room until either the TSC or EOF have been activated (CEI, 1983). The hand calculation of offsite doses is therefore a backup method for use in the event that MIDAS cannot be used to generate computerized dose projections.

The method to be selected for hand calculation of offsite doses is based on the availability of data and on the time constraints for performing a dose assessment. These methods are discussed in Section 7.3.11.2 of the Emergency Plan.

This section contains descriptions of the assumptions, methods, and technical bases used in generating the hand-calculated dose projection procedures. The instructions for the hand calculations are contained in the Emergency Plan Implementing Instructions. Each dose projection method is contained in a separate attachment to that instruction; the basis of each attachment is described below.

In the 10 subsections that follow, the first three deal with obtaining the atmospheric dispersion parameters that are required for dose calculations. The next five subsections use the atmospheric dispersions parameters and available monitoring parameters to calculate offsite dose rates. One subsection is available as a quick method to determine offsite dose when monitoring data are not available. The last subsection is used to determine accumulated and projected offsite doses based on dose rates calculated in previous sections and on the estimated duration of the accident.

A number of the dose projection procedures require an identification of accident type before the analysis can proceed. Accident identification provides a source term as the starting input for the dose projection. It is the responsibility of the operator to identify the accident.

For all of the dose calculation procedures addressed in the remainder of this chapter, the standard methodology of multiplying a release rate by a dispersion factor and a dose factor is used; this methodology is employed in Regulatory Guide 1.109, Revision 1 (USNRC, 1977). In all of these methods, the Chi/Q values for the site boundary and downwind distances are obtained from the more appropriate of the two methods contained in the first three subsections. Next, the appropriate dose factor(s) are selected for whole body, child thyroid, or both. Selection is based on the source term that results from each incident, i.e., the amount of noble gas and iodine released. Finally, the main difference from one calculational method to another is the manner in which radioisotope release rate is determined. Using actual grab sample analysis and release flow rates, an actual release rate can be calculated. Otherwise, the release rate must be inferred from available data. Obviously, actual isotopic analysis is the most accurate means of assessing the release. Once the concentration and dose factor have been determined, the difference in dose rate (R/hr) or dose projection (rem) at each of the downwind locations is the result of the differing amount of atmospheric dispersion at these locations.

2.1 Preliminary Estimate of Dispersion from Onsite Data

One part of this method describes the automatically determined dispersion information. A "Preliminary Estimate" of the information is prepared by each of the independent systems at the Perry meteorological tower. This information includes normalized concentration (Chi/Q), the direction of plume travel, the speed of plume travel, the travel time, and the plume width. Both the Main and Backup Systems have a microprocessor (MDPS, Meteorological Data Processing System) which uses validated, realtime, 15-minute meteorological data to prepare the Preliminary Estimate. (Same-tower substitutions are obtained if data are missing; see Section 7.3.7 of the Emergency Plan for further discussion.) Each

MDPS routinely sends the Preliminary Estimate information to the Control Room (as well as ERIS) so it is always immediately available. The Preliminary Estimate can also be obtained by interrogating either MDPS by telephone or by going to the Meteorological Tower for a hard copy.

The Preliminary Estimate calculations are less sophisticated than those for the Model A' that are performed in MIDAS. The Preliminary Estimate uses the FSAR approach to atmospheric dispersion estimates. A straight-line Gaussian dispersion model, as described in Regulatory Guide 1.145 (USNRC, 1979), is used for consequence assessment; release characteristics are the same. Input meteorological data are wind speed, wind direction, and atmospheric stability class.

2.2 Related Meteorology

This part provides the methodology for acquiring the meteorological information needed to obtain an estimate of atmospheric dispersion (Chi/Q) at selected distances from the site. This method is only used when an automated Preliminary Estimate (discussed in 2.1) is not available or when values for other distances are desired. This method is used to generate wind speed, wind direction, and stability. This information is then used with the methodology described in the next section to generate an estimate of atmospheric dispersion.

Of course, onsite data are preferred for this method because the Perry meteorological tower location is representative of the site region. However, provision is made, too, for using offsite sources should they be needed. The Cleveland National Weather Service is open 24 hours a day. Closer high-quality sources are preferred when they are available to supply wind speed, wind direction, and have the necessary observations to eventually yield stability class. Stability classification schemes include delta T (USNRC, 1972), modified sigma theta (Mitchell & Timbre, 1979; USEPA, 1981), and Turner-Pasquill sky conditions (Turner, 1970).

2.3 Tabular Estimate of Dispersion

This method describes the means of generating the preliminary estimate of dispersion from the output of the method described in Section 2.2. Seven tables of dispersion parameters are presented; they are organized by stability class. From each table the normalized concentration (Chi/Q), plume travel time, and plume width can be determined.

These tabular estimates are based on the same technique used for making the Preliminary Estimate (Section 2.1). Input data required are current wind speed, wind direction, and atmospheric stability class. The straight-line Gaussian model used is in accordance with that described in Regulatory Guide 1.145 (USNRC, 1979). Release characteristics are the same as used in the Perry FSAR. Dispersion values are generated for the Exclusion Area Boundary and for each incremental mile out to 10 miles.

2.4 Dose Assessment Based on Effluent Monitor Reading

This method can be used to project offsite dose and release rates when the release is monitored by an effluent monitor, the release flow rate is known or can be estimated, and the accident (incident) that causes the release can be correlated to an accident type analyzed in the FSAR. This method is only used when actual analyses of the release are unavailable. Since actual analyses are not available, the source terms from the FSAR are used. An identification of the accident must, therefore, be made first so that the appropriate source terms can be determined.

In this method, the effluent monitor reading is combined with the effluent release flow rate to obtain a release rate. However, an initial identification of the accident type (FSAR) must be made before determining the effluent release rate. In the event that the flow rate out this path is zero, this method cannot be used because the effluent monitor readings will be invalid. AFter the release rate is determined, it is multiplied by the appropriate dose factors and Chi/Q values as detailed above to obtain dose rates in R/hr at each of the four downwind locations.

2.5 Dose Assessment Based on Effluent Analyses

This method can be used to determine dose rates at selected downwind locations using a known isotopic release rate. This method is appropriate when sample results provide a radionuclide breakdown for the release.

This method is the most accurate of any of the methods described in this procedure since it is based on:

- An actual measurement of the radionuclide mix and concentration being released
- Actual measurements of the flow rates from the event.

In this method actual concentrations of noble gases and iodines are determined from analyses of effluent samples. The actual concentration is multiplied by the actual release point flow rate, appropriate dose factors for each identified isotope, and Chi/Q to obtain dose rates in R/hr.

2.6 Dose Assessment Based on Containment Monitor Reading

This method can be used to project offsite dose rates and release rates based on the high range containment monitor reading. This method assumes that the containment activity is being released at the design leak rate of 0.2 percent per day and that 96 percent is collected and filtered by the filtration system and 4 percent is released directly (FSAR source assumptions). This method is used only for accidents inside the containment when containment ventilation is not operating. Release rates in this method are inferred from the containment release rates described above and the readings of the high range containment monitor.

2.7 Dose Assessment Based on Containment Analysis

This method can be used for projecting offsite dose rates based on a measured isotopic concentration in containment. This method is appropriate when sample

results provide a radionuclide inventory that could leak from containment. In the event of a LOCA, this method accounts for child thyroid dose rates due to releases from both direct leakage to the environment and indirectly through a filtered pathway.

Using the containment activity release rate described in Section 2.6, as provided in the FSAR, and the isotopic analyses as actual source terms, the designed containment leakage release rate is calculated.

This method would only be used when a LOCA has occurred and the containment ventilation is not operating.

2.8 Dose Assessment Based on Offsite Measurements

This method can be used to project offsite dose rates and release rates from offsite measurements of dose rates or iodine concentrations. An estimate of the atmospheric dispersion factor is required for the sampling location. This method assumes that the offsite isotopic composition for dose rate measurements corresponds to a representative FSAR accident type (for estimates based on external dose rate measurements). For gross iodine measurement this method makes the conservative assumption that all iodine is I-131.

For the calculation of doses using an offsite dose rate reading, the reading in R/hr is divided by the Chi/Q at that location to obtain a release rate. Calculations for dose rates at each of the downwind locations then proceed as described at the beginning in Section 2.4.

For the calculation of doses using measured offsite iodine concentrations, the measured concentration is divided by the Chi/Q at the sample location to get a release rate. Calculation then proceeds as described at the beginning in Section 2.4.

2.9 Dose Projection Based on FSAR Analysis

This method can be used to project offsite dose when the accident (incident) can be correlated to an accident type which has been analyzed in the FSAR. This method is very approximate and should be used only when parameters are not available to perform other methods or when an offsite estimate is needed very quickly.

After the accident is identified, the FSAR-calculated offsite dose factors are multiplied by the site-related Chi/Qs (atmospheric dispersion factor) to obtain an offsite dose estimate.

2.10 Calculation of Accumulated and Projected Doses from Releases

This method is used to determine accumulated dose and projected dose based on the results of previous methods.

Accumulated dose is simply obtained by multiplying the dose rate obtained from the methods in Sections 2.4 through 2.9 by the elapsed time between whatever (previous and present) onsite or offsite monitor readings (used for the calculations) and summing this product for each subsequent period.

The projected dose is obtained by multiplying the current dose rate by the projected duration of release and adding to it the accumulated dose.

3.0 AUTOMATED EMERGENCY OFFSITE DOSE CALCULATIONS

Automated calculation of offsite doses during emergencies are described in this section under the following headings:

- o General Model Description
- o Lake Breeze Capability
- o Meteorological Basis
- o Input Meteorological Data

The first two address the model itself. The second focuses on the site-specific capability to represent the lake breeze with input of realtime onsite data and use of climatologically-based adjustments. The third addresses the information used to develop the climatological basis. The fourth describes the available meteorological information.

These discussions describe the ability of Perry's dose assessment model to estimate offsite doses within the 10-mile EPZ and beyond.

3.1 General Model Description

Background

Dose assessments in the event of an emergency at the Perry Nuclear Power Plant will be accomplished utilizing a computerized system that receives data automatically from the meteorological tower and plant radiation monitors. Two plume dispersion models are available--one that utilizes the straightline Gaussian approach and a second that estimates plume trajectory utilizing a plume segment approach. The plume segment model incorporates methodology for approximating dispersion conditions during lake breeze situations. Results are displayed as dose rates or dose projections for comparison with the EPA Protective Action Guides (PAGs). The software package that performs these functions was provided by Pickard, Lowe and Garrick, Inc. (PLG). It is referred to as MIDAS (for Meteorological Information and Dose Assessment System).

Hardware

The software package is installed and operational on a VAX 11/780. A magnetic tape drive is provided for data archive functions and system utilities. A 300 line per minute printer is available for development and system management use. The computer runs in a multi-tasked environment under a virtual memory operating system which can accommodate many users simultaneously via local or remote terminals. Tektronix 4113 19" color graphics terminals with hard copy devices are provided in the EOF and TSC facilities, and a Tektronix 4107 13" color terminal is provided in the Control Room.

General Software Characteristics

The software is entirely menu driven and is configured to supplement the emergency plan for rapid calculation of offsite doses. Site-specific parameters are stored in disc files under system manager control. Security is provided by log-on procedures under control of the system manager. Dispersion and dose calculations can be initiated by a single operator on the CRT keyboard.

The Gaussian model is used for rapid initial dose estimates and projections while the plume segment model can be utilized for more refined estimates of plume location and dose history. Results are displayed on site maps extending to a 50-mile distance from the plant. Once the maps are loaded into the terminal from the VAX, they are stored in the terminal to enable more rapid display of results. Printed information is provided to supplement the graphics output. The software provides for manual entry of both meteorological and radiological effluent data if monitor data are unavailable.

Files are available for operator entry of simulated data for use during drills. This enables trainees to practice using predetermined scenarios in a mode that does not interfere with the online emergency mode that would be used during a real emergency.

All software is written in FORTRAN. Listings are maintained onsite for use in interpretation or problem solving.

File Structure

Meteorological and radiological data bases are stored on disc for use in making the required dose calculations. Files containing ("constant") information specific to the site-plant situation are changed by privileged edit routines provided in the package. A series of routines perform these calculations using both the "fixed" and "time-dependent" data and in many cases stores the results of the calculations in files used by other routines for system output. The user can schedule runs that automatically read and display results from these files without operator intervention.

Meteorological and Effluent Data Maintenance Tasks

A series of tasks is provided to inspect, maintain and archive the data bases created by the system. Examples follow:

- o A task is provided to print the hourly or 15-minute meteorological parameter averages over any specified time period (within the bounds of the file).

- o The "bad data" task can display the areas of bad data recovery for quick inspection.

- o The "joint frequency" task categorizes and prints the meteorological data (in joint frequency form) by direction, speed group and stability class for use in Regulatory Guide 1.21 reports.

- o Summaries of total release by isotope can be printed.

- o The "trend plot" task can be used to plot meteorological or radiological effluent data which enables checking for problem areas in the data.

- o Other tasks can be used to summarize the delta-T and wind rose data.

Input Data Requirements

The computer interrogates microprocessors periodically to determine 15-minute averages of meteorological and radiological effluent monitor signals. Wind speed and wind direction at the 10- and 60-meter level along with vertical temperature difference between the 10- and 60-meter levels is derived from redundant instruments on the meteorological tower. Digital signals are sent to the computer via redundant data links. Radiological data are received from the monitors in the plant vents, the condenser offgas system and the heater bay/turbine ventilation systems. Releases can be assigned to any of four release points from which a release rate (microcuries/sec) is computed. Since these effluent monitors do not provide an isotopic breakdown, the fraction of the total release for each isotope is determined from default isotopic mixes as a function of accident type. Manual entry of the isotopic breakdown is also provided.

Accident Dispersion and Dose Calculations

Results of real-time atmospheric dispersion and dose calculations for accidents are available in printed and graphical form. MIDAS software is available for the models referred to in NUREG-0654 (USNRC, 1980b), Appendix 2 as Class A and/or enhanced Class A. The following two sections describe these models.

The Class A Model

The Class A model used for real time assessment of dispersion is the standard Gaussian model. The graphical isopleth output, representing a straight-line Gaussian-shaped plume, was designed to replace the plastic overlays (for maps of the same scale) currently found in the emergency kits in many control rooms. A background map of the site is plotted along with the isopleths so that both appear on the same plot.

All accident calculations are under menu control for ease of use by the operator. The map scale, release point (along with vent flows), level for data on the meteorological tower and terrain height can all be pre-selected or selected

during the run by the user. Any previous hour (or the last 15-minute average) can be selected for the calculation.

Certain self-checks are provided to warn the user of problems. For example, if meteorological data are "bad" the user is notified and asked if data from some other source are available. If so they are entered by the operator. Likewise, if dose results are selected and there are no effluent release values present (from real time effluent monitors) or the data are bad, the user will be prompted for input. Beta, gamma and/or thyroid-inhalation doses are computed after all input data have been entered. A calculation will not be completed without contemporaneous meteorological and effluent data. Results are in printed or plotted form.

Several choices are available to the user for the source term. If the accident classification is known, but the release is unknown, preset release scenarios can be used for up to ten accident categories. Otherwise, real time data from effluent monitors can be used.

Enhanced Class A Model

NUREG-0654, Appendix 2 also refers to a more complex model for estimating diffusion and exposures out to greater distances. The model currently programmed and operational in the Perry Plant MIDAS package is a plume segment model based on a program developed by PLG called CRACIT (For Calculation of Reactor Accident Consequences Including Trajectory) which is similar in concept to that of the CRAC program which was written for the Reactor Safety Study (WASH-1400, USNRC, 1975). The "front end" source term and "run" menu options provided for the Class A model are also used to drive the enhanced version, thus the operator interface is essentially unchanged.

The Plume Segment Model

The basic functions of the plume segment model are the calculation of meteorological dispersion of the released radioactive material as it travels downwind and the estimation of the resulting doses from this material. The meteorologi-

cal dispersion is modeled assuming Gaussian diffusion and variable trajectory transport.

The transport portion of the dispersion model allows the plume travel direction to vary as the wind direction varies. The model divides the plume into segments called spatial intervals according to the travel distance for each quarter-hour. The standard Gaussian model is used to estimate plume dispersion based on the wind speed, wind direction and delta temperature measured on the weather tower. The plume, therefore, is represented by a series of segments, each of which has different characteristics based on the meteorology at the time the segments are in their respective locations.

The model simulates plume rise, building wake effects, dry deposition and wet deposition as a function of rain rate. The model is run using quarter-hourly wind averages.

Short-term Releases

The dose calculation in the plume segment model provides information necessary for use in making immediate protective action decisions. Projected integrated organ doses for the whole body, thyroid, and lung are computed for each plume segment for a given short-term (usually 15-minute) release. Three pathways are used including plume shine, inhalation and ground shine. The whole body dose consists of the sum of plume shine dose due to plume passage overhead, inhalation dose due to inhaling airborne radioactive material and to ground shine dose from particulates deposited on the ground. The thyroid inhalation dose is reported separately for use in comparison with the PAGs, although the plume shine and ground shine components are available in printed tables. The average dose rate (rem/hour) to each of the three organs is also estimated from the three pathway components.

The model can be run in a predictive mode using the most recent data from the tower. After the first hour, persistence is used for all dose projections. The lake breeze processing, if in effect, will cause changes to the otherwise straight-line plume trajectory.

The results of the plume trajectory and dispersion modeling and the calculated doses can be plotted on the graphics CRT overlaid on the site map. The widening of the plume as it moves away from the site is a function of the atmospheric stability. The changing plume direction is controlled by the changing wind directions based on information from the meteorological data files. Characteristics of each spatial interval can also be printed in tabular form.

Long-term Releases

The same calculation routine is used for making longer-term dose estimates (for more than one 15-minute release). In this program a release is simulated as several short-term releases. Each of the releases is treated as a separate plume moving away from the site according to the meteorological conditions for that time. Therefore, each successive release is controlled by a different weather sequence. The dose over the area is accumulated separately on a fine mesh grid for each release. The total dose over all releases for each of up to four requested projection time periods can be displayed graphically as isopleths on the CRT.

Lake Breeze Processing in the Plume Segment Model

During warmer seasons, wind patterns caused by "lake breeze" effects can occur at the Perry site. The lake breeze phenomenon is well-known along the shores of the Great Lakes and has been the subject of extensive field studies for many years. Several lake breeze characteristics are of note which affect atmospheric dispersion and plume trajectory (Figure 1). During onshore flow, a parabolic shaped boundary or lid (referred to as a TIBL) can be formed starting near the shoreline and increasing in height with distance inland. This lid can result in plume trapping or fumigation with associated high ground level concentration. The flow from the lake penetrates inland to a certain distance where turning and also uplifting occurs. These phenomena are the result of air density effects caused by temperature differences between the warm land and colder water. A reverse condition can occur at night causing a "land breeze" that flows out over the lake.

Since releases are from the plant would be essentially at ground level below the TIBL boundary only, modelling of the fumigation conditions is not appropriate for the Perry site.

Plume trajectory changes may occur when the plume reaches the "convergence zone" or the inland location where the lake breeze stops. Thermal convection can actually form a "cell" which results in a return flow aloft back toward, and generally moving (spiraling) parallel to, the shoreline. This 3-dimensioral phenomenon, after reaching the convergence zone, is extremely difficult to characterize. However, plume dispersion under these circulating conditions is very good. To account for these phenomena, methods for estimating plume dispersion and location are applied in the MIDAS model. They are based on algorithms which use conditions measured on the meteorological tower at the site as well as lake water temperatures and time of day as described below.

The lake breeze submodel is incorporated in the MIDAS plume segment model using a series of preprocessors in the software which provide three basic functions as follows:

- o Determine whether meteorological conditions meet the criteria established for the existence of a lake breeze.
- o Estimate future meteorological input parameters using existing meteorological conditions.
- o Estimate the inland distance of lake breeze penetration and estimate changes in wind flow patterns as a function of time.

These functions are accomplished by a series of logic checks on the available data to categorize current weather conditions. These checks require use of the previous few hours of data which are stored in the computer to determine when lake breeze conditions started. Since the plume segment model is time-dependent (i.e., it steps into the future) and is used to project doses, lake breeze input to the model must be prepared for the future as well. For example, it would not be correct to assume lake breeze conditions exist after sundown.

Projections beyond that time would, by necessity, be made using the tower data without lake breeze preprocessing or dispersion equations.

The following data are used in the preprocessors:

- o Date (season)
- o Time of day
- o Lake temperature
- o Air temperature
- o Wind speed
- o Atmospheric stability
- o Wind direction

<u>Remote User Emergency Reports (the Broadcast Function)</u>

Software is provided which automatically sends reports to predefined remote terminals. The "Broadcast" reports include meteorological data in the format specified originally in NUREG-0654. The remote terminal operator does not have to constantly monitor the terminal and schedule tasks to receive 15-minute updates.

3.2 Lake Breeze Model Capability

The model accounts for the lake breeze circulation. The lake breeze is the most significant site specific effect of the terrain and lake-shore location of the Perry Nuclear Plant. The lake breeze occurs a quarter to a third of the days during the lake breeze season of the year when the daytime air temperatures often rise above the Lake Erie surface temperature.

Because the Perry meteorological tower is located sufficiently inland, it is representative of the overland conditions even during the onshore flow of the lake breeze with one exception. The model accounts for this exception: during the lake breeze a release from the plant would be transported only as far as the lake breeze front before being moved upward into the halical circulation. Because the model has this site-specific capability to account for the lake

breeze, the Perry dose assessment system provides representative estimates of dispersion for airborne releases from the Perry plant.

In the following subsections, the various characteristics of the lake breeze are described as to how they are accounted for in the model.

3.2.1 Detection of the Lake Breeze

The lake breeze must first be detected before it can be represented in the dispersion parts of the model. The detection algorithm used for Perry is summarized in Table 1.

The method for detecting the presence of the lake breeze was based upon the local and regional information provided in Section 3.3, Meteorological Basis for Model.

The meteorological variables required for evaluation of the criteria are observed on the Perry Meteorological Tower (discussed in Subsection 3.3.4, Input Meteorological Data). Observation for these are continually available (updated every 15 minutes) for routine assessment as to the presence of the lake breeze. A climatological data base of Lake Erie is needed for surface water temperature. Table 2 indicates the weekly values that are used based on a study by Webb (1974). In addition, an operator can manually enter an observed lake surface temperature.

3.2.2 TIBL Trapping

In the presence of the lake breeze, material released into the air from a ground-level source may be slightly restricted in its dispersion. (See Figure 1.) If the air over land is sufficiently turbulent, the airborne material may spread to the top of the TIBL (actually by the stable air above the TIBL restricts material from moving higher). If some of the material reaches the top of the TIBL, it becomes trapped. In time, this may result in ground-level concentrations that are slightly higher than on a day when vertical dispersion is not restricted by the TIBL.

However, because the possible effect of the trapping is relatively small in comparison to changes in concentration due to the direction of transport (helical circulation), no direct account is made of trapping.

3.2.3 Lake Breeze Helical Circulation

The lake breeze circulation as described in Section 3.3 is characterized by a helical circulation. A parcel near the ground moves with the inflow to the lake breeze front, moves up in the front, enters the return flow back past the coast, until it descends and starts an over-water reversal back into the inflow. At this point a parcel has usually moved up or down the coast such that its continuing path would represent a helix.

Inland Penetration

The distance that the sea breeze (front) penetrates inland is represented in Table 3. The table shows the maximum inland penetration as a function of the start time of the lake breeze.

The table provides values for both the "classic" and the "parallel confluence" types of lake breeze. The "classic" type occurs when the inflow is quite direct to the shoreline (directions 280^{o} through north to 20^{o}). The "parallel confluence" type occurs when the inflow is less direct to the shoreline (directions 250^{o} through 280^{o} and 40^{o} through 70^{o}) and if before the lake breeze the wind speed was greater than 4.5 mph for directions of 220^{o} through 250^{o} or 70^{o} through 100^{o}.

Return Flow

The speed and direction of the wind in the return flow of the lake breeze is determined by the algorithm described in Table 4.

The component of the wind parallel to the shore in the inflow is maintained. The perpendicular component of the inflow is reversed and cut in half. These two new components are combined to yield the return flow speed and direction.

This return flow is used to transport airborne material from the frontal zone (inland penetration) of the lake breeze to the point of over-water reversal.

The lake breeze model uses a Pasquill stability class of E to determine plume dispersion in the return flow. Stability E dispersion is used from the time the plume turns back toward the lake and out over the lake until the plume turns back toward the land. At this point, the stability goes back to the classification used at the start of the lake breeze.

The use of Class E stability was tested by Dr. Lyons (1978) during the late 1970s. His field tests using airplanes to trace the path of plumes in a lake breeze showed the return flow layer to be stable.

Over-Water Reversal

The offshore distance at which there is an over-water reversal of the lake breeze is selected. At this distance, airborne material in the return flow subsides and re-enters the inflow. The algorithm used to select the distance is that the offshore distance is one half of the inland penetration distance.

3.3 Meteorological Basis

The site-specific lake breeze characteristics of the model for real time dose assessment were just described in the previous section. The meteorological basis for the model is provided under two headings in this section:

- Results of Lake Breeze Case Study
- Lake Breeze Climatology for Perry

3.3.1 Results of Lake Breeze Case Study

This section describes a study of the lake breeze that was conducted for the 1980 season of the Lake Breeze. This was a local study that included the use of observations from the Perry Meteorological Tower. The results of this study were used along with the lake breeze climatology as the basis for the site-specific capabilities of the model that are described in Section 3.3.2.

The site-specific factors developed for the Perry lake breeze model were determined from a climatography study performed in 1984 by Dr. Walter Lyons. The study was of the site area using all available local data and available literature concerning lake breeze from the Great Lakes region. The climatography involved attaining hourly meteorological data from all sites in the Perry area and an in-depth analysis of the data for all lake breeze days in 1980. The following sites were used in the study:

Surface Data

Perry Plant	Eastlake Plant
Avon Lake Plant	Cuyahoga County Airport
Cleveland Hopkins Airport	Ashtabula Plant
Burke Airport	Youngstown Airport

Upper Air Data

Buffalo Airport

Pittsburgh Airport

Refer to Figures 2 and 3 for geographical locations.

Each day from April 1 through July 31 was characterized as to the mesosynopitc climatology. Table 5 shows the final classification of the 4 months of data.

Next the lake breeze days were examined to test criteria critical to the formation and termination of a lake breeze. Tables 6 through 10 show the results of tests performed on categories wind speed and direction, stability, ambient temperature and onset time versus penetration. As a result of this climatological study and our literature search, the following site-specific criteria were developed for determining existence of conditions for a lake breeze to exist at the Perry site.

- Calendar date: between 3/1 and 10/15
- Time of day: one hour after sunrise to sunset

- o Temperature comparison: ambient temperature (10m) minus lake water temperature is greater than or equal to -2.0^{o}F

- o Wind speed: wind speed (10m) is between calm and 13.4 mph

- o Stability: using delta temperature (60-10m) is a Pasquill Category A, B, C, or D

- o Wind direction: wind direction (10m) is from between 250^{o} and 68^{o}.

All criteria must be met for two 15-minute periods before the model will initiate use of the lake breeze algorithm. Once the lake breeze has started, it will persist for at least four 15-minute periods. The criteria are checked every 15 minutes and if they are not all satisfied during four consecutive 15-minute periods, the lake breeze is terminated. The lake breeze is automatically terminated at sundown. If a lake breeze is terminated during the day, it may be started again using the same criteria.

The extent of inland penetration was difficult to accurately assess given the available data. However, it was determined that the penetration distance could be related to the start time of the lake breeze and the angle of the wind direction in relationship to the shoreline.

3.3.2 Lake Breeze Climatology for Perry

This section describes the lake breeze circulation as it applies to Perry. The description is a climatology for the Great Lakes Region and focused on Lake Erie. The climatology was used along with the lake breeze case study as the basis for the site-specific capabilities of the model that are described in Section 3.2.

A stylized drawing of the lake breeze is presented in Figure 1. As reported in Section 2.3.2.3.2 of the PNPP FSAR (p. 2.3-24, -25):

> The major local effect on site meteorology is the presence of Lake Erie and the resultant occurrences of lake and land breeze circulations. The fact that water has a higher thermal capacity

than the land mass, and therefore responds more slowly to changes in radiation intensity, implies that temperature/density gradients between the water and land will occur with diurnal and seasonal periods. Turbulent mixing within the lake, effecting a downward transport of surface heat through large masses of water, also contributes to the land-lake temperature variation. Lake breezes (surface wind blowing from lake to land) form when the water temperatures are colder than the land temperatures, i.e., during spring and summer on a seasonal scale and late morning to late afternoon on a diurnal scale. The air over the land will be more buoyant than the lake air, and as it rises, a horizontal density gradient will form causing the colder air over the water to flow underneath the warmer air. Land breezes are the converse of lake breezes and occur when the water is warmer than the land, such as during the fall and winter or during the night in the summer. The lake breeze is generally stronger and occurs more frequently than the land breeze due to the fact that the buoyancy of the warmer air is the driving mechanism, and this is accomplished more effectively by heating the land mass relative to the water as in summer, than vice versa. This phenomena becomes most pronounced when synoptic scale motions are weak, such as when a large high pressure system is centered in the region. When synoptic scale motions are strong due to larger horizontal pressure gradients, the land/lake breeze circulation is effectively masked.

During onshore wind flows, such as a lake breeze, cool air flowing off the lake is modified by thermal (surface heating) and by surface roughness effects as the air flows over the land. The air from the lake is modified significantly as it flows over the land especially during the spring and early summer. The air is heated from below resulting in an unstable vertical temperature gradient and hence enhanced diffusion conditions. Surface roughness effects over the land increase atmospheric turbulence (also resulting in enhanced diffusion conditions), although low level wind speeds will decrease. The thermal and roughness effects occur at the shoreline and form a "boundary layer" which increases in depth with distance inland. Within this boundary layer the air is unstable with more stable air (suppressed diffusion) above the boundary layer.

In continuing discussion, the following characteristics of the lake breeze are discussed:

Frequencies and inland penetration

Inflows and outflows

Helical recirculation

Wind speed

Penetration speed

Time dependency

Air-water temperature differences
TIBL

3.3.2.1 Frequencies and Inland Penetrations

It is estimated that about a quarter to a third of the spring and summer have an associated lake breeze circulation. The Lake Erie frequency is estimated to fall within the range of occurrences on Lake Michigan and Lake Ontario.

In the Great Lakes region to the west, Lyons and Olsson (1973) reported that approximately 35 percent of the days during May and August were associated with a true lake breeze on the Lake Michigan-Chicago shoreline.

In 1974, there were two separate studies on Lake Ontario, to the east of Lake Erie. On the north shore, Bennet and List (1975) reported 21 lake breeze events for April to July. On the south shore of Lake Ontario, Mitchell (1975c) reported 25 lake breeze events for the same period. Based on an average of 23 events over the 122-day study period for the two studies, 19 percent of the days were associated with a lake breeze. This frequency is about half of that for Lake Michigan for the whole season.

In another study for Lake Ontario, Guski and Miller (1980) found a 20 and 30 percent frequency of occurrence for the same April to July period in 2 different years, respectively. However, for the entire season (March to September, the average lake breeze frequency was 32 percent of the days.

The maximum inland penetration distance of Lake Erie lake breezes is estimated to be about 50 miles. This is based on Guski and Miller's (1980) findings on Lake Ontario. They found, for example, that penetrations as far inland as 28 miles occur with 43 percent of the lake breezes. They concluded that their results were consistent with the distance of inland penetration for Lake Michigan (Lyons and Olsson, 1973; Moroz, 1967).

3.3.2.2 Inflows and Outflows

The depth of the inflows is greatly varied but could be typified as approximately 500 m for Lake Erie. On Lake Ontario, Mitchell (1975a) reported depths of 240 to 500 m, and Moroz and Koczkur 1967) reported depths of 500 to 750 m. Guski and Miller (1980), in their 2-year study, observed depths of 100 to 3000 m.

On Lake Michigan, depths of 500 to 1000 m were reported by Lyons and Olsson (1973); 400 m, by Olsson (1969); and 400 to 750 m, by Moroz (1967). Lyons (1975) identified depths of 100 to 1000 m with 500 m as typical.

The classical outflow--or return flow--is probably best described as "typically about twice the depth and half the peak speeds found in the inflow" (Lyons and Olsson, 1973). The reports for Lake Ontario and Lake Michigan lake breezes (Guski and Miller, 1980; Lyons and Olsson, 1973; Mitchell, 1975a; Moroz, 1967; Moroz and Koczkur, 1967; and Olsson, 1969) point towards this. They suggest an outflow height of up to 500 to 2000 m, perhaps typically 1500 m. However, these reports also indicate that the return flow is frequently indistinguishable or not observed because of the influence of large-scale winds.

3.3.2.3 Helical Recirculation

The typical two-dimensional picture (Figure 1) of the lake breeze circulation suggests the probable return of shoreline releases to the shoreline. A ground-level release is transported inland to the frontal or convergence zone, it moves upward, moves toward the lake in the return flow, subsides once more to the inflow, and thus turns to the shoreline.

In reality, the flow is three-dimensional and the synoptic, large-scale winds influence the actual trajectory of a release. The recirculation usually results in an along-shore drift. Trajectories resemble flattened helices (Lyons, 1975). Only rarely might a release return to its point of origin near the shoreline.

3.3.2.4 Wind Speed

The wind speed in the inflow region is typically about 7 mph at the 10-m level (Mitchell, 1975c; Guski and Miller, 1980). This data suggests a typical range of hourly wind speeds of 3 to 12 mph. These values are consistent with a typical description by Lyons (1975). Thus an onshore speed of 16 mph or more is likely not associated with a lake breeze and characteristic recirculation.

3.3.2.5 Penetration Speed

The penetration speed of the lake breeze front can be determined from previous studies. As reported in the next subsection on time dependency, the average duration of the lake breeze is about 7 hours, with about a 3 hour standard deviation. In Guski and Miller's (1980) study the distance of inland penetration 50 percent of the time was about 38 km. Relating the average duration to the distance of inland penetration yields an average frontal speed of 1.5 m/s.

Another study of the south shore (Mitchell, 1975c) of Lake Ontario showed a similar duration (7 hours). Field measurements (Mitchell, 1975a) for two cases within 1.5 km of the shoreline showed penetration speeds of 0.6 and 1.3 m/s can be used for Perry. The value could easily vary by ± 50 percent.

3.3.2.6 Time Dependency

Lyons (1975) reported a typical onset time for lake breezes as 0800 to 1000 LST (local standard time). This was supported by the Lake Ontario study by Mitchell (1975c) for which monthly average onset times of 0930, 0830, 1030, and 1000 LST were reported. However, as Lyons (1975) described, onsets as late as sunset have been reported. Usually, the lake breeze is best developed about 1600 LST (Lyons, 1975).

The duration of lake breezes is about 7 hours, as reported from Lake Ontario studies. Mitchell (1975c) reported monthly average durations of 5 to 9 hours and monthly maximum durations of 9 to 12 hours. Guski and Miller's (1980) study implies durations of 1 to 14 hours.

3.3.2.7 Air-Water Temperature Differences

The lake breeze circulation is related to the differential temperature of air over land and water; the land temperature is normally warmer. However, it may happen for a time that at a particular point over land the temperature is about the same as that of the water. In this instance the lake breeze circulation may well be continuing; it is just that a cloud has shadowed the particular point and the upwind over land fetch and unmodified (unwarmed) marine air has reached that particular location.

A typical air-minus-water differential temperature as about 11°F as reported in the two Lake Ontario studies. Mitchell (1975c) reported differentials in categories ranging from less than 2°F up to 27°F, with a mean of approximately 11°F. Guski and Miller (1980) reported an average of 11°F with a standard deviation of 9°F.

3.3.2.8 TIBL

The TIBL (Turbulent, or Thermal, Internal Boundary Layer) forms near the ground as unmodified lake air moves over the warmer, rougher land (downwind) in the inflow of the lake breeze. (The same happens during a stable onshore flow, although no return circulation occurs.) Although the turbulent characteristics of the air flowing over the land start to be modified immediately, some distance of travel is required in order for the complete modification to occur. See Figure 1.

Over the lake, in a lake breeze, the air tends to be stable before it moves inland. This is caused by subsidence and by conduction cooling by the water. As air moves onshore in the inflow, a shallow TIBL forms as a result of the warmer and rougher land. As the inflow continues, more of it is modified by the increasing depth of the TIBL. The depth of the TIBL grows faster near the shoreline than it does later in the downwind (over land) fetch. The growth rate has been approximated as being proportional to the square root of travel distance or of travel time. Raynor, et al. (1974) provided a more complete formulation for the TIBL depth; it is referred to as Equation (1) in NUREG/CR-0936 (Raynor, et al., 1979).

Septoff, et al. (1976) reported a calculational estimate of the TIBL depth at 1.5 km inland of 109 m: several methods from the literature were used to make the composite estimate. The Raynor method reported in NUREG/CR-0936 yielded TIBL heights at 1.5 km of 134 to 300 m for a variety of conditions associated with an 11°F (6°C) air-minus-water temperature difference (which is typical for Lake Ontario during a lake breeze situation). Mitchell (1975b) demonstrated the applicability of Raynor's formula slightly modified for Lake Ontario lake breezes; it provides an estimated 100 m depth for the TIBL at 2 km during a typical situation of B stability (unstable) and a 12°F air-minus-water temperature difference.

Observed TIBL depths at 2 km inland include the Lake Ontario reports by Mitchell (1975a) of 100 to 150 m; the Lake Michigan report by Lyons (1975) of approximately 150 m; and the Lake Erie report at FERMI (NUREG/CR-0936) of 61 to 183 m. These values averaged together indicate a typical TIBL depth of approximately 130 m at 2 km inland.

Figure 4 illustrates both these observed and estimated TIBL depths as a function of inland distance (downwind fetch from shoreline). Characteristically, the Perry tower will be completely in the TIBL because the overland fetch is 1.8 km--or more, if the wind comes onshore at an angle rather than perpendicular.

3.4 INPUT METEOROLOGICAL DATA

Data that can be routinely used for the preparation of dose assessments are described in this subsection. This includes a discussion of the following:

- Meteorological Tower and Validation
- Determination of Stability Class
- Other (Supplemental) Meteorological Data

3.4.1 Meteorological Tower and Validation

The tower is an open lattice structure with sensors at the 10 and 60-m levels. It is 60 m tall and is located in terrain similar to that of the site region that is of relatively low relief. Even during stable onshore flow, the tower

is representative of the over-land conditions because it is well within the TIBL (Thermal Internal Boundary Layer). The shoreline is oriented approximately NE-SW as illustrated in Figure 2.

Table 11 describes the instrumentation with manufacturers, model number, reporting range, location of the tower, and performance characteristics.

Table 12 summarizes the meteorological variables measured. There are two independent systems on the tower, Main and Backup. Each systems has its own processors, recording equipment, and microcomputer (MDPS-Meteorological Data Processing System) that are housed in separate shelter near the tower. Every 15 minutes, each MDPS transfers validated data and preliminary estimates of dispersion to onsite--Control Room, TSC ERIS computer, and the Plant Process computer--by various multiple communication links.

For each parameter, the MDPS normally develops hourly values that are derived from 15-minute values. The 15-minute values are developed from sub-second sampling. The MDPS automatically performs electronic and status checks. Daily, it makes calibration zero and span checks for each data channel, except for the dewpoint reading. It uses the information to refine subsequent observations for any normal electronic drift that might be detected. Nominal, small, and large drifts are reported. The MDPS continually monitors for reduced air flow in temperature aspirators, for the dewpoint system in auto-balance, for manually initiated bypass codes (used during weekly checks or calibrations), etc.

In addition, samples are taken in 5-second groups (primary and validity) and then screened at the end of 15 minutes before being accepted for use in processing calculations. If the sample is out of acceptable limits, it is rejected. At the end of each 15 minutes, all of the screened values are used to determine the 15-minute value (if there were an insufficient number of the potential samples, i.e., less than 80 percent, then the 15-minute value would be reported as missing).

Before the 15-minute value is finally accepted by MDPS to store, print, or transmit, a realtime validation is performed. This is done by performing meteorological reasonability checks on the 15-minute value and concurrently generated

statistics. For parameters of prime importance, a dual statistics approach is used that employs signals from colocated, redundant sensors (Table 12). The dual statistics approach (Mitchell, et al., 1984) is based upon NOAA comparability techniques (Hoehne; 1971, 1977). For other parameters, a single statistic approach is used. The single statistic approach involves an evaluation of various single statistics for their relation to known ranges of statistics, to climatological extremes, and (in limited cases) to other parameters. If the validation is not positive, the data is reported as missing along with a validity indicator.

In the event that a particular variable is missing, the ERIS computer can seek out a substitute within the reported tower data from each of the two system, Main and Backup. See Table 13.

The meteorological data collection program at PNPP is subject to detailed quality assurance and quality control procedures which are supplemented with site-specific plans and procedures. Data are reviewed regularly. A Site Observer performs a weekly inspection to verify proper system operation, routine operations (change charts) and minor preventive maintenance. Calibrations and routine preventive maintenance are conducted at four-month intervals by trained personnel according to set procedures. Repairs requiring emergency maintenance between regularly scheduled calibrations are performed promptly.

3.4.2 Determination of Stability Class

Atmospheric stability class is determined for use in estimating dispersion parameters of airborne material. In the split sigma Gaussian modeling concepts, there is an horizontal dispersion parameter for the y direction and a vertical dispersion parameter for the z direction. There is a different growth rate with distance for each that is associated with each of seven atmospheric stability classes.

Four methods of classifying atmospheric stability are used in the microcomputer at the Perry Meteorological Tower:

- o delta T (for vertical, z, dispersion)
- o sigma theta (for horizontal, y, dispersion

- o modified sigma theta (for vertical, z, dispersion)
- o pseudo sigma (for horizontal, y, dispersion)

As a result there are a variety of sources of stability class information (see Tables 12 and 13).

o <u>Delta T</u> (Table 14)

The method reported in Regulatory Guide 1.23 (USNRC 1972, 1980a) uses the vertical temperature (delta T) gradient as the basis. This method is normally used for dispersion estimate submittals to the NRC. In ERs, FSARs, Appendix I assessments, and semi-annual operating reports, usually, delta T is used to determine both the horizontal and vertical dispersion factors. However, it is generally a better description of vertical rather than horizontal dispersion. The latter may be significantly altered by meander, especially during low wind speeds and stable conditions, as is recognized in the methodology of Regulatory Guide 1.145 (USNRC, 1979). The delta T classification ranges are presented in Table 14.

o <u>Sigma Theta</u> (Table 15)

This method reported in Regulatory Guide 1.23 (USNRC, 1980a) uses as its basis the horizontal wind direction fluctuation, sigma theta. This method has been used historically to estimate both vertical and horizontal dispersion. However, at night it is generally a better description of horizontal rather than vertical dispersion. During low wind speeds and stable conditions (common at night), horizontal meander may be large and result in large time-averaged horizontal dispersion, while vertical dispersion is small. The sigma theta classification is reported in Table 15.

o <u>Modified Sigma Theta</u> (Table 16)

This method has been reported in the literature and considered for monitoring by EPA: Mitchell and Timbre, 1979; Irwin, 1980; Mitchell and Snell, 1981; and Mitchell, 1982.

The method uses as its basis the horizontal wind direction fluctuation, sigma theta, during the day; however, it also uses wind speed at night. The method takes into account the increased horizontal meander associated with low wind speeds and stable conditions at night. As such, this method yields the same stability classes as does the sigma theta method during the day and thus is a good description of horizontal and vertical dispersion. At night, however, this method better describes vertical dispersion than the standard sigma theta method since this method yields classifications to mimic those yielded by the delta T method. This classification is reported in Table 3.3-6.

o <u>Pseudo Sigma</u> (Table 17)

This method utilizes delta T measurement to approximate the stability class estimated by sigma theta. As indicated in Table 3.3-5, this method provides an adjustment to incorporate the effect of horizontal meander of the wind direction. This adjustment is consistent with Regulatory Guide 1.145 (USNRC, 1979) which prescribes an enhancement of horizontal plume growth during stable, light-wind conditions. And, it is this enhancement described in Regulatory Guide 1.145 that is also the basis for the Modified Sigma Theta method. The approach of the method presented in Table 17 is to make the adjustment to the stability class controlling horizontal, y, dispersion.

3.4.3 Other (Supplemental) Local Meteorological Data

While the Perry dose assessment system does characterize lake breeze dispersion through the use of input from the meteorological tower (as described in 3.2), there are local (supplemental) sources of meteorological data. These sources could be used to verify current conditions (extent of inland penetration of the lake breeze).

Regional sources of meteorological observations are presented in Figure 2. These sources are 17 or more miles from Perry and are generally operated by agencies, like the National Weather Service, for example.

In addition, there are a variety of generally non-governmental stations that are close to the site (Figure 3). These stations can be contacted for supple-

mental information, especially during a lake breeze event. Although all the stations are not open 24 hours a day, the lake breeze itself is limited to the daytime. Therefore, it is reasonable to expect that several of these could provide wind information to confirm the extent of penetration of the lake breeze.

These local stations are listed in Table 18 that includes a description of their inland distance as well as their relationship to the plant.

Table 1. Algorithm for Detection of the Lake Breeze

Onset

1.	Calendar Date:	Between 3/1 and 10/15
2.	Time of Day:	One hour after sunrise to sunset
3.	Temperature Comparison:	Ambient temperature 10m - Lake water temperature is greater than or equal to $-2.0^{o}F$
4.	Wind Speed:	Wind speed (10m) is between calm and 13.4 mph
5.	Stability:	Stability using delta temperature 60-10m is a Pasquill category A-D and the stability has shifted at least one category towards unstable (i.e., from E to D) after sunrise
6.	Wind Direction:	The wind direction (10m) is from between 250^{o} and 70^{o}; and the wind direction has shifted from an over-land sector between 80^{o}-240^{o} to an over-water sector (250-70^{o}). The shift in direction must occur between one hour before sunrise and thirty minutes before the onset of the lake breeze
7.	Rainfall:	No rainfall during the 15-minute period

All criteria must be met for two 15-minute periods before the model will initiate use of the lake breeze algorithm. The shift in wind direction from over-land to over-water need only have taken place before the onset of the lake breeze as described above.

Cessation

Once the lake breeze has started, it will persist for at least four 15-minute periods. Each criterion will be checked every 15 minutes. If they are not all met for four consecutive 15-minute periods the lake breeze is terminated. The lake breeze is automatically ended at sundown.

Restart

When a lake breeze is ended during the day, it can be started again by meeting the two 15-minute period checks, above, but without any wind direction shift.

Table 2. Surface Temperature for Lake Erie

Values are interpolated from the six-year study by Webb (1974).

Date		Temperature (^{O}F)
March	1-7	33
	8-14	33
	15-21	34
	22-28	34
	29-4	35
April	5-11	36
	12-18	38
	19-25	40
	26-2	42
May	3-9	43
	10-16	45
	17-23	48
	24-30	51
	31-6	53
June	7-13	55
	14-20	59
	21-27	62
	28-5	65
July	6-12	67
	13-19	69
	14-20	71
	21-27	72
	28-3	73
August	4-10	74
	11-17	74
	18-24	73
	25-31	72
September	1-7	71
	8-14	69
	15-21	67
	22-28	65
	29-5	63
October	6-15	58

Table 3. Algorithm for the Maximum Inland Penetration Distance of the Lake Breeze

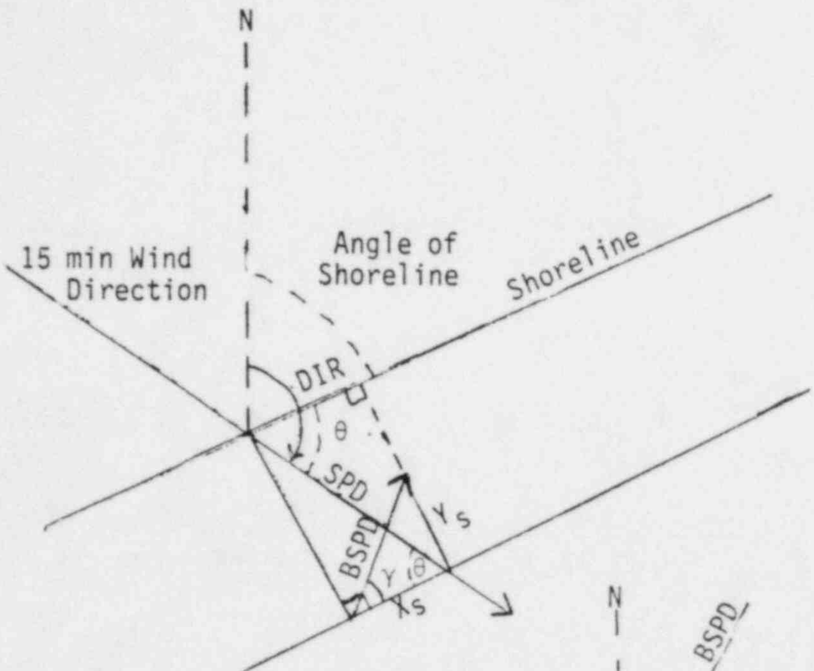
Start Time (EST)	Distance (miles*) by Lake Breeze Type	
	Classic	Parallel Confluence
0600	20	5
0700	20	5
0800	20	5
0900	16	4
1000	16	4
1100	12	4
1200	12	3
1300	10	3
1400	10	3
1500	8	2
1600	8	2
1700	5	1
1800	3	1
1900	0	0

* Inland penetration rate for the classic type is 2.66 mph and for the parallel confluence type is 0.75 mph.

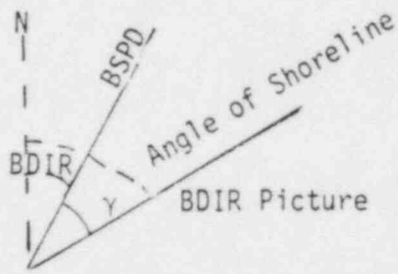
TABLE 4

Algorithm for the Return Flow Wind of the Lake Breeze

Calculation of Return Wind Speed and Direction



BSPD = Return Speed
BDIR = Return Direction
DIR = Initial Direction
SPD = Initial Speed



θ = Angle of Shoreline - DIR

X_s = SPD x Cosθ

Y_s = (SPD x SINθ)/2.0

$$BSPD = X_s^2 + Y_s^2$$

$$\cos\gamma = \frac{X_s}{BSPD}$$

γ = Arc Cos (X_s/BSPD)

BDIR = Angle of shoreline - γ

Speed Calculation

↓

Direction Calculation

Table 5. Mesosynoptic Characterization for April through July 1980 at Perry

(Days with Events Indicated)

Code	Characterization	N*	%
0	Steady Synoptic Influences Predominate All Day	12	6.0
1	Synoptic Discontinuity, _ 50% Change/2 Hours	10	5.0
2	Gradient Onshore Flow (Cloudy/Night) with Plume Trapping	10	5.0
3	Gradient Onshore Flow (Sunny) with Fumigation	31	15.5
4	Gradient Offshore Flow - Stable Air Over Colder Water	8	4.0
5	Near Calm (Pooling)	1	0.5
6	Land Breeze	21	10.5
7	Classic Lake Breeze - Onset Past Hour	Not Used	--
8	Classic Lake Breeze in Progress	39	19.5
9	Parallel Shore Confluence - From West	8	4.0
10	Parallel Shore Confluence - From East	0	0.0
11	Ridge/Trough Passage Lake Creeze	5	2.5
12	Gradient Onshore Flow - Lake Warmer (Night)	Not Used	--
13	Gradient Onshore Flow - Lake Warmer (Day)	Not Used	--
14	Thunderstorm Mesosystem in Area	40	20.0
15	Poorly Defined Mesosynoptic Regimes/Inertial Flows	15	7.5
		200	100

* N - Number of events (more than one event can occur in a day).

Table 6. Wind Speed at 10-m Level of the Perry Meteorological Tower during Lake Breezes in April through July 1980

Wind (m/sec)	Number of Observations	%
0.0 - 1.0	6	2.4
1.1 - 2.0	28	11.4
2.1 - 3.0	63	25.7
3.1 - 4.0	75	30.6
4.1 - 5.0	47	19.2
5.1 - 6.0	23	9.4
6.1 - 7.0	4	1.6
7.1 - 8.0	0	0
8.1 - 9.0	0	0
9.1 -10.0	0	0
10.0	0	0
	246	100

TABLE 7
HISTOGRAM OF OBSERVED WIND DIRECTION -- FROM 10M PERRY TOWER

Time

Direction (From)	06 GMT		12 GMT		18 GMT		00 GMT	
18	XXXXXXXXXXX	(11)	XXXXXXXXXX	(10)	XXXXX	(5)	XXX	(3)
19	XXXXXXXXXXXXXXXXXX	(18)	XXXXXXXXXXXXXXX	(15)	XXXXX	(5)	XXXXXXXXXXXX	(12)
20	XXXXXXX	(7)	XXXXXXXXXX	(10)	XXXXXX	(6)	XX	(2)
21	XXXXXXXXX	(9)	XXXXXXXXXXXXXXXX	(16)	XXXXXX	(6)	XXXXXX	(6)
22	XXXXXXX	(7)	XXXXXX	(6)	XXX	(3)	X	(1)
23	XXX	(3)	XXXX	(4)	XXXX	(4)	XXX	(3)
24	XXXXX	(5)	XX	(2)	XX	(2)	XXXXXXX	(7)
25	XXXXXX	(6)	X	(1)	XXXXXX	(6)	XXXXXX	(6)
26	XXX	(3)	XXXX	(4)	XXXXXXXXX	(9)	XXXXXXXXXXXX	(12)
27	XXXX	(4)	XX	(2)	XXXXXXXXXXXXXX	(14)	XXXXXXXXXXXXXXXX	(16)
28	XX	(2)	XXXX	(4)	XXXXXXXXXXXXX	(13)	XXXXXX	(6)
29	XXXX	(4)	XXX	(3)	XXXXXXXXXXXX	(12)	XXXXXXX	(7)
30		(0)	XXXX	(4)	XXXXXXXXXXXXXXXXXXX	(19)	XXXXXXXX	(8)
31	XX	(2)	XX	(2)	XXXXXXXXXXX	(11)	XXX	(3)
32	X	(1)	XXX	(3)	XXXXXXX	(7)	XXXX	(4)
33	XX	(2)	XXX	(3)	XXXX	(4)	XXXX	(4)
34		(0)		(0)	XXXXXXX	(7)	XXXXXXX	(7)
35	XX	(2)	XX	(2)	XXXX	(4)	XX	(2)
36/00	XX	(2)	XX	(2)	XXXXXXXXX	(9)	XXXXX	(5)
1		(0)	XXX	(3)	XXXXXX	(6)	XX	(2)
2	XXXX	(4)	XXXX	(4)	XXXX	(4)	XXXX	(4)
3	XXX	(3)	X	(1)	XXXXXX	(6)	X	(1)
4	XXX	(3)	XX	(2)	XXXX	(4)	XXXXXXX	(7)
5	XX	(2)	X	(1)	X	(1)	XXXXX	(5)
6	XX	(2)	X	(1)	XX	(2)	XXXXXXXXXXXXX	(13)
7	XXX	(3)	XXX	(3)		(0)	XXXXX	(5)
8	XXX	(3)	XXXX	(4)		(0)	XX	(2)
9	XXXX	(4)	XX	(2)	X	(1)	XXX	(3)
10	XXXXXXX	(7)	XXX	(3)		(0)	XXXX	(4)
11	XXXX	(4)	XXXXXXX	(7)	X	(1)	XXX	(3)
12	XXXXX	(5)	XXXXXXX	(7)	X	(1)	X	(1)
13	XXXX	(4)	XXXXX	(5)	X	(1)	XXXX	(4)
14	XXXXXXXXXXXXX	(13)	XXXXXXX	(7)	XXXX	(4)	XXX	(3)
15	XXXXXXXXXXXXXXX	(15)	XXXXXXX	(7)	XX	(2)	XXX	(3)
16	XXXXXXX	(7)	XXXXXXXXXXXX	(12)	XX	(2)	X	(1)
17	XXXXXXXX	(8)	XXXXXXXXXXXX	(12)	X	(1)	XXX	(3)
		(0)		(0)		(0)		(0)
Missing		(8)		(8)		(6)		(5)

Table 8. Pasquill-Gifford Stability Class (60-10m Delta T) at Perry During Lake Breeze Hours in April through July 1980

P-G Class	Number of Observations	%
A	4	1.6
B	14	5.7
C	47	19.2
D	159	64.9
E	14	5.7
F	5	2.0
G	2	0.8
	245	100

TABLE 9

LAND-WATER TEMPERATURE DIFFERENCE DURING SEA BREEZE HOURS AT PERRY NUCLEAR PLANT, APRIL-JULY 1980

DELTA T (°F)		N	%
-10	X	1	0.4
-09	XXXXX	5	2.0
-08	X	1	0.4
-07	X	1	0.4
-06	X	1	0.4
-05	XXX	3	1.2
-04		0	0
-03	XXXX	4	1.6
-02	XXXXXXXXX	9	3.7
-01	XXXX	4	1.6
0	XXXXXXXXXXXX	12	5.0
+01	XXXXXXXX	8	3.7
+02	XXXXXXXXXXXXXXXXXXX	19	7.8
+03	XXXXXXXXXXXXXXXX	16	6.5
+04	XXXXXXXXXXXXXXXXXXX	19	7.8
+05	XXXXXXXXXXX	11	4.9
+06	XXXXXXXXXXXXXXXXXXXXXXX	23	9.4
+07	XXXXXXXXXXXXX	13	5.3
+08	XXXXXXX	7	2.8
+09	XXXXXXXXXXXXXX	14	5.7
+10	XXXXXXXXXXXXXXXX	16	6.5
+11	XXXXXXX	7	2.8
+12	XXXXX	5	2.0
+13	XXXX	4	1.6
+14	XXXXXXX	7	2.8
+15	XXXX	4	1.6
+16	XXXXXX	6	2.4
+17	XXXXXX	6	2.4
+18	XXX	3	1.2
+19	XXX	3	1.2
+20	X	1	0.4
+21		0	0
+22		0	0
+23		0	0
+24		0	0
+25		0	0
+26		0	0
+27		0	0
+28		0	0
+29	X	1	0.4
+30		0	0
+31	X	1	0.4
+32	XXXX	4	1.6
+33	X	1	0.4
+34		0	0
+35		0	0

TABLE 10

CONDITIONS OBSERVED AT THE PERRY NUCLEAR POWER PLANT
IN THE HOUR BEFORE THE ONSET OF A LAKE BREEZE REGIME

Month	Day	Hour (GMT)	Penetration (km)	PNP (10m)		PNP (60m)		P-6	Solar	Precip.	T_1*
				DD	VV	DD	VV				
April	6	15	8	24°	3.0	24°	3.2	D	M	0	+16°
April	22	16	3	23°	2.9	23°	3.4	D	H	0	+29°
May	15	13	30	23°	3.2	24°	4.2	D	M	0	-01°
May	16	13	30	09°	2.7	10°	3.8	D	H	0	+01°
May	27	12	30	19°	2.3	06°	3.1	F	H	0	-07°
June	12	14	20	25°	3.9	25°	6.0	D	H	0	+05°
June	13	18	2	18°	3.8	17°	4.2	C	M	0	+18°
June	14	14	9	21°	3.8	21°	4.8	D	M	0	+14°
June	17	13	35	22°	1.3	30°	2.1	F	H	0	-14°
June	18	14	15	24°	3.0	24°	3.2	D	M	0	+04°
June	21	12	25	22°	2.5	24°	5.0	E	M	0	-05°
June	22	14	9	20°	2.1	21°	2.2	D	M	0	+06°
June	24	14	10	22°	1.5	23°	1.5	D	H	0	+08°
June	25	13	12	23°	1.9	23°	2.9	D	H	0	+05°
June	26	14	8	24°	4.0	24°	4.8	D	H	0	+10°
June	29	12	8	25°	4.8	25°	7.0	D	-	0	+04°
July	3	13	30	19°	0.9	27°	2.3	F	M	0	-11°
July	14	11	9	14°	2.6	16°	6.8	G	-	0	-13°
July	18	14	18	11°	1.1	10°	1.2	D	M	0	-02°
July	24	13	35	10°	1.2	07°	2.1	E	H	0	-06°
July	25	14	16	22°	2.7	23°	3.3	D	M	0	+01°
July	26	15	10	24°	2.9	25°	3.6	D	H	0	+05°

*T_1 = Average Ambient Temperature - Lake Water Temperature.

DD = Wind Direction
VV = Wind Speed
P-6 = PG Stability Class

Table 11

PNPP METEOROLOGICAL SYSTEM EQUIPMENT SPECIFICATION
(Page 1 of 3)

System	Manufacturer	Model Number	Range	Location	Characteristics
MAIN SYSTEM					
Wind speed system includes cups, sensor, and processor	Teledyne Geotech	Cup 170-41 Sensor 1564B Processor 21.11	0 to 100 mph	10m (primary) 9' W of tower 60m (primary) 9' W of tower 10m (validity) 9' W of tower 60m (validity) 9' W of tower	Threshold 0.60 mph Distance constant 5.0 ft Error ± 0.29 mph less than 5 mph ± 1.12% from 5 mph to 50 mph
Wind direction system includes vane, sensor, and processor	Teledyne Geotech	Vane 53.2 Sensor 1565B Processor 21.22-1	0 to 540°	10m (primary) 9' W of tower 60m (primary) 9' W of tower 10m (validity) 9' W of tower 60m (validity) 9' W of tower	Threshold 0.70 mph Damping 0.4 Distance constant 3.7 ft Error ± 3°
Temperature system RTDs and processor T	Teledyne Geotech	RTD T-200 Processor 40.35 327C aspirated shield	T -20 to 100°F	10m (primary) 6' W of tower 10m (validity) 6' W of tower 60m (primary) 6' W of tower 60m (validity) 6' W of tower	T accuracy ± 0.11°F Time constant 1 min
Delta T (60-10m)		Delta T range card 20.42X	Delta T -4 to 8°F		Delta T accuracy ± 0.11°F
Precipitabtion	Belfort Weather Measure Teledyne Geotech	5-405H rain gauge P565 wind shield Processor 21.52	0.01" increments	Ground level	Accuracy ± 1% (0.01" for 1"/hour)
Dewpoint	EG&G	220	-20 to 100°F	10m 6' W of tower	Accuracy ± 0.7°F
Station pressure sensor and processor	Teledyne Geotech	BP-100 Processor 40.61	28 to 32" of Hg	2m (Main shelter)	Accuracy ± 0.02" of Hg

Table 11 (Cont.)

PNPP METEOROLOGICAL SYSTEM EQUIPMENT SPECIFICATION
(Page 2 of 3)

System	Manufacturer	Model Number	Range	Location	Characteristics
MAIN SYSTEM (CONTINUED)					
Multipoint recorder Temperature Delta T (60-10m) Dewpoint Pressure Precipitation	Esterline-Angus	E1124E 12 channel	-20 to 100°F -4 to 8°F -20 to 100°F 28 to 32" of Hg 0 to 1"	Main shelter	Accuracy ± 0.25% of full scale
Speed Servo II Recorder (3 ea) (ws/wd)	Esterline-Angus	L11S2S	0 to 100 mph (10m) 0 to 100 mph (60m) 0 to 540° (10,60m)	Main shelter	Accuracy ± 0.25% of full scale
Microprocessor	Digital Equipment Corporation	LSI11/23 CPU KFD11-AA Analog to Digital Converter 1012	--	Main shelter	Accuracy of analog to digital converter is better than ± 0.10% of full scale
BACKUP SYSTEM					
Wind speed system includes cups, sensor, and processor	Teledyne Geotech	Cup 170-41 Sensor 1564B Processor 40.12CX	0 to 100 mph	10m (primary) 13' W of tower 10m (validity) 10' W of tower	Threshold 0.60 mph Distance constant 5.0 ft Error ± 0.29 mph less than 5 mph ± 1.12% from 5 mph to 50 mph
Wind direction system includes vane, sensor, and processor	Teledyne Geotech	Vane 53.2 Sensor 1565B Processor 40.22-1	0 to 540°	10m (primary) 13' W of tower 10m (validity) 10' W of tower	Threshold 0.70 mph Damping 0.4 Distance constant 3.7 ft Error ± 3°

Table 11 (Cont.)

PNPP METEOROLOGICAL SYSTEM EQUIPMENT SPECIFICATION
(Page 3 of 3)

System	Manufacturer	Model Number	Range	Location	Characteristics
BACKUP SYSTEM (CONTINUED)					
Temperature system RTDs and processor	Teledyne Geotech	RTD T-200 Processor 21.32 327C Aspirated shield	-20 to 100°F	10m (primary) 6' W of tower 10m (validity) 6' W of tower	Ambient ± 0.20°F Time constant 1 min.
Servo recorder Temperature ws/wd	Esterline-Angus	6 channel recorder MS426C	-20 to 100°F 0 to 100 mph 0 to 540°	Backup shelter	Accuracy ± 0.5% full scale
Microprocessor	Digital Equipment Corporation	LSI11/23 CPU KFD11-AA Analog to Digital Converter 1012		Backup shelter	Accuracy of analog to digital converter is better than ± 0.10% of full scale

Table 12. Summary of Variables Reported from the Perry Meteorological Tower

Main System	Backup System
10m wind speed*	10m wind speed*
10m wind direction*	10m wind direction*
10m sigma	10m sigma
Stability classes (for y and z)	Stability classes (for y and z)
10m temperature*	10m temperature*
Delta temperature*	
Stability classes (for y and z)	
Dewpoint	
Precipitation	
Station pressure	
60m wind speed*	
60m wind direction*	
60m sigma	
Stability classes (for y and z)	

* Dual instrumentation for validation

Table 13. Alternate Data Sequence in ERIS for Onsite Perry Meteorological Data

Variable and Primary Source	First Alternate	Second Alternate	Third Alternate
Main System 10m Wind Speed	Backup System 10m Wind Speed	Main System 60m Wind Speed(3)	N/A
Main System 10m Wind Direction	Backup System 10m Wind Direction	Main System 60m Wind Direction	N/A
Stability for Dispersion Horizontal(1) (Main System 10m Sigma)	Backup System 10m Sigma	Main System Delta T (60-10m)	Backup System 60m Sigma
Stability for Dispersion Vertical(2) (Main System Delta T, 60-10m)	Main System 10m Sigma	Backup System 10m Sigma	Main System 60m Sigma
Main System Temperature	Backup System Temperature (10m)	N/A	N/A

1. Stability classification based on sigma theta method or equivalent pseudo sigma method.

2. Stability classification baed on delta T, or equivalent modified sigma theta method.

3. Power law wind profile applied.

Table 14

CLASSIFICATION OF ATMOSPHERIC STABILITY BY TEMPERATURE CHANGE WITH HEIGHT

Stability Classification	Pasquill Categories	Temperature Change with Height (°C/100 m)
Extremely unstable	A	$\Delta T/\Delta z \leq -1.9$
Moderately unstable	B	$-1.9 < \Delta T/\Delta z \leq -1.7$
Slightly unstable	C	$-1.7 < \Delta T/\Delta z \leq -1.5$
Neutral	D	$-1.5 < \Delta T/\Delta z \leq -0.5$
Slightly stable	E	$-0.5 < \Delta T/\Delta z \leq 1.5$
Moderately stable	F	$1.5 < \Delta T/\Delta z \leq 4.0$
Extremely stable	G	$4.0 < \Delta T/\Delta z$

Based on Regulatory Guide 1.23 (1980)

Table 15

CLASSIFICATION OF ATMOSPHERIC STABILITY BY SIGMA THETA

Stability Classification	Pasquill Categories	σ_θ* (degrees)
Extremely unstable	A	$\sigma_\theta \geq 22.5$
Moderately unstable	B	$22.5 > \sigma_\theta \geq 17.5$
Slightly unstable	C	$17.5 > \sigma_\theta \geq 12.5$
Neutral	D	$12.5 > \sigma_\theta \geq 7.5$
Slightly stable	E	$7.5 > \sigma_\theta \geq 3.8$
Moderately stable	F	$3.8 > \sigma_\theta \geq 2.1$
Extremely stable	G	$2.1 > \sigma_\theta$

*Standard deviation of horizontal wind direction fluctuation over a period of 15 minutes to 1 hour.

Based on Regulatory Guide 1.23 (1980)

Table 16

Modified Sigma Theta Method to Estimate the Stability Class for Sigma Z from Sigma Theta

---

This table is followed during the night which is defined as the period of one hour prior to sunset to one hour after sunrise. During the day the stability is determined directly from Sigma.

If the Sigma stability class is	And if the wind speed u is (m/s)	(mi/h)	Then the stability class for the vertical (z) is
A	u LT 2.4	u LT 5.3	G
	2.4 LE u LT 2.9	5.3 LE u LT 6.4	F
	2.9 LE u LT 3.6	6.4 LE u LT 7.9	E
	3.6 LE u	7.9 LE u	D
B	u LT 2.4	u LT 5.3	F
	2.4 LE u LT 3.0	5.3 LE u LT 6.6	E
	3.0 LE u	6.6 LE u	D
C	u LT 2.4	u LT 5.3	E
	2.4 LE u	5.3 LE u	D
D	no restriction		D
E	no restriction		E
F	no restriction		F
G	no restriction		G

Table 17

Pseudo Sigma Method to Estimate the Atmospheric Stability Class Applicable to Horizontal (y) Dispersion on the Basis of Delta T

If it is daytime, the delta T stability class is used directly as being representative for sigma y. If it is nighttime, apply the following:

If the Delta T stability class is	And if the wind speed (mi/h) is	Then the stability class for the horizontal (y) is
G	u LT 5.3	A
	5.3 LE u LT 6.4	B
	6.4 LE u LT 7.9	C
	7.9 LE u	D
F	u LT 5.3	B
	5.3 LE u LT 6.6	C
	6.6 LE u	
E	u LT 5.3	C
	5.3 LE u	
D	any speed	D
C	any speed	C
B	any speed	B
A	any speed	A

GT = greater than
GE = greater than or equal
LT = less than
LE = less than or equal

Table 18. Sources of Local Meteorological Data

Location Number	Station Name	Distance from PNPP	Inland Distance
1	Eastlake Plant, CEI	17 miles, WSW	0 mile
2	Ashtabula USCG	19 miles, ENE	0 mile
3	Perry (PNPP)	On site	1 mile
4	Lost Nation Airport	16 miles, WSW	1 mile
5	Woodworth Airport	5 miles, E	2 miles
6	Casement Airport	6 miles, SW	2 miles
7	Woerner Airport	12 miles, E	2 miles
8	Lake County Health District, Painsville	8 miles, SW	3 miles
9	Germack Airport	12 miles, E	6 miles
10	Concord Airport	10 miles, SSW	7 miles
11*	Eckhard Airport	10 miles, SE	8 miles
12	Birdland Airport	10 miles, S	9 miles
13	Ashtabula Co. Airport	23 miles, E	9 miles
14	Armington Airport	15 miles, ESE	10 miles
15	Whispering Pines (Fielitz) Airport	11 miles, SSE	11 miles
16	Thompson Airport	13 miles, SSE	13 miles

* No longer in operation - 1/84

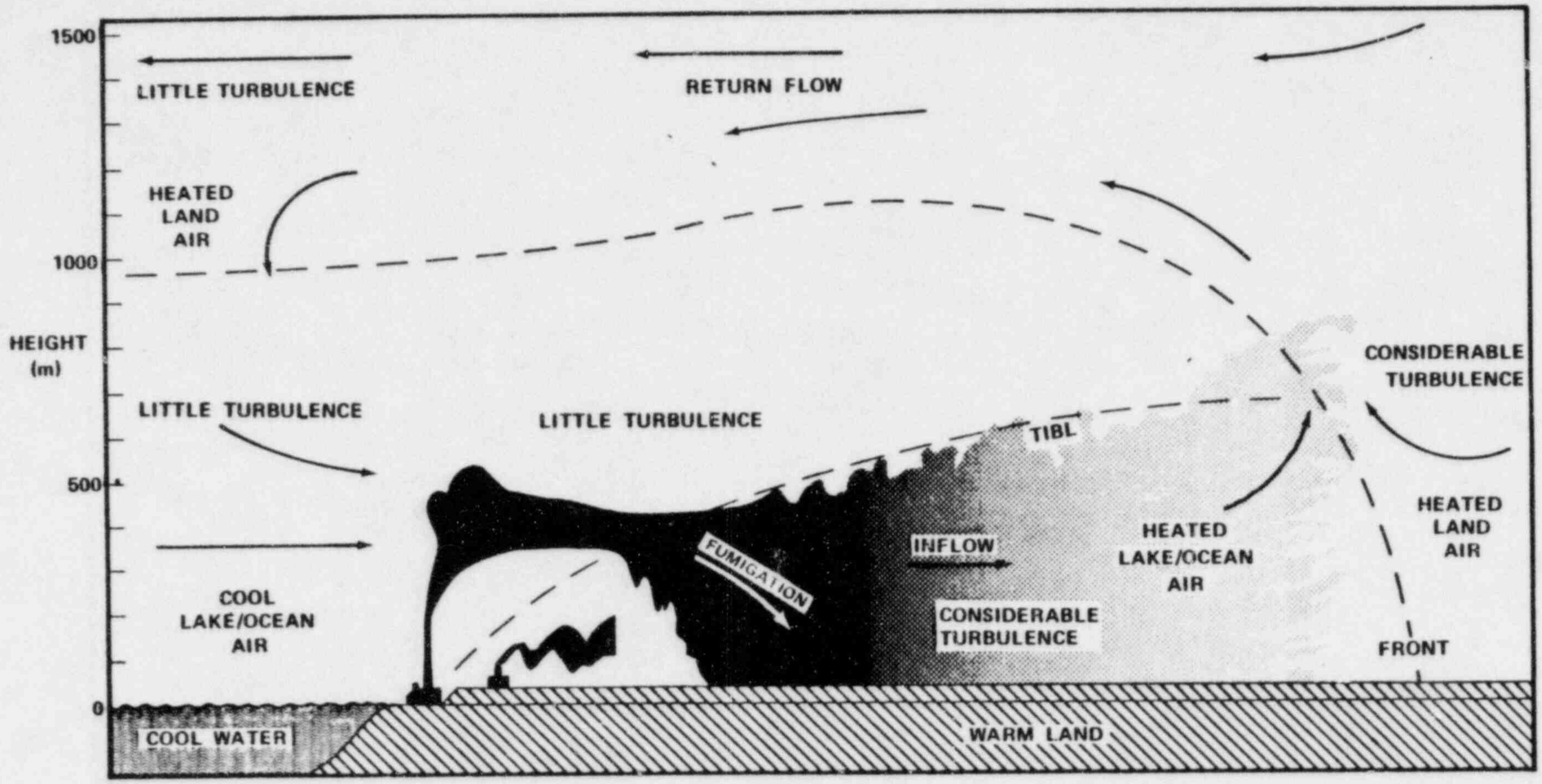
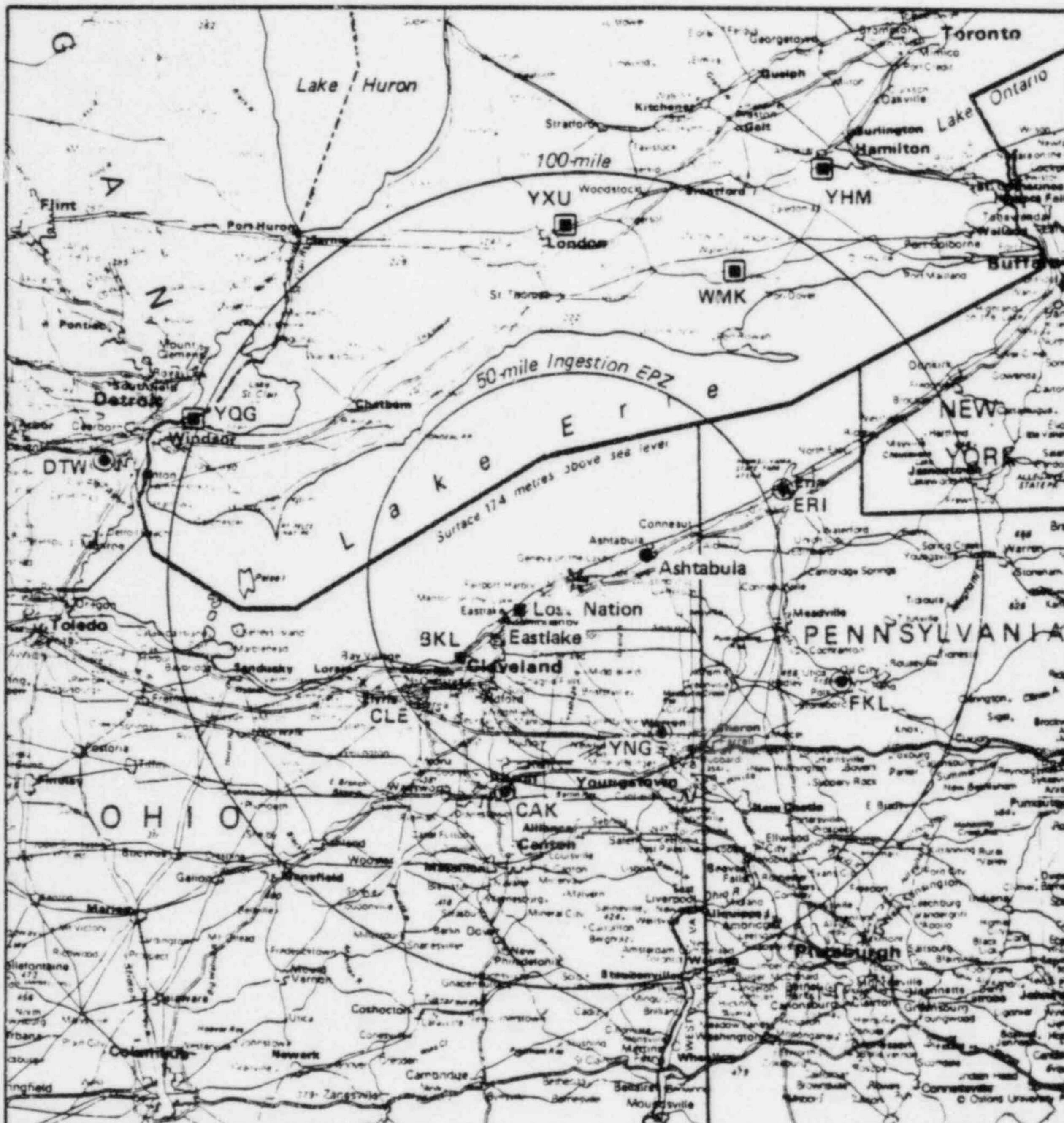


Figure 1 Lake/Sea Breeze Circulation And Its Effect On Near-Coastal Releases



LEGEND

- ✱ Perry Nuclear Power Plant (PNPP)

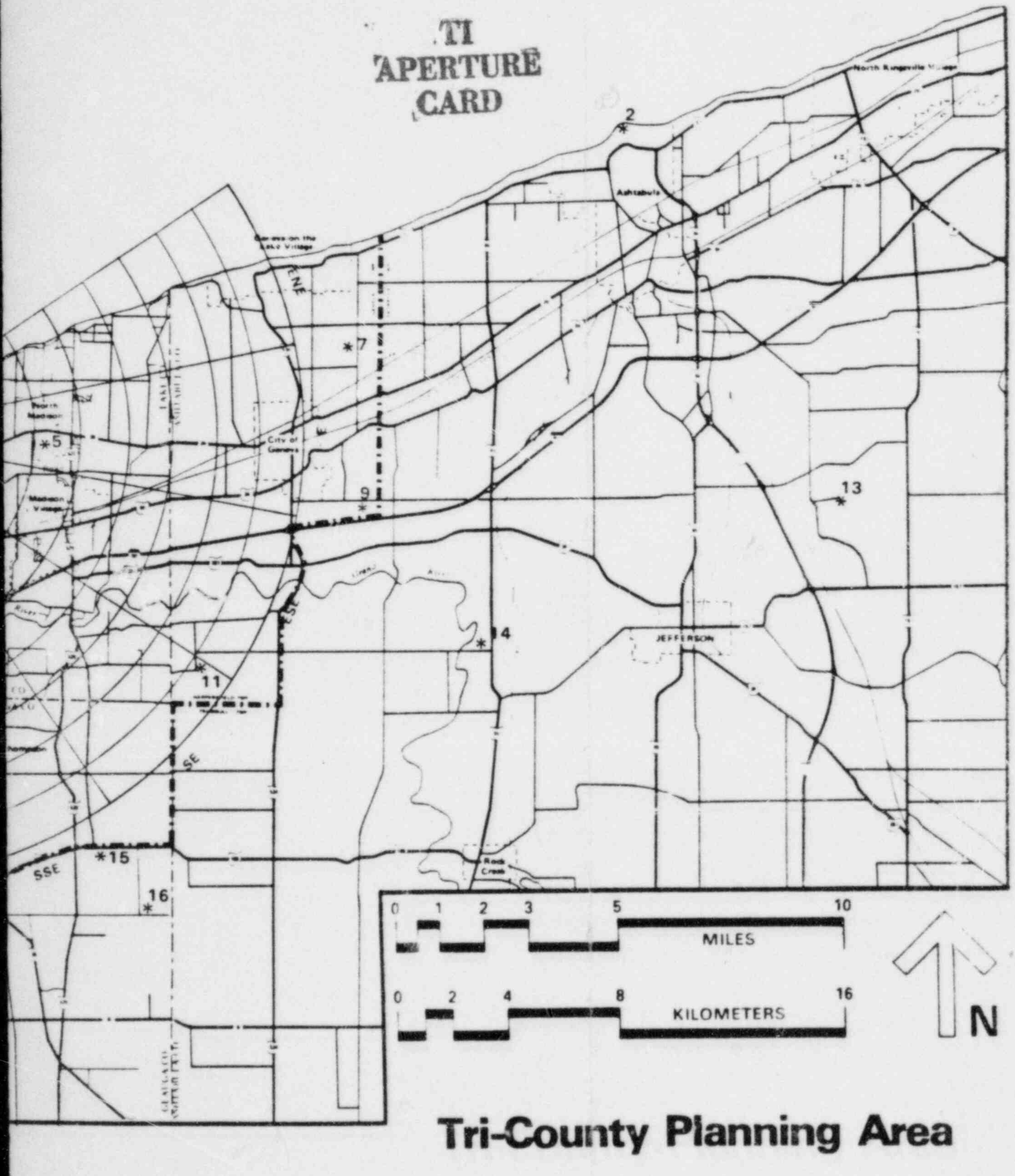
Meteorological Data Locations
(ABC = Station identifier)

- ◉ National Weather Service (U. S.)
- ▣ Atmospheric Environmental Service (Canada)
- ● USCG
- ■ FAA
- ▲ Other

SCALE
0 10 20 30 40 50 MILES

Figure 2 Locations within 100 miles of the PNPP

1 EASTLAKE PLANT
2 ASHTABULA USCG
3 PERRY (PNPP)
4 LOST NATION AIRPORT
5 WOODWORTH AIRPORT
6 CASEMENT AIRPORT
7 WOERNER AIRPORT
8 LAKE COUNTY HEALTH DISTRICT
9 GERMACK AIRPORT
10 CONCORD AIRPORT
11 ECKHARD AIRPORT
12 BIRDLAND AIRPORT
13 ASHTABULA COUNTY AIRPORT
14 ARMINGTON AIRPORT
15 WHISPERING PINES (FIELITZ) AIRPORT
16 THOMPSON AIRPORT



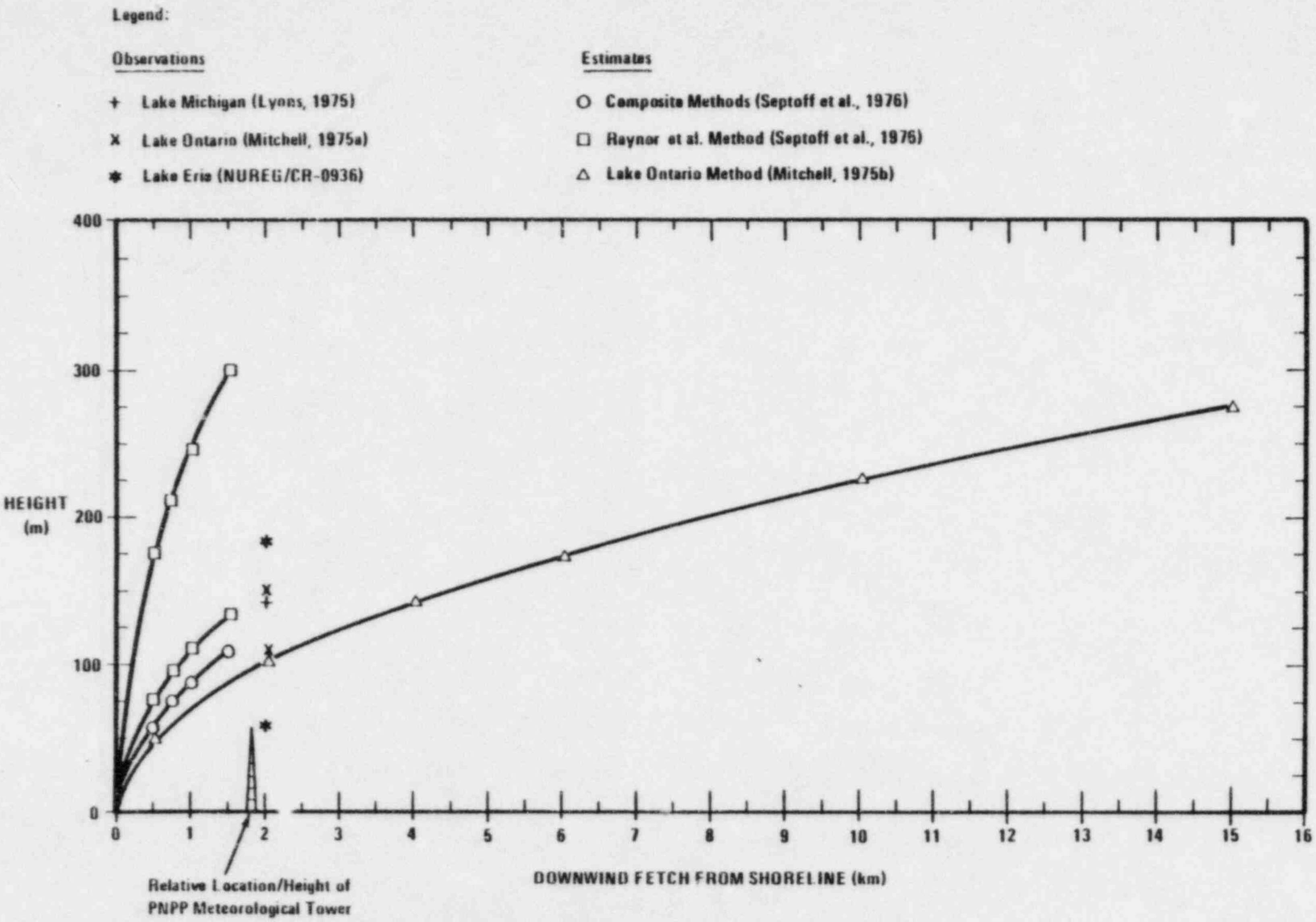
Tri-County Planning Area

Perry Nuclear Power Plant

Figure 3.

Map of Sources for Meteorological Data

Figure 4 TIBL Depth as Function of Inland Distance



Note: Two of the same symbols at a given distance imply the range of values observed.

4.0 SUMMARY

The methods and technical bases have been presented for making emergency offsite dose calculations at the Perry Nuclear Power Plant. Both a hand-calculated and a compatible automated method will be adopted.

The automated method is the more sophisticated one. It uses real-time source term and release characteristics information, as well as real-time meteorology that takes into account the coastal location of the PNPP. The system is menu driven to enhance the man-machine interface. The system will provide for rapid dose assessment for the Perry EPZ in the event of an accidental atmospheric release.

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6.0 CROSS-REFERENCE TO NRC COMMENTS

6.1 Round 1 Questions

This lists the sections of this document in which NRC Round 1 questions on the Perry Emergency Plan are addressed. Only questions directly relating to emergency offsite dose calculations are cross-referenced. References to Chapter 2 concern the hand-calculated method; Chapter 3 contains the automated methodology.

Question	Location(s) Addressed	Comments
I.3	Sections 2.0, 2.4-2.10 Section 3.1	Identification of the accident, and therefore, the source terms, is the responsibility of the operator. Once the accident is identified, the source terms and release magnitude can be "fine-tuned" using results of effluent analyses.
I.4	Sections 2.4, 2.5, 2.8 Section 3.1	Section 3.2 includes an incorporation of the lake breeze.
I.6	Sections 2.9, 3.2, 3.1	If the ERIS computer is inoperable, use entire Chapter 2.
I.10	Sections 2.8, 2.10 Section 3.1	Integrated doses are addressed in Sections 2.10 and 3.1.

6.2 Round 2 Questions

This lists the sections of this document in which NRC Round 2 questions on the Perry Emergency Plan are addressed. Only questions directly relating to emergency offsite dose calculations are cross-referenced. References to Chapter 2 concern the hand-calculated method; Chapter 3 contains the automated methodology.

Question	Location(s) Addressed	Comments
H.5	Sections 2.1, 2.2, 2.3 Section 3.1	Sections 2.2 and 2.3 contain backup methods for estimating dispersion parameters based on visual observations.

H.6	Section 3.1	Actual dose calculation methods are in Section 3.1.
H.7	Sections 2.1, 2.2, 2.3 Sections 3.1, 3.2	Sections in Chapter 2 contain backup methods for obtaining dispersion estimates.
I.3	Sections 2.4, 2.5 Section 3.1	Backup methods are in Sections 2.4 and 2.5.
I.4	Chapter 2, Chapter 3	Chapter 2 addresses hand-calculated methods; Chapter 3 discussed automated methods.
I.5	Sections 2.9, 3.1, 3.2	If the ERIS computer is inoperable, use entire Chapter 2.

6.3 Contractor Evaluation Findings on Meteorology

This lists the sections of this document in which the NRC-Contractor evaluation is addressed. (Reference NRC letter August 22, 1984 (Youngblood to Edelman)).

Recommendation	Location(s) Addressed
1	Sections 3.1, 3.2, 3.3
2	Sections 3.2, 3.4

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