BEFORE THE

UNITED STATES ATOMIC ENERGY COMMISSION

APPLICATION OF

PHILADELPHIA ELECTRIC COMPANY

FOR

Construction Permit and Class 104 License

PART B

Preliminary Hazards Summary Report

Peach Bottom Atomic Power Station

VOLUME II — SITE AND ENVIRONMENTAL INFORMATION

50-171
Formal File

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PRELIMINARY HAZARDS SUMMARY REPORT

PEACH BOTTOM ATOMIC POWER STATION

VOLUME II - SITE AND ENVIRONMENTAL INFORMATION

JULY 1960

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I. SITE DESCRIPTION

A. Geographical Location

The proposed site for the Peach Bottom Atomic Power Station is located in Peach Bottom Township, York County, in southeastern Pennsylvania, on the westerly shore of Conowingo Pond at the mouth of Rock Run Creek. The plant is about 38 miles northeast of Baltimore, Maryland, and 63 miles southwest of Philadelphia, Pennsylvania. Conowingo Pond is formed by the backwater of the Conowingo Dam on the Susquehanna River; the dam is located about nine miles down stream from the site. Figures I-1 and I-2 (Appendix A) are maps showing the site location with respect to the surrounding communities.

Philadelphia Electric Company (Applicant) owns the 600 acre plant site. Land along both sides of Conowingo Pond from below the Holtwood Dam to Conowingo Dam, ranging up to 300 feet back from the water line, is owned by Applicant's wholly owned subsidiaries. The nearest communities are Delta, Pennsylvania, and Cardiff, Maryland, approximately four miles southwest of the site. The reactor, situated about 225 feet from the shoreline, has an exclusion distance on the west side of the pond averaging 3700 feet with a minimum exclusion distance of 3000 feet. The pond to the east is approximately 7600 feet wide. Figures I-3 and I-4 (Appendix A) give aerial photographs of the site, and Figure I-5 (Appendix A) is a Plot Plan.

B. Topographical Description

A topographical map of the site is included as Figure I-6 (Appendix A). The plant will be located on a moderately wooded, gentle slope near the point at which Rock Run Creek discharges into the Conowingo Pond.

Within a one mile radius of the plant and on both sides of the Conowingo Pond, steep sloping hills rise directly up to about 300 feet above plant grade with outcroppings of rock apparent at many locations. Because of the rough terrain much of this area is desolate with wooded areas scattered throughout, although the more gentle sloping areas are cleared and cultivated. The rugged terrain persists to a distance of 12 to 15 miles from the site. Thereafter, the land becomes low-rolling hills, the population density becomes greater and more concentrated centers of population occur.

C. Access

U.S. Highway Number 1 intersects Maryland Route Number 136 about nine miles south of the site. From this point eight miles of bituminous all-weather roads lead to the Slate Hill-Peach Bottom road, a hard-surface road which leads to the plant area. Three other hard-surface roads also enter the exclusion area. A spur track from the Maryland and Pennsylvania Railroad presently ends about two and one-half miles from the site.

D. Population Distribution

As shown in Figures I-2 and I-6 (Appendix A) the reactor is approximately 3000 feet from Applicant's property boundary lines to the north, west and south. Hills rising 300 feet or more above plant grade are interposed between the plant site and the boundary. At plant start-up in 1963, no persons will be residing within the property boundaries.

Beyond the plant site property lines a few scattered residences will continue to be occupied. The nearest residence will be 3200 feet to the southeast of the plant, 600 feet from the Pond. Three other homes, with a total of eleven occupants, are located 5200 feet south of the plant site. Four homes with a total of seventeen people are located near the property boundary to the west, about 4500 feet from the plant.

About thirty-five people reside permanently within a one mile radius of the plant. Summer residents would increase this total to about 120 during several months of the year. Most of the permanent residents are farmers located on the hills surrounding the plant, while the summer residents are usually located on the shore of the pond.

The area adjacent to the plant site included in an arc with a radius of 7600 feet or more, extending from north to east to south, is covered by Conowingo Pond. The pond is used for recreation and small boats may occasionally be in this area.

The counties in proximity to the Peach Bottom site are (1) York, with a population of 238,000 (1957); (2) Lancaster, 260,000 (1957); (3) Harford, 63,000 (1954); and (4) Cecil, 45,000 (1957). The first two counties are in Pennsylvania while the latter two are in Maryland. (Appendix A). Projected population increases through 1980 for each of these counties are shown in Figure I-7 (Appendix A).

Present and projected population data within various radii of the proposed site is summarized in Table I-1 (Appendix B).

Population within a ten mile radius of the site is estimated from Applicant's customer service records.

The only sizable communities within a ten mile radius are Delta, Pennsylvania, and Cardiff, Maryland, with a combined population of 1590 located four miles southwest of the site. Some fifty people live in the Slate Hill area, 1.7 miles southwest of the site and about seventy people reside in the Peach Bottom community, 2.3 miles east of the site.

Within the ten to twenty-five mile zone are the Cities of Lancaster, Pennsylvania, metropolitan area population 109,000 (1956), 21 miles to the north, and Columbia, Pennsylvania, metropolitan area population 51,000 (1956), 24 miles to the northwest.

The twenty-five to fifty miles radius includes the cites of Harrisburg, Pennsylvania, metropolitan area population 255,000 (1956) 45 miles northwest; Wilmington, Delaware, metropolitan area population 275,000 (1956), 38 miles east; and Baltimore, Maryland, metropolitan area population 1,480,000 (1956), 38 miles southwest. Philadelphia with a metropolitan population of about 4,000,000 is 63 miles to the east and Washington, D. C. with a metropolitan population of 2,000,000 is 72 miles to the southwest. A complete listing by zones including smaller cities is included in Tables I-2 through I-5 (Appendix B).

E. Land Use

The area immediately surrounding the reactor site is predominately in agricultural use or woodland, with some dairying. As indicated in Figure I-8 (Appendix A), the major portion of the total land of the surrounding four-county area is in farmland use, about 70% being so used in York County, Pennsylvania, 80% in Lancaster County, Pennsylvania, 70% in Cecil County, Maryland and 60% in Harford County, Maryland.

Lancaster County leads the State of Pennsylvania in the production of dairy products, poultry and poultry products, hogs and feed products. Over 50% of the farm income of Lancaster County is due to dairy and poultry products. Over 11% of the county working force is employed in agriculture.

York County is also one of the leading agricultural counties of Pennsylvania. It ranks third in the State in total value of farm products sold. York County ranks second behind Lancaster County in livestock and poultry products sold. About 8% of the county working force is employed in agriculture.

Cecil County, Maryland is also primarily agricultural with over 70% of the total land area in farmland use. Dairy products account for over 50% of the farm income of the county. About 16% of the county working force is employed in agriculture.

A number of Government installations are located in these four counties. Cecil County, Maryland, contains the Bainbridge Naval Training Center, the Veterans Administration Hospital at Perryville and a unit of the Army Engineers Corps along the Chesapeake and Delaware Canal. Harford County, Maryland, is the site of the Aberdeen Proving Grounds and the Army Chemical Center at Edgewood. Included in York County, Pennsylvania, are a Naval Ordnance Plant in North York and the New Cumberland General Depot of the U. S. Army, located in New Market.

Table I-6 (Appendix B), shows the industries located within a ten-mile radius of the reactor site, together with the numbers employed in these industries and the products involved. Table I-7 (Appendix B), indicates the type of industries within a ten to twenty-five mile radius and a twenty-five to fifty mile radius of the site. The number of people in various classifications of employment in York, Lancaster, Harford and Cecil Counties is shown in Table I-8 (Appendix B).

Industrialization is becoming increasingly important in these four county areas. In Lancaster County the main industrial area is the Manheim Township area which is located north of the City of Lancaster. The county has a diversified number of manufactured products. About 40% of the working force is engaged in manufacturing.

Most of the industry in York County is located in the area of the City of York. The county also has a diversified number of manufactured products but its most important industries are non-electrical machinery, the metal working industries, apparel and related products and furniture. Over 45% of the county working force is employed in manufacturing.

Harford and Cecil Counties have comparatively few industries. Harford has only about 19% of the county working force engaged in manufacturing and Cecil about 22%. It may be expected, however, that additional industry will move into both counties, locating in the southern portion of Harford County along rail lines, and in the northern and northwestern sections of Cecil County.

F. Meteorology

1. Macro-meteorology

The reactor site is in an area for which ample meteorological records are available. Within a radius of eighty miles there are five Weather Bureau Class A Stations, all with long and excellent climatological records. These stations are at Harrisburg, Allentown and Philadelphia, Pennsylvania; Baltimore, Maryland; and Washington, D.C. For each of these stations, five-year summaries of hourly observations have been published for the approximate interval October 1949 through September 1954. Data from these stations have been averaged in evaluating the macro-meteorology of the region surrounding the reactor site.

As is typical of the Central Atlantic States, the prevailing wind is south of west during the summer months, veering to north of west during the winter. For the year as a whole, the most frequent wind direction to eight points of the compass is west, observed slightly more than 17% of the time. The least common wind direction is southeast, with less than 8% occurrence. Calms occur about 7% of the time, mostly during the night and early morning hours. There is also a slight tendency for a greater frequency of stagnant conditions during the summer season.

The average annual precipitation is approximately 42 inches per year. The seasonal distribution is fairly uniform, although there is a tendency for a maximum during the summer as a result of convective precipitation. The average temperature varies from approximately 32 F in January to about 75 F during July.

2. Micro-meteorology

The Susquehanna River valley and the Conowingo Pond have a considerable effect on local wind and temperature regimes. Excellent observations are available near the reactor site at Holtwood Dam, approximately six miles upstream. Records for this station were examined for the interval October 1949 through September 1954. A substantial channeling of the wind up and down stream is observed. For the year as a whole, down-channel winds (from the north or northwest) occur 47% of the time; up-channel winds (from the south or southeast) occur 43% of the time. After allowing for the occurrence of calms, winds at an appreciable angle to the axis of the channel are observed only 7% of the time.

A substantial program has been under way to relate weather data at Holtwood Dam with the meteorology of the surrounding region, as determined by observations at the five Class A Weather Bureau Stations mentioned above. These studies are being performed on an IBM 650 digital computor. Three different time series of wind vectors are being compared. These are: the average surface wind velocity for the five Class A stations; the average geostrophic wind for the region, obtained from mean sea level pressures at the same five stations; and the surface wind velocity at Holtwood. Other meteorological parameters under study include surface temperature, precipitation, and the stability of the ambient air mass as estimated from available radiosonde observations.

A program of weather observation at the reactor site has also been inaugurated. A local weather station has been set up a few hundred feet down channel from the reactor site. A recording rain gauge and hygrothermograph were installed in July 1959. A ninety-foot tower has been erected and Bendix-Frieze aerovances have been placed ten meters and thirty meters above the ground. Matched thermisters have also been put in operation. Data from these on-site sources is being accumulated and correlated.

An auxiliary weather station has been set up at a higher elevation near the reactor site. A recording anemometer has been placed approximately thirteen meters above ground elevation and fifty meters above the level of the primary weather station. A matched thermister has also been installed. Output signals are carried by cable to the primary weather station where the data are recorded.

As additional meteorological data become available at the reactor site, further insight is being obtained into the micro-meteorological factors which control local diffusion regimes. Special micro-meteorological studies will be developed as necessary and desirable, possibly using smoke clouds as a tracer.

Detailed information on the site meteorology is contained in Section II hereof.

G. Hydrology

The Peach Bottom site is located on Conowingo Pond formed in the Susquehanna River by the Conowingo Dam. With the exception of the plant site, which as previously indicated, is owned by Applicant, the property bordering the Pond is owned by Applicant's wholly owned subsidiaries. A ten-mile radius from the plant (314 square miles) encompasses 18 square miles of water. The Susquehanna River drains an area of 27,500 square miles in New York, Pennsylvania, and Maryland. A total of 27,000 square miles of drainage area is located upstream from the Peach Bottom site. Along the lower 35 miles, where the River flows between steep hills, are located three major hydroelectric plants: Safe Harbor, Holtwood and Conowingo. The Conowingo Dam is nine miles downstream from the site while the Holtwood Dam is six miles upstream.

The observed flows on the Susquehanna River over the past thirty years have ranged from a minimum of 1450 cubic feet per second to a maximum of 875,000 cubic feet per second (peak) in 1936. Average flow is 36,200 cubic feet per second.

The river below Peach Bottom is at present the sole source of water for the city of Havre de Grace, the Perry Point Veterans' Hospital, the Bainbridge Naval Training Station, including Port Deposit and the Conowingo Hydro-electric Power Plant. To supplement its present water supply from other sources the City of Baltimore has under construction a facility which will take water from the Conowingo Pond about one-quarter mile upstream from the dam. During the initial years this system will be used intermittently to firm up the present upland water supplies but as the Baltimore metropolitan area grows the Susquehanna supply will come into continuous use.

At Peach Bottom the water table rises from Conowingo Pond up through the building site into the hill to the rear. Under these conditions groundwater must discharge directly into Conowingo Pond. Since there are no known deep aquifers of great extent in the region and bedrock tightens rapidly with depth, it is almost inconceivable that water could flow through the ground to and across the land boundaries of the general site area. The time required for water to move through the sand-clay overburden, through the rock fissures and into Conowingo Pond is unknown but it is suspected that both the time and the path will be highly variable.

The finished grade of the plant will be at elevation 115 feet (Conowingo Dam Datum) which is approximately three feet above the estimated flood level at the site during the record flood of 1936. The dams upstream at Safe Harbor and Holtwood are gravity structures which are inherently safe. Even in the event of a catastrophe it is extremely unlikely that complete failure of these dams would occur. However, should complete failure of the upstream dams take place the rise in the lake level at the site probably would not be excessive since the lake is about one mile wide at Peach Bottom and the water level would be rapidly relieved by over-topping of the downstream dam.

One of the three gantry cranes used to lift the gates at Conowingo Dam is equipped with a gasoline-generator for an emergency power supply and consideration is being given to providing an emergency power supply for a second gantry crane.

Detailed information pertaining to Hydrology is contained in Section III hereof.

H. Geology

Peach Bottom, Pennsylvania, is located in the Piedmont Province in the middle of a NE-SW trending, structurally complex belt composed chiefly of schists and lesser gneisses. The belt narrows from ninety to forty-five miles in width at distances of fifty miles to the southwest and northeast of Peach Bottom respectively. The degree of metamorphism decreases toward the northwest where the schists are bordered by Cambrian quartzites and Ordovician carbonates and phyllites. A three to fifteen mile wide strip of Triassic red beds overlies Ordovician sediments about thirty miles northwest of Peach Bottom. About eighteen miles southeast of Peach Bottom the Piedmont metamorphic belt is overlain by loosely consolidated sediments of Cretaceous to Quarternery age which dip gently southwest along the Atlantic coastal plane.

The formations exposed in the vicinity of Peach Bottom include the following members of uncertain (Precambrian Ordovician) age of the Glenarm series:

Peach Bottom slate	- dark gray lustrous slate, probably more than 100 feet thick.
Cardiff conglomerate	- conglomerate quartz schist, at least 75 feet thick.
Peters Creek schist	- chlorite and muscovite schists, quartzitic beds, and narrow belts of "serpentinized" rock; ± 2500 feet thick.
Wissahickon formation	- includes an oligoclase-mica schist and an albite-chlorite schist facies; ± 2500 feet thick.

The oligoclase-mica schist facies of the Wissahickon formation passes under the southeast edge of the six mile wide belt of Peters Creek schist. The latter schist conformably underlies the Cardiff conglomerate and the Peach Bottom slate in the tightly folded "Peach Bottom syncline". The Cardiff and Peach Bottom crop out in an area eighteen miles long and half a mile to a mile in width in the center of the syncline which extends from northern Maryland to southern Pennsylvania. On the northwest limb of the syncline the Peters Creek schist conformly overlies the albite-chlorite schist facies of the Wissahickon formation. Several Triassic diabase dikes which strike slightly north of the regional NE-SW trending schistosity traverse the area.

At the site of the proposed plant, bedrock is the Peters Creek schist which here forms the northwest limit of the narrow Peach Bottom syncline. Tight isoclinal folds, thin lenticular bedding, a strong flow cleavage giving a well developed schistosity, and many joints and fractures characterize the schist. Cleavage and bedding strike on the average about N 35 E and dip about 70 degrees to the southeast. Many of the fractures roughly parallel the cleavage (schistosity). Many joints form two sets, one striking north and dipping west, the other striking east and dipping north; but joints having other random attitudes are common.

Bedrock is exposed on the building site only in a small outcrop on the hillside and at the shore of the reservoir. Bedrock elsewhere is overlain by unconsolidated material, primarily red to brown sandy clay with numerous rock fragments, some of boulder size. Thus unconsolidated material is dominantly rock slide that has weathered in varying degree to sandy clay and more or less rotten boulders, along with some clay and sand formed as slope wash. The weathering and typical soil profile on the slide indicate that it is old, probably Pleistocene, but it undoubtedly is still very slowly moving downhill as ordinary hill-slope creep.

Ground water drainage undoubtedly follows the slope of the topography into the reservoir, and the fractured nature of the rock probably leads to an open, porous, and permeable system. It should be assumed that abundant ground water will drain downslope towards the reservoir.

Detailed information pertaining to the Geology of the area is contained in Section IV hereof.

I. Seismology

The Peach Bottom, Pennsylvania area is one of minor seismicity. A review of the Coast and Geodetic Survey's United States Earthquake Series for the past thirty years, a complete compilation of earthquakes of all intensities, reveals no report of any earthquakes having occurred in Peach Bottom or the immediate vicinity. Earthquakes with epicenters elsewhere were felt in the area, with no damage reported, in November 1935, in November 1939 and in September 1944, as shown in Table I-10 (Appendix B).

J. Current and Planned Investigations

The completed, current and planned site investigations are summarized below:

1. Macro-Meteorology: Data collection and evaluation from records of five Weather Bureau Class A Stations within an eighty mile radius of the reactor site.

2. Micro-Meteorology: Data collection and evaluation of weather information collected at Holtwood Dam (approximately six miles upstream of the reactor site).

3. Site-Meteorology: A main and auxiliary weather station on the reactor site has been established. These stations consist of two towers equipped with aerovane indicators and recorder, matched thermisters with recorder, recording rain gauge and hygrothermograph.

4. Macro-Hydrology: Evaluation of data, concerning Susquehanna River flows, Chesapeake Bay area, and Conowingo Pond.

5. Micro-Hydrology: Extensive dye studies have been conducted in the Conowingo Pond at various conditions to determine the flow patterns in the Conowingo Pond.

6. Geology: Core borings have been made on grids at and adjacent to the reactor site covering approximately 390,000 square feet of land area.

7. Seismology: Inquiry made of the Geophysics Division, U.S. Department of Commerce and the Maryland State Geologist, Dr. J. T. Singewald.

8. Radiation Monitoring Program: Applicant is participating in the Water Quality Network Program conducted by the U.S. Public Health Service. Participation in this program, which is now in operation, consists of using Conowingo Hydro Plant as a sampling station in the USPHS National Network. Quarterly checks will be made at Holtwood Dam to correlate the results obtained there with the results obtained at Conowingo. Since engaging the services of Nuclear Science and Engineering Company as consultants in the environmental radiation monitoring program, the erection of equipment at all sampling locations has been completed in all the stations shown in Table I-11 (Appendix B) and Figure I-9 (Appendix A). The over-all environmental radiation monitoring program is summarized in Table I-12 (Appendix B).

August, 1961

As of July 1961, samples have been taken as follows:

Item	Samples
Air particulate	350
Surface water	25
Rain water	28
Well water	12
Silt	6
Earth	27
Milk	12
Shell fish	21
Cat fish	20
Rabbits	10

II. METEOROLOGY

A. Macrometeorology

The contemplated reactor site is on the Conowingo Pond of the Susquehanna River in southeastern Pennsylvania, a few miles north of the Maryland line. This is an area for which ample meteorological records are available. Within a radius of eighty miles of the reactor site, there are five Weather Bureau Class A Stations, all with long and excellent climatological records. These stations are Washington, D. C., and Baltimore, Maryland, to the southwest; Philadelphia, Pennsylvania, to the east-north-east; Allentown, Pennsylvania, to the northeast; and Harrisburg, Pennsylvania, northwest of the site. The geographic center of these five stations is at 39°45' north, 75°16' west, a point within three miles of the contemplated site of the reactor.

In evaluating the macrometeorology of the region, data collected from these five Class A Weather Bureau Stations have been averaged. Furthermore, when climatological parameters related to hourly observations are discussed, attention will be restricted to the interval from October, 1949 through September, 1954. This five-year period has been selected for use in comparing the meteorology and climatology of the surrounding region with the micrometeorological and microclimatic regime characteristic of the Susquehanna River Valley in the vicinity of the reactor site. Choice of the particular five-year interval was dictated by the availability of published statistical summaries of hourly observations for each of the five Class A Stations.[1] Actually, the summaries are for October, 1949 through September, 1954 for only three of the five stations. For Washington, D. C., the published summary covers the period from March, 1950 through February, 1955; for Philadelphia, from November, 1949 through October, 1954. This slight variation of period has been neglected in the analysis.

In using a particular five-year interval, a major portion of the climatological record is ignored. Nevertheless, when hourly observations are considered, five years of record at five stations constitute a substantial statistical sample. Thus, seasonal averages are based on a total of 75 station-months, or approximately 54,000 individual hourly observations; annual data are based on a total of 300 station-months, or approximately 216,000 hourly observations. Unless otherwise explicitly stated, all regional climatological statistics in the following pages are obtained by averaging data for the five-year published summaries from the five Class A Weather Stations mentioned above.

1. U. S. Weather Bureau, "Summary of Hourly Observations, Climatography of the United States, No. 30-18." Govt. Printing Office.

Table II-1 (Appendix B), shows the percentage frequency of wind direction and speed for the region. Data are presented for each season and for the year as a whole. As is typical of the Central Atlantic States, the prevailing wind is south of west during the summer months, veering to north of west during the winter. For the year as a whole the most frequent wind direction to eight points of the compass is west, observed slightly more than 17% of the time. The least common wind direction is southeast, with less than 8% occurrence. Calms occur about 7% of the time, with a slight tendency for a maximum during the summer season. Average wind speeds range from 7.3 miles per hour during the summer to 10.6 miles per hour during the winter months. The frequency of various wind speeds as a function of time of day is shown in Table II-2 (Appendix B). The tendency for light winds to occur during the nocturnal hours is, of course, obvious.

The average annual precipitation as determined from complete climatological records is approximately 42 inches per year. The seasonal distribution is fairly uniform, although there is a tendency for a maximum during the summer as a result of convective precipitation. Of more interest are the frequencies with which various intensities of precipitation are observed. These data are significant in connection with evaluating the likelihood and extent of radioactive rainout. For the five years used as a control, Table II-3 (Appendix B) shows the frequency with which various hourly precipitation rates are observed for each season and for the entire year. The diurnal distribution is also shown. It will be observed that precipitation in excess of .25 inches per day occurs on the average about 50 days each year.

The average temperature in the region varies from approximately 32° in January to 75° during the month of July. Table II-4 (Appendix B) shows the seasonal and annual distribution of hourly temperatures.

B. Micrometeorology

1. Climatic Records. The major micrometeorological problem is to evaluate the effect of the Susquehanna River Valley and the Conowingo Pond on the local wind and stability regimes. Local observations are available near the reactor site. The best single source of such data is from Holtwood Dam. This Weather Station is located on top of the power house near the northeast bank of the Susquehanna River, approximately six miles above the site. Frequent observations of temperature, water temperature, and weather are available, as well as a continuous triple-register record of wind direction and speed, and quantity of precipitation. Other nearby points for which weather data are recorded include: Safe Harbor Dam,

approximately twelve miles upstream from Holtwood on the Susquehanna River; the U.S. Weather Bureau Station at Lancaster, Pennsylvania; and a cooperative U.S. Weather Bureau Station at the Police Barracks near Conowingo Dam. A limited amount of surface and upper air information is also available from the Aberdeen Proving Grounds near Aberdeen, Maryland; and water temperatures are recorded regularly at Conowingo Dam.

Records at Holtwood Dam were examined for the interval October, 1949 through September, 1954. Wind direction and speed, dry-bulb temperature, water temperature, precipitation, and a description of current weather conditions were obtained four times a day: at 0100, 0700, 1300, and 1900, E.S.T. This constitutes a total of approximately 7,300 hourly observations. The data were hand-punched into IBM cards to facilitate statistical analysis.

Table II-5 (Appendix B), shows the occurrence of wind speed as a function of wind direction. Data are presented for each season, and for the year as a whole. It should be noted that Table II-5 (Appendix B) is identical in form to Table II-1 (Appendix B), which presents comparable statistics for the region surrounding the lower Susquehanna Valley.

The tremendous effect of the Valley on the local wind regime is obvious. As might be expected, a substantial channeling of the wind up and downstream is observed. At Holtwood Dam, the axis of the channel runs approximately 30° west of north. For the year as a whole, down channel winds (from the north or northwest) occur 47% of the time; up channel winds (from the south or southeast) occur 43% of the time. After allowing for the occurrence of calms, winds at a substantial angle to the axis of the channel are observed only 7% of the time. The high frequency of up-channel winds is all the more noticeable since for the surrounding area winds from the southeast were less frequent than from any other direction.

In addition to the channeling of the wind, a slight reduction in wind speed is observed when the data in Table II-5 (Appendix B) are compared with the regional averages. The decrease is not as substantial as was originally anticipated. By way of comparison, a much greater reduction in wind speed was observed at Shippingport, Pennsylvania in a river valley very similar in its general features to the Susquehanna.[2] In interpreting the present data, however, it must be noted that the anemometer at Holtwood Dam is located on top of the power house, away from the shore line. Its elevation is about 80 feet above the Holtwood Reservoir and 135 feet above the tail race. The former elevation is approximately the same as the average anemometer height at the five Class A Weather Bureau Stations used as a control. However, winds from the south to southeast at Holtwood should be regarded as from an equivalent elevation well above that used in preparing the regional averages.

A further point of interest is the frequency with which calms are observed. Despite the tendency for the local wind speed to be lower, Holtwood Dam records a "calm" less than 3% of the time, as compared with over 7% for the regional average. This rather surprising statistic is at least in part related to the way in which the observations were taken at the different locations. At Holtwood the data were obtained from triple-register sheets and the wind speed was computed by counting the miles of wind that had passed during the preceding hour. On the other hand, Weather Bureau hourly observations are "spot" observations, and are therefore not necessarily representative of average conditions over longer intervals. In view of these facts, the difference in frequency of calms between the two sets of data is probably not significant.

The compilation of local climatological statistics is not yet complete. The diurnal distribution of various wind speeds is being investigated, as well as other pertinent climatological parameters. Undoubtedly, other differences in climatology will be uncovered. However, it is almost certain that none of these will be as striking as the differences which exist in the wind regime. It is obvious that the extreme channeling of the wind by the Susquehanna River valley, as well as the associated decrease in wind speed, will be of considerable significance in the analysis of atmospheric diffusion of radioactive materials from the reactor.

2. Correlation of Macro- and Micrometeorology. The compilation of local climatological averages is an important part of a micrometeorological program. Nevertheless, such statistics represent only a first step toward an understanding of the micrometeorology of a region. Of considerable interest, also, is the relation between local

2. Hosler, C. R., D. H. Pack and T. B. Harris, "Meteorological Investigations of Diffusion in a Valley at Shippingport, Pennsylvania," U. S. Weather Bureau, 1959.

weather conditions and the weather conditions prevailing in the region as a whole. This is particularly true when diffusion studies are to be undertaken, since an insight must be gained into what may happen as a cloud of radioactive material moves from the immediate vicinity of a reactor into the surrounding area.

As previously indicated, weather data for Holtwood Dam were entered on punch cards for six hourly intervals (at 0100, 0700, 1300 and 1900, E.S.T.) for the five-year period October, 1949 through September, 1954. For each of the five Class A Weather Bureau Stations used as a control, comparable hourly observations were obtained on punch cards from the National Weather Records Center at Asheville, North Carolina. Studies are in progress to relate the regional averages of weather conditions, determined from observations at the five Class A Weather Bureau Stations, to local weather conditions at Holtwood at the head of the Conowingo Reservoir.

Three different time series of wind vectors are being compared. There are: the average surface wind velocity for the five Class A Stations; the average geostrophic wind for the region, obtained from mean sea level pressures at the same five stations; and the surface wind velocity at Holtwood near the reactor site. Careful statistical comparisons of these three sets of observations will clarify the large-scale weather conditions which control the direction of channeling and the speed of the wind along the Reservoir. Comparison of the wind at Holtwood with an average of several other stations, rather than with observations at a single Class A Weather Bureau Station, has definite advantages since this procedure avoids to a large extent variations in the control data due to local weather conditions. In addition, the use of the geostrophic wind -- a wind representative of atmospheric motion just above the surface friction layer -- provides a stable quantity, closely related to flow fields in the ground layer, yet representative of conditions over a substantial area.

In addition to the wind, other meteorological parameters are being analyzed. These include surface temperature, precipitation, and the stability of the ambient air mass. The latter quantity is estimated from semi-daily radiosonde observations at Silver Hill, Maryland, and at Lakehurst, New Jersey. After January 1, 1953, observations are available from Silver Hill at six-hour intervals.

The statistical program has been set up for machine computation on an IBM 650. Mean surface winds and temperatures for the region are computed as simple vector or scalar averages of observations at the five Class A Stations. The mean geostrophic wind is obtained by fitting a plane by least squares to the mean sea level pressure at these same five Class A Stations. In order to evaluate the degree to which the averages are representative of conditions over the region, the variance of the observed surface data and the standard error of estimates of the geostrophic wind components are also being computed.

The results of these studies will be presented in full in the Final Hazards Summary Report. However, investigations thus far conducted have indicated there is an excellent statistical relation between the wind over the reservoir, as observed at Holtwood Dam, and the regional wind regime. The best correlation is obtained between the component of the wind parallel to the Susquehanna channel at Holtwood and the observed wind for the region, computed as the vector average of wind velocities at the five Class A Weather Bureau stations.

Using a sample of 1934 observations from a total of 7300 available, the following regression equation is obtained:

$$u_h = .897\, u_r - .153\, v_r + .103 \text{ (mi/hr)}$$

where u_h is the component of the observed wind at Holtwood Dam parallel to the pond; u_r is the component of the regional wind parallel to the pond; and v_r is the component of the regional wind perpendicular to the pond. Wind components downstream and cross-channel toward the northeast are considered to be positive in value. The total variance in u_h is 49. 33 $(mi/hr)^2$. Of this amount, 37.65 (or 76%) is removed by use of the regression equation, leaving a residual variance of 11.68. The standard error of estimate of u_h from the regional wind is 3.4 mi/hr. The optimum condition for strong wind flow up or down the valley occurs when the average wind in the region is blowing 10° to the right of the axis of the channel.

It is expected that further studies, introducting the effect of additional parameters such as time of day and stability, will improve the estimate of wind over the Conowingo pond. It should be pointed out, however, that a substantial improvement in the estimate of the channel component cannot be logically expected, since there is a considerable amount of random error in the data due to the limited number of stations used in estimating the regional wind, and due to the fact that the observed winds at Holtwood are only available to eight points of the compass. An attempt will be made to obtain a reasonable regression equation for the cross-channel wind component at Holtwood Dam. The likelihood of success is substantially less in this case, however, since the wind components perpendicular to the channel are comparatively small and their magnitude is partially masked by the combined effect of the larger channel wind component and the inaccuracies in wind direction.

The studies outlined above indicate that regional meteorological data can be used to gain insight into the mechanics of the local wind systems. For certain types of weather situations, to be selected after the statistical studies are essentially complete, it may be desirable to undertake more detailed micrometeorological analyses, using all available local data. This would include, of course, observations from nearby cooperative and regular U.S. Weather Bureau Stations.

3. Weather Observations at the Reactor Site. Additional micro-meteorological data pertaining to the reactor site will be accumulated, for although excellent weather observations exist at a point only six miles up-channel, local diffusion patterns will vary importantly from place to place within the pond. Holtwood is situated near the bank of the pond which is opposite to the proposed reactor site. Local conditions at Holtwood -- the distance of the station from the shore line, the sharp drop in elevation of the water at Holtwood Dam, the presence of the power house and related buildings, and the existence of a fairly large island parallel to the channel downstream from the Weather Station -- are substantially different from those at the reactor site. It is essential, therefore, that local weather observations of high quality be assembled at the site itself. A program is now in operation for this purpose.

In conducting a program of local weather observations, it should be noted that relatively few well-placed instruments need be installed on a permanent basis. As the records accumulate, and as the climatological studies discussed previously are completed, the need may appear for special site studies under certain types of weather situations. These special site studies will be conducted as necessary and desirable as a supplement to the regular observational program now under way.

A local Weather Station has been set up at the mouth of Rock Run Creek across the stream and a few hundred feet down channel from the reactor site. A recording rain gauge and hygrothermograph were installed early in July, 1959. A 90-foot tower was erected, and Bendix-Friez aerovanes were placed 10 meters (33 feet) and 30 meters (99 feet) above the ground. Thermometers (matched thermisters capable of measuring temperature difference with an accuracy of $\pm 0.2^{\circ}F$) were installed at these same elevations.

To supplement the above data, and to obtain weather information from higher elevations above the pond, an auxiliary weather station was set up near the top of the hill overlooking the site, northwest of Rock Run Creek. A single pole was used, and a recording anemometer and matched thermisters were installed approximately 13 meters above ground elevation and 50 meters above the level of the primary weather station. Output signals are carried by cable to the primary weather station, where the data are recorded. The elevation of the auxiliary weather station would be slightly above the top of a 150-foot stack at the proposed reactor site.

Due to the difficulty of obtaining early delivery of the thermisters and the related recording equipment, the program of observation was not fully under way until March, 1960. Nevertheless, wind records at three levels have been obtained regularly since August 1, 1959.

A program of abstracting local meteorological data from the instrument records was inaugurated on September 1, 1959. Wind, temperature, and precipitation are read from the charts at six hourly intervals: at 0100, 0700, 1300, and 1900 E.S.T. These data are transferred to punch cards. As the number of observations accumulates, pertinent statistical summaries can easily be tabulated. In addition, these cards will be used to relate observations at the reactor site to simultaneous weather conditions at Holtwood Dam six miles upstream, and also to prevailing weather conditions as observed at the five Class A Weather Stations in the surrounding region. While extensive studies of this type cannot be undertaken for some time, due to lack of sufficient local data, they may ultimately be of considerable value in developing satisfactory monitoring and operating procedures. Meanwhile, even a limited amount of data from the site will be of considerable help in interpreting local wind, temperature, and diffusion regimes.

4. Micro-meteorology of the Reactor Site. A great deal can be said about micro-meteorological conditions at the reactor site on the basis of limited data from the site, the Holtwood data, and a knowledge of the micro-meteorology of other similar locations. It might be expected that at the reactor site the wind direction would be up or down channel a great preponderance of the time, as at Holtwood. However, the local situation is complicated by the fact that here the shore line of the pond is being dealt with, rather than a location out in the channel which is comparatively free from topographic influence. Thus, the local wind regime is modified by drainage winds which move down Rock Run Creek during periods of nocturnal cooling. Conversely, in the afternoon when the surrounding land is heated more than the water, there may be a stronger component of the wind on shore.

The relative temperature of the immediate shore line and the pond is of the utmost importance. When the pond is colder than the shore line there is a tendency for air to subside over the pond and spread out over the bordering land areas. This air eddies against the hills and returns over the channel at higher elevations. When the pond is warmer than the shore line a reverse eddy is to be expected, with rising air over the channel and descending currents along the borders of the channel. Eddies of this type have been observed in many locations. They are described, for example, in a report on meteorological diffusion at Shippingport, Pennsylvania.[3] Cross-channel eddies of the sort described above may be expected to intensify, partially counter-balance, or possibly reverse the direction of the nocturnal katabatic flow down Rock Run Creek.

In addition to these expected and fairly predictable circulations, there are a host of minor eddies associated with the local topography. The slopes of the hills bordering the pond heat and cool at different rates, depending on their exposure, vegetal covering, and time of day, the season of the year, the degree of cloudiness, and many other parameters. The eddies set up by this differential heating and cooling tend to be advected up or down channel by the prevailing winds. The result is a complex wind and temperature structure near the shore line which is not at all similar in detail, at least, to the regimes in mid-channel.

a. Anemometer records at the reactor site -- Wind observations at Peach Bottom for the interval from September 1, 1959 to April 17, 1961 are summarized in Tables II-6(A), II-6(B), and II-6(C) (Appendix B). Two full seasons of record are available for the autumn and winter seasons; slightly more than one season of record for spring and summer. These data constitute an extremely small statistical sample. They should be used with considerable caution. Nevertheless, even a cursory study of the data indicates that the wind regimes show many of the attributes anticipated on the basis of a general knowledge of micrometoerology. As expected, the winds at Peach Bottom are lighter and show a smaller degree of channeling parallel to the axis of the pond.

The mean annual wind speed of the three anemometers at the reactor site averages 4.5 mi/hr, compared to 6.0 mi/hr for Holtwood Dam, and 9.0 mi/hr for the region surrounding the Susquehanna Valley. A substantial increase in the frequency of calms is noted: 23% at Peach Bottom compared to 3% at Holtwood. This may be due in part to the method of observation. The Peach Bottom anemometer records have been examined visually to estimate the average wind

3. See Footnote 2, Supra Page II-4.

speed over a period of one hour preceding the time of observation. In principle, the data at Peach Bottom and at Holtwood are therefore comparable. However, it is difficult to estimate the average flow accurately for extremely low wind speeds, and the statistics on the frequency of calm conditions at Peach Bottom should therefore be used with caution. It may be noted in this connection that winds of less than 4 mi/hr are observed at Peach Bottom 52% of the time, as compared with 33% at Holtwood Dam and 17% in the region surrounding the Susquehanna Valley. These latter statistics may offer a better comparison between the wind regimes.

The decrease in wind channeling is quite large. At Holtwood, it has already been noted that the wind is almost parallel to the channel, or is calm a total of 93% of the time. The comparable figure at Peach Bottom is 50%. This has been accompanied by a substantial increase in the frequency of winds blowing at a high angle to the shore line. Thus, the wind is from the west or southwest 34% of the time as compared with 6% at Holtwood. Similarly, onshore winds from the northeast or east occur 10% of the time, compared to 1% at Holtwood.

There are, of course, significant variations in the wind structure with elevation. As might be expected, the lightest winds were recorded at the 10 meter anemometer at the Weather Station near the mouth of Rock Run Creek. The mean annual wind speed at this location was 3.5 mi/hr, and winds under 4 mi/hr occurred 62% of the time. At an elevation of 30 meters, the mean annual wind speed was 5.6 mi/hr, and winds less than 4 mi/hr occurred 44% of the time. At the hill exposure (approximately 13 meters above ground elevation and 50 meters above the level of the primary Weather Station) the mean wind was 4.6 mi/hr, and winds less than 4 mi/hr occurred 49% of the time.

There is also a marked seasonal variation in wind speed. Lowest winds are recorded during the summer season. To cite the most extreme condition, winds at the 10 meter anemometer averaged only 1.9 mi/hr during the summer, and winds less than 4 mi/hr occurred 82% of the time. No winds in excess of 12 mi/hr were observed. Although only four summer months of record have been analyzed, the data are sufficiently uniform to be of considerable significance.

The occurrence of winds at a high angle to the shore line also show a marked variation with elevation and season. There is a steady increase in wind variability with elevation above the pond. At each elevation the most frequent observations are winds from the northwest, west, southeast, and calm. The percentage of observation in these four categories total 90% at the lowest level; 80% at the 30 meter level; and 60% at the hillside station. Nevertheless, winds at a very high angle to the shore line occur with approximately the same frequency at the 10 and 30 meter levels; from the southwest or west, 26% of the time at both elevations; and from the northeast or east, 7% to 8% at both elevations. Such winds are more frequent at the hillside location, the appropriate figures being 34% and 14%, respectively.

Some interesting tentative conclusions can be drawn from the above data. It is reasonable to suppose that above the elevation of the hillside anemometer the variability of the wind speed increases with height until it eventually becomes comparable to that of the surrounding region. However, the zone of transition seems to extent well below the top of the hills surrounding the pond, since the hillside anemometer is located more than 100 feet below the crest of the hills bordering the reservoir.

The substantial occurrence of off-shore winds from the southwest or west deserves special comment. Although katabatic flow toward the reservoir is to be expected, especially during nocturnal hours, it is somewhat surprising that off-shore winds occur with remarkable consistency throughout the entire year. The effect of seasonal variation of the difference in temperature between the pond and the surrounding land is surprisingly small. Thus, only at the 10 meter and 30 meter level is there a significant reduction in the frequency of off-shore flow during the spring season due to the presence of cold water in the reservoir. Even in this case the reduction is slight (approximately 20%).

On-shore winds (from the northeast or east) also exhibit only a slight seasonal variation. At the lowest two elevations, these winds tend to occur less frequently during the autumn season, when the pond is comparatively warm. This effect might be anticipated, but the reduction is not substantial and one may doubt the statistical significance of the observed variation.

The comparative infrequency of on-shore winds of measurable strength and the apparent lack of influence of the reservoir in the production of such currents, is reassuring when taken in conjunction with the records at Holtwood which emphasize even more strikingly the infrequency of on-shore flow. The likelihood of steady and prolonged wind motion up Rock Run Creek would appear to be slight. This tentative conclusion will be referred to later in connection with estimates of relative dilution of airborne contaminants.

b. Temperature records at the reactor site -- Temperature data at Peach Bottom for the interval from March 1, 1960 to April 17, 1961 are summarized in Tables II-13 (A) and II-13(B) (Appendix B). In these tables the percentage frequency of various temperature differences between pairs of stations have been tabulated.

The seasonal and diurnal variation of temperature structure is evident, as is the effect of the pond. Considering the day as a whole, maximum stability occurs during the cold half year, but due to the modifying effect of the reservoir the difference between the cold and warm part of the year is not as great as it otherwise would be.

Maximum stability occurs during the autumn season. However, wind speeds are substantially lower during the summer months.

It is probable that minimum diffusion of atmospheric contaminants will occur during the latter season.

The above comments are developed from inspection of a relatively short period of record. The continuing program of observation will provide a rapidly increasing reservoir of data concerning the micrometeorology of the reactor site.

5. Winds Associated with Period of Precipitation. Before concluding the general discussion of the climatology of the Peach Bottom reactor ~~site and th~~e surrounding region, it will be important ~~to mention briefly~~ the wind regimes associated with periods of precipitation. These data are of particular significance in evaluating rainout as a possible source of contamination of the Conowingo pond and the surrounding area.

Two sets of precipitation wind roses have been prepared: one for the average of five Class A Weather Bureau Stations in the surrounding region, Table II-7 (Appendix B), and one for Holtwood Dam, Table II-8 (Appendix B). Again, four observations a day were considered over a total period of five years. In preparing the wind roses for the region, an observation was included if any one of the five Class A Weather Stations reported precipitation within an hour of the time of observation. In preparing the wind roses for Holtwood Dam, the weather at the single station was used as the deciding factor. A total of 1948 observations in the region was classified as occurring with precipitation. This constitutes about 27% of all observations. On the other hand, only 383 observations were classified as occurring with precipitation at Holtwood Dam. This constitutes only slightly more than 5% of the total number. This discrepancy seems to be somewhat larger than can be explained solely on the basis of the number of stations involved. One probable factor is the absence of an observer at the Holtwood Station, coupled with the fact that the triple-register does not show accumulations of precipitation less than .01 inch.

A wind rose of the regional geostrophic wind direction and speed is shown in Table II-9 (Appendix B); the same parameter for periods of precipitation is shown in Table II-7 (Appendix B). Examination of these tables indicates that periods of rainfall tend to be associated with somewhat higher wind speeds. The increase is approximately four miles per hour. Furthermore, as might be expected, there is an increase in the frequency of geostrophic winds from the east and southeast, and a corresponding decrease in the frequency of winds from the west and northwest. Nevertheless, the occurrence of precipitation is not overwhelmingly associated with a geostrophic wind from any particular direction.

The annual wind rose for periods of precipitation at Holtwood also exhibits an increase in wind speed, from6.0 to 6.9 mi/hr (compare,Tables II-5 and II-8 (Appendix B). The frequency of winds of less than 4 mi/hr is reduced from 40% to 28% and this change is most noticeable during the fall season. It was anticipated that periods of rainfall at Holtwood would tend to be associated with up-channel flow. For all Holtwood observations, the occurrence of down-channel winds is 47%, of up-channel winds is 43%, and of calms 3%. For the 383 cases of concurrent precipitation, there were 41% down-channel winds, 51% up-channel winds and 1% calm. The increased frequency of up-channel flow is evident, but the association is not as substantial as had been expected.

The climatology of periods of precipitation will be examined further. The regional and local wind field associated with periods of moderate to heavy precipitation must also be considered. These and other data will be used in the Final Hazards Summary Report.

C. Preliminary Diffusion Estimates

1. Introduction. In order to evaluate the adequacy of the contemplated reactor site, quantitative diffusion estimates are required. It is important to emphasize that such estimates are inherently subject to a substantial error. Even the physics of diffusion of a contaminant in an infinite, homogeneous, isotropic turbulent flow is imperfectly understood. In the atmosphere, however, an anisotropic turbulent wind field is being dealt with, in which both mean wind direction and speed vary with height above the ground. Thermal stratification may be stable or unstable. Finally, the flow occurs over an aerodynamically rough surface for which the height of the roughness elements may be substantial.

A variety of empirical formulae have been developed to describe atmospheric diffusion. None of these are completely satisfactory even under the best of circumstances. Where applicable, Sutton's formula is used herein, not because this formula has greater physical validity than many of the others, but because a large number of previous investigators have chosen to fit their observed data to this particular empirical relationship. A substantial body of information has therefore accrued concerning the average value and the variability of the empirical coefficients which appear in Sutton's Equation. Such information is essential if adequate estimates of diffusion quantities are to be developed.

It should be emphasized that estimates of diffusion in the immediate vicinity of the Peach Bottom site are much more difficult to prepare and are subject to greater error than estimates for a location where topographic influence is slight. Sutton's Equation has been most successful when it has been applied to regions of low topographic variation. When flow is over rough terrain, suggestions have been advanced for introducing the effect of the increased turbulence into the equations by so-called "macroviscosity" corrections. These methods are of doubtful validity when diffusion is considered in the immediate vicinity of hills which are substantially higher than the radioactive cloud being considered. The many eddies, organized and quasi-random, act to diffuse the contaminant in a way which cannot be adequately predicted. For this reason it must be emphasized that the diffusion estimates are order of magnitude estimates only. In their preparation, however, an effort has been made to be somewhat conservative -- that is, to arrive at figures which probably are underestimates of the actual diffusion which will occur.

In the following, certain meteorological situations will be considered for which the use of Sutton's Equation in any form is clearly inappropriate. An example of this is the diffusion of the stack effluent up or down channel a considerable distance from the site. In this case the contaminant is largely confined to the river channel by the bordering hills, and a volumetric computation is far more reliable than any impirical relation. Such special methods of analysis are presented in greater detail in later sections.

2. Meteorological Conditions to be Considered. Estimates of diffusion can be prepared for many different points within and outside of the Susquehanna River Valley. In addition, many different types of meteorological conditions could be considered. The actual choice of locations and weather situations to be studied must be dictated by the exigencies of the physical problem: the evaluation of the impact of radioactive effluents from the reactor on the environment.

Consideration is first given to the problem of evaluating the effect of normal stack effluents from the Peach Bottom reactor. As has been shown in Volume I of the Preliminary Hazards Summary Report, the normal effluents will be exceedingly low. Diffusion of these effluents by the atmosphere can therefore be regarded as an additional safety factor, which will serve to further reduce exposure of the population surrounding the site. For this case, therefore, only two types of statistics need be developed: (1) the relative dilution to be expected at the site boundary under the "worst reasonable" meteorological situation, and (2) an average relative dilution at the site boundary. It is not necessary to estimate diffusion far from the reactor, since the environmental effect will obviously be negligible.

Under accident conditions, particularly one as serious as the Maximum Credible Accident, the problem is different. In this case, the "worst reasonable" meteorological situation is of little concern, since it is extremely unlikely that an accident which itself has a very low probability of occurrence will coincide with a rare meteorological event. Of more concern are the meteorological conditions which occur with reasonable frequency and also yield comparatively high concentrations of radioactivity at specific points or over specific regions. Since in a serious accident the environmental implications of the release of radioactivity are of more concern, there must be examined not only the dilution at the site boundary, but also the diffusion which may be expected as the radioactive effluent which has leaked from the secondary containment moves far from the reactor site.

Two types of meteorological conditions are significant for accident conditions at the Peach Bottom reactor site. First, under stable meteorological conditions and low wind speeds, such as might frequently occur during a normal nocturnal inversion, radioactive effluents would tend to accumulate near the reactor site. This condition might result in contamination of a comparatively restricted area. In addition, radioactive effluents would largely be confined to the channel of the Susquehanna River valley and would tend to move far up or down stream with the prevailing wind. Mixing of radioactive contaminants outside of the channel would occur very slowly. Therefore, this type of meteorological situation might also result in movement of airborne contaminates along the shore line considerable distances up or down stream. If precipitation accompanied or immediately followed such an event, rainout of radioactivity would probably cause maximum contamination of the pond.

A second type of meteorological situation which would be of significance under accident conditions is one in which the radioactive effluent is advected away from the channel and across the surrounding countryside. Under unstable meteorological condition and low wind speeds parallel to the pond, radioactive effluents will tend to move slowly up or down channel, but will mix comparatively rapidly with the surrounding environment. The prevailing wind in the region above and on both sides of the river valley may be a large angle to the axis of the valley. Under such conditions, radioactive isotopes may be carried many miles from the pond. If precipitation accompanies or immediately follow such a situation, maximum contamination of the agricultural region away from the Susquehanna River valley will result.

In the following two sections, only airborne contaminants will be discussed. An analysis of fallout and rainout will be presented in a third section. Pertinent types of meteorological situation will be evaluated for locations in the immediate vicinity of the reactor (i. e. essentially at the site boundary), and for locations far removed from the reactor (along or inland from the channel).

Estimates of relative dilutions will be presented. This quantity, which will be expressed in terms of sec/m^3, is the ratio of atmospheric concentration (activity per unit volume) to stack discharge (activity per second). Since the stack effluent is not heated, and since the rate of flow is not particularly high, the assumption of a point source at the stack outlet is completely satisfactory. In the following computations it has been assumed that the stack will rise 150 feet above the plant, to 265 feet m. s. l. Under accident conditions, the stack effluent will be cut off, and the only source of airborne contamination will be from leaks from the secondary containment to the environment. When appropriate, diffusion estimates will therefore be made for two cases: (1) a point source Q_o at an elevation of 265 feet m. s. l.; and (2) a diffuse source extending from ground level (115 feet m. s. l.) to essentially the top of the plant (at about 255 feet m. s. l.). When points far from the reactor site are considered, there will be no significant difference between these two cases.

D. Relative Dilutions at Site Boundary

1. Meteorological Conditions which Cause "Worst Reasonable" Concentrations.

Consideration is first given to those weather situations which will be associated with exceedingly low rates of diffusion near the plant. Under very stable nocturnal conditions, a very light up or down channel flow will cause the stack effluents to drift slowly along the side of the channel parallel to the shore. This will yield comparatively high concentrations of radioactive material at the boundaries of the site up or downstream and on the same side of the pond as the reactor. The concentrations may, however, be quite different aloft from those observed at the shore line. Two sub-cases will therefore be considered: the relative dilution at neighboring off-site locations 150 to 200 feet above the pond; and the relative dilution at neighboring off-site locations essentially at pond elevation. These are shown in Figure II-1 (Appendix A) as locations A and B, respectively.

Locations labeled A will be considered first. Since an elevation essentially equal to that of the point source is being considered, Sutton's Equation for relative dilution becomes:

$$\frac{X}{Q_o} = \frac{2}{\pi C_y C_z \bar{u} x^{2-n}} \qquad (1)$$

where x is oriented in the direction of the mean wind $\bar{u}$, parallel to the shore line. The problem is to assign reasonable values for the empirical coefficients n, C_y and C_z, and for the mean wind speed. These values are to be chosen so that the resulting relative dilution will be its "worst reasonable" value: i. e., it must be about as large as would reasonabely be likely to occur over a period of many years.

The distance x is approximately 1000 meters. A wind speed which is very light, but non-zero, is assumed. Appropriate values of Sutton's coefficients are more in question. The factor n, which is a measure of vertical wind shear and indirectly the stability, should be in the vicinity of 0.6. If it were not for the local topographic effects, a reasonable choice for C_y and C_z might be in the range 0.04 to 0.08 and 0.02 to 0.03, respectively, in units of $(\text{meters})^{n/2}$. These values are certainly far too low for the present case, since inevitably local roughnesses and drainage currents will cause substantial diffusion to occur. There is absolutely no way to know what a reasonable extreme value of these coefficients may be.

There has been arbitrarily selected 8×10^{-3} sec/m^3 as the "worst reasonable" relative dilution at locations A. This is based on a wind speed of 0.2 m/sec (slightly less than one-half mile per hour) and values of C_y and C_z of 0.22 and 0.12, respectively. These values of the diffusion coefficients are far below estimates obtained from smoke-diffusion tests conducted at Shippingport, Pennsylvania.[4] However, as the authors of this report note, their results should be interpreted with caution under stable conditions. Again it must be emphasized that the "worst reasonable" estimate of 8×10^{-3} sec/m^3 must be considered an order of magnitude estimate only, although it is believed to be a conservative one.[5]

It should be noted that the "worst reasonable" concentrations at all locations A in Figure II-1 (Appendix A) will not actually be the same. For example, southeast of the reactor site a hill rises abruptly from the channel. The upstream face of this hill will be approximately normal to stack effluents drifting southeastward along the boundary of the pond. Obviously, the resulting concentrations should be higher at this point than at a point where the hill is more nearly parallel to the channel. There is no applicable information available concerning the relation between concentration and angle of attack. It is reasonable to suppose that for barriers of this lateral dimension, a variation by a factor of two is quite probable. This range is, however, not as large as the fundamental uncertainty in the original estimate. It would imply an unwarranted degree of accuracy to attempt to differentiate "worst reasonable" relative dilutions as a function of orientation of slope for specific locations adjoining the site.

Consideration should now be given to relative dilution factors at the site boundary but at the elevation of the pond, at location B in Figure II-1 (Appendix A). Here Sutton's Equation in its usual form will do virtually no good. Maximum concentrations will probably occur when the effluent drifts along the shore, and when an organized circulation over the pond exists such that the contaminant gradually descends toward the ground as it moves away from the source. This would be characteristic of periods for which the pond is warmer than the land along the shore line. Such vertical motion would not be associated with periods of maximum stability, and would almost inevitably result in increased mixing compared to the previous example for which no such vertical circulation was considered. In view of these facts, a relative dilution of 2×10^{-3} sec/m^3 at

4. See footnote 2, Supra, page II - 4
5. Only the product $C_y C_z \bar{u}$ appears in Equation (1). Thus the same relative dilution would result, for example, from assuming $\bar{u} = 1$ m/sec and $(C_y C_z) = .005$ (meters)^n.

pond level at the site boundary has been assumed.

Sutton's Equation can be used to check this estimate, provided suitable modifications are introduced. If the plume is tilted downward due to organized subsidence, Sutton's Equation for surface relative dilution along the axis of the plume becomes:

$$\left.\frac{X}{Q_o}\right)_{\substack{y=0\\z=0}} = \frac{2}{\pi C_y C_z \bar{u} x^{2-n}} \quad e^{\frac{-h\bar{u} - x\bar{v}}{\bar{u} C_z^2 X^{2-n}}} \qquad (2)$$

where $\bar{v}$ is the mean rate of descent. This is identical in form to the modified equation normally used for small particles settling at a speed v under the influence of gravity.[6]

If x is taken as the distance to the site boundary, it is obvious that highest concentrations are observed when $\bar{v} = h\bar{u}/x$. In the present example, h is 50 meters, and x is 1000 meters. For "worst reasonable" conditions, with $\bar{u} = 0.20$ m/sec, $\bar{v}$ would be 0.01 m/sec. This is a low rate of subsidence for a cross-channel circulation such as has been hypothesized, and could occur with a small temperature difference between the pond and the shore. Such slight organized vertical motions might reasonably be present under fairly stable conditions. At a speed of 0.20 m/sec, a particle of air requires approximately 1.4 hours to move from the stack to the site boundary. In this period of time, it might well be possible for the particle to cool sufficiently to subside 50 meters without destroying an average inversion.

For substitution in Equation (2), the estimate of Sutton's coefficients developed in the next section for normal inversion conditions were used. These values ($n = 0.5$; $C_y = 0.32$; $C_z = 0.18$) also lead to a relative dilution of 2×10^{-3} sec/m^3 at the site boundary and at pond elevation (locations B), Figure II-1 (Appendix A).

One further case must be considered. When the wind is essentially normal to the shore line, stack effluents may move inland up Rock Run Creek. The stream takes a sharp turn within the site boundary. However, a small tributary extends up the road leading toward Delta. Stack effluents will more naturally tend to drift up this tributary. The result might be fairly high concentrations at point C in Figure II-1 (Appendix A).

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6. U.S. Weather Bureau, "Meteorology and Atomic Energy", Government Printing Office, 1955.

Probably this condition will be rare. It has been seen that the usual meteorological situation involves a wind up or down channel. Under stagnant conditions when the temperature of the water is high, eddies will tend to form which will carry the stack effluent inland. However, a preliminary analysis of anemometer records from the reactor site indicates it is unlikely that these eddies will be strong enough, will extend far enough inland, and will last for a sufficient period of time to make this situation critical. Therefore, it will be tentatively assumed that a substantial movement of stack effluents up Rock Run Creek and its tributary will occur only under those rare conditions when the average wind flow is across the channel, almost at right angles to its axis. It may be possible to obtain some insight into the likelihood of such an occurrence from climatological studies now under way.

Assume that during a period of approximately 16 hours the wind blows continuously across channel, forcing the stack effluent up Rock Run Creek and its tributary. (It may be noted that such an extended period of cross-channel flow has not been observed in the five years of record examined at Holtwood Dam.) It will also be assumed that the wind speed is sufficiently low and the stability is sufficiently high to prevent movement of the effluent far out of the channel, away from the site boundary.

Under such circumstances a crude estimate of the relative dilution at location C can be obtained from volumetric considerations. The width of the channel is approximately 150 meters; a reasonable length over which the effluent could be spread is of the order of 1500 meters; the depth of the cloud is assumed to be 40 meters; and it is assumed that 50% of the effluent remains within this volume. Finally, the volume is itself reduced 50% on the assumption of a uniform slope towards the channel. On this basis the average relative dilution for the entire cloud would be approximately 6×10^{-3} sec/m^3. For maximum concentrations, this average value must be increased substantially. Perhaps a reasonable estimate of the maximum relative dilution under such circumstances would be 3×10^{-2} sec/m^3. Again, it must be emphasized that this is an order of magnitude estimate only.

One final point needs to be considered. When the source is diffuse, extending from the ground to the top of the secondary containment, conditions will be somewhat modified. There is no object, however, in preparing elaborate computations for this case. Concentrations at pond level and aloft should be essentially equal -- close to the average of the two values previously obtained. This leads to a "worst reasonable" estimate of 5×10^{-3} sec/m^3 for points A and B. No change is suggested for the case of flow up Rock Run Creek and its tributary. A check of the first of these figures against a volumetric estimate is of interest. If the wind speed is 0.2 m/sec, and if the cloud depth remains essentially 50 meters, a relative diffusion of 5×10^{-3} sec/m^3 implies a cloud width of about 20 meters -- a figure well in keeping with available diffusion data.

2. Diffusion Associated with a Normal Nocturnal Inversion

Estimates developed in this section will be used for two purposes: (1) to help determine the average relative dilution at the site boundary under normal operating procedures, and (2) to provide an estimate of relative dilutions which is above average, but which may be expected to occur with reasonable frequency, for use in evaluating the hazard in the immediate vicinity of the reactor site under accident conditions. Estimates will therefore be prepared using stack effluent as a point source, and also using a diffuse effluent from the secondary containment.

For relative dilutions along the channel, Sutton's Equation will again be used. As a reasonable value for nocturnal inversions, n = 0.5 is chosen. The choice of values for the diffusion parameters C_y and C_z is more obscure. Macro-scale roughness of the terrain, combined with drainage flows which vary markedly in intensity from place to place, cause the diffusion parameters to be much larger than would be expected in a region of low topographic relief.

At present, there is not an adequate number of field experiments to determine with sufficient confidence the appropriate values to be used. Smoke-diffusion tests were conducted at Shippingport, Pennsylvania, under topographic conditions very similar to those at Peach Bottom.[7] For moderately stable conditions, a macro-viscosity correction of about six was obtained: that is, values of the diffusion coefficients used in regions of low topographic variation were multiplied by this amount due to turbulence induced by local topography. An average of ten runs showed an increase in the coefficient C_y from .10 to about .55. However, as the authors themselves pointed out, there are certain inadequacies in the data and in the method of computation. The results are not conclusive and must be used with caution. Better field observations are required, taken under a greater variety of meteorological con-

7. See Footnote 2, Supra, page II - 4

ditions with recording anemometers at several locations, before this large an increase in the usual values of the diffusion coefficients can be safely assumed.

For the present analysis, values of the diffusion coefficients C_y and C_z have been chosen as 0.32 and 0.18, respectively. For light winds, this represents an increase by a factor of about three in the values of the coefficients normally used in regions of low topographic variation. It is believed that the resulting estimates of relative dilution are conservative, but not unrealistically so.

Since normal nocturnal conditions are being considered, a wind speed parallel to the channel has been selected which is considerably larger than that used for the "worst reasonable" meteorological situation. The value u = 1.0 m/sec has been selected as typical. Substitution of these values in Sutton's Equation leads to a relative dilution of 3×10^{-4} sec/m^3 for hillside locations at stack height near the site boundary.

At pond elevation (location B), Figure II-1 (Appendix A), Sutton's Equation is again likely to be misleading if used without modification. This is due to the fact that cross-channel circulations develop to a substantial extent. When the pond is colder than the shore line, the stack effluent will tend to drift over the channel. The resulting off-site concentrations, both at pond elevation and aloft, will be comparatively low. It is clear, therefore, that if it is desired to consider an inversion condition which can be expected with reasonable frequency but which will yield high concentrations of stack effluent at pond elevation at the site boundary, primary concern must be with circumstances when the pond is warmer than the surrounding shore line. In these cases there will be a tendency for the stack effluent to stay near the shore line and to be displaced downward.

In view of the fact that the temperature of the pond is sometimes colder, sometimes warmer, and sometimes at essentially the same temperature as the shore line, the concentration to be expected at pond elevation should not be very different on the average from that observed at stack height near the site boundary. An average relative dilution of 3×10^{-4} sec/m^3 may be used for locations near the pond under conditions of normal inversion.

When the source is diffuse, extending through the entire height of the secondary containment, the effluent will often tend to vary only slightly with elevation when it reaches the site boundary. An estimate of relative dilution of 3×10^{-4} sec/m^3 may once more be used. Again, it will be constructive to use volumetric considerations to check these results. The above relative dilutions imply a cloud width of about 50 meters, if it is assumed that the cloud depth extends to 65 meters and the wind speed is 1 m/sec. This is a reasonable, though probably a conservative, estimate.

No estimate of relative dilution will be made for off-site locations up Rock Run Creek and its tributary under conditions of normal nocturnal inversion. During the night drainage winds typically occur, moving downward toward the pond. In addition, there is usually at least a small wind component parallel to the channel. These facts would imply that the opportunity for a substantial amount of effluent to move far inland up Rock Run Creek is very low. It might tend to occur only under large-scale meteorological conditions which lead to a cross-channel flow over the entire reservoir. Wind records indicate that a persistent regime of this kind is rare. This possibility is not considered, therefore, at the present time.

3. Average Relative Dilutions

For investigating the probable effects of accidents at locations which are off-site but in the immediate vicinity of the reactor, it is useful to have estimates of the average value of the relative dilution to be expected at a single point. To obtain such data, relative dilutions associated with normal daytime (unstable) lapse rates are required.

Under lapse conditions it is reasonable to use Sutton's Equation, with $n = 0.20$. A typical value of $\bar{u}$ is 3 m/sec (about 7 mph) directed up or down channel. The values C_y and C_z are assumed to be 0.40 and 0.30 $(\text{meters})^{n/2}$, respectively. These values are one to two times larger than would be expected at comparable wind speeds in regions of low topographic relief -- a ratio smaller than that assumed for stable regimes, since the correction associated with "macro-viscous" effects decreases with increasing instability. These values of meteorological parameters lead to a relative dilution of 10^{-5} sec/m^3 along the axis of the plume at the site boundary ($x = 10^3$m). Due to the strong mixing and to organized vertical circulations, no distinction will be drawn between locations at pond elevation and on slopes bordering the channel.

An estimate can now be obtained of the relative dilution at a point near the pond at the site boundary under "average" weather conditions. If a typical nocturnal regime yields a relative dilution of 3×10^{-4} sec/m^3, and a typical daytime regime yields 10^{-5} sec/m^3, a reasonable average value would be about 2×10^{-4} sec/m^3 if the plume were always oriented in the same direction. This takes into account the fact that nocturnal relative dilutions will occasionally be substantially . . . . .

larger than the "normal" values, and that these occurrences will have a substantial effect on the average.

The wind is usually up or down channel. However, there may also be sufficient cross-channel flow (in vertical cells or in the mean horizontal advection) to carry the axis of the plume off-shore. It is reasonable, therefore, to divide this figure by a factor of about four to allow for variations in the direction of advection of the effluent.

For points near the channel at the site boundaries (locations A and B), Figure II-1 (Appendix A), a time-averaged value of the relative dilution should therefore be about 5×10^{-5} sec/m^3. This is an order of magnitude estimate only.

E. Relative Dilutions Far From Reactor Site

1. Basic Theory

Relative dilutions at or very near the site boundary have been considered in the immediately preceding sections. It will now be necessary to examine those situations under which radioactive effluent could be carried substantial distances. In the present section, the necessary mathematical models will be developed; in the following two sections, these results will be applied to meteorological conditions of particular interest.

As has been emphasized on several previous occasions, the wind over the Conowingo Pond is directed up or down channel a vast preponderance of the time. Plant effluents will therefore tend to drift initially in a direction parallel to the pond provided conditions are not stagnant. At the same time, the cloud will spread out across the channel. This tendency will be enhanced by cross-channel circulations set up due to temperature differences between the pond and the bordering shore line. A substantial distance up or downstream from the site, the cloud will essentially be distributed homogeneously across the channel. Trapped between the hills which border the Susquehanna River valley, the effluent may then continue to move far up or downstream.

Under conditions such as these, Sutton's Equation is of no use. A better estimate can be made from volumetric considerations. If the average wind speed over the channel is $\bar{u}$, and if the width of the cloud is denoted by W_c, the width of the channel by W, and the height of the bordering hills by H, the relative dilution far up or downstream becomes

$$\frac{X}{Q_o} = \frac{1}{W_c H \bar{u}} \quad ; \quad W_c \leq W \qquad (3)$$

provided it is assumed no contaminent is diffused from the channel across the surrounding countryside. If, on the other hand, the loss of effluent material from the channel is estimated in some way, and if the flux of the remaining contaminants up or downstream is denoted as Q (activity/sec), then the expression for the relative dilution at any point becomes, more realistically:

$$\frac{X}{Q_o} = \frac{1}{W_c H \bar{u}} \cdot \frac{Q}{Q_o} \quad ; \quad W_c \leq W \tag{4}$$

where both Q and W_c are functions of x, the distance up or downstream.

Losses from the channel should now be considered. Above and on both sides of the channel, the prevailing wind may be at a substantial angle to the axis of the channel itself. There will be a turbulent exchange of effluent between the channel flow and this overlying current of air. It is reasonable to assume that the rate of exchange dQ/dx (activity/cm-sec) is proportional to the width of the cloud and to the concentration. In mathematical terms:

$$dQ = -k_o W_c X \, dx \tag{5}$$

where k_o is a proportionality factor, assumed to be constant for any given meteorological condition.

Substituting from Equation (5) into Equation (4), the result is

$$dQ = -kQ \, dx \tag{6}$$

where $k = k_o/H\bar{u}$. On integration, an exponential decay is obtained:

$$Q = Q_o e^{-kx} \tag{7}$$

The corresponding expression for the relative dilution is:

$$\frac{X}{Q_o} = \frac{1}{W_c H \bar{u}} e^{-kx} \quad ; \quad W_c \leq W \tag{8}$$

For x greater than a few kilometers it is probably reasonable to set $W_c = W$.

It is now pertinent to examine what happens to the effluent which escapes from the channel. These contaminants will tend to move with the prevailing wind. As a first approximation, Sutton's Equation may be used for a ground source to describe the resulting diffusion.

However, allowance must be made for the fact that the channel actually represents a line source of decreasing intensity.

Reference is made to the coordinate system shown in Figure II-2 (Appendix A). As before, x is chosen parallel to the channel; y is at right angles pointing toward the direction in which the effluent is being advected. The coordinates x' and y' are in the direction of and normal to the wind flow $\bar{v}$ in the surrounding region, and the origin of this coordinate system is chosen at $x = x_o$. The line source of exponentially decreasing intensity extends from $x = 0$ to $x = \infty$. At $x = x_o$, the intensity of the source per unit length is given by the expression:

$$- \left. \frac{dQ}{dx} \right|_{x = x_o} = + kQ_o e^{-kx_o} \qquad (9)$$

At an arbitrary point P (x, y) the contribution to the concentration due to the source at x_o is:

$$dX = \frac{-2}{\pi C_{y'} C_z \bar{v} (x')^{2-n}} \; e^{\frac{-(y')^2}{C_y^2 (x')^{2-n}}} \; dQ \qquad (10)$$

or, in terms of x, y and x_o:

$$dX = \frac{2k\, Q_o e^{-kx_o}}{\pi C_{y'} C_z \bar{v} \left[(x-x_o) \cos\theta + y \sin\theta \right]^{2-n}}$$

$$\cdot \exp \left[- \frac{\left\{ (x-x_o) \sin\theta - y \cos\theta \right\}^2}{C_{y'}^2 \left\{ (x-x_o) \cos\theta + y \sin\theta \right\}^{2-n}} \right] dx_o \qquad (11)$$

Thus, the relative dilution at the point P (x, y) becomes:

$$\frac{X}{Q_o} = \frac{2k}{\pi C_{y'} C_z \bar{v}} \int_0^{x + y \tan\theta} \frac{1}{\left\{ (x-x_o) \cos\theta + \sin\theta \right\}^2}$$

$$\cdot \exp \left[- kx_o - \frac{\left\{ (x-x_o) \sin\theta - y \cos\theta \right\}^2}{C_{y'}^2 \left\{ (x-x_o) \cos\theta + y \sin\theta \right\}^{2-n}} \right] dx_o \qquad (12)$$

The value of the upper limit is determined by the fact that when x_o exceeds this limit, x' becomes negative and there is no contribution to the concentration at the point P from effluent leaving the channel at larger values of x_o.

To reduce the number of parameters, the non-dimensional variables are defined:

$$K = \frac{X}{Q_o} \frac{\pi C_y' C_z \bar{v}}{2k^{2-n}} \quad ; \quad a = kx \; ; \; b = ky \; ; \; c = c_y{}^2 k^n$$

Then, it follows that

$$K = \int_0^{a+b\tan\theta} \frac{e^{-a}}{\left[(a-\eta)\cos\theta + b\sin\theta\right]^{2-n}} \, e^{-\frac{\left[(a-\eta)\sin\theta - b\cos\theta\right]^2}{c\left[(a-\eta)\cos\theta + b\sin\theta\right]^{2-n}}} d\eta \qquad (13)$$

where $K = K(a, b)$ for given values of the meteorological quantities c, n, θ. Equations (12) and (13) should not be used for locations too close to the channel, since the results become unrealistic as y (and therefore b) approaches zero.

Given estimates of the meteorological factors involved, Equation (13) can be integrated numerically. Such analyses are being prepared. For example, if the channel wind is directed downstream, and if the prevailing wind in the surrounding area is from the southwest, radioactive effluent will drift toward the heavily populated regions surrounding Philadelphia. Investigations are being conducted as to the extent to which airborne radioactivity is carried to such large metropolitan areas under accident conditions.

It is desirable to have some indication of the extent to which airborne radioactivity may be expected to move across the surrounding countryside under conditions of the Maximum Credible Accident. Accordingly, estimates have been made in the following manner: If, in Equation (13) it is assumed that the angle between the channel wind and the prevailing wind is 90^o, the expression for K can be cast in the form of an integral of the error function. After development it is found

$$K' = \frac{1}{\beta} e^{\beta^2/2 - \alpha} \cdot \frac{1}{\sqrt{2\pi}} \int_{-\frac{\alpha}{\beta}+\beta}^{\infty} e^{-t^2/2} \, dt \qquad (14)$$

in terms of new independent variables:

$$K' = \sqrt{\pi/2} \; \frac{X}{Q_o} \; \frac{\bar{v}\, C_z}{K^2 C_x} \quad ; \quad \alpha = kx \; ; \; \beta^2 = \frac{k^2 C_x{}^2 y^{2-n}}{2}$$

Since K' approaches infinity as β goes to zero, Equation (14) is not applicable in the immediate vicinity of the channel, where y (and hence β) is very small. However, by comparing Equations (8) and (14), it can readily be shown that Equation (14) yields a relative dilution substantially lower than the relative dilution at the channel given by Equation (8) when:

$$\beta \gg \frac{1}{\sqrt{2\pi}} \quad \frac{\bar{u}\, C_z}{\bar{v}\, C_x} \quad k^2 WH$$

W is almost constant at 2×10^3m; H is approximately 10^2m; C_x and v are generally larger than C_z and $\bar{u}$, respectively; and k is probably smaller than $5 \times 10^{-4}m^{-1}$ (i. e., the effluent in the channel Q decreases to 1/e times its original value Q_o in a distance greater than 2 km) except for unusual meteorological conditions. Thus, Equation (14) is surely applicable for $\beta \gg .01$, or for β greater than about one-tenth.

Table II-10 (Appendix B) shows values of K' as a function of α and β. These data, together with estimates of the meteorological parameters n, C_x, C_z, $\bar{v}$, and k, yield relative dilutions for airborne effluents at locations far from the channel of the Susquehanna River when the prevailing wind v is normal to the axis of the pond.

2. Meteorological Conditions Which Cause High Concentrations Far Up and Down Channel.

Set forth below in some detail are the meteorological conditions which are likely to cause high concentration of effluent at points along the Susquehanna River, far up or downstream from the reactor site. For such cases to occur, it is obvious from Equation (8) that the loss of effluent from the channel to the region surrounding the river valley must be small. In other words, k (the inverse of the distance in which there is a 1/e drop in concentration as one moves up or downstream) must be a small quantity. As k approaches zero, the relative dilution within the channel approaches a maximum value $(HW\bar{u})^{-1}$.

This limiting case must be examined first. As previously noted, the width of the channel W is approximately constant at 2×10^3 m and H is 10^2m. A reasonable value for $\bar{u}$ under inversion conditions, for which k will be small, is 1 m/sec. Thus, the relative dilution far up and downstream should not exceed 5×10^{-6} sec/m^3.

Actually, the value of k cannot be negligibly small for points far from the reactor site. There is no way of knowing exactly what value of k is reasonable to assume for inversion conditions. This will actually depend upon many additional factors, such as the angle between the channel wind and the overlying wind, the speed of the overlying wind, and the temperature of the ambient air mass as contrasted with the air within the channel. Nevertheless, the order of magnitude of k is surely known. It is not unreasonable to assume for normal nocturnal inversions a value of $5 \times 10^{-5} m^{-1}$. This implies that the effluent confined to the channel of the Susquehanna River is depleted by a factor 1/3 over a distance of 20 km. If this estimate is at all correct, the exponential decay term in Equation (8) should not be neglected for x greater than about 10 km.

The largest neighboring city located on the Susquehanna River is Havre de Grace, which lies approximately 25 km down channel from the reactor site. Relative dilutions at Havre de Grace during nocturnal inversions and a weak down-channel flow ($\bar{u}$ = 1 m/sec and kx = 1.25) might be expected to be approximately 10^{-6} sec/m^3 in the early morning hours, when presumably the inversion and the associated light wind would have persisted a sufficient number of hours for the effluent to reach the city.

3. Meteorological Conditions Which Result in High Concentrations at Distances Far from the River.

Consideration should now be given to those conditions which will result in strong flow of effluent material from the reactor over the surrounding countryside under assumed accident conditions. This widespread dispersion of effluent will be associated primarily with unstable conditions along the pond, for which the factor k will be large. As noted previously, for reasons of mathematical convenience, the case is limited to the situation where the wind in the area surrounding the river valley is at right angles to the axis of the channel. Under such circumstances, it is likely that the wind speed within the channel will be low. This is probably not an unusual combination of meteorological circumstances, since the surrounding region often experiences a southwest wind, approximately normal to the axis of the channel.

The results of the non-dimensional computation shown in Table VI can be used directly to estimate relative dilutions once suitable values for the pertinent meteorological parameters have been selected. The value of k is assumed to be $2 \times 10^{-4} m^{-1}$, corresponding to a 1/e decrease in channel effluent in a distance of 5 km. Sutton's coefficient n has been set equal to 0.25. The values of C_x and C_z are assumed to be 0.2 and 0.1 (meters)$^{n/2}$. The wind component in the surrounding region normal to the axis of the channel is estimated at 3 m/sec. The resulting distribution of relative dilutions is shown in Figure II-3 (Appendix A). Note that different scales are used for the abscissa and the ordinate.

Under the meteorological conditions hypothesized, measurable concentrations of effluent might be encountered many miles from the reactor site under accident conditions. This may have significance for various large centers of population. For example, if x is directed down-channel, or southeast, the ordinate y corresponding to Philadelphia is 90 km. At such large distances, the line source along the channel will not behave very differently from a point source, and therefore it is certain the maximum value of the relative dilution (along the axis of the plume) will not change substantially with variation in wind direction. Under appropriate weather conditions, relative dilutions as large as 2×10^{-7} sec/m^3 could occur in the Philadelphia area. The significance of this and similar estimates is under investigation.

F. Fallout and Rainout

1. Mathematical Relationships.

In many instances the accumulation of radioactivity due to fallout and rainout is of considerably more significance than airborne concentrations. This is due, of course, to the fact that the fallout and rainout remain at the surface of the earth for long periods of time, whereas the airborne contamination moves to other regions and is continually diluted by atmospheric diffusion. Only rainout will be considered herein, for the reason that rainout constitutes a substantially greater hazard than dry fallout. This will be particularly true in a situation for which the particulate sizes are likely to be small.

The theory of the previous section will be modified to include the effect of rainout. As before, consideration will be given to two regions: the channel of the Susquehanna River, and the surrounding countryside. Along the channel the flux of radioactive effluent Q will now decrease as a result of two factors: loss to the atmosphere moving across the channel at higher elevations, and loss to the ground as a result of rainout. Let λ (sec^{-1}) be the rate at which a cloud is removed by precipitation. Then if the concentration is again assumed to be a function of x only within the channel:

$$dQ = -kQdx - \lambda H W_c X\, dx \qquad (15)$$

Using Equation (3) to eliminate concentration X, and integrating:

$$Q = Q_o\, e^{-(k+\lambda/\bar{u})\, x} \qquad (16)$$

Thus, the rate of rainout R (activity/area-time) is:

$$R = -\frac{1}{W_c}\,\frac{dQ_R}{dx} = \frac{1}{W_c} \cdot \frac{\lambda}{\bar{u}}\; Q_o\, e^{-(k+\lambda/\bar{u})x} \qquad (17)$$

where dQ_R is the rate at which channel flux decreases due to rainout.

For x greater than a few kilometers, W_c should be set equal to W. It has been assumed that λ is a constant. Equation (17) should therefore be used only for a given soluble gas or for a specified particle size.

To compute rainout over the countryside away from the Susquehanna River, the channel may again be considered to be a surface line source of decreasing strength. A wind $\bar{v}$ normal to the channel (i. e. in the y-direction) will be assumed for mathematical convenience. Sutton's Equation, integrated through the vertical to obtain rainout for constant values of λ, yields the following differential equation:

$$dR = \frac{-\lambda e^{-\lambda y/\bar{v}}}{\sqrt{\pi}\,\bar{v}\,C_x y^{(2-n)/2}} \quad e^{\frac{-(x-x_o)^2}{C_x^2 y^{2-n}}} \, dQ^* \qquad (19)$$

where $-dQ^*$ is the decreasing source strength at $x = x_o$, $y - O$. Substituting the expression for dQ^* as a function of x_o and dx_o, transforming to an error function, and integrating:

$$R = \frac{k\lambda Q_o}{\bar{v}} \; e^{-\lambda y/\bar{v} - (k+\lambda/\bar{u})x}$$

$$\cdot \, e^{\frac{C_x^2 y^{2-n}(k+\lambda/\bar{u})^2}{4}} \cdot \frac{1}{\sqrt{2\pi}} \int_{-\ell}^{\infty} e^{-t^2/2} \, dt \qquad (20)$$

where:

$$\ell = \frac{\sqrt{2}\,x}{C_x y^{(2-n)/2}} - \frac{C_x y^{(2-n)/2}(k+\lambda/\bar{u})}{\sqrt{2}}$$

To place this in non-dimensional form analogous to Equation (14), let:

$$K'' = \frac{R}{Q_o} \cdot \frac{\bar{v}\,e^{\lambda y/\bar{v}}}{k\lambda} \cdot \frac{1}{\beta'}$$

$$\alpha' = (k+\lambda/\bar{u})x \; ; \; (\beta')^2 = \frac{C_x^2 y^{2-n}(k+\lambda/\bar{u})^2}{2}$$

Then:

$$K'' = \frac{1}{\beta'} \; e^{(\beta')^2/2 - \alpha'} \cdot \frac{1}{\sqrt{2\pi}} \int_{-\frac{\alpha'}{\beta'}+\beta'}^{\infty} e^{-t^2/2} \, dt \qquad (21)$$

If (K', α, β) are replaced by (K'', α', β') in Table II-10 (Appendix B), these data may also be used for the solution of Equation (21). As before, λ is considered constant; therefore, the equation should be applied only to specific gases or particle sizes.

It must be noted that Equations (15) through (21) take into account scavenging of the air by falling precipitation as it moves from the reactor to the point in question. When intervals of precipitation of the order of several hours are considered, and when distances from the reactor of the order of a few kilometers are considered, this is not an inappropriate approximation. It would, however, be clearly inappropriate to make such an assumption for rainout at a point possibly 50 or 100 kilometers from the reactor. This case is now examined.

Along the channel, Equation (15) is still valid after the beginning of precipitation. On integration:

$$Q = Q_B\, e^{-(k + \lambda/\bar{u})x'}$$

where Q_B is the radioactive effluent in the channel at the beginning of rainfall and x' is the distance the radioactive cloud has moved since the onset of precipitation. However, Q_B is known from Equation 7, and $x' = \bar{u}t$ where t is the length of time since the beginning of rainfall. Thus, the corrected values of the radioactive effluent Q^* and the relative rainout $(R/Q_o)^*$ become, respectively:

$$\left.\begin{aligned} &\text{(a)} \quad Q^* = Q_o\, e^{-kx - \lambda t} \\ &\text{(b)} \quad \frac{R}{Q_o}^{*} = \frac{R}{Q_o}\, e^{\lambda x/\bar{u} - \lambda t} \end{aligned}\right\} \frac{x}{\bar{u}t} \geqslant 1 \qquad (23)$$

where (R/Q_o) is the uncorrected value of relative rainout from Equation (17). These equations should be used whenever the inequality in Equation (23) is valid.

The average value of relative rainout for a storm of duration T can now be obtained by integration. It can readily be shown that:

$$\text{(a)} \quad \overline{\left(\frac{R}{Q_o}\right)}^{*} = \frac{R}{Q_o} \cdot e^{\lambda x/\bar{u}}\, \frac{1 - e^{-\lambda T}}{\lambda T} \quad ; \quad \frac{x}{\bar{u}T} \geq 1$$

$$\text{(b)} \quad \overline{\left(\frac{R}{Q_o}\right)}^{*} = \frac{R}{Q_o}\left[1 + \frac{e^{\lambda x/\bar{u}} - 1 - \lambda x/\bar{u}}{\lambda T}\right] \quad \text{for} \quad \frac{x}{\bar{u}T} \leq 1 \qquad (24)$$

where the bar denotes an average over the interval T.

Similar corrections can be made in Equations (20) and (21), neglecting the length of time a particle remains in the channel (relative to the time required to move across the region surrounding the channel):

$$\text{(a)} \quad \left(\overline{\frac{R}{Q_o}}\right)^* = \frac{R}{Q_o} \cdot e^{\lambda y/\bar{v}} \cdot \frac{1 - e^{-\lambda T}}{\lambda T} \quad ; \quad \frac{y}{\bar{v}T} \geq 1$$

$$\text{(b)} \quad \left(\overline{\frac{R}{Q_o}}\right)^* = \frac{R}{Q_o} \left[1 + \frac{e^{\lambda y/\bar{v}} - 1 - \lambda y/\bar{v}}{\lambda T}\right] \quad ; \quad \frac{y}{\bar{v}T} \leq 1$$

where the (R/Q_o) refers to the uncorrected values in Equation (20) or (21).

Table II-11 (Appendix B) shows the value of the correction factor $(R/Q_o)^*/(R/Q_o)$ as a function of the two-non-dimensional numbers $\lambda\, x/\bar{u}$ (or $\lambda y/v$) and λT. It may be observed that the correction may be large, especially for storms of "short" duration (i. e., λT small) and for points "far" from the reactor ($\lambda\, x/\bar{u}$ or $\lambda y/\bar{v}$ large).

In the following pages, uncorrected values of the relative rainout will be presented. These can be generalized to storms of any given duration by use of Equations (24) and (25), or Table II-11 (Appendix B). The assumption is made, of course, that the source Q_o is steady in strength to the soluble gas or particulate considered. Changes in source strength would require further corrections in rainout values.

2. Rainout at the Site Boundary.

In this and subsequent sections, the ratio R/Q_o (m^{-2}) will be evaluated for specific meteorological situations. At the site boundary, along the channel, Equation (17) is applicable without correction.

Two types of meteorological regimes will be considered for locations at the site boundary ($x = 10^3$ m): (1) For inversions, again let $\bar{u}$ = 1 m/sec; $k = 5 \times 10^{-5}\ m^{-1}$; and W_c = 50 m; (2) for daytime conditions, let $\bar{u}$ = 3 m/sec; $k = 2 \times 10^{-4}\ m^{-1}$; and W_c = 400 m. The last figure is computed volumetrically from data in the preceding section.

Two different radioactive isotopes will also be considered: (a) the solulable gas iodine; and (b) a particulate (e.g., strontium) of fairly uniform size. If the rate of precipitation of .15 in/hr, corresponding values of λ are about $2 \times 10^{-4}\ sec^{-1}$ and $2.5 \times 10^{-5}\ sec^{-1}$, respectively. The latter value is applicable to particles ranging in diameter from about

0.5 to 1.5 microns.[8] Larger values of λ must be used if particulates of greater diameter are considered. If the rate of precipitation is 0.03 in/hr, the two values of λ become about 7×10^{-5} sec^{-1} and 5×10^{-6} sec^{-1}, respectively.

For these four cases and two rates of rainfall, the values of relative rainout (R/Q_o) shown in Table II-12 (Appendix B) are obtained. To obtain total rainout in curies/m^2, these figures must be multiplied by the emission rate Q_o of the specified gas or particulate, and by the period of precipitation.

3. Meteorological Conditions Which Cause High Rates of Rainout Far Up and Down Channel.

As the radioactive effluent moves up or down channel, the width of the cloud W_c will increase steadily. Beyond a certain distance (which will probably vary from about two to ten kilometers, depending on the stability) it will be reasonable to assume the cloud covers the entire width of the channel. From this point on, the width of the cloud will be approximately constant at 2×10^3m. As Equation (17) shows, relative rainout (R/Q_o) is then a function of only three meteorological factors: the mean wind speed along the channel, $\bar{u}$; a measure of the rate of mixing of effluent with the surrounding environment exterior to the channel, k: and the rate of rainout, λ.

Figure II-4 (Appendix A) shows the relative rainout along the channel far from the site for three different meteorological conditions. A rate of rainfall of 0.15 inches per hour has been assumed. As in the previous section, rainout of a soluble gas (iodine) and of a particulate (strontium, one micron diameter), is shown. Figure II-5 (Appendix A) shows similar data for a precipitation rate of 0.03 in/hr. It is clear that the worst situation arises when precipitation is associated with stable meteorological conditions. This is due primarily to the fact that under such situations the radioactive effluent will be largely confined to the channel, where it will be available for precipitation.

Some of the inadequacies of the estimates in Figures II-4 and II-5 (Appendix A) should be emphasized. The rate of mixing of the effluent into the surrounding region, and the rate of rainout of soluble gases and particulates, are both poorly known. In addition, these data have been prepared on the basis of a steady-state assumption: that is, it has been assumed that the rate of precipitation is constant in space and time and has continued during the entire interval necessary for the movement of effluent from the reactor to the point x. The latter assumption

8. Atomic Energy Commission, "The Theoretical Possibilities and Consequences of Major Accidents in Large Nuclear Power Plants," Wash. 740, 1957.

can, of course, be eliminated by assuming Q_o constant and by using Equation (24). The resulting correction is small for strontium, if reasonable rainfall durations are assumed, due to the fact that $\lambda x/\overline{u}$ does not exceed unity for the ranges of x and $\overline{u}$ considered. However, the correction for iodine rainout may be large, as much as two orders of magnitude, since $\lambda x/\overline{u}$ may be substantially greater than one.

In view of these facts, the data in Figures II-4 and II-5 (Appendix A) must be used with caution. They will be sufficient, however, to obtain a first estimate of the possible consequences of rainout of radioactivity at points along the channel of the Susquehanna River.

4. Meteorological Conditions Which Result in High Rates of Rainout Far from River.

Consideration should now be given to those situations which may result in maximum contamination of areas far from the river channel. One pertinent meteorological situation will be considered, except for rate of precipitation, which will again be chosen as either 0.15 or 0.03 in/hr. The situation selected is the same as the one used in estimating atmospheric diffusion in the absence of precipitation, for which relative dilutions are illustrated in Figure II-3 (Appendix A). It is assumed that the channel wind is 1 m/sec up or down channel. In the surrounding region, the wind is assumed to be 3 m/sec, at right angles to the axis of the channel. Values of other meteorological parameters ($n = 0.25$; $C_x = 0.2$ and $C_z = 0.1$ $(\text{meters})^{n/2}$) are fairly typical of what might be expected under conditions of daytime rainfall.

It is also assumed that there is a fairly high rate of exchange between the effluent in the channel and the air moving cross-channel. Thus the factor k is chosen as $2 \times 10^{-4} m^{-1}$. Although it might be argued that such a value of k is more characteristic of unstable situations, there is undoubtedly a relationship between the value of k, the speed of the channel wind $\overline{u}$, and the angle at which the wind at higher elevations sweeps across the channel. In the present case, the regional wind is assumed to be normal to the channel and $\overline{u}$ is small; therefore, a comparatively large value of the coefficient k seems to be appropriate.

Figures II-6 and II-7 (Appendix A) show the relative rainout of iodine and one micron strontium associated with a rate of precipitation of 0.15 in/hr. Figures II-8 and II-9 (Appendix A) show corresponding data for a rate of precipitation of 0.03 in/hr. It must again be noted that steady-state assumptions have been used. In other words, it is assumed that precipitation at the specified rate has occurred throughout the entire trajectory of radioactive effluent from the reactor to each point. Adjustments can be introduced using Equation (25), once a storm duration has been chosen. Again, the corrections will be small (generally less than a factor of two) for strontium, since $\lambda\ y/\bar{v}$ does not exceed unity even at a distance of 100 km. The corrections may, however, be as much as two orders of magnitude for iodine. Figures II-6 and II-8 (Appendix A) in particular must be used with caution.

Rainout associated with other types of meteorological situations will be examined. Until such data becomes available, Figures II-6 to II-9 (Appendix A) can be used together with Equations (24) and (25) to develop a first evaluation of rainout hazards.

G. Conclusions

The objectives of investigations now under way are: (1) to improve our understanding of the micro-meteorology and micro-climatology of the reactor site through local observations; (2) to determine the relations between the micro-meteorology of the site and macro-scale phenomena of the surrounding region; and (3) to make use of the information thus obtained in a systematic evaluation of the meteorological aspects of the effect of the reactor on the environment, both in the immediate vicinity of the plant and substantial distances away.

To achieve the first two objectives, a local weather station has been set up at the reactor site. In addition, five years of meteorological data from Holtwood Dam have been used in a statistical comparison of local and regional meteorological observations. These statistical studies will be extended to include additional data from the site itself, as soon as such information is available in sufficient quantity. Special field studies may be made at the reactor site, using smoke clouds, should this prove desirable.

The third objective of evaluating the meteorological distribution of radioactive effluent can be achieved by making use of computational procedures outlined in this report. The relative dilution of radioactive effluents and the rainout or fallout to be expected can be computed for a wide variety of meteorological circumstances. By appropriate weighing of these cases, an estimate can be made concerning the probable consequences on the environment of various releases. These will extend from normal operating conditions, at one extreme, to severe accidents at the other.

It is important to note that the investigations outlined herein have not revealed the existence of any meteorological factor which would make the Peach Bottom site unsuitable for an atomic reactor of the type contemplated. In fact, from a purely meteorological point of view, the proposed site is an excellent one. The tendency of radioactive effluents to remain trapped within the channel of the Susquehanna River; the remoteness of the reactor site from centers of population along the Susquehanna; and the width of the channel, which allows a substantial diffusion of trapped effluents - all of these factors make the Peach Bottom site an attractive one. The role of these and other factors in the relation between the reactor and its environment are being explored in detail.

III. HYDROLOGY

A. Introduction

The Susquehanna River drains an area of 27,500 square miles in New York, Pennsylvania and Maryland. The Peach Bottom site is about 14 miles north of the river's mouth at the head of the Chesapeake Bay. At this point the drainage area is approximately 27,000 square miles. Along the lower 35 miles, where the river flows between steep hills, are located three major hydro-electric plants: Safe Harbor, Holtwood and Conowingo. Peach Bottom is on Conowingo Pond 9 miles above Conowingo Dam and 6 miles below Holtwood Dam. The pond varies in width between 0.6 and 1.5 miles and contains when full to elevation 108.5 feet above mean sea level (M.S.L.) 240,000 acre feet or 80 billion gallons of water. The top 10 feet, or about 80,000 acre feet of water, are used as pondage to regulate power generation.

The observed flows of the Susquehanna River have ranged from a minimum of 1450 cubic feet per second (sec. ft.) to a maximum peak 875,000 sec. ft. The average discharge is 36,200 sec. ft. Conowingo Dam passed the peak flood without difficulty. Peak flows are now reduced somewhat by 6 flood control dams on upland tributaries. The U. S. Corps of Engineers will soon build 4 more such dams and is now studying 10 additional storage projects. The U. S. Congress has authorized 8 of the latter, but has not provided funds for planning and design.

During low flows, the hydro-electric plants are operated intermittently to meet peak daily demands. Conowingo Pond is scheduled to be full on Monday morning and is lowered by intermittent operation through the week to the point that it will just fill over the week-end. At high flows the hydro-electric plants operate on the base load and peaks are carried by steam.

Thus during low flows, when water is standing in Conowingo Pond, wind and temperature variations cause general diffusion and mixing. Turning on of the plants set up eddies which are gradually dampened as operation continues. At high flows and continuous plant operation water movement is more consistently in the down-river direction. Dye tracer studies are now being made to determine the circulation and displacement of water in Conowingo Pond under different conditions of river flow and plant operation.

The river below Peach Bottom is at present used as a sole source of water supply for the City of Havre de Grace, the Perry Point Veteran's Hospital, the Bainbridge Naval Training Station and the Conowingo Power Plant. The City of Baltimore, Maryland has under construction a pipeline which will bring Susquehanna River water 35 miles to the City from an intake on the west bank about one-quarter of a mile above Conowingo Dam. During the initial years this system will be operated intermittently to firm the present upland supplies where some 80,000 million gallons of water is held in storage when all reservoirs are full. This storage is equal to 400 days supply at present rates of use and 235 days at the estimated 1980 use. As the Metropolitan area grows, the Susquehanna supply will come into continuous use.

That the quality of water in the lower river is good, is indicated by the uses for water supply, recreation and sport and commercial fishing.

During the past 20 years depth soundings have been made in Conowingo Pond at 5 year intervals. These indicate that the pond is filling with sediments at an average rate of about 0.4 ft. per year. Average cross-sectional depths, with the reservoir full, ranged in 1941 from 13.5 ft. in the upper end of the pond to 81.6 ft. near the dam. In 1957 the range was from 13 ft. to 75.5 ft. at the same cross sections. Reduction in depth by silting was greatest in the middle reaches where losses in excess of 10 ft. were observed for the 16 year period 1941-1957.

When the dye tracer and other studies of Conowingo Pond and the Upper Chesapeake Bay are completed an attempt will be made to predict the effect of further sedimentation on the fate of contaminants that might be discharged or washed into the river or might fall out over its surface.

The site is in the Piedmont region where groundwater occurs in the relatively shallow overburden and may be collected in quantities suitable for domestic use. These small groundwater supplies are derived from rainwater that soaks into and through the soil in limited areas surrounding each wall. This water percolates into drilled wells through fissures and cracks that thin out and disappear rapidly with depth in the rock. Groundwater moves in the overburden and rock fissures in the direction of the nearest stream or spring. Its discharge under natural conditions supports the continuous dry weather flow of the abundant small streams in the area.

At Peach Bottom the water table rises from Conowingo Pond up through the building site into the hill to the rear. Under these conditions groundwater must discharge directly into Conowingo Pond. Since there are no known deep aquifers of great extent in the region and bedrock tightens rapidly with depth, it is almost inconceivable that water could flow through the ground to and across the land boundaries of the general site area.

B. River Flows

The minimum flows of the Susquehanna River are unregulated except for the minor influences of the three run of river power plants near the Maryland-Pennsylvania line. Measured flows near the mouth of the River have ranged from a minimum of 1450 cubic feet per second (sec. ft.) in the 1930-32 drought to a maximum of 875,000 sec. ft. (peak) in the 1936 flood. The ratio of maximum to minimum or more than 500 to 1 is typical of unregulated streams in the eastern United States. The mean flow of the Susquehanna is 36,200 sec. ft. This is 1.34 sec. ft. per square mile or 18 inches of runoff annually which is about normal for a large watershed on which some 40 inches of rain falls annually. The major gaging stations and the drainage areas above them are shown in Figure III - 1 (Appendix A). The average monthly and annual river flows and the maximum and minimum discharges in each month for the period 1929-1958 are shown in Table III (Appendix B). Figure III-2 (Appendix A) is a duration curve which indicates the percentage of total time that the river flows exceeded any magnitude. In Table III-2 (Appendix B) are listed for each month the minimum average 7-day flows at Conowingo.

The minimum unregulated flow of 1450 sec. ft. may be considered a very extraordinary occurrence on the Susquehanna River for no recorded drought has exceeded in severity that of the 1930-32 period. Omitting this period, the minimum flows next in order are 1775 sec. ft. in the 1941 drought and 2125 sec. ft. in the 1939 drought. All other annual minimums exceed 2500 sec. ft. and the average of all annual minimums is 4000 sec. ft. The river flow exceeds 5000 sec. ft. about 90 per cent of the time. Future regulation of the river will undoubtedly increase the minimum discharges. However, the extent of increase is unpredictable because of the many uncertainties as to future policy with regard to water resource conservation and development in the Susquehanna Basin.

The maximum discharge of 875,000 sec. ft. (peak) which occurred in the 1936 flood, is also thought to be a rare occurrence.

How much greater the flow might be in some future flood if the river were left unregulated is a matter of conjecture. In view of the control measures described below, it is reasonable to assume that a future discharge in excess of 875,000 sec. ft. (peak) at Conowingo Dam is extremely unlikely. The three dams on the lower Susquehanna River passed the 1936 flood without difficulty.

The average of the peak annual discharges is 290,000 sec. ft. Once in about twenty years on the average the peak, unregulated discharge, might have been expected to exceed 550,000 sec. ft. Construction of flood control reservoirs already has and in the future will further reduce the frequency at which high discharges occur in the lower Susquehanna River.

In its 1941 report [1] the U.S. Corps of Engineers used as a demonstration flood a discharge of 1,032,000 sec. ft. at Harrisburg. The three relatively small reservoirs recommended at that time would have reduced the Harrisburg peak by only 4000 sec. ft.

Since World War II the Corps of Engineers has worked continuously on flood problems of the Susquehanna Basin. Reports on the West Branch and on the North Branch were published in 1954 [2] and 1957 [3] and a report on the Juniata Basin is now in preparation. Seven dams have been completed, four are progressing toward either initiation or completion of construction, eight others have been authorized but no funds provided for detailed planning and two additional major dams have been given considerable study. Table III-3 (Appendix B)

1 "Susquehanna and Tributaries in New York, Pennsylvania and Maryland," Report of the Division Engineer, North Atlantic Division of the U. S. Corps of Engineers, 1 May 1941. Published 1942 as House Document 702, 70th Congress, Second Session.

2 "West Branch of the Susquehanna River, Pa.," Report of the District Engineer, Baltimore District, U. S. Corps of Engineers, 29 February 1952. Published 1954 as House Document 25, 84th Congress, 1st session.

3 "North Branch of the Susquehanna River and Tributaries, New York and Pennsylvania," Report of the District Engineer, Baltimore District, U.S. Corps of Engineers, 30 December 1950. Published 1957 as House Document 394, 84th Congress, 2nd session.

gives some of the details of these dams and Figure III - 3 (Appendix A) shows their locations. The George B. Stevenson Dam was originally planned by the U. S. Corps of Engineers under the name of First Fork Dam. It was constructed by the Pennsylvania Department of Forest and Waters.

The recent progress in the construction of flood control reservoirs in the Susquehanna Basin is believed to warrant an assumption that it is exceedingly improbable that Conowingo Dam will in the future have to pass a flood greater than that of 1936.

C. Water Quality

Data on the quality of water in Conowingo Pond is now being gathered by two groups: by Baltimore City in connection with the development of its Susquehanna water supply and jointly by the Solomons Island Biological Laboratory and the Chesapeake Bay Institute as part of the fisheries study being made to determine the possible value of constructing a fish ladder at Conowingo Dam.

When these studies have progressed further full data on water quality will be presented in a revision of this report. Meanwhile, analyses of samples taken every week or so since July 1957 by the Baltimore City Bureau of Water Supply produced the average and ranges in water characteristics shown in Table III - 4 (Appendix B).

These tests indicate that the quality of the Susquehanna River water is good. It is now used for water supply and for game fishing and other recreational activities.

Temperature records kept by the Conowingo Power Company show, for the last ten years, average July and August water temperature of somewhat less than $80^{o}F$. The minimum winter temperature of the river water is about $34^{o}F$. Information on the variations in temperature throughout Conowingo Pond will be developed in connection with the studies of water circulation and displacement that are described later.

D. Water Power

There are four hydro-electric plants on the lower Susquehanna River. Data on the three of these which were mentioned above as well as for the small plant upstream at York Haven, are given in Table III-5 (Appendix B).

The flows into and out of Conowingo Pond and the circulation of water within the Pond are of great significance in determining the rate at which wastes will be diluted and moved down the river. Special studies, using tracers, are being made to determine circulation in the pond under various conditions of river flow and plant operation. When the results of these studies are available, they will be reported in connection with the fate of any contaminants that might enter Conowingo Pond.

Since the manner of operation of the hydro plants has a profound effect on the circulation in Conowingo Pond, particularly during periods of low flow, the operating procedures are described here.

In order to use the available hydro energy most effectively, water is drawn from pondage during the hours and days of heavy demand and the pond is allowed to refill during light loads. The use of pondage is scheduled to have the level at top elevation on Monday morning to meet the load demands of another week, and for all but the lower flows, top elevation also is scheduled for each morning in the early part of the week.

With low river flow, the steam base load is carried at an amount such that, up to the hydro plant capacity, the available energy from river flows can be used to meet peak demands. Thus the draught on pondage is greater on heavy load days, less on light load days and the storage is recuperated over the week-end. The available pondage at Conowingo is ample for weekly operation because the 5 million kwh of energy contained in the top 8 feet is about double the available weekly energy during periods of minimum flow.

When the river flow is greater, the steam base load is decreased and the hydro energy is used on a daily basis by operating the plant for longer hours at greater loads. With high river flows, Conowingo will generate at full capacity on the base load 24 hours a day and the steam plants will assume the burden of absorbing variations in load and of regulating the frequency. There will then be a steam base, a hydro base, and steam generation varying with the load. Examples of the manner of operation to meet a given load curve under 3 different conditions of river flow appear in Figure III - 4 (Appendix A).

In order to use hydro energy to best advantage, river flow must be forecast as far in advance as possible and measures must be taken to maintain the head and station efficiency.

Philadelphia Electric Company had developed satisfactory methods for predicting flows with reasonable accuracy for several days in advance.[4] These involve the collection of current rainfall measurements or predictions of rainfall and the application of a modified unit hydrograph procedure to various portions of the river basin.

At low and moderate flows the problem of head maintenance is one of having the pond at the maximum possible level at those times when the most expensive steam generation is being replaced. At flows in excess of about 45,000 sec ft water must be spilled. The pond is full and head loss results from the effect of spilling upon the tail water elevation. The spillway gates are opened in the sequence and combination that produces the least effect on tailwater elevations. The full elevation of Conowingo Pond is limited by agreement with the owners of the Holtwood Plant upstream to a maximum of 108.5 feet above mean sea level.

The head on the Conowingo turbines is also affected by seiches. Conowingo Pond has a regular period of oscillation which is set in motion by sudden changes in inflow or outflow and by the action of winds. This period of oscillation has been found by both calculation and measurement to be about one hour and ten minutes. Figure II-5 (Appendix A) shows the oscillations produced by a 20 to 60 mph wind which blew directly downstream for a period of about 15 minutes.

Operation of three major run-of-river hydro-electric plants in sequence along the river demands a high degree of cooperation between the Companies and the operators involved. Flow estimates are interchanged and operations at each plant are scheduled to obtain the most efficient overall utilization of river flow.

The circulation and displacement of water in Conowingo Pond is influenced not only by the rates of flow through turbines and spillway gates at Conowingo Dam but also by the turbine discharges and spillway overflows at upstream power plants. The effects of inflows and outflows, as well as the effects of wind, temperature, silt load and other factors upon the movement of water in Conowingo Pond will be discussed in a later section which deals specifically with these matters.

E. Water Supply

There are three existing and one proposed water supply intakes on the Susquehanna River downstream from the Peach Bottom

[4] Turner, Robert E., "The Operation of the Conowingo Hydro-electric Plant", Trans. Am. Soc. Civ. Engrs., Volume 114, p. 79, (1949).

site. The existing supplies furnish water to the Conowingo Hydroelectric Power Plant, to the City of Havre de Grace, to the Perry Point Veterans' Hospital and to the Bainbridge Naval Training Station, which in turn supplies water to the town of Port Deposit. All of these supplies are treated by the usual water purification processes of coagulation, sedimentation, filtration and chlorination. Quantities of water used are approximately as follows:

Water Supply (1)	Approximate quantity used in 1958 Million Gallons (2)
Conowingo	4.251
Havre de Grace	289.176
Perry Point Hospital	187.222
Bainbridge and Port Deposit	375.256

The City of Baltimore, Maryland, has under construction a pipeline which will bring the Susquehanna River water to the City from an intake on the west bank of Conowingo Pond, about one quarter of a mile above the power plant and 9 miles downstream from the Peach Bottom site. Baltimore's Susquehanna River Water Supply system will probably be ready to operate sometime in the mid-1960's. According to present plans, it will be used during initial years of operation on an intermittent basis for the purpose of firming up an increased draft on the existing upland supplies.

Baltimore has three impounding reservoirs which store, when full, a total of 80,000 million gallons. This is over 400 days supply at present rates of use or 235 days supply at the estimated 1980 draft of about 340 mgd. At present much water is lost over the spillways of these reservoirs during wet seasons and wet years because they must now be kept as full as possible in preparation for protracted droughts. When the Susquehanna River supply is available to fall back on, the upland gravity sources may be drawn on more heavily and the amount of loss over the spillways thus reduced.

With the drafts estimated for 1980 the City will probably not need to draw water from the Susquehanna River more than 20 per cent of the time to supply the Baltimore area. However, it is anticipated that when the Susquehanna pipeline is in service, the availability of water will stimulate growth of industries and communities along the excellent transportation routes which the pipeline parallels. Such industries and communities will, at all times, then have to depend upon the Susquehanna River as their source of water supply. In any event, by the year 2000 the demand for water in Baltimore City and its environs will have increased to the point that Baltimore's upland sources will have to be supplemented, more or less continuously by water drawn from the Susquehanna River.

F. Conowingo Pond: Circulation, Mixing and Displacement Time

The circulation and mixing, and the displacement time of water in Conowingo Pond are the primary hydrologic factors governing the concentration of non-conservative contaminants that might be discharged or washed into the pond or might fall out over its surface. Special studies were initiated to evaluate these hydrologic factors for Conowingo Pond as well as for the Upper Chesapeake Bay. These studies have been directed towards answering questions regarding the dispersion and movement of any contamination which might enter the reservoir at the Peach Bottom Site.

The basic field data required to answer questions concerning thermal structure and circulation in the Pond have been gathered under a research program conducted by the Chesapeake Bay Institute (CBI) of The Johns Hopkins University. The results of this study have been published as Technical Report XX, Chesapeake Bay Institute, The Johns Hopkins University, under the title "Physical and Chemical Limnology of Conowingo Reservoir" by R. C. Whaley. Additional field studies, not reported in the above publication, have been made in order to directly measure the pertinent mixing characteristics of the waters in the reservoir. These studies have involved the use of a tracer dye to simulate possible contaminant releases.

Three such dye studies have been completed. The complete analysis and graphical presentation of the data collected during these studies are now under way. Essential conclusions regarding the dispersion mechanism in the lake are now available from these studies, and will be utilized in the following section to evaluate the probable dispersion pattern for a contaminant introduced into the Pond at the Peach Bottom Site.

The first experiment involved an instantaneous release of some 50 pounds of tracer substance into the lake waters off the Peach Bottom Site. This discharge was made during a period of below normal temperatures during early August, when the temperature of the inflowing waters was much lower than in upper layers of the thermally stratified Pond. The dyed volume of water moved downstream with the flow, and dispersed both longitudinally and laterally. On reaching the section of the reservoir where the bottom slopes sharply downward to form the deep lower portion of the Pond, the dyed volume sank below the surface layers and moved along the bottom towards the dam. Concentration continued to decrease with time as a result of both horizontal and vertical mixing. The first traces of dyed water reached the dam about 48 hours after the inital release at Peach Bottom, though the bulk of the dye had not discharged until two days later.

The second experiment involved an instantaneous release of dye later in the month of August at a time when more normal inflow temperatures prevailed. The tagged water volume in this study did not abruptly sink below the surface layers as had been the case in the previous study. Instead, the dye was dispersed over an ever-increasing horizontal area as it slowly moved down the Pond in a relatively thick layer.

In both these experiments the effect of the peaking operation of the Conowingo Power Plant was evident. At this time of year water is discharged through the turbines from the reservoir only during the mid-day hours of high power demand. The rather abrupt initiation and later cessation of discharge set up rather large scale eddy patterns in the reservoir which resulted in a much larger rate of horizontal dispersion than would have been the case if the flow through the reservoir was at a continuous, steady value.

In the third experiment dye was pumped for a period of five days at a continuous rate to a diffusor located in the lake off the Peach Bottom Site. The dye discharge was made during the month of May when the mean flow through the reservoir was over 100,000 second-feet. Over half of this flow was continuously discharged through the spillway gates, and the turbine discharge was continuous throughout the period. The dye spread downstream through the reservoir in a plume, much like the smoke plume from a smoke stack in a high wind. Observations of the dye concentration were obtained both down the axis of the plume and laterally across the plume at a number of sections.

Complete analysis of the observed distribution, in time and space, of the dye concentration in the Pond from these studies is not yet complete. However, certain basic relationships have been derived from the data and serve to provide for first order predictions of the probable concentration of any released radionuclide in the waters of Conowingo Pond.

Data from the first two experiments have been utilized to evaluate the rate of decrease of the peak concentration in the center of a dispersing contaminated volume from an instantaneous point source discharge. Designating the amount of dye released by $\underline{M}$, the maximum concentration in the center of the dispersing contaminated volume by C_p, the time interval after the time of release by t, and the vertical thickness of the layer over which the dye was mixed by D, it was found that the data fitted the relationship

$$\frac{C_p}{M} \cdot D \sim t^{-2} \tag{1}$$

Thus the peak concentration decreased in proportion to the inverse second power of time. As will be seen later, this functional relationship is consistent with several of the existing theories of horizontal eddy diffusion. The constant of proportionality for the above relationship as observed in Conowingo Pond during periods of peaking power production was $1.2 \times 10^4 m^{-2} s^2$.

Data from the third experiment has been utilized to evaluate the rate of decrease in concentration in the plume of a contaminant downstream from a continuous point source. Setting the origin of a rectangular coordinate system at the point of discharge, with the x-axis directed downstream along the axis of the plume and the y-axis directed laterally across the reservoir, designating the rate of release of dye by Q_r, and using the same designations as given above for the concentration and mixing depth, the data from the third experiment was found to fit the relationship

$$\frac{C_p}{Q_r} \cdot D \sim x^{-1} \tag{2}$$

Thus the peak concentration along the axis of the plume decreased in proportion to the inverse first power of distance downstream from the continuous point source. The constant of proportionality for this experiment was found to be $2.0 \times 10^2 m^{-1} \cdot s$. These numerical results will be used below in computing the probable distribution of any radioactive material which might be introduced into the Conowingo Pond.

G. Estimates of Dispersion in Conowingo Pond

There have been, in the last years, several important new theoretical studies of the problem of horizontal dispersion in natural water bodies. Three such studies in particular appear most suitable for utilization in predicting the distribution of any contaminant which might possibly be released into the Conowingo Pond. The first of these is a work by Joseph and Sendner, "Horizontal diffusion in the sea": Duetsche Hydrographische Zeitschrift, 11:2, 49-77, 1958; the second by Schönfeld, "Diffusion by homogeneous isotropic turbulence": Mimeographed Report from the Rukswaterstaat, The Netherlands, 1959; and the third by Pritchard and Okubo (Unpublished Notes, Chesapeake Bay Institute, The Johns Hopkins University, 1959). In all three of these studies equations for the horizontal dispersion of an instantaneous release of strength M in a layer of vertical thickness D are developed which predict that the peak concentration should decrease in proportion to the inverse second power of time, which is just the relationship found empirically from the dye study in the Conowingo Pond.

The work of Joseph and Sendner cannot be extended to treat the case of a continuous point source discharge. However, both of the other studies are amenable to such extension. In both cases the equations so developed predict that the concentration in the center of the plume of contaminant which develops downstream from the source will decrease in proportion to the inverse first power of distance from the source, which again is confirmed by the dye experiments in Conowingo Pond.

The equations developed by Schönfeld on the one hand and by Pritchard and Okubo on the other give essentially the same results for the maximum concentration in the center of the dispersing volume from an instantaneous release, and also along the axis of the downstream plume from a continuous release. These equations differ with respect to the shape of the concentration distribution outside the center of the dispersing volume and laterally from the axis of the plume. As shown by Pritchard and Carpenter ("Measurements of turbulent diffusion in estuarine and inshore waters". Proc. of Symposium on Tidal Rivers, International Union of Geodesy and Geophysics XII General Assembly, Helsinki, Finland, July 25-August 6, 1960, pp. 37-50.), the equation developed by Pritchard and Okubo appears to fit the lateral distribution in the spreading plume from a continuous source somewhat better than that developed by Schönfeld. In the following, therefore, the work of Pritchard and Okubo will be utilized.

This study is restricted to conditions relatively unfavorable to rapid dispersion to the pond. In the summer, thermal stratification develops which greatly restricts vertical mixing. Much of the vertical extent of the pond is therefore not available as dilution water for radioactive materials which might enter the pond.

Consideration is given to three different cases involving discharge of radioactive materials to the pond. First the case of a nearly instantaneous release of activity into the pond at the condenser outfall is considered. Such a release might occur as a result of the accidental rupture of a tank containing collected "drips", or in some other manner not specified here. The local volume contaminated by such a release will move downstream with the flow, and will diffuse into an ever-increasing volume with ever-decreasing concentrations. The time-space variations in concentration about the center of the horizontally dispersing volume after release in a medium of infinite horizontal extent can be expressed by:

$$C(r, t) = \frac{M}{2\,DP^2t^2} \exp - \left[\frac{r^2}{2P^2t^2}\right] \tag{1}$$

where C(r,t) is the concentration at distance r from the center of the contaminated volume at time t; M is the source strength; D the thickness of the layer in which vertical mixing is restricted by thermal stratification; and P is a constant "diffusion velocity".

The Conowingo Pond of course is not of infinite horizontal extent. The boundary conditions at the sides of the pond can be satisfied by reflecting the above solution from the shores. This is accomplished by considering the dispersion from pseudo sources which are located as mirror-images of the true source on land on either side of the pond, and adding the contribution from all these sources.

For present purposes the pond is considered as having a rectangular surface area, 1,500 meters wide and 15,000 meters from the source to the dam. Designating the velocity directed toward the dam as U, the distance from the west shore to the point of release as a, and the distance from the point of release to the east shore as b, equation (1) becomes, in a rectilinear coordinate system with the x-axis directed downstream and the y-axis laterally across the pond, centered at the point of release and positive toward the east shore:

$$\frac{C}{M} = \frac{1}{2\,DP^2t^2} \exp\left[-\frac{(x-Ut)^2}{2P^2t^2}\right]\left\{\exp\left[-\frac{y^2}{2P^2t^2}\right] + \exp\left[\frac{(y-2a)^2}{2P^2t^2}\right] + \exp\left[\frac{(y^2+2b)}{2P^2t^2}\right]\right\} \tag{2}$$

Here the effect of two mirror-image pseudo sources, one on each shore, has been included to take into account the reflection at the shore line.

In the first two dye experiments discussed in the previous section, lateral reflection did not appear to be important. The empirical fit of the data gave the relationship:

$$\frac{C_P}{M} \cdot D = \frac{1.2 \times 10^4}{t^2}$$

for the length parameter in meters and the time parameter in seconds. Comparison of equation (1) with the above equation indicates that, for Conowingo Pond

$$\frac{1}{2\pi P^2} = 1.2 \times 10^4$$

or

$$P = 3.6 \times 10^{-3} \ m \cdot s^{-1}$$

These experiments were conducted during a period of peaking power plant operation when the mean daily discharge was of the order of 10,000 second-feet. As will be shown later, this value of P is nearly the same as that computed from the continuous dye release experiment conducted when steady flows of over 100,000 second-feet occurred. Thus the value of the diffusion velocity P does not appear to vary to any significant extent with river flow, at least within the flow range normally encountered in Conowingo Pond.

The source is not a true point source, since mechanical dilution will have occurred within the condenser discharge prior to release. The fact that there is thus a finite, rather than a theoretical infinite, initial concentration may be treated by introducing a pseudo time correction which represents the time which would have been required by natural dispersion to reduce the concentration to the actual initial concentration. If V_c represents the volume of condenser discharge which has been mechanically mixed with the source prior to release, then the initial concentration is simply $C_o = M/V_c$. The pertinent form of equation (2) is

$$\frac{C}{M} = \frac{t_o^2}{V_c (t + t_o)^2} \exp\left[-\frac{(x-Ut)^2}{2P^2 t^2}\right]\left\{\exp\left[-\frac{y^2}{2P^2 t^2}\right] + \exp\left[-\frac{(y-2a)^2}{2P^2 t^2}\right] + \exp\left[-\frac{(y+2b)^2}{2P^2 t^2}\right]\right\} \quad (3)$$

where the time correction term, t_o, is given by $t_o = \frac{1}{P}\sqrt{\frac{V_c}{2\pi D}}$ (4)

The ratio of concentration, in curies / m^3, to the amount of activity released, in curies, has been computed from equations (3) and (4) for the following conditions:

(a) Flow and vertical mixing are considered to be restricted by thermal stratification to a layer 5 meters thick (i.e. D = t meters).

(b) The flow is taken at 5,000 cfs (case 1 a) and at 50,000 cfs (case 1b).

(c) The volume V_c of condenser discharge initially mixed with the contaminant is taken as 2×10^3 m^3. Note that the choice of this parameter is important only in the early stages of dispersion.

(d) The diffusion velocity, $\underline{P}$, is taken at 3×10^{-3} meters/sec. This value is somewhat less than the 3.6×10^{-3} $m \cdot s^{-1}$ determined empirically from the dye experiments in Conowingo Pond, and should provide conservative estimates for all flow conditions.

(e) The point of release is taken at 500 meters from the west shore.

Conditions (a) and (b), together with an assumed constant width of 1,500 meters, provide the information that the center of the dispersing contaminated volume would reach the vicinity of the Baltimore water intake in about 10 days for case (1 a) and in about one day for case (1b).

Table III - 6 (Appendix B) lists the computed ratios of concentration to the amount of activity discharged as a function of relative position about the center of the diffusing volume for 12 hours, 1 day, 5 days, and 10 days. Here $x' = x - U_t$, and hence $x' = 0$, $y = 0$ is the center of the contaminated volume. For case (1 a) x' is located about 750 meters below the discharge point at 12 hours, 1,500 meters downstream at 1 day, halfway to the dam at 5 days, and at the dam in 10 days. For case (1b) the center is located halfway to the dam at 12 hours, and at the dam at one day. The distribution appears to extend downstream from the dam as if the reservoir continued on downstream.

The second case for which initial computations have been made is for a continuous discharge of activity with the condenser cooling water. This might be a normal operating condition, in which case the amount released would presumably be kept at very low levels, or it might be a temporary condition resulting from a slow leak.

The pertinent equation for a continuous point source, having a strength per unit time of Q_r, discharged into a current U along the x-axis, is given by:

$$C(x, y) = \frac{Q_r}{2\sqrt{2\pi}\, DP\,(x^2+y^2)^{1/2}} \exp\left[-\frac{U^2 y^2}{2P^2(x^2+y^2)}\right]\left\{1+\Phi\left[\frac{xU}{2P(x^2+y^2)^{1/2}}\right]\right\} \quad (5)$$

Again, this equation must be reflected at the east and west shores in order to satisfy the side boundary conditions. If the solution is applied only to distances of 1 km or more downstream, the point source assumption is reasonably valid.

Under conditions of U>>P, which is the case in the Conowingo Pond, the function Φ in the last term in brackets in equation (5) approaches a constant value of unity. In the continuous release dye experiment, it was empirically found that along the axis of the plume (y=0),

$$\frac{C_p}{Q_r} \cdot D = \frac{2.0 \times 10^2}{x}$$

Comparison of this equation with equation (5) under conditions of a single reflecting boundary (the dye was released near the western shore, at flow rates such that no significant reflection occurred at the eastern shore), indicates that

$$\frac{2}{\sqrt{2\pi}P} = 2.0 \times 10^2$$

or

$$P = 4.0 \times 10^{-3}\ m \cdot s^{-1}$$

This value, found for flow rates of over 100,000 cfs, is very close to the $3.6 \times 10^{-3}\ m \cdot s^{-1}$ found from the instantaneous release experiment under very much smaller flow rates. Thus the assumed value of $3.0 \times 10^{-3}\ m \cdot s^{-1}$ for the diffusion velocity appears to be conservative for all flow rates.

Equation (5) has been utilized to compute the stead state distribution of the ratio C/Q_r for the following conditions:

(a) The mixing and flow is restricted by thermal stability to a layer 5 meters thick;

(b) the velocity U is taken at 2×10^{-2} m/sec corresponding to a flow of 5,000 cfs.

Table III - 7 (Appendix B) lists the values of the ratio C/Q_r for these conditions at selected values of the lateral coordinate from -5×10^{-2} m (the west shore) to a $+10^3$m (the east shore) and for selected values of the longitudinal coordinate downstream to a distance of 10 kilometers below the outfall. The location of the outfall again was assumed to be 500 meters from the west shore and 1,000 meters from the east shore. As a result of the effects of the side boundaries, the distribution becomes uniformly spread out across the pond fairly rapidly in the downstream direction.

In the lower pond the concentration will become simply that which would result from complete mixing of the steady rate of discharge of material with the assumed steady inflow of fresh water. Thus, with the assumed flow, (Q_f), of 5,000 cfs (141 m^3/sec), the final steady state concentration would be given by:

$$C = \frac{Q_r}{Q_f} = \frac{Q_r}{141}$$

or the ratio C/Q_r is given by

$$C/Q_r = 7.1 \times 10^{-3}$$

for C in curies/m^3 and Q_r in curies per second. It is seen from Table III - 7 (Appendix B) that this concentration has been nearly reached 10 kilometers below the discharge point.

An inspection of equation (5) reveals that, for the case of U>>P, the flow rate has no significant effect on the concentration along the axis of the plume. Flow rate does, however, significantly influence the lateral spread of the plume at any given distance downstream from the discharge point. Thus, for a flow of 50,000 cfs, the maximum concentrations along the axis of the plume (y=0) would be approximately the same as given in Table III - 7 (Appendix B), but the lateral spread at any given value of x would be only about one-tenth as great as that indicated in the table.

The effect of a discharge right at the shoreline, rather than at a distance of 500 meters off-shore, would be to significantly increase the concentrations near the source only. The concentration at a distance of 10^3 meters downstream from the discharge point would be increased by approximately 50 per cent, but for all distances beyond 2×10^3 meters the increase over the values listed in Table III - 7 for y=0 would be less than 10 per cent.

In both cases treated above, the flow and mixing were assumed to be restricted to a layer 5 meters thick, though no condition was placed on the actual depth at which this layer occurred. In the upper end of the pond the five meter interval would extend from the surface to the bottom. However, at about 10 kilometers above the dam, the depth changes relatively rapidly. The depth interval within which the flow will be contained depends on the temperature of the waters in the upper end of the reservoir and on the thermal stratification in the lower pond. Studies to date indicate that under various combinations of weather history the water flow through the lower pond and out through the turbines may occur at almost any depth interval from surface to bottom. The values of dilution ratio given in Tables III - 6 and III - 7 (Appendix B) then apply to the 5 meter layer within which the flow is confined, which may occur at any depth dependent on the previous and current weather situations.

The third case treated is that of washout of activity, which had previously been released to the atmosphere, onto the surface of the pond in direct rainfall. The inital distribution of washout on the surface is assumed to be that described in the meteorological section for the case of an inversion with low wind velocities up or down the canyon containing the pond. The surface concentration of activity, in curies per unit surface area, is related to the distance up or downstream from the atmospheric source by the relationship

$$\zeta = \zeta_o e^{-\kappa |x|} \qquad (6)$$

where ζ_o is the maximum washout concentration, and occurs at the locale of the source. For the particular meteorological situation assumed, κ has a value of about $2.5 \times 10^{-4} m^{-1}$.

In order to treat the dilution of this surface source of varying concentration along the pond, a modified form of a line source equation for diffusion has been utilized. The concentration C at a distance x from an instantantaneous line source of total strength M and confined length l, a time t after release, is given by

$$C = \frac{M}{\sqrt{2\pi}\, DlPt} \exp\left[-\frac{x'^2}{2P^2 t^2}\right] \qquad (7)$$

where $x' = x - Ut$.

$\underline{U}$ is the velocity along the x-direction, and $\underline{D}$ is the mixing depth.

Now the strength M can be related to the peak surface concentration ζ_o, since

$$M = \int_0^\infty \ell \zeta \, dx = \ell \zeta_o \int_0^\infty e^{-\mathcal{H} x} \, dx = \frac{\ell \zeta_o}{\mathcal{H}} \qquad (8)$$

Therefore, equation (7) becomes

$$\frac{C}{\zeta_o} = \frac{1}{\mathcal{H} \sqrt{2\pi} \, DPt} \exp \left[- \frac{x'^2}{2P^2 t^2} \right] \qquad (9)$$

Since the source is not a true line source, the time $\underline{t}$ in equation (9) must be corrected by a pseudo time, t_o, such that, at time $t = 0$, the peak concentration in the water is given by $C_p = \zeta_o / D$. Thus:

$$t_o = \frac{1}{\mathcal{H} \sqrt{2\pi} P} \qquad (10)$$

and

$$\frac{C}{\zeta_o} = \frac{t_o}{D\,(t + t_o)} \exp \left[- \frac{x'^2}{2P^2 (t + t_o)^2} \right] \qquad (11)$$

Now, at time $t = 0$, the source is on the very surface. As time proceeds, the depth to which the activity is mixed in the pond increases. It is therefore assumed that $\underline{D}$ is a linear function of time; i. e.:

$$D = \beta t \qquad (12)$$

and

$$\frac{C}{\zeta_o} = \frac{t_o}{\beta\, t(t+t_o)} \quad \exp\left[-\frac{x'^2}{2P^2\,(t+t_o)^2}\right] \tag{13}$$

The value of β is taken at 2×10^{-5} m/sec; that is, the depth to which the activity is mixed is assumed to increase at a rate of about 1.7 meters per day. The diffusion velocity $\underline{P}$ is taken at 3×10^{-3} m/sec, and [illegible] at $2.5 \times 10^{-4} m^{-1}$.

The above conditions have been utilized in Equation (13) to compute the ratio C/ζ_o for selected values of the distance from the locale of the maximum concentration, for one day, five days, and 10 days after the washout. These values are listed in Table III-8 (Appendix B). The maximum concentration would occur at about halfway between the source and the dam at five days, and would be in the vicinity of the dam in 10 days. The longitudinal coordinate in this table is given relative to the location of the line of maximum surface concentration, which would move downstream with the flow velocity $\underline{U}$. Therefore, for a discharge of 5,000 cfs the distribution at 10 days would be centered at the dam, while for a discharge of 50,000 cfs the distribution for 1 day would be centered at the dam.

H. Silting

Since the completion of the Conowingo Dam in 1928, five surveys have been made to determine the loss of storage capacity by deposition of silt in Conowingo Pond. The first survey was made during the summer of 1936 and the last in May and June, 1957. Reports on sedimentation were prepared in 1936[5] and 1943[6].

Refuse from the cleaning of river coal for the Holtwood Steam Plant, which is just upstream from the Holtwood Dam, together with the ashes are deposited downstream from the dam and washed into Conowingo Pond. This amounts to approximately 3 million cu. ft. per year.

Sounding made in 1943 showed considerable evidence of silting in the upper reaches of Conowingo Pond. The silt was coarse river sand with a high content of river coal. It was concluded

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5. Lane, Richard A., "Erosion or Silting of Reservoir, Conowingo Hydro Plant," The Philadelphia Electric Co., March 3, 1957.

6. Lane, Richard A. and Turner, Robert E., "Sedimentation in the Conowingo Reservoir and Other Reservoirs on the Lower Susquehanna River," The Philadelphia Electric Co., August 17, 1943.

however, that in 1943 the conditions in the entire pond had not changed a great deal considering the number of years that the plant had been in operation.

Comparison of the 1957 soundings with those of 1943 indicates that depths in the upper end of Conowingo Pond are approaching stability and that most of the deposition in recent years has occurred in the middle and lower reaches. See Table III-9 (Appendix B). The average rate of filling appears to be in the vicinity of 0.4 ft. per year. This rate is sure to decline as a result of increased velocities through the pond as it fills with silt, and as a result of flood reservoir construction on upstream tributaries. During great floods like that of 1936, scouring may remove considerable volumes of silt. It is, therefore, difficult to predict when and at what depths the pond bottom may become relatively stable.

Studies of circulation and displacement are under way in an attempt to predict the effect of silting upon the future behavior of Conowingo Pond.

I. Ground Water Hydrology

The Peach Bottom Site is situated in the Piedmont province, which is the foothill region of the Appalachian Mountains, where the rocks are largely hard Precambrian or lower Paleozoic schist, quartzite, granite, gobbro, marble and phyllite. The soil overburden is generally shallow, 10 to 30 feet in depth, and consists of decomposition products of the underlying rock.

Groundwater occurs in the overburden and in the fissured and weathered upper zone of rocks under water table conditions. The water table slopes in the general direction of the ground surface. The levels rise in the winter and spring and decline during the summer growing season. The underground movement of water is generally from the hill tops downward toward the small springs and streams that occur abundantly throughout the area. Groundwater is used throughout the area for rural and domestic wells. Yields are small, generally less than 10 gallons per minute, except in a few localities. Groundwater is not a major resource. The relative small quantity of water withdrawn from the ground is rainwater that has soaked into and been stored in the overburden immediately surrounding a well.

The joints and other fractures are the only openings in the fresh crystalline rocks through which water may move with sufficient rapidity and in sufficient volume to supply a well. There are generally two systems of joints oriented at right angles to each other and a third system crossing them at an oblique angle. Joints occur at intervals ranging from a few inches or less in closely jointed rock to several tens of feet in more massive rocks. Joint systems in serpentine and in Peters Creek quartzite of the type that occur in the Peach Bottom area have been observed in cuts and quaries to be several inches wide near the surface of the decomposing and dissolving rock. The widths decrease rapidly with depth.

Loss of drilling water from several holes during core boring operations at the site and injection of water into one test hole indicate that once water finds its way into the upper fissured zone it can at some spots move away rapidly, undoubtedly in the direction of Conowingo Pond. Under natural conditions the rainwater percolates slowly through the sand-clay overburden. Suspended matter is removed by filtration and the mineral content of the water is altered by ion-exchange and solution. The time required and the path followed by the water in moving from the overburden through the rock fissures into Conowingo Pond is unknown. Both time and path must be highly variable. There is, however, almost no possibility that groundwater could move in a direction away from the pond or that it could flow underground to points outside the site.

IV. GEOLOGY

A. Introduction

The following is based on examination of drill cores, study of thin-sections, and field inspection of the site. It includes four core correlation diagrams; a map showing the thickness of the soil and land slide zone and elevation contours on the base of this zone; a map showing the depth from the surface to the base of a zone of fractured bedrock and the elevation contours on this base; and this brief written discussion.

It has been assumed that all drilling was straight. Considerable interpretation is involved in preparation of the maps, both in reading the cores, and in contouring. Accuracy is probably no better than one contour and considerable generalization is undoubtedly present. The site, Figure IV-1 (Appendix A) has only one small outcrop, and most of the general discussion of the geology is based on outcrops in nearby areas.

B. General Geology

The site of the proposed plant at Peach Bottom, York County, Pennsylvania, is on a hillside on the west side of the Conowingo Pond. Bedrock is the Peters Creek schist which here forms the northwest limb of the narrow Peach Bottom syncline. Tight isoclinal folds, thin lenticular bedding, a strong flow cleavage giving a well-developed schistosity, and many joints and fractures characterize the schist. Cleavage and bedding strike on the average about N 35 E and dip about 70 degrees to the southeast. Many of the fractures roughly parallel the cleavage (schistosity). Many joints form two sets, one striking north and dipping west, the other striking east and dipping north; but joints having other random attitudes are common.

Bedrock is exposed on the site only in a small outcrop near hold C-7, Figure IV-1, (Appendix A) and another one at the shore of the reservoir. Bedrock elsewhere is overlain by unconsolidated material, primarily red to brown sandy clay with numerous rock fragments, some of boulder size. This unconsolidated material is dominantly rock slide that has weathered in varying degree to sandy clay and more or less rotten boulders, along with some clay and sand formed as slope wash. The weathering and typical soil profile on the slide indicate that it is old, probably Pleistocene, but it undoubtedly is still very slowly moving downhill as ordinary hill-slope creep.

C. Core Data

The grid on which the cores were taken is shown in Figure IV-1 (Appendix A). Core data are shown in Figures IV-2 through IV-5 (Appendix A).

Three main units were differentiated in the cores: (1) the upper weathered soil, slide rock, and alluvium; (2) a zone of fractured and more or less weathered bedrock beneath zone 1; and (3) fresh and relatively unfractured bedrock.

Zone 1. The base of zone 1 was picked where the driller transferred to core bits and commenced to obtain cored samples. This limit is somewhat arbitrary and may be off as much as three or four feet. Some of the last spoon samples were of more or less weathered pulverized schist which probably represents the upper limit of bedrock essentially in place. However, this rock is so weathered that, as far as strength is concerned, it belongs with zone 1 rather than zone 2.

Spoon samples from zone 1 show a soil profile typical of this area, although somewhat thinner than encountered generally on flat hilltop areas. The upper foot or so is brown to black loamy soil followed by an underlying zone of red to brown sandy clay with soft, clayey, highly weathered schist fragments and iron-stained quartz pebbles. This is in turn underlain by a brown to gray zone gradational into bedrock in which the clay becomes more and more sandy and micaceous, rock fragments less and less weathered, and the ratio of rock fragments to clay increases.

The core correlation sheets and the map of the contours on the base of zone 1 and of the thickness of zone 1 clearly show that the zone thickens downslope from row D to rows A and B. At the site maximum thickness is about 26 feet and the presence of a landslide fan or toe some 25 feet thick near hole B-6 is apparent.

It should be noted that the base of zone 1 lies below the reservoir level approximately as far inshore from the pond as row B at the site. In addition to this problem of excavation below water level, zone 1 is undoubtedly actively creeping and will require stabilization upslope from excavation limits.

Zone 2. Criteria for choosing the base of this zone of more or less fractured and weathered bedrock were: (1) much fractured cores in which the fractures were not along cleavage planes; (2) the presence of iron-staining and bleached micas indicating weathering and alteration; and (3) core recovery of less than 60%.

This last criteria depends to some extent, of course, on the skill of the driller and how hard he pushes his drill. Included within zone 2 are some cores having thin zones, rarely more than 5 feet long, in which the rock was not particularly fractured and core recovery was better than 60%. A number of holes, as indicated on the correlation charts, did not reach the base of zone 2. With the exception of core D-5, in those cores which did not reach firm rock, it was assumed for contouring purposes that the base of the hole was the base of the fractured zone. Another error involved in choosing the base of zone 2 is that some cores penetrated firm rock for only 4 or 5 feet. It is possible that this firm rock is only a relatively thin variant in a fractured zone that actually goes deeper.

Depth from the surface to the base of zone 2 is generally in the 20 to 35 foot range, but a zone of fracturing and weathering as much as 92 feet deep and possibly deeper, occurs in the area bracketed by holes B-9, C-9, D-8 and D-9. The trend of this fractured zone is about N 20 E, almost parallel to the strike of the bedding and schistosity. The possibility that this zone also parallels the southeast dip of the schistosity should be taken into account. Drilling hole C-8 to a depth of 70 to 80 feet would serve to check this possibility.

If it is necessary to excavate zone 2 to its base, it will be necessary to go from 28 to 18 feet below the pond level as far inland from the shore as row B at the site.

As the schistosity, bedding, and many of the fractures strike northeasterly and dip steeply southeast, any deep cuts in the fractured zone parallel to this northeast trend will be liable to slab and landslike. It probably will be necessary to stabilize from creep those faces of at least the upper part of zone 2 left standing upslope from excavations.

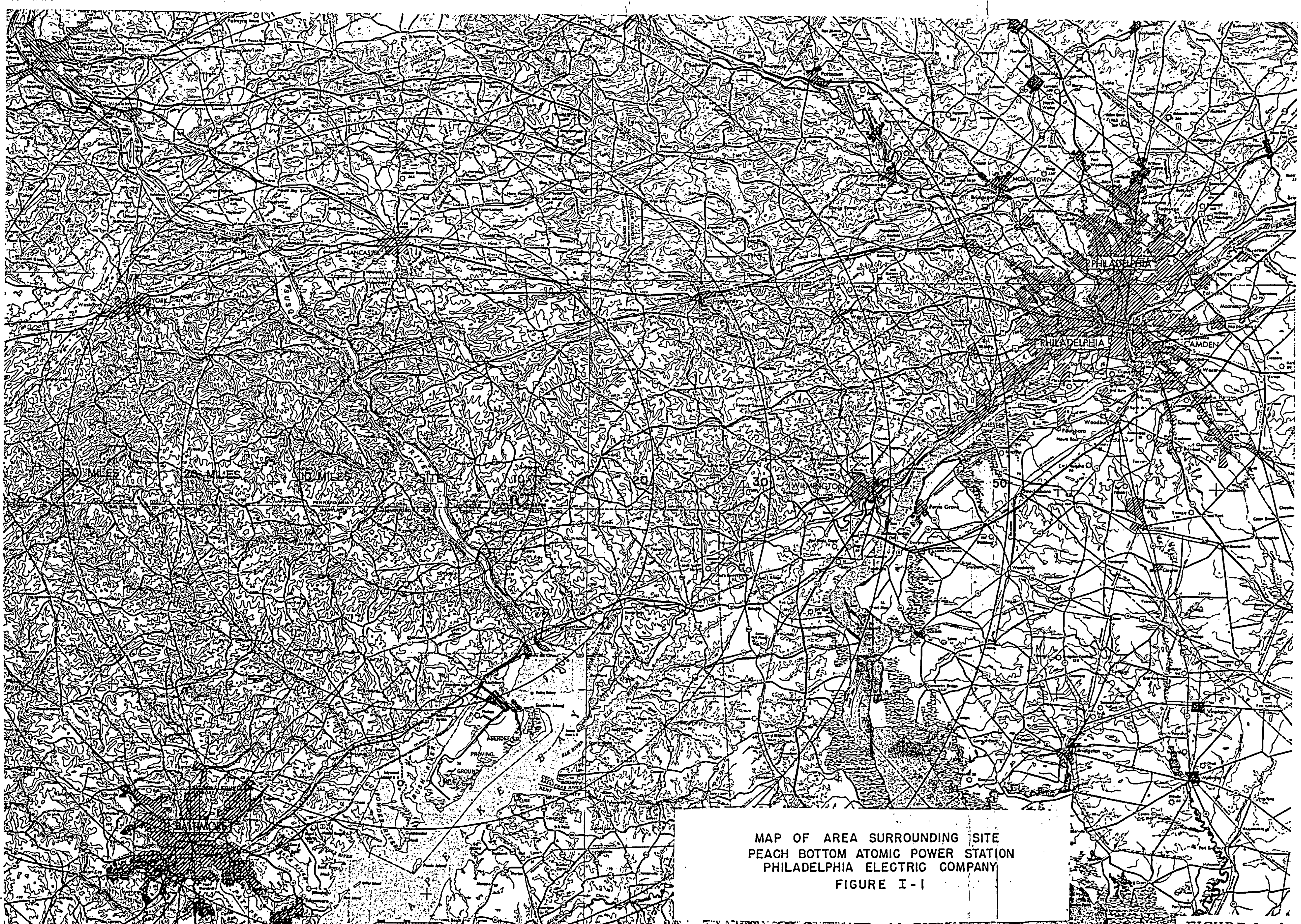
Zone 3. Fresh, unaltered rock, good core recovery and fracturing of cores primarily along cleavage planes served to identify relatively firm bedrock in the cores. The term "relative" is used because the excellent schistosity forms planes along which the rock easily splits, fractures are not completely absent, and there are scattered narrow zones of alteration.

Most of the fresh rock of zone 3 is a quartz, muscovite, chlorite, rather fine-grained schist, commonly finely laminated, with an excellent cleavage. (Quartz-mica schist is synonymous in the core correlation diagrams.) Scattered throughout this schist are zones rich in irregular pods, lenses, and veins of quartz. There are also narrow (less than an inch thick) seams of talc, chlorite, and serpentine

(serpentine seams on the correlation diagrams), commonly associated with the zones of quartz veining. With a decrease in quartz and muscovite, these seamy zones grade into pods and lenses of talc, chlorite, serpentine schist (chlorite schist synonymous) usually carrying pyrite. These are probably discontinuous masses formed by the hydrothermal alteration of the quartz mica schist. They are rarely more than 10 feet thick in any one core and could not be satisfactorily correlated from core to core. They are very soft and cleave very readily.

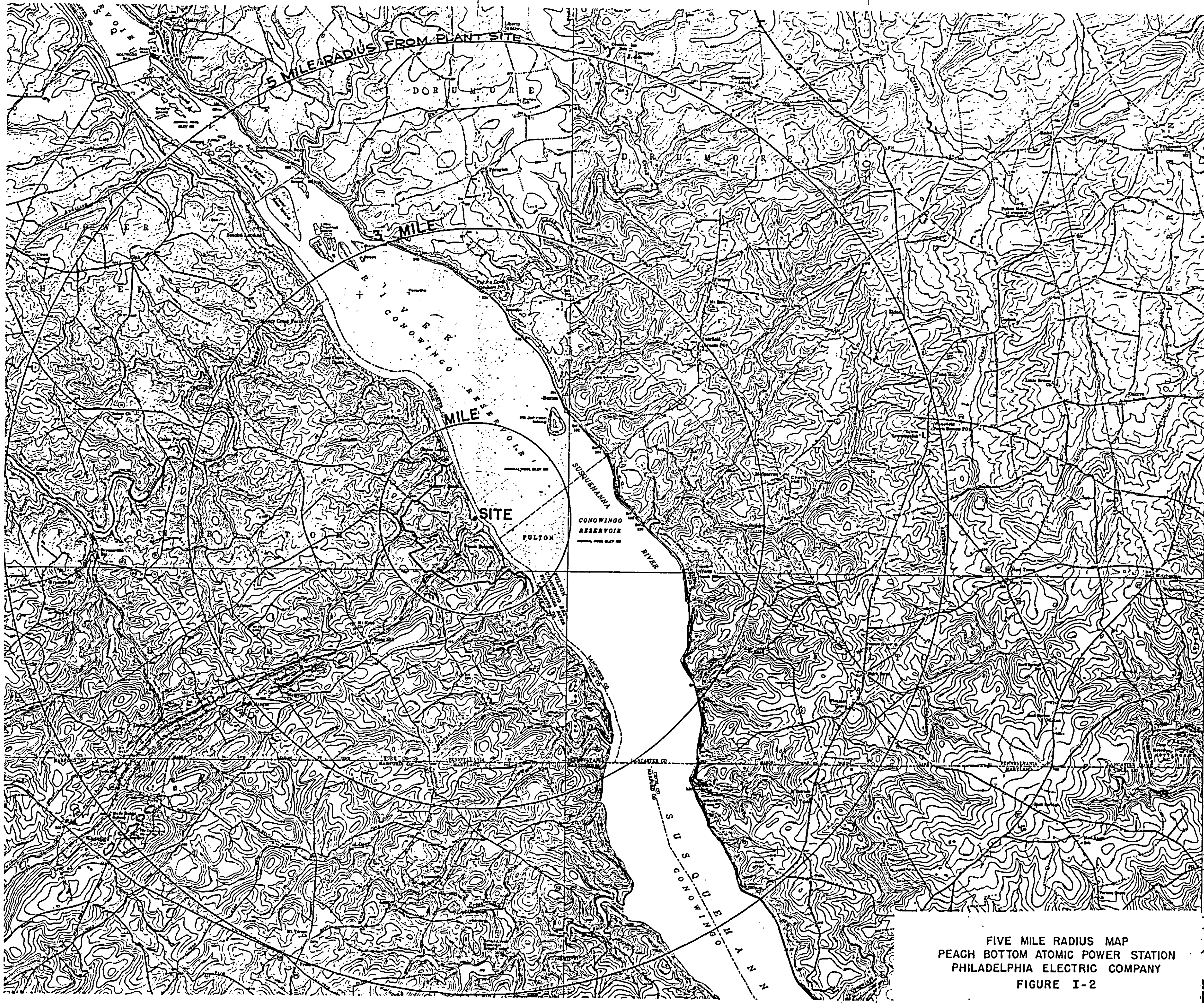
Because of its excellent cleavage, the Peters Creek schist, even where relatively unfractured, may be difficult to blast and bulldoze and attain a surface of firm unfractured rock. Excavation of the Peters Creek schist may entail difficulties like those encountered in excavating for the Pretty Boy reservoir dam. Footings for the dam were in Wissahickon schist, a rock similar to the Peters Creek schist. Continued blasting and bulldozing merely extended the zone of fractured rock ahead of the excavating operation because the schist cleaved very readily due to its excellent schistosity. It was necessary to resort to sawing before firm foundation rock could be found. Whether this situation will be encountered in excavating the Peters Creek schist cannot be certainly predicted, but the possibility will be considered in planning.

Ground water drainage. The depths at which ground water was encountered by the driller are given on the core correlation diagrams. The ground water level, of course, will vary according to the amount of precipitation, so that correlations of the water table from core to core drilled at different times means little. In general, however, it is apparent that ground water level is a subdued replica of the topography, with maximum elevation along row D (160 feet at D-9) and decreasing to approximately pond level along row A. Ground water drainage undoubtedly follows the slope of the topography into the pond, and the fractured nature of the rock probably leads to an open, porous, and permeable system. Excavated faces will probably be wet and, in foundation planning, it should be assumed that abundant ground water will drain downslope towards the pond.

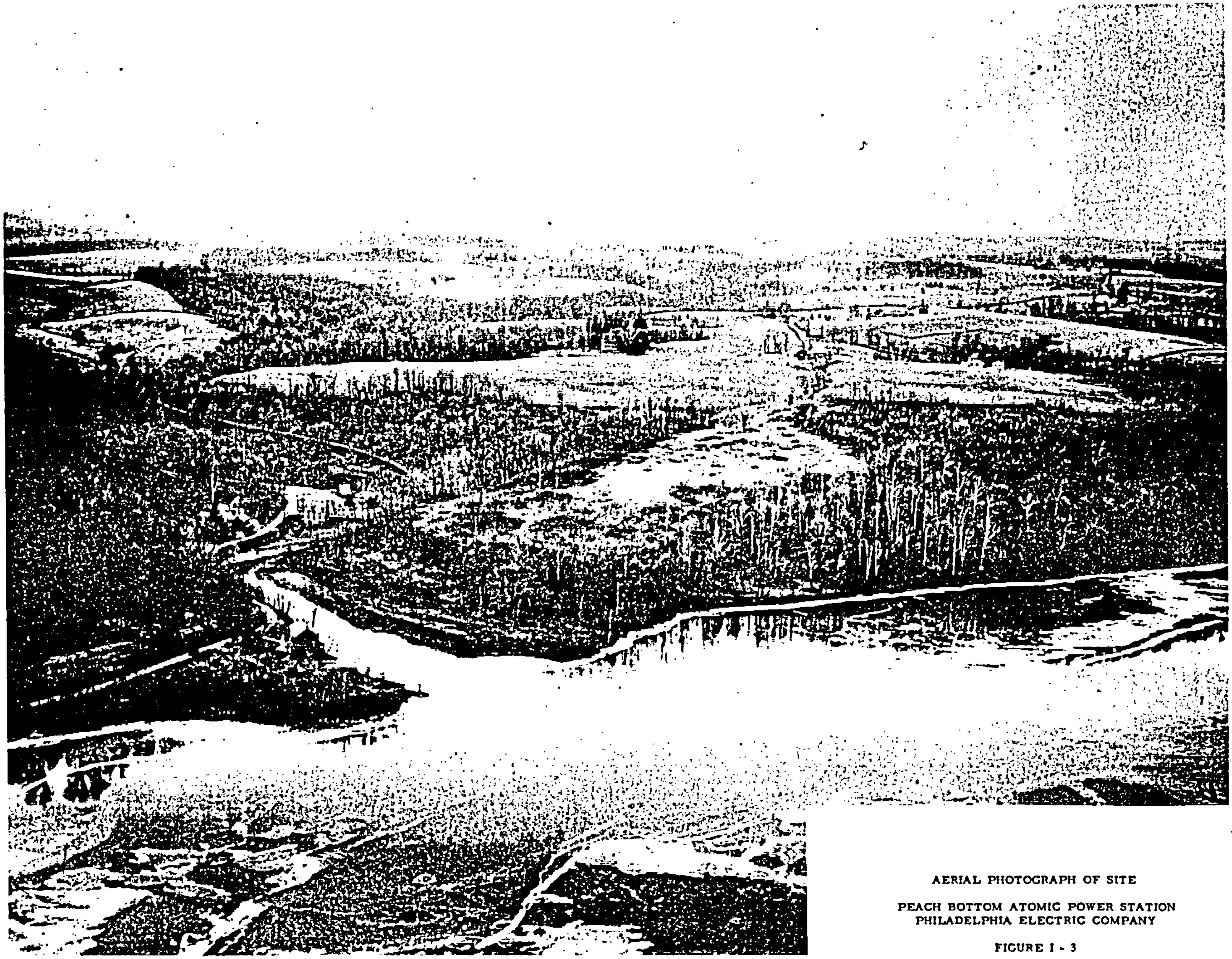


MAP OF AREA SURROUNDING SITE
PEACH BOTTOM ATOMIC POWER STATION
PHILADELPHIA ELECTRIC COMPANY
FIGURE I-1

FIGURE I - 1



FIVE MILE RADIUS MAP
PEACH BOTTOM ATOMIC POWER STATION
PHILADELPHIA ELECTRIC COMPANY
FIGURE I-2

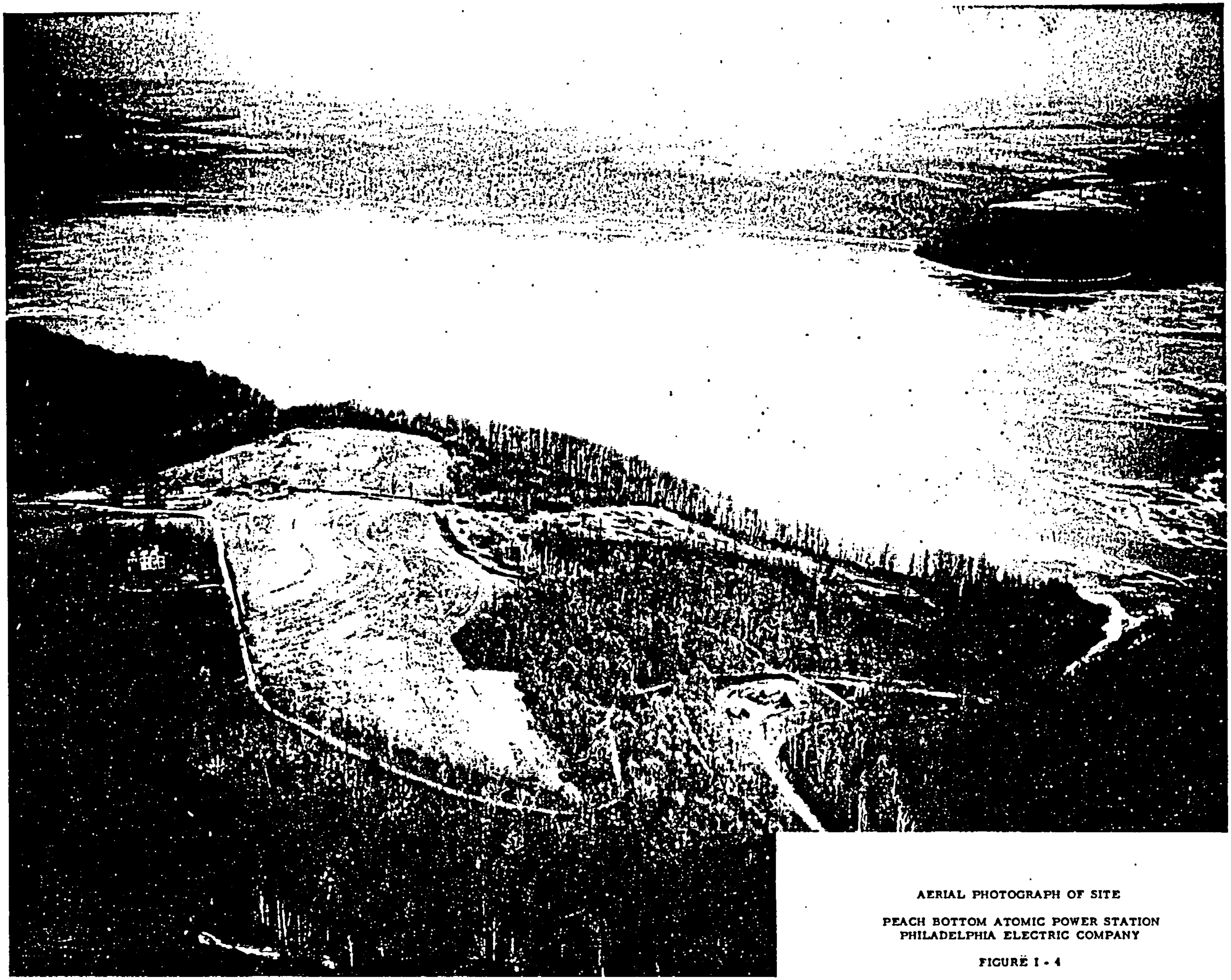


AERIAL PHOTOGRAPH OF SITE

PEACH BOTTOM ATOMIC POWER STATION
PHILADELPHIA ELECTRIC COMPANY

FIGURE I - 3

FIGURE I - 3

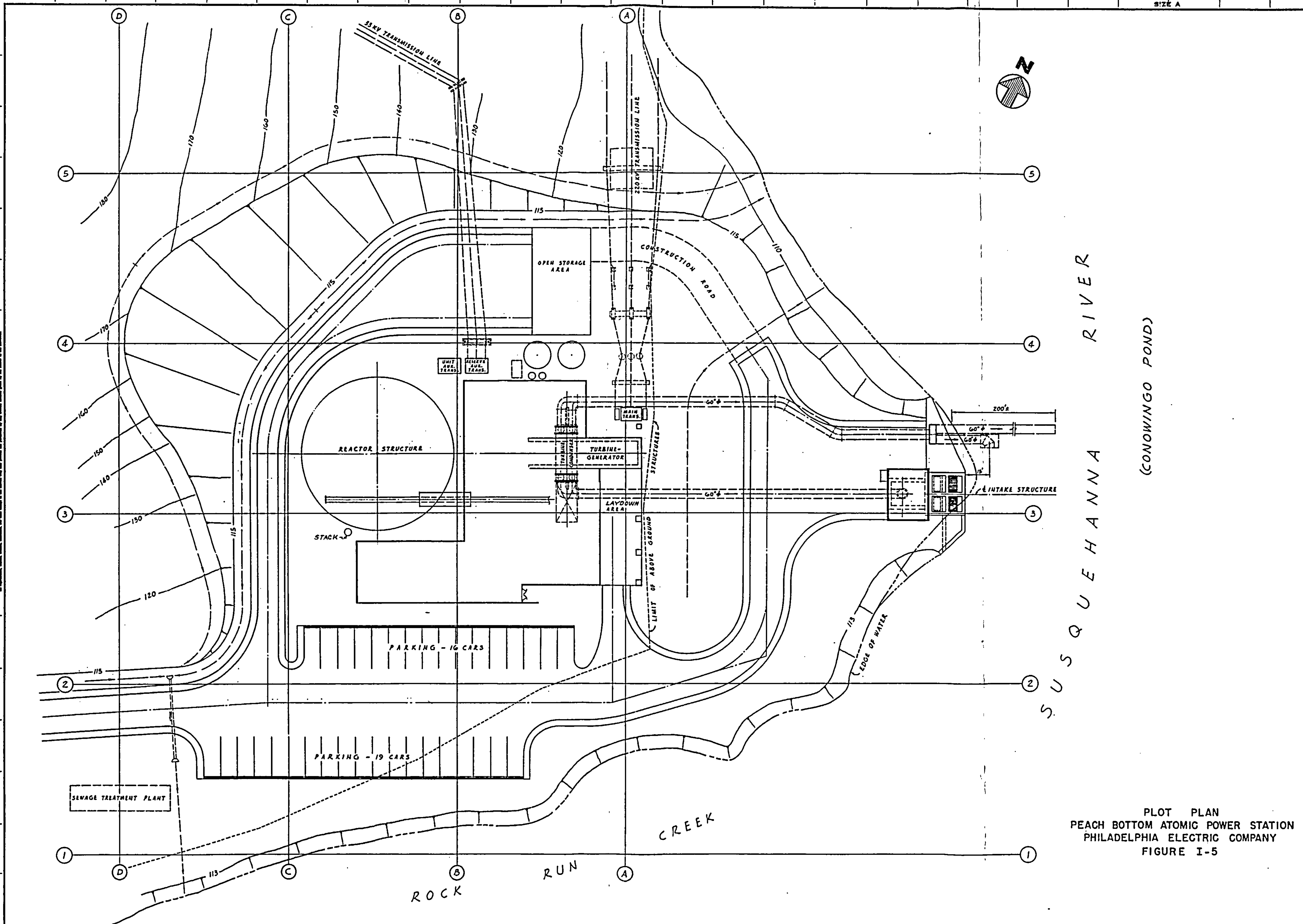


AERIAL PHOTOGRAPH OF SITE

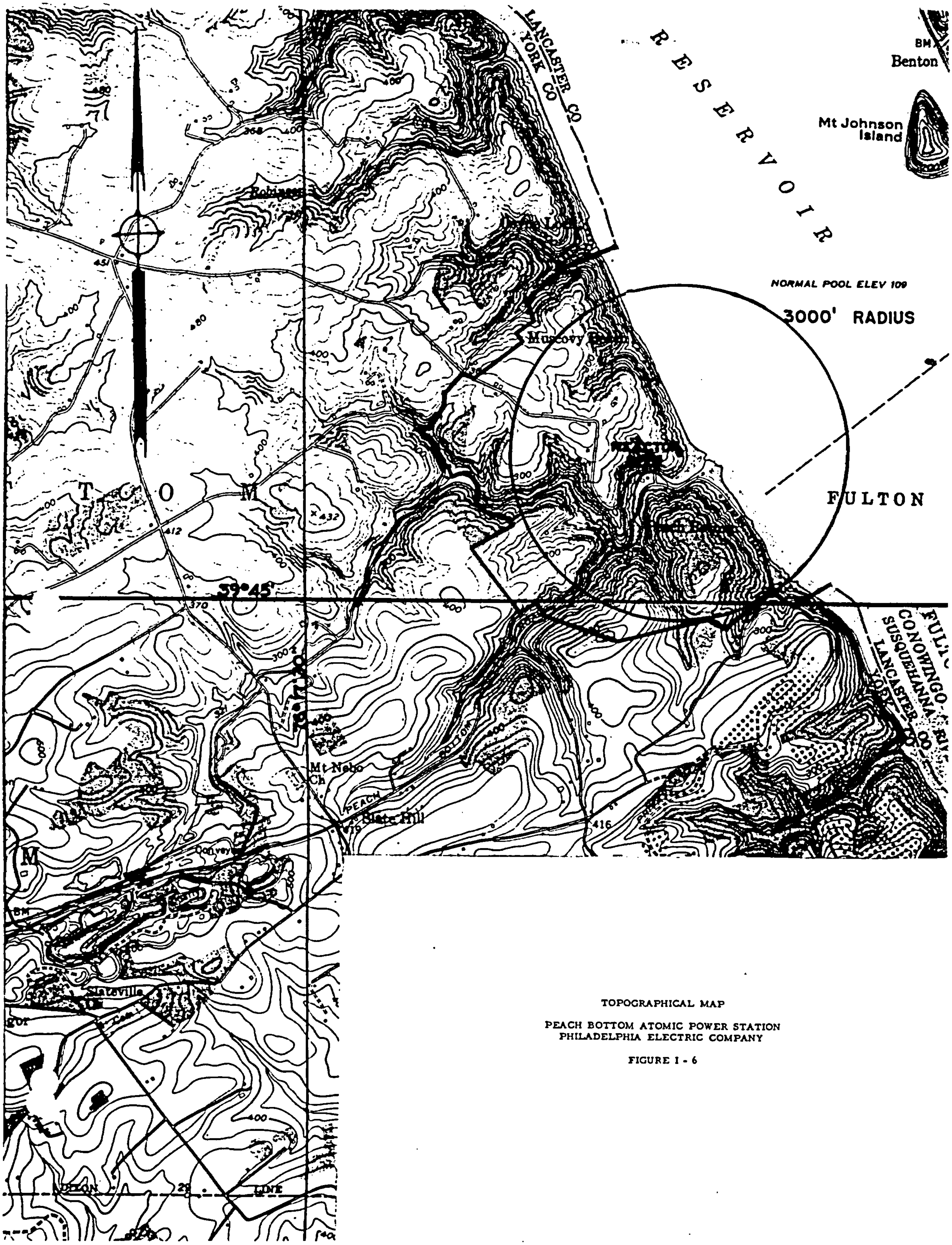
PEACH BOTTOM ATOMIC POWER STATION
PHILADELPHIA ELECTRIC COMPANY

FIGURE I - 4

FIGURE I - 4



PLOT PLAN
PEACH BOTTOM ATOMIC POWER STATION
PHILADELPHIA ELECTRIC COMPANY
FIGURE I-5



TOPOGRAPHICAL MAP

PEACH BOTTOM ATOMIC POWER STATION
PHILADELPHIA ELECTRIC COMPANY

FIGURE I - 6

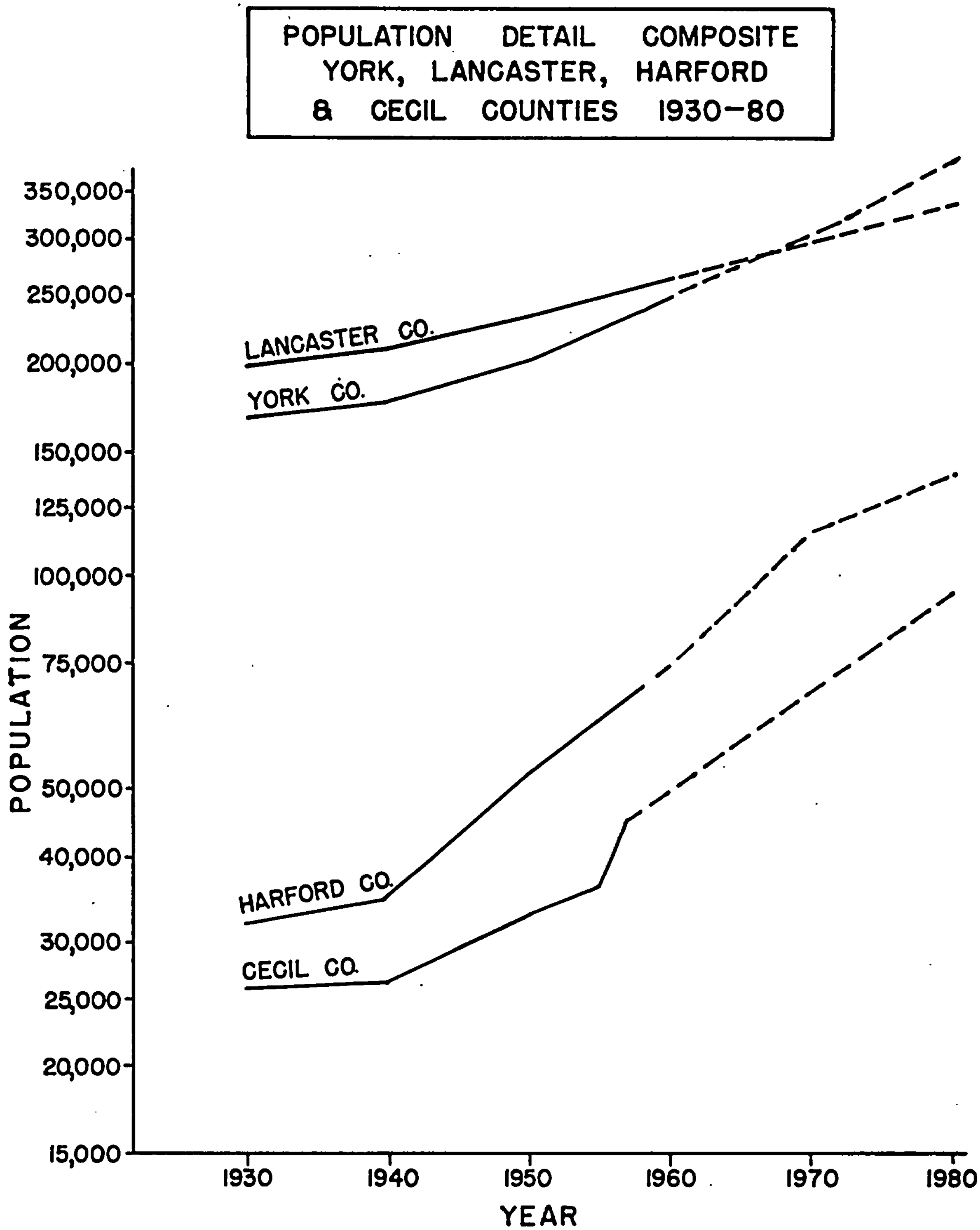
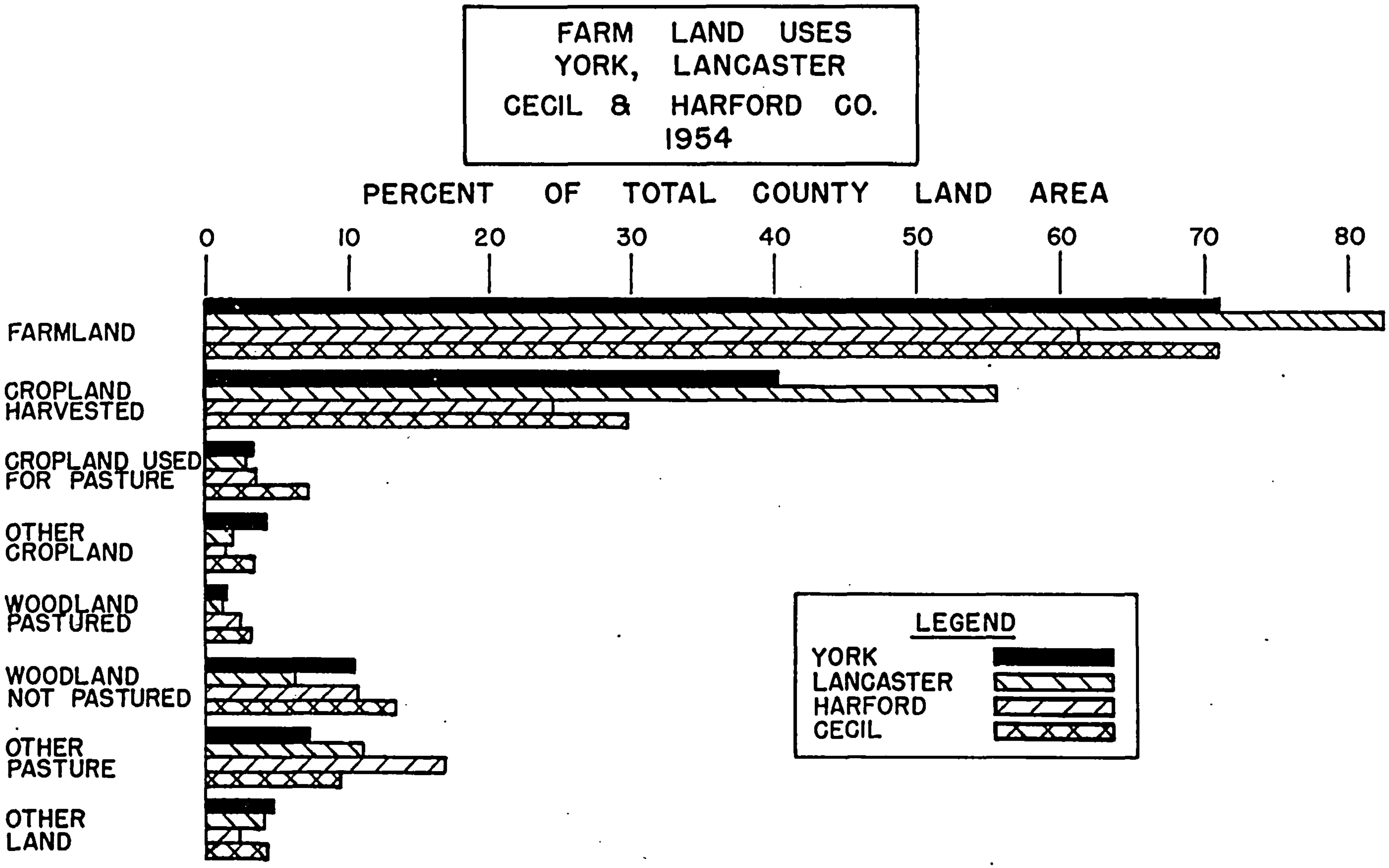

POPULATION DETAIL COMPOSITE
YORK, LANCASTER, HARFORD
& CECIL COUNTIES 1930-80
350,000
300,000
250,000
200,000
150,000
125,000
100,000
75,000
50,000
40,000
30,000
25,000
20,000
15,000
POPULATION
LANCASTER CO.
YORK CO.
HARFORD CO.
CECIL CO.
1930
1940
1950
1960
1970
1980
YEAR

FIGURE I-7

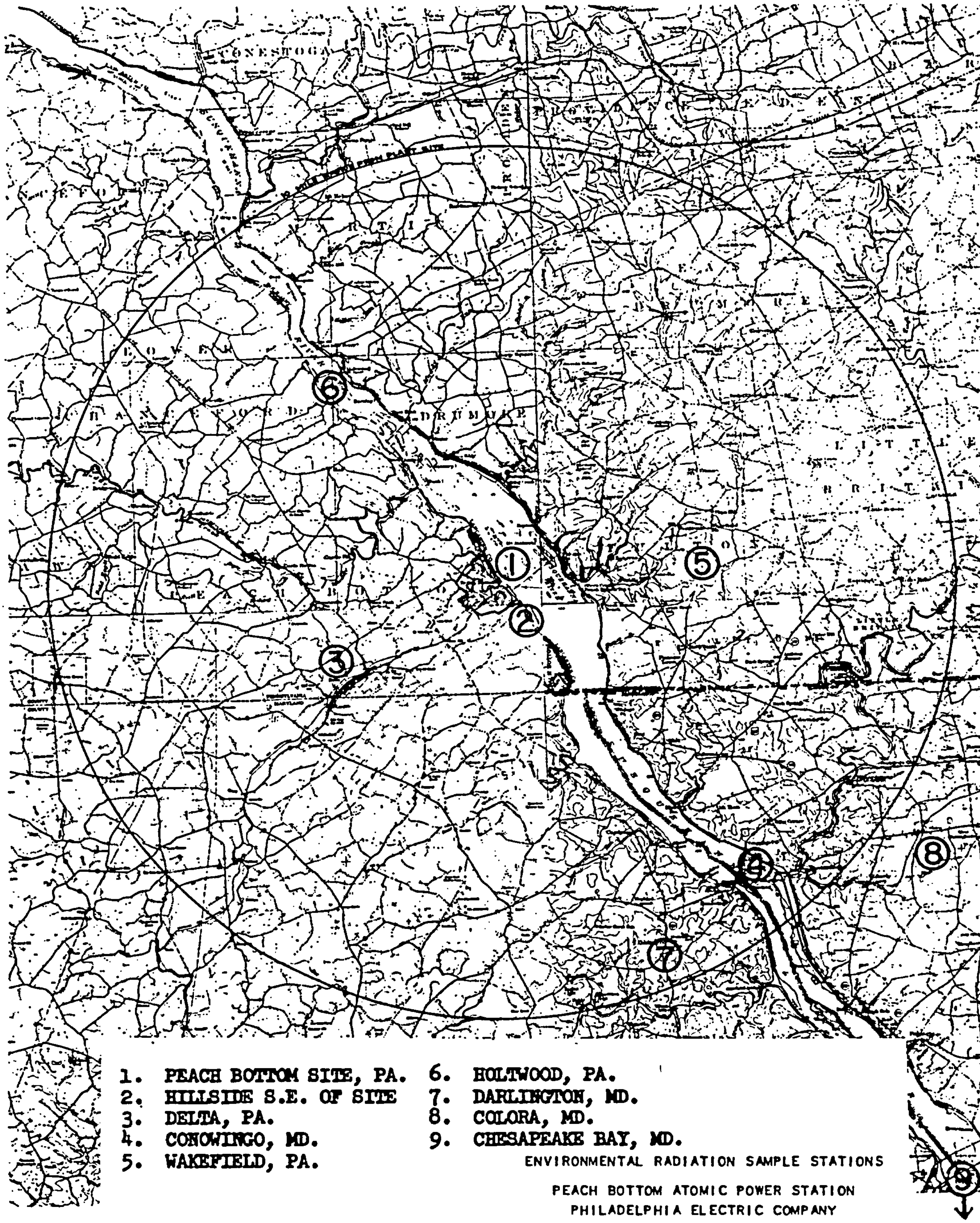


SOURCE: 1954 CENSUS OF AGRICULTURE
U. S. DEPT. OF COMMERCE
NOVEMBER, 1955

FIGURE I-8

FIGURE I - 8

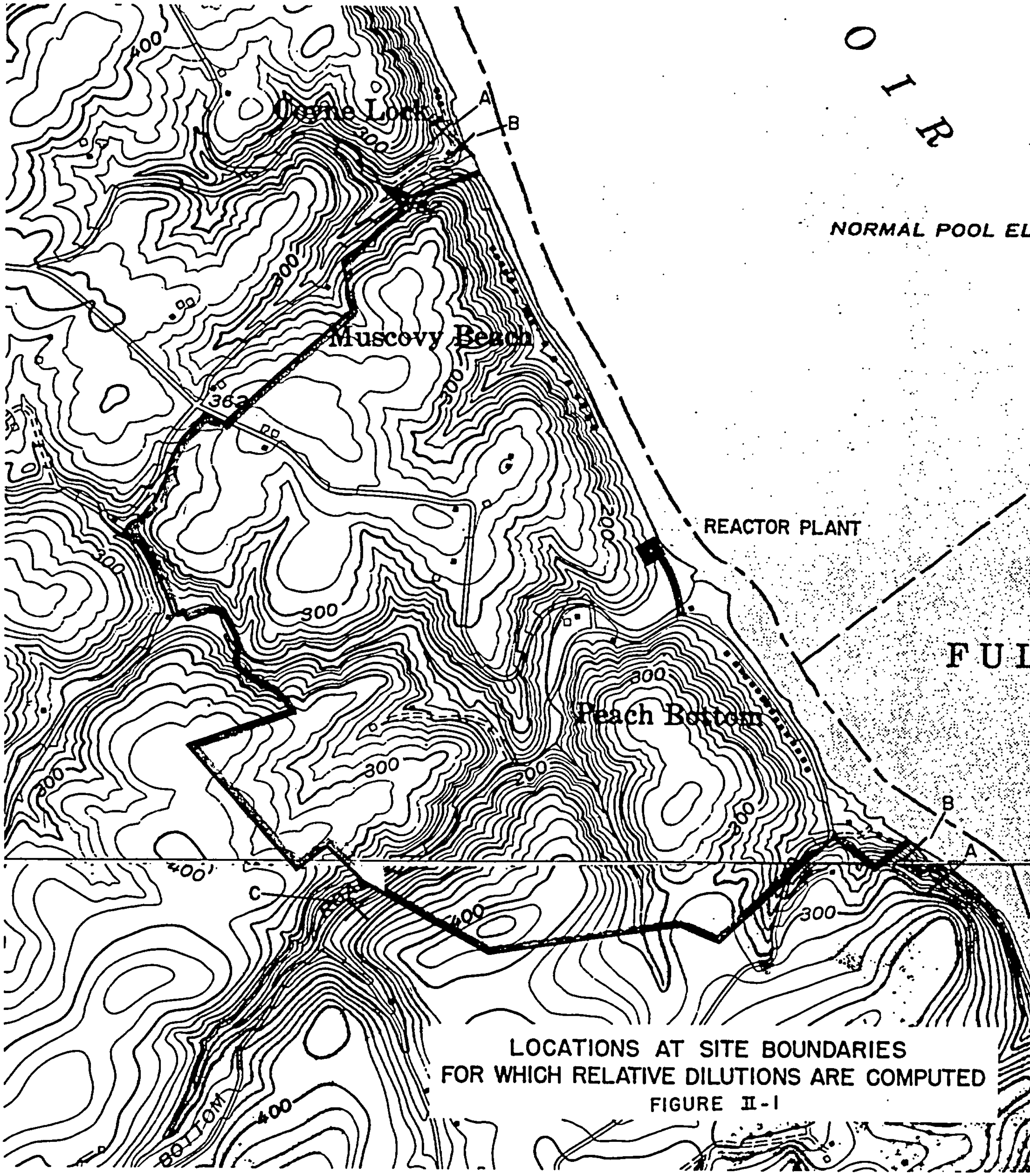
August, 1961



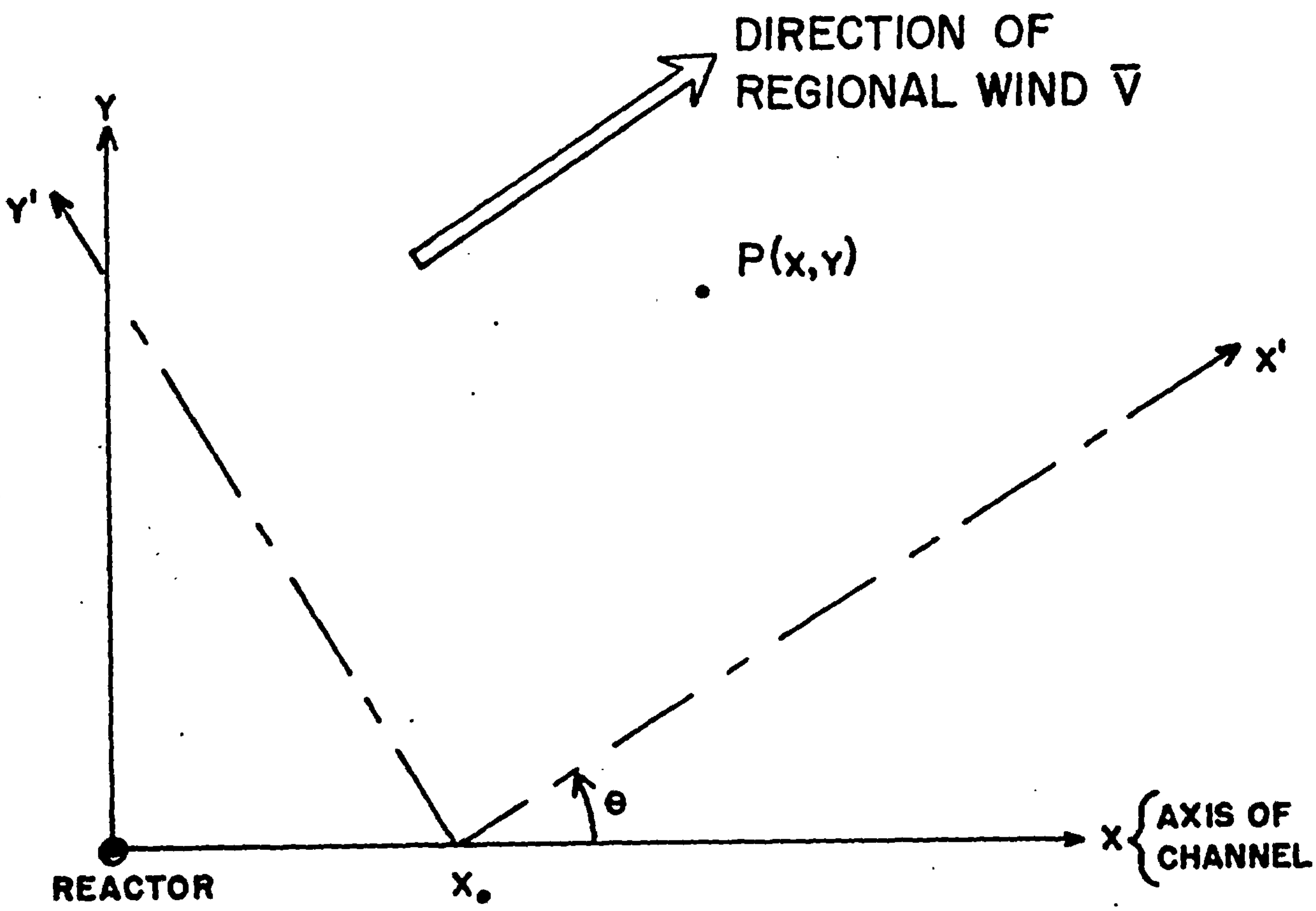
ENVIRONMENTAL RADIATION SAMPLE STATIONS

PEACH BOTTOM ATOMIC POWER STATION
PHILADELPHIA ELECTRIC COMPANY

FIGURE 1-9



LOCATIONS AT SITE BOUNDARIES
FOR WHICH RELATIVE DILUTIONS ARE COMPUTED
FIGURE II-1

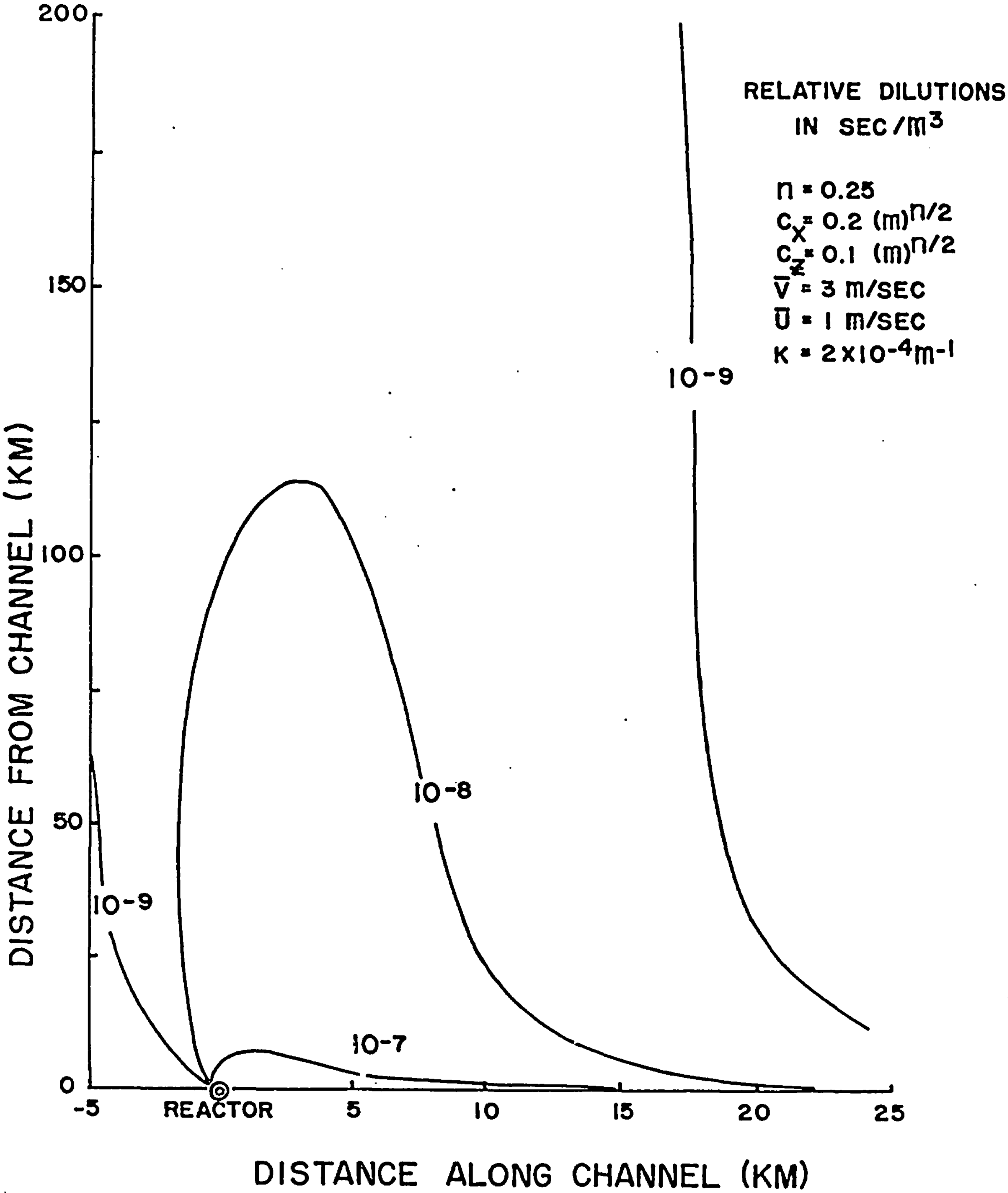


$$X' = (X - X_o) \cos\theta + Y \sin\theta$$

$$Y' = -(X - X_o) \sin\theta + Y \cos\theta$$

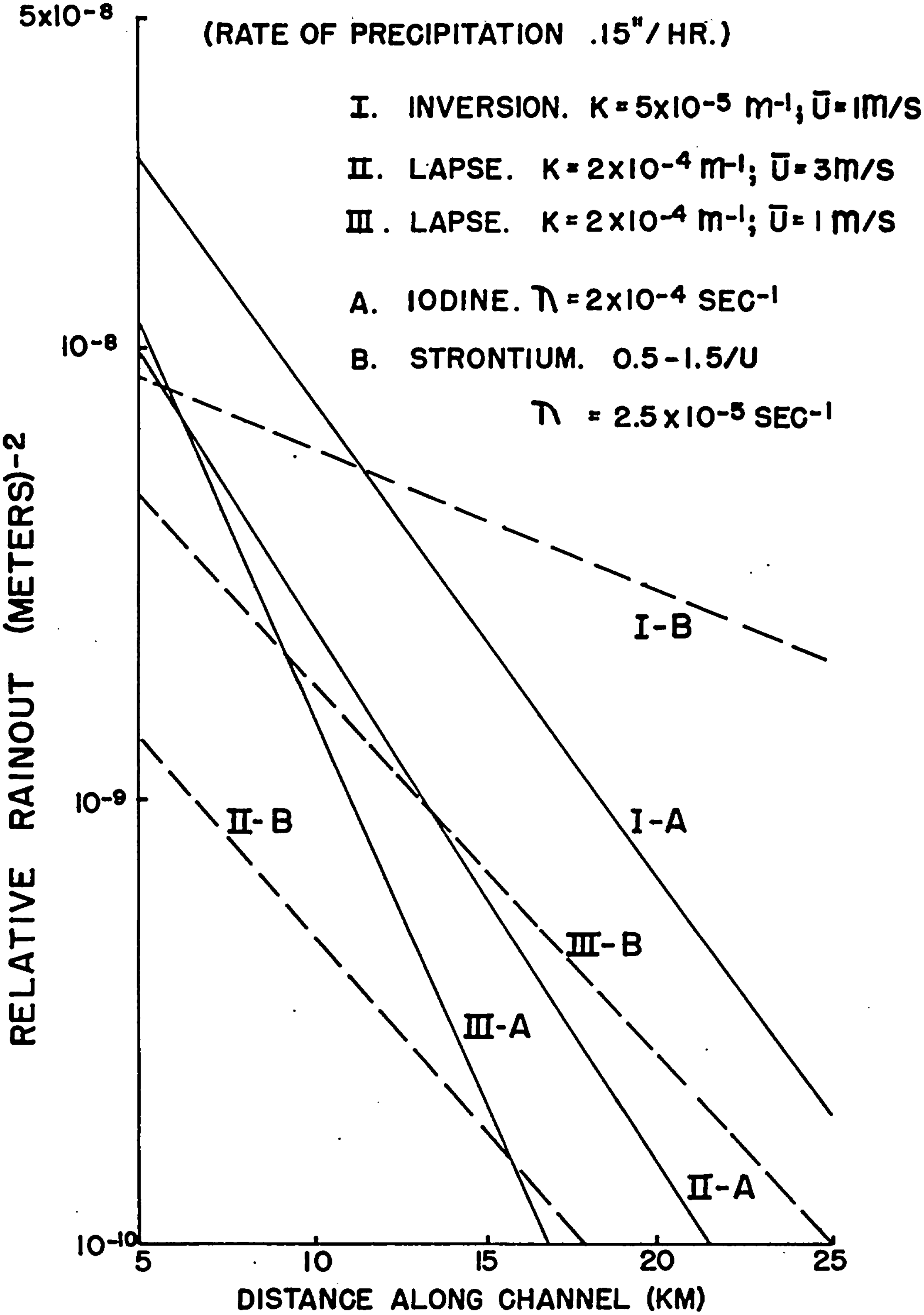
COORDINATE SYSTEMS USED IN DEVELOPING EQUATIONS (10) TO (13)

FIGURE II-2



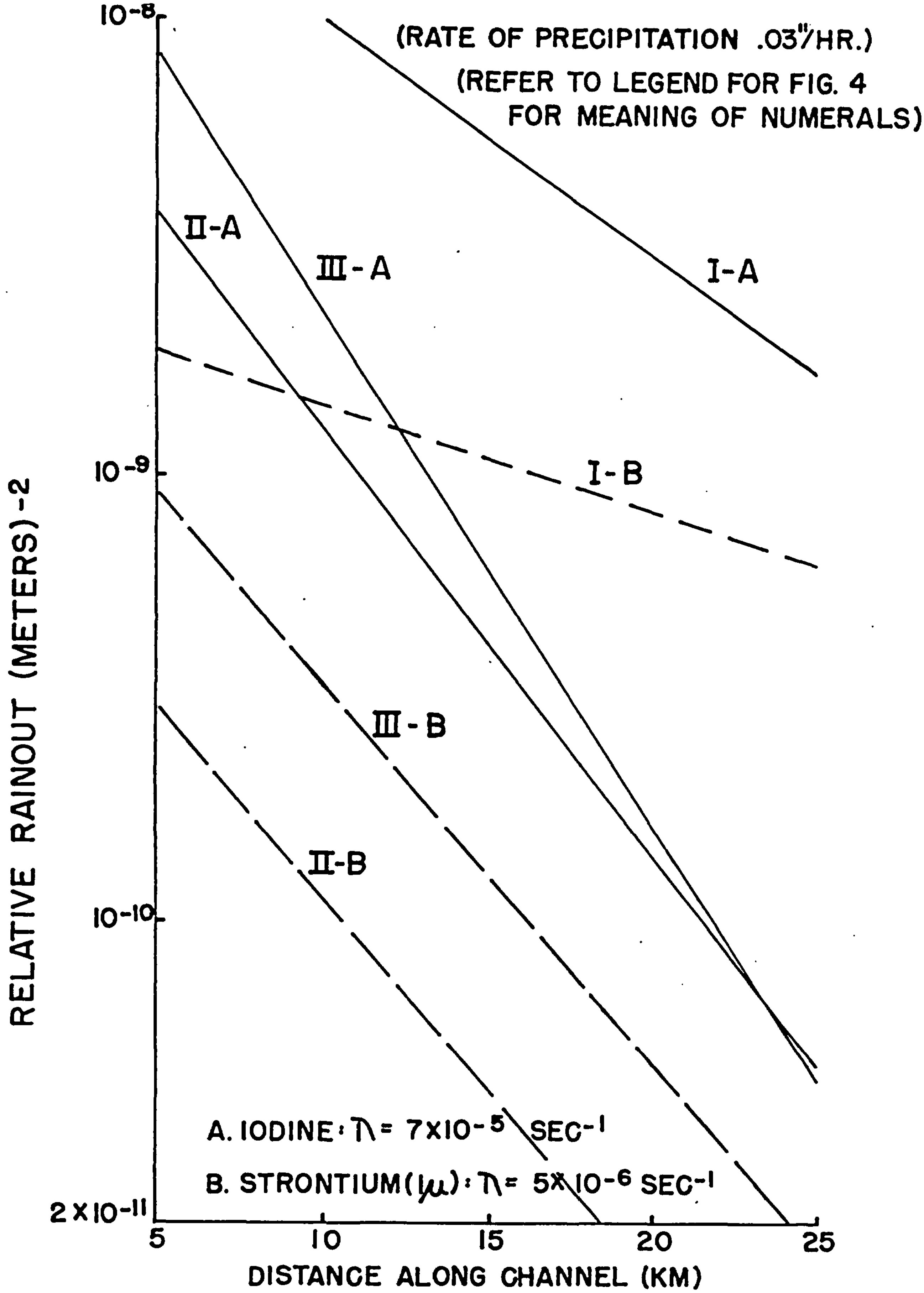
RELATIVE DILUTIONS ASSOCIATED WITH REGIONAL WIND NORMAL TO CHANNEL

FIGURE II-3

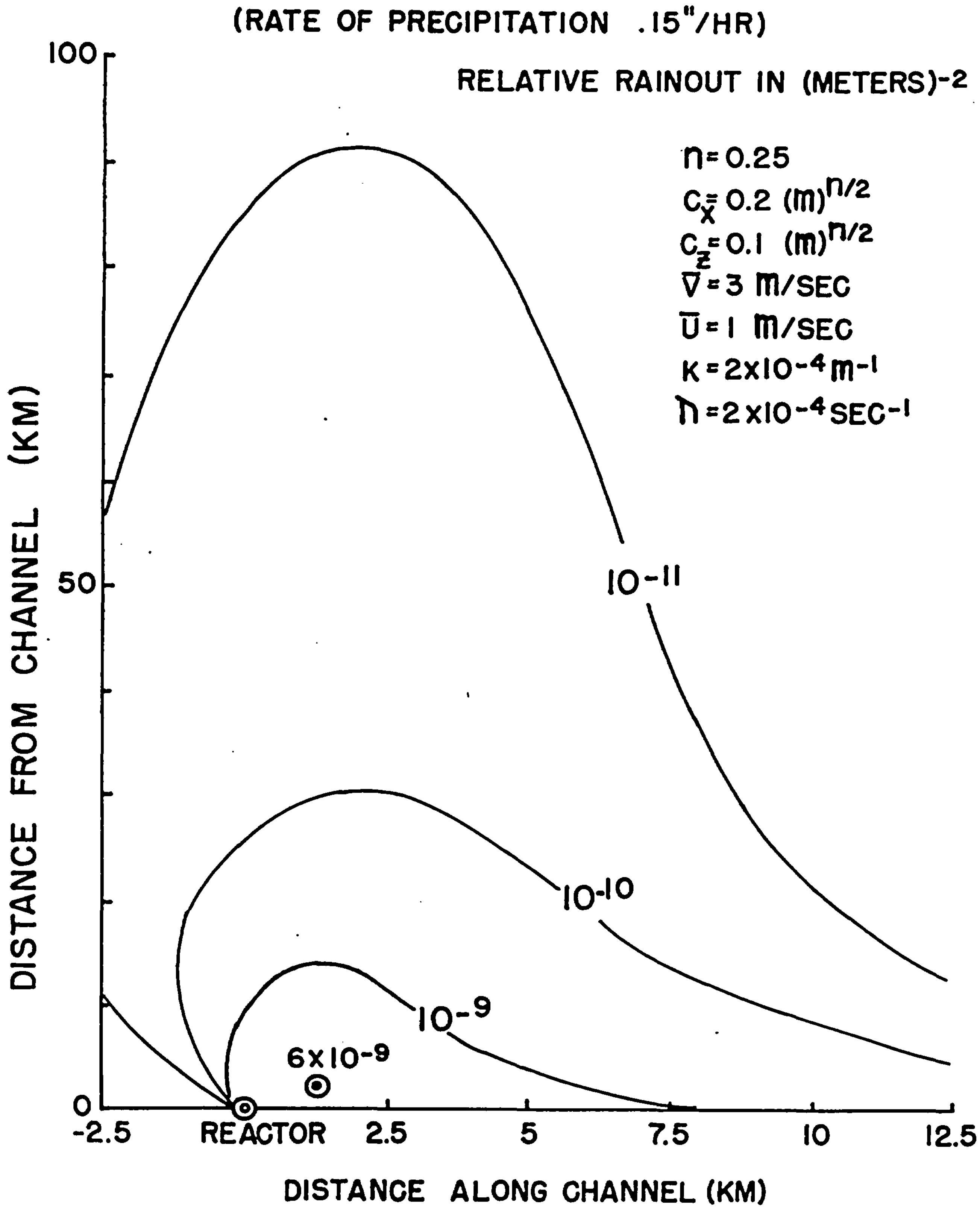


RELATIVE RAINOUT ALONG CHANNEL
FAR FROM SITE

FIGURE II-4

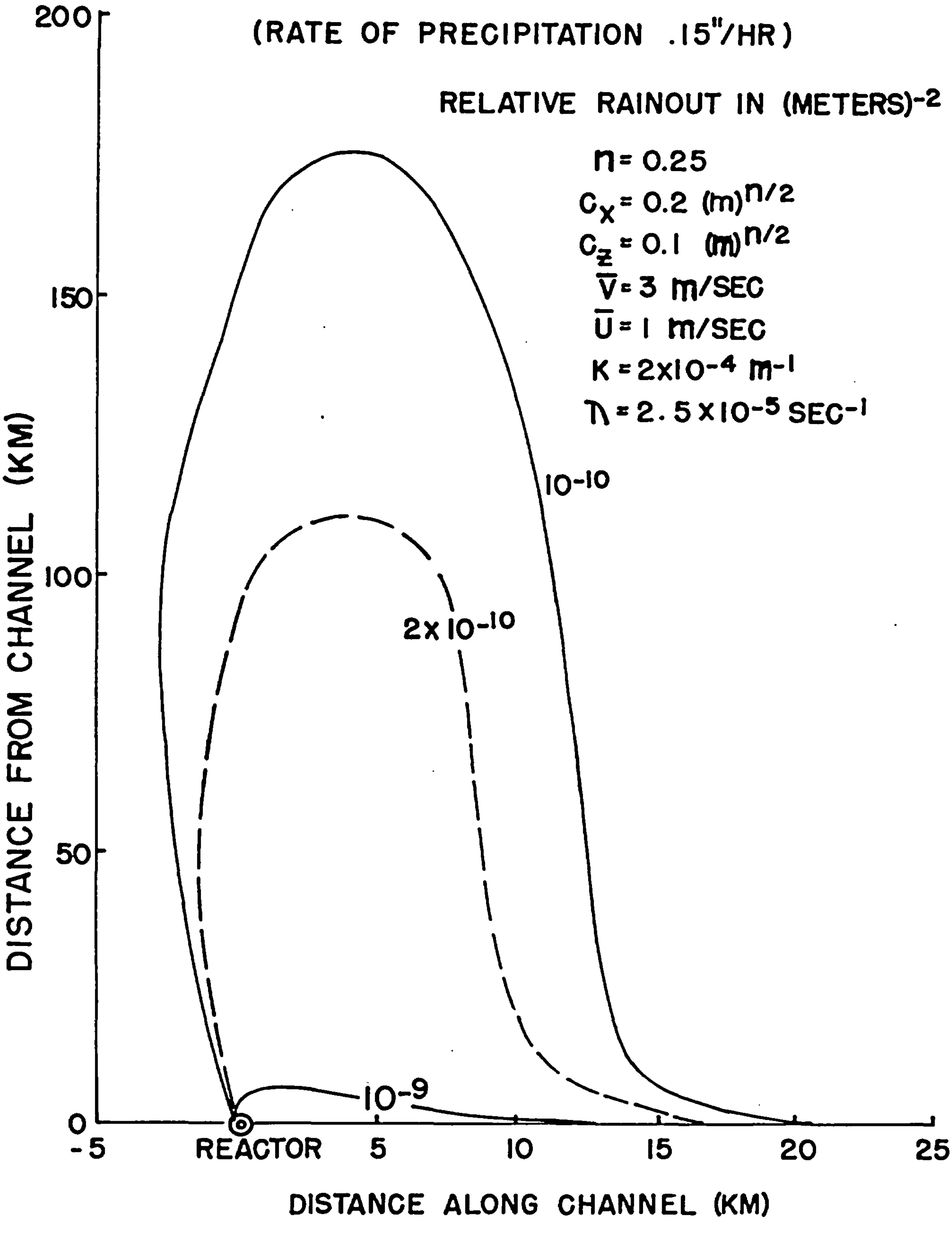


RELATIVE RAINOUT ALONG CHANNEL
FAR FROM SITE
FIGURE II-5



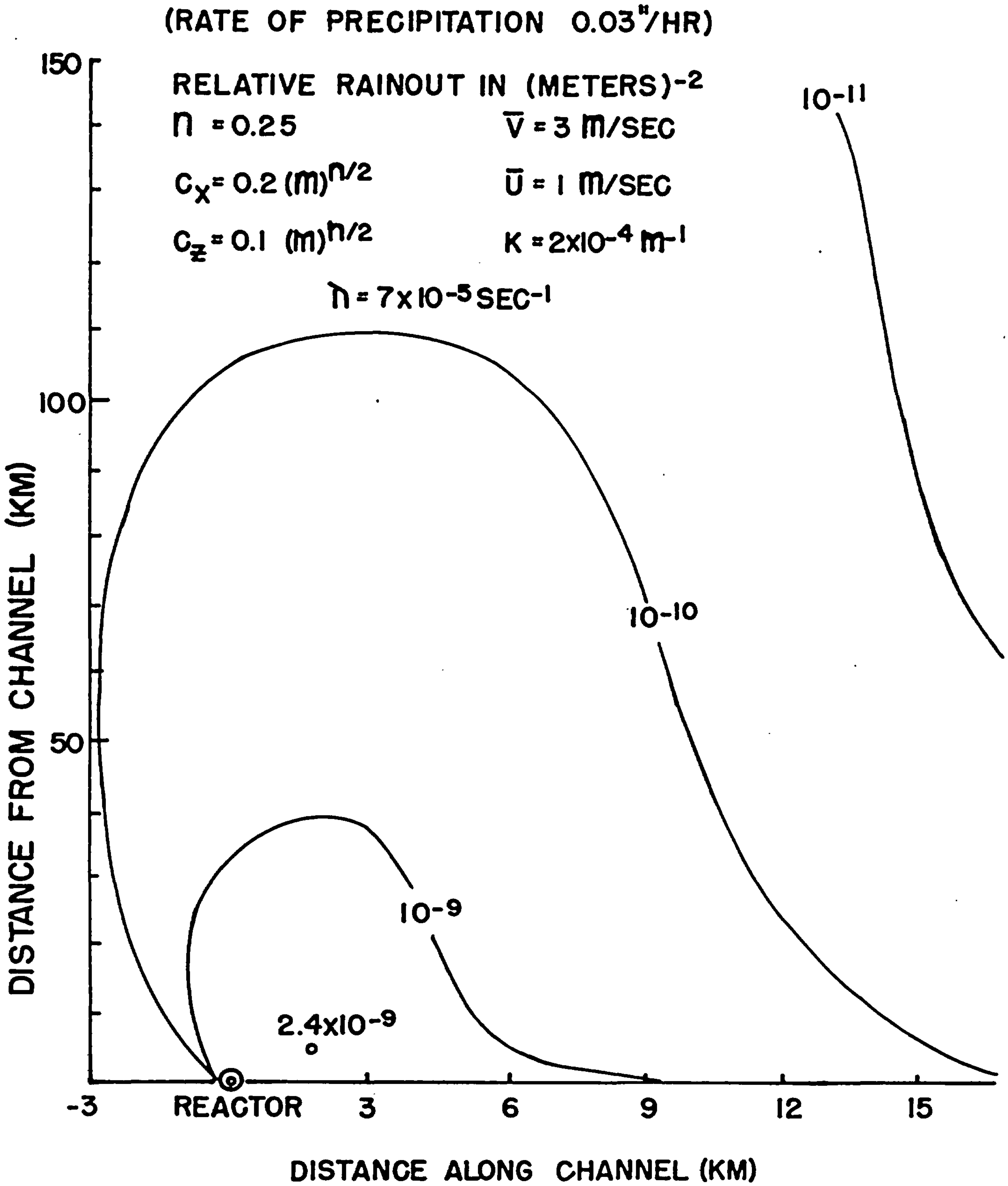
RELATIVE RAINOUT OF IODINE (R/Q)
ASSOCIATED WITH WIND NORMAL TO CHANNEL

FIGURE II-6



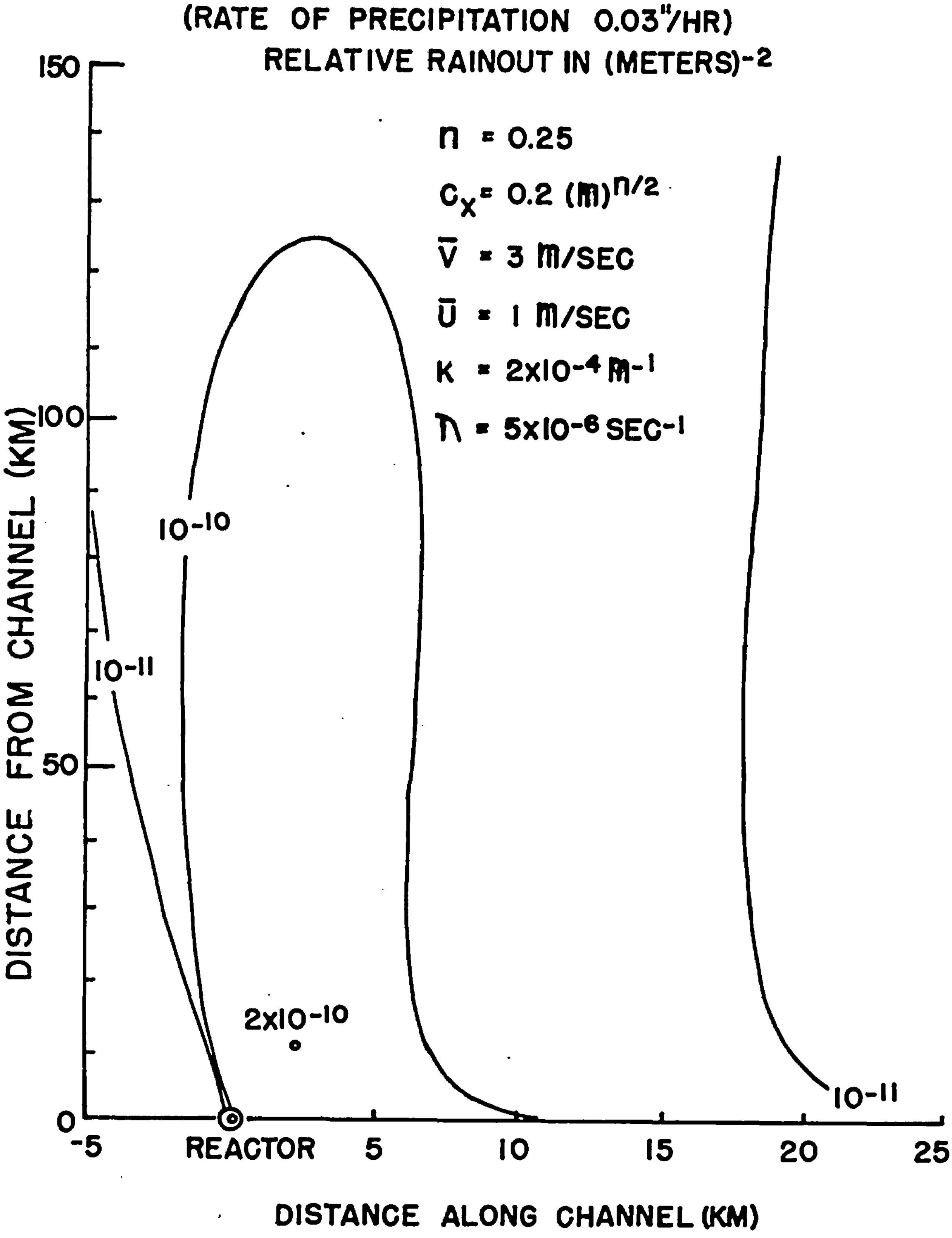
RELATIVE RAINOUT OF 1μ STRONTIUM ASSOCIATED WITH WIND NORMAL TO CHANNEL

FIGURE II-7



RELATIVE RAINOUT OF IODINE (R/Q)
ASSOCIATED WITH WIND NORMAL TO CHANNEL

FIGURE II-8



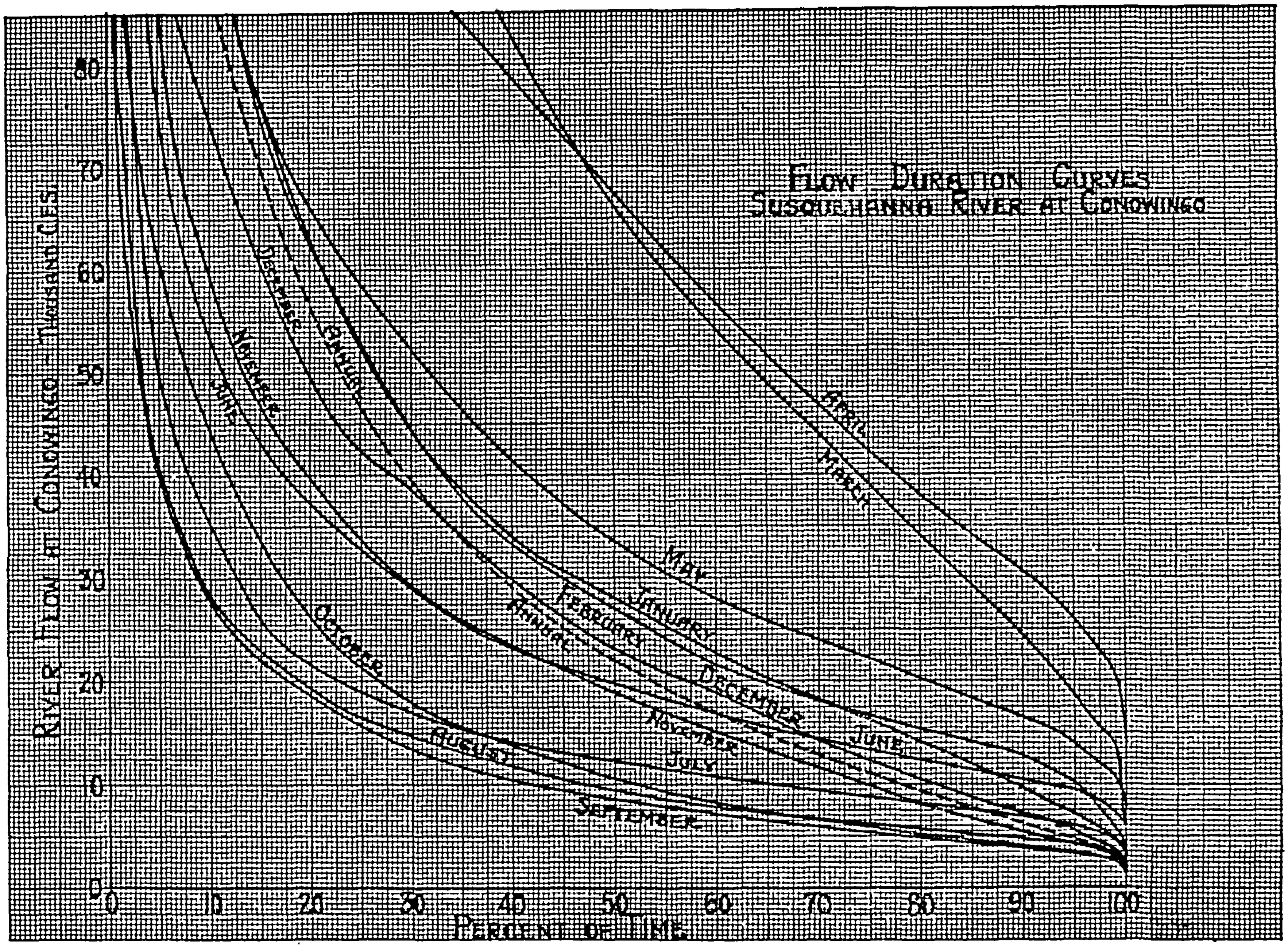
RELATIVE RAINOUT OF 1μ STRONTIUM (R/Q)
ASSOCIATED WITH WIND NORMAL TO CHANNEL

FIGURE II-9


GENERAL MAP
OF THE
SUSQUEHANNA RIVER BASIN
SHOWING
MAJOR GAGING STATIONS
AND CORRESPONDING DRAINAGE AREAS
THE SUSQUEHANNA POWER COMPANY
STONE & WEBSTER, INC
BOSTON
OCTOBER 1925
SCALE-MILES
LEGEND
★ Major Gaging Stations
+ Other Gaging Stations
CANADA
Lake Ontario
Lake Erie
NEW YORK
PENNSYLVANIA
MARYLAND
DELAWARE
NEW JERSEY
ATLANTIC OCEAN
Delaware Bay
Hudson River
Potomac River
Williamsport
5670 Sq. Mi.
Wilkes-Barre
9960 Sq. Mi.
Danville
11,200 Sq. Mi.
18,200 Sq. Mi.
Sunbury
Newport
3300 Sq. Mi.
Harrisburg
24,100 Sq. Mi.
McCalls Ferry
26,170 Sq. Mi.
CONOWINGO
27,100 Sq. Mi.
Binghamton
Conklin
PHILADELPHIA
BALTIMORE
WASHINGTON
NEW YORK
PITTSBURGH
BUFFALO
SYRACUSE
AUBURN
UTICA
ALBANY
SCHENECTADY
ROCHESTER
JAMESTOWN
ERIE
Susquehanna

FIGURE III-1

FIGURE III - 2



Flow Duration Curves
Susquehanna River at Conowingo
River Flow at Conowingo - Thousand CFS
Percent of Time
0
10
20
30
40
50
60
70
80
90
100
April
March
May
January
February
Annual
December
June
November
July
October
August
September

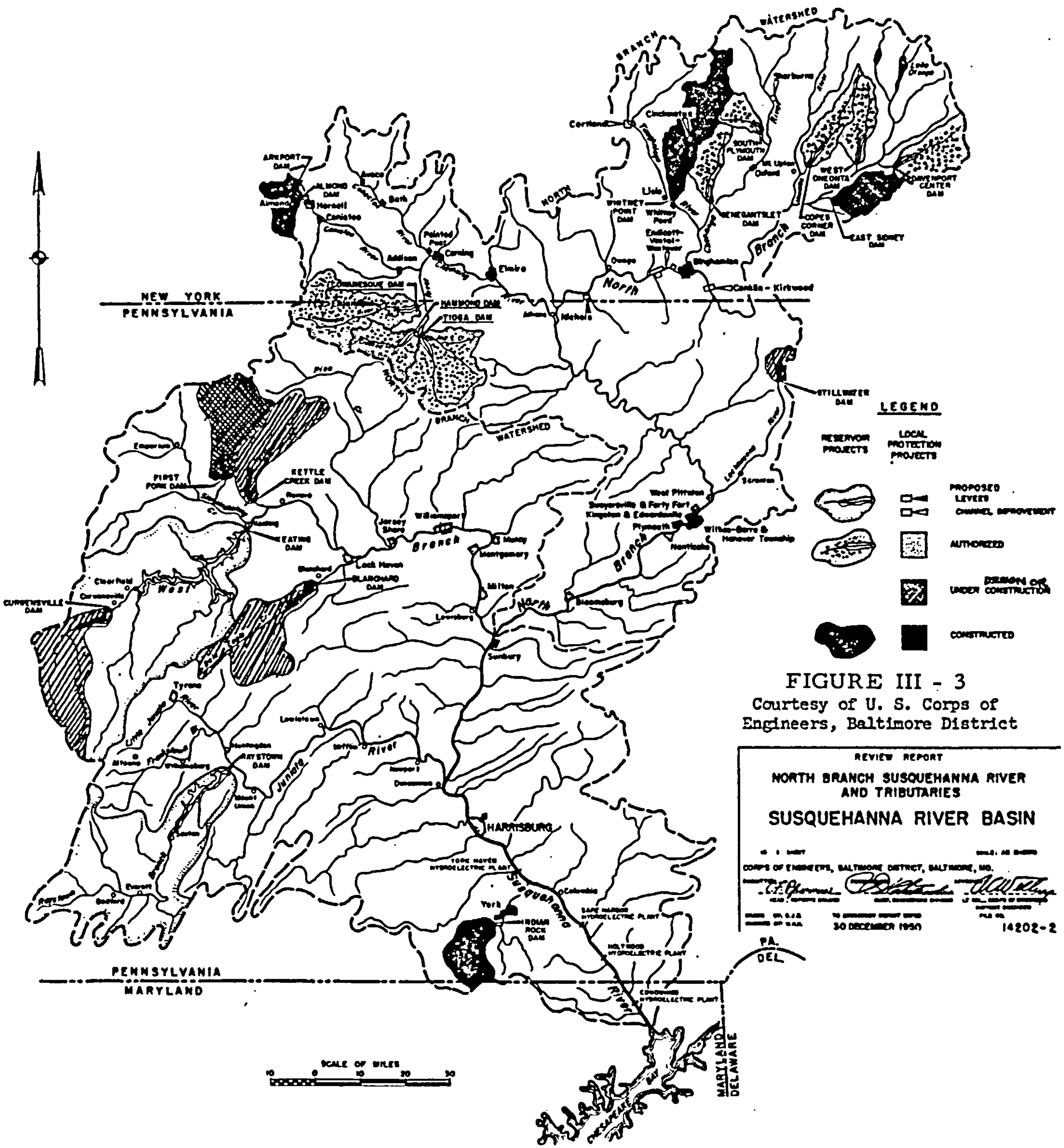
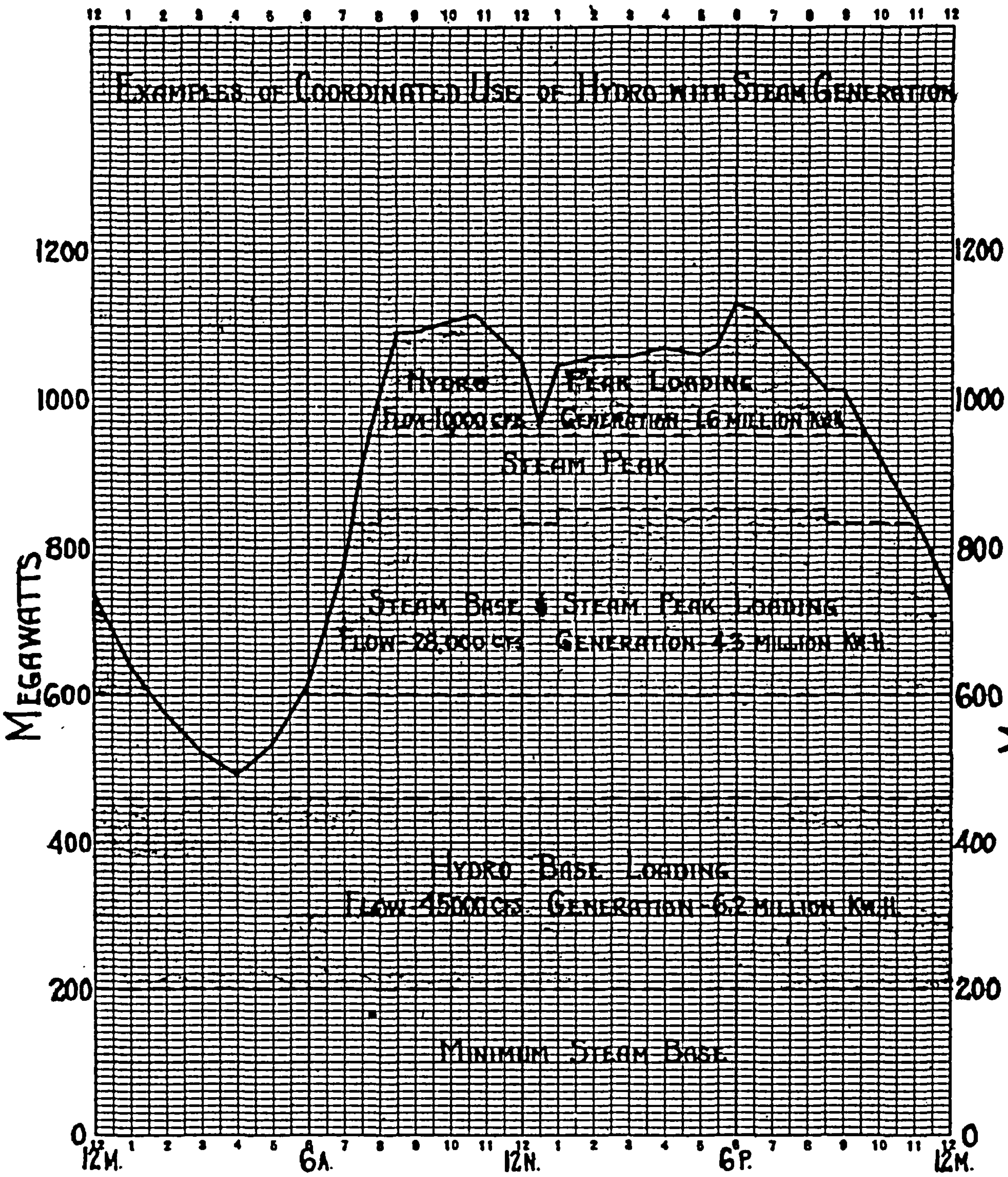


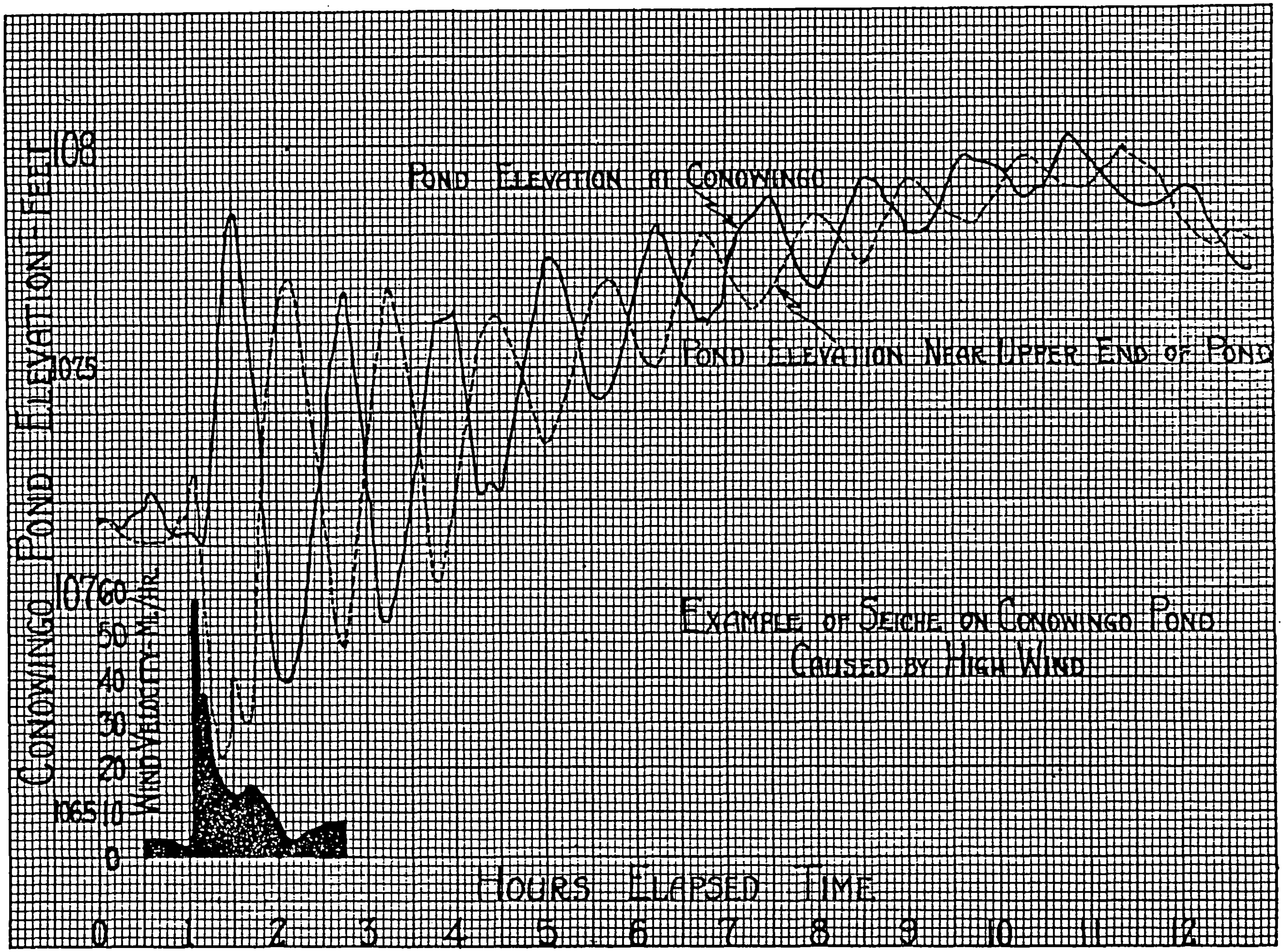
FIGURE III - 3
Courtesy of U. S. Corps of Engineers, Baltimore District

FIGURE III - 3



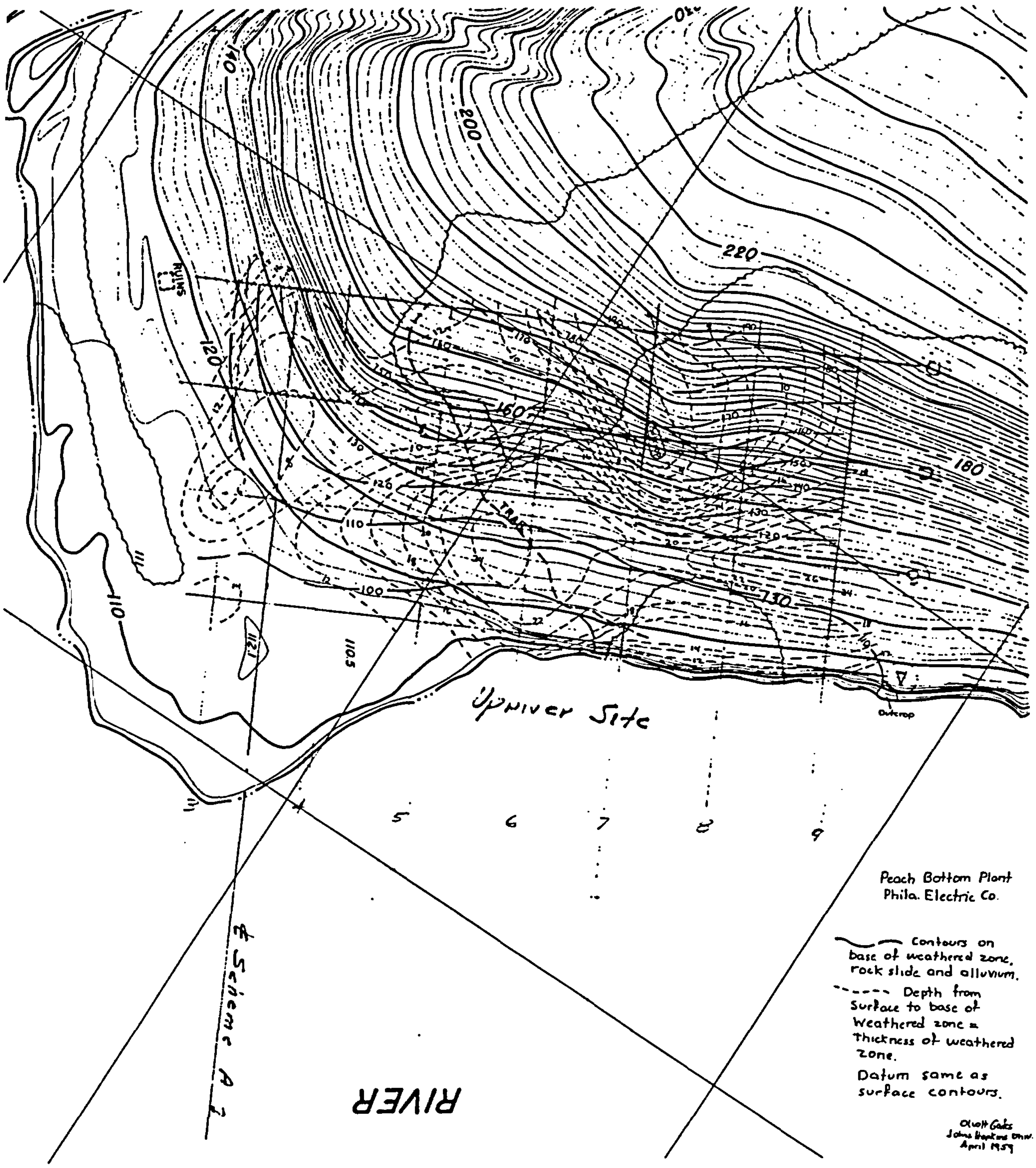
Examples of Coordinated Use of Hydro with Steam Generation
12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
Megawatts
1200
1000
800
600
400
200
0
Hydro Peak Loading
Flow 10000 cfs Generation 1.6 million KWH
Steam Peak
Steam Base & Steam Peak Loading
Flow 28,000 cfs Generation 4.3 million KWH
Hydro Base Loading
Flow 45000 cfs Generation 6.2 million KWH
Minimum Steam Base
12M. 6A. 12N. 6P. 12M.

FIGURE III - 4



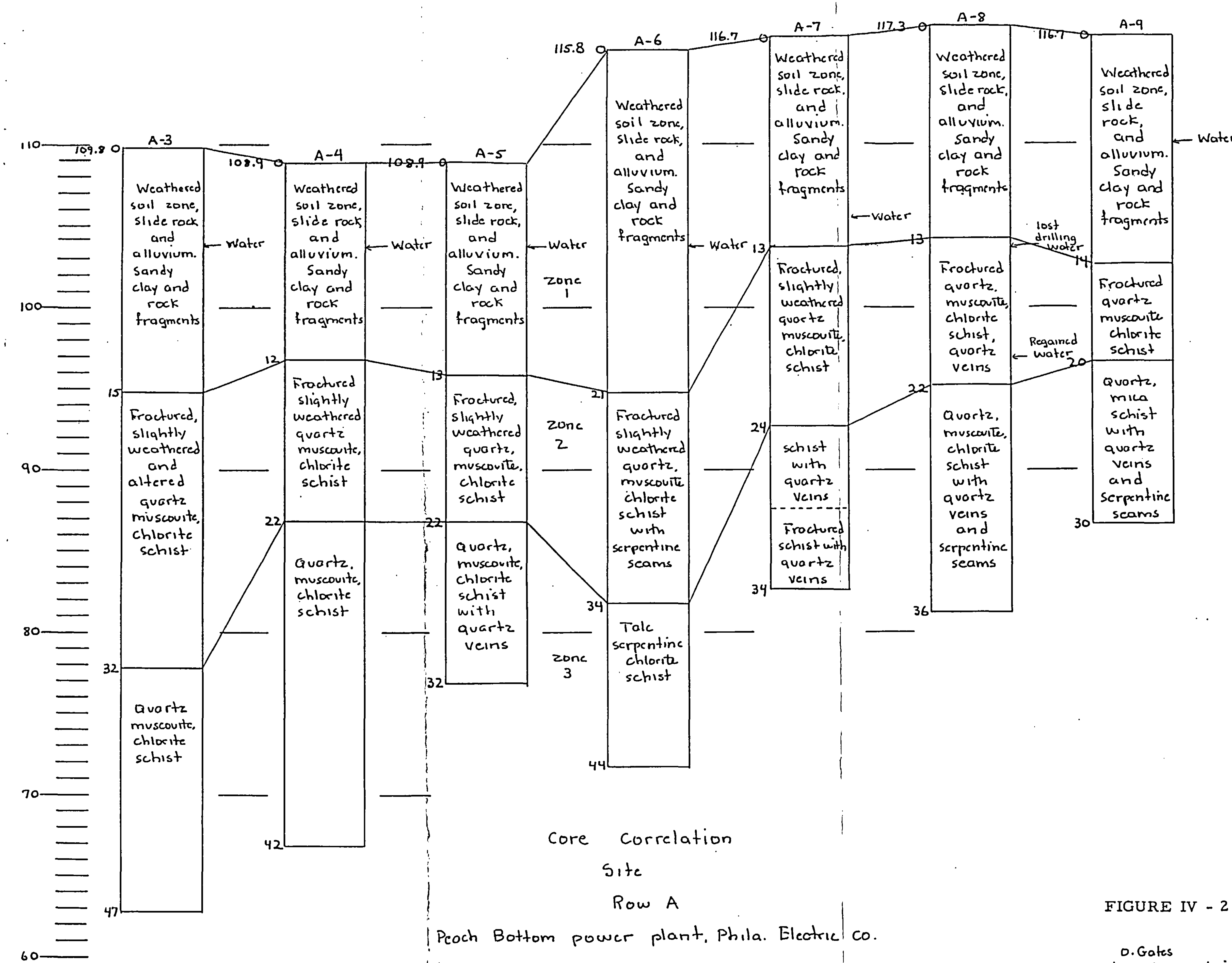
Conowingo Pond Elevation - Feet
108
107.5
107
106.5
Wind Velocity - M.P.H.
60
50
40
30
20
10
0
Pond Elevation at Conowingo
Pond Elevation Near Upper End of Pond
Example of Seiche on Conowingo Pond
Caused by High Wind
Hours Elapsed Time
0
1
2
3
4
5
6
7
8
9
10
11
12

FIGURE III - 5



Upriver Site
Outcrop
5
6
7
8
9
RIVER
Peach Bottom Plant
Phila. Electric Co.
Contours on base of weathered zone, rock slide and alluvium.
Depth from Surface to base of Weathered zone = Thickness of weathered zone.
Datum same as surface contours.
April 1959

FIGURE IV - 1



Core Correlation

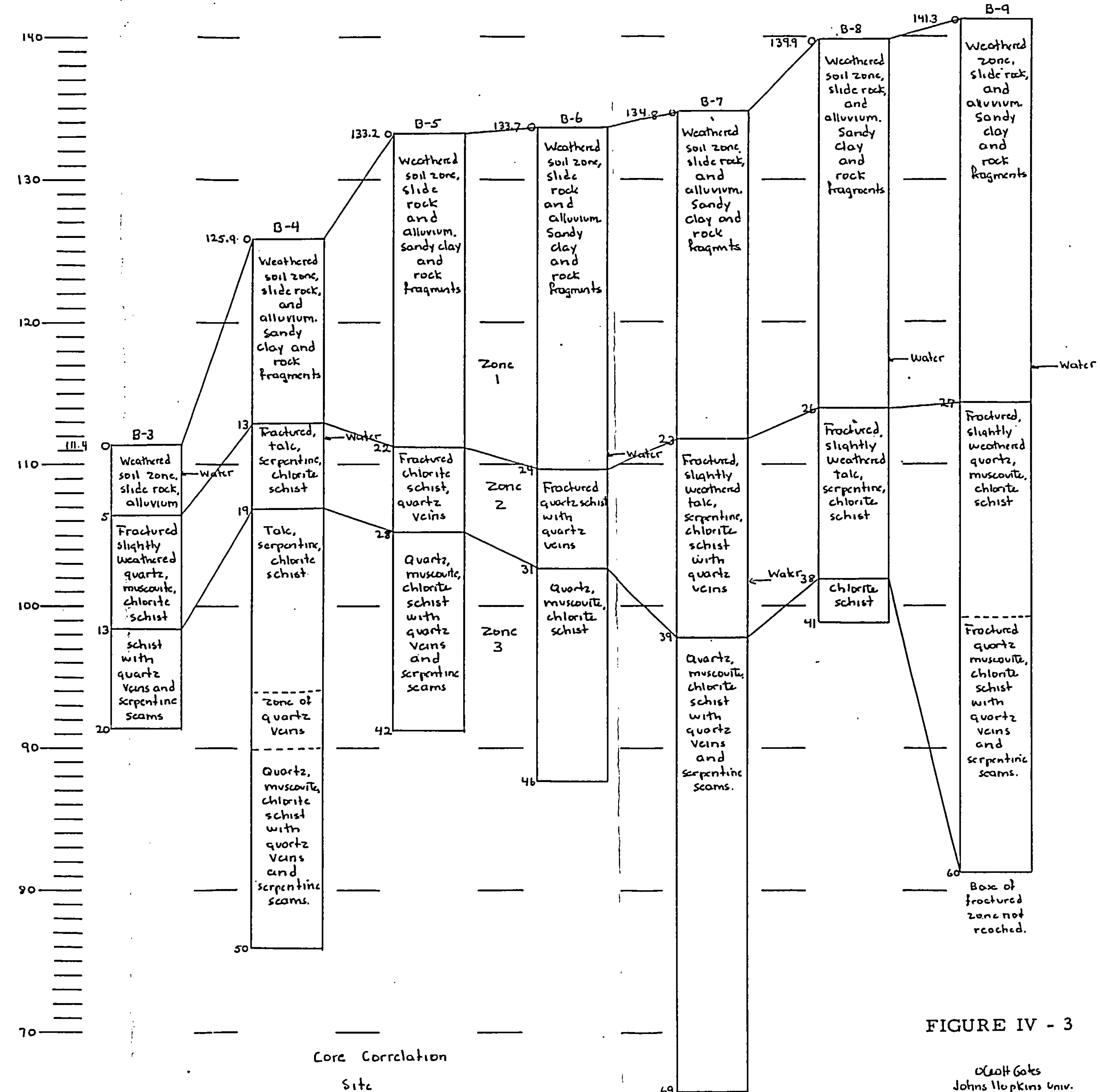
Site

Row A

Peach Bottom power plant, Phila. Electric co.

FIGURE IV - 2

D. Gates
Johns Hopkins Univ.
April 1959



Core Correlation

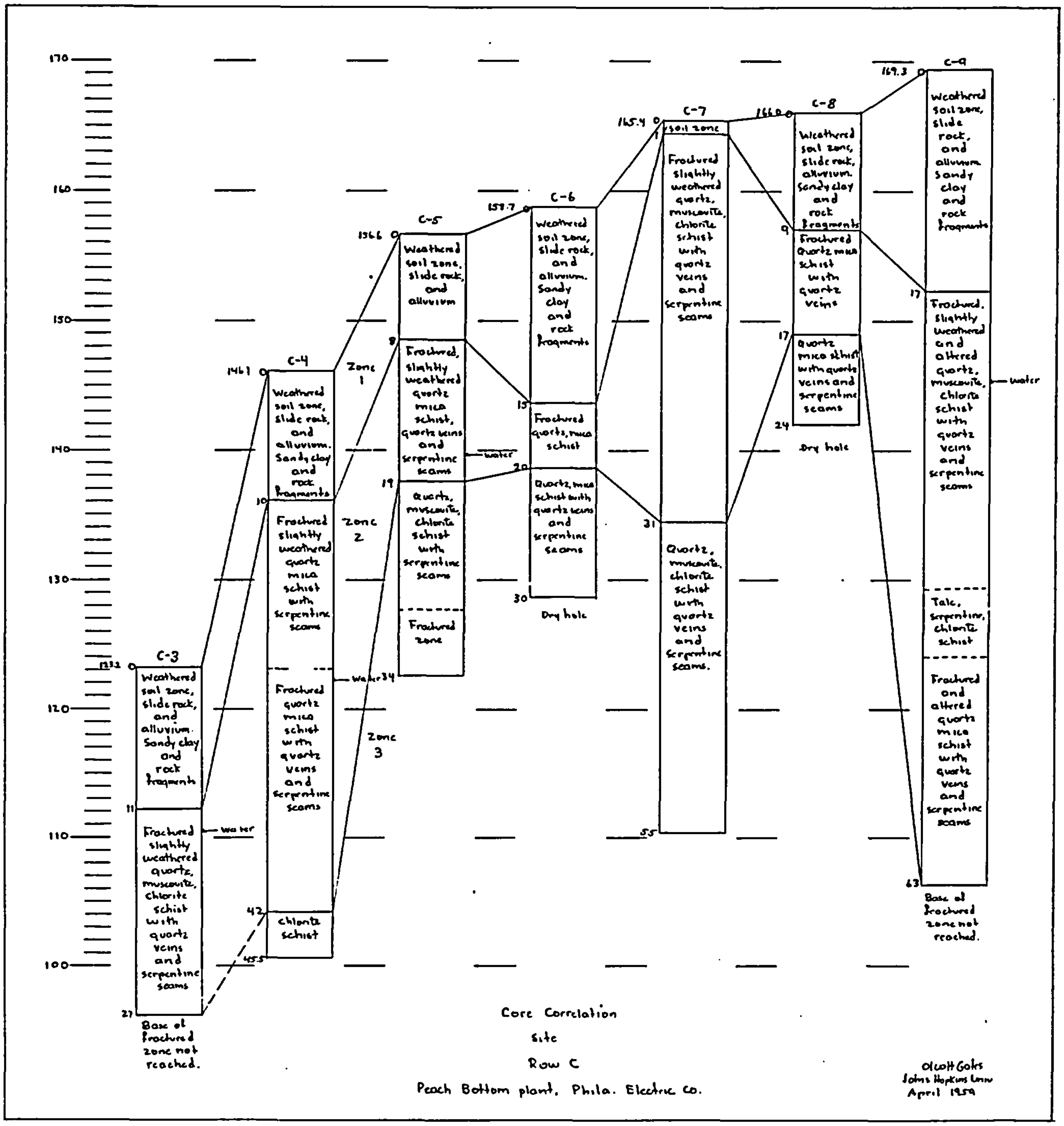
Site

Row B

Peach Bottom plant, Phila. Electric Co.

FIGURE IV - 3

Olcott Gates
Johns Hopkins Univ.
April 1959



170
160
150
140
130
120
110
100
C-3
123.2
Weathered soil zone, slide rock, and alluvium. Sandy clay and rock fragments
11
Fractured slightly weathered quartz, muscovite, chlorite schist with quartz veins and serpentine seams
water
27
Base of fractured zone not reached.
C-4
146.1
Weathered soil zone, slide rock, and alluvium. Sandy clay and rock fragments
10
Fractured slightly weathered quartz mica schist with serpentine seams
Fractured quartz mica schist with quartz veins and serpentine seams
water 34
42
Chlorite schist
45.5
Zone 1
Zone 2
Zone 3
C-5
156.6
Weathered soil zone, slide rock, and alluvium
8
Fractured, slightly weathered quartz mica schist, quartz veins and serpentine seams
water
19
Quartz, muscovite, chlorite schist with serpentine seams
Fractured zone
C-6
158.7
Weathered soil zone, slide rock, and alluvium. Sandy clay and rock fragments
15
Fractured quartz, mica schist
20
Quartz, mica schist with quartz veins and serpentine seams
30
Dry hole
C-7
165.4
soil zone
1
Fractured slightly weathered quartz, muscovite, chlorite schist with quartz veins and serpentine seams
31
Quartz, muscovite, chlorite schist with quartz veins and serpentine seams.
55
C-8
166.0
Weathered soil zone, slide rock, alluvium. Sandy clay and rock fragments
9
Fractured quartz mica schist with quartz veins
17
Quartz mica schist with quartz veins and serpentine seams
24
Dry hole
C-9
169.3
Weathered soil zone, slide rock, and alluvium. Sandy clay and rock fragments
17
Fractured, slightly weathered and altered quartz, muscovite, chlorite schist with quartz veins and serpentine seams
water
Talc, serpentine, chlorite schist
Fractured and altered quartz mica schist with quartz veins and serpentine seams
63
Base of fractured zone not reached.
Core Correlation
Site
Row C
Peach Bottom plant, Phila. Electric Co.
Olcott Gates
Johns Hopkins Univ
April 1959

FIGURE IV - 4

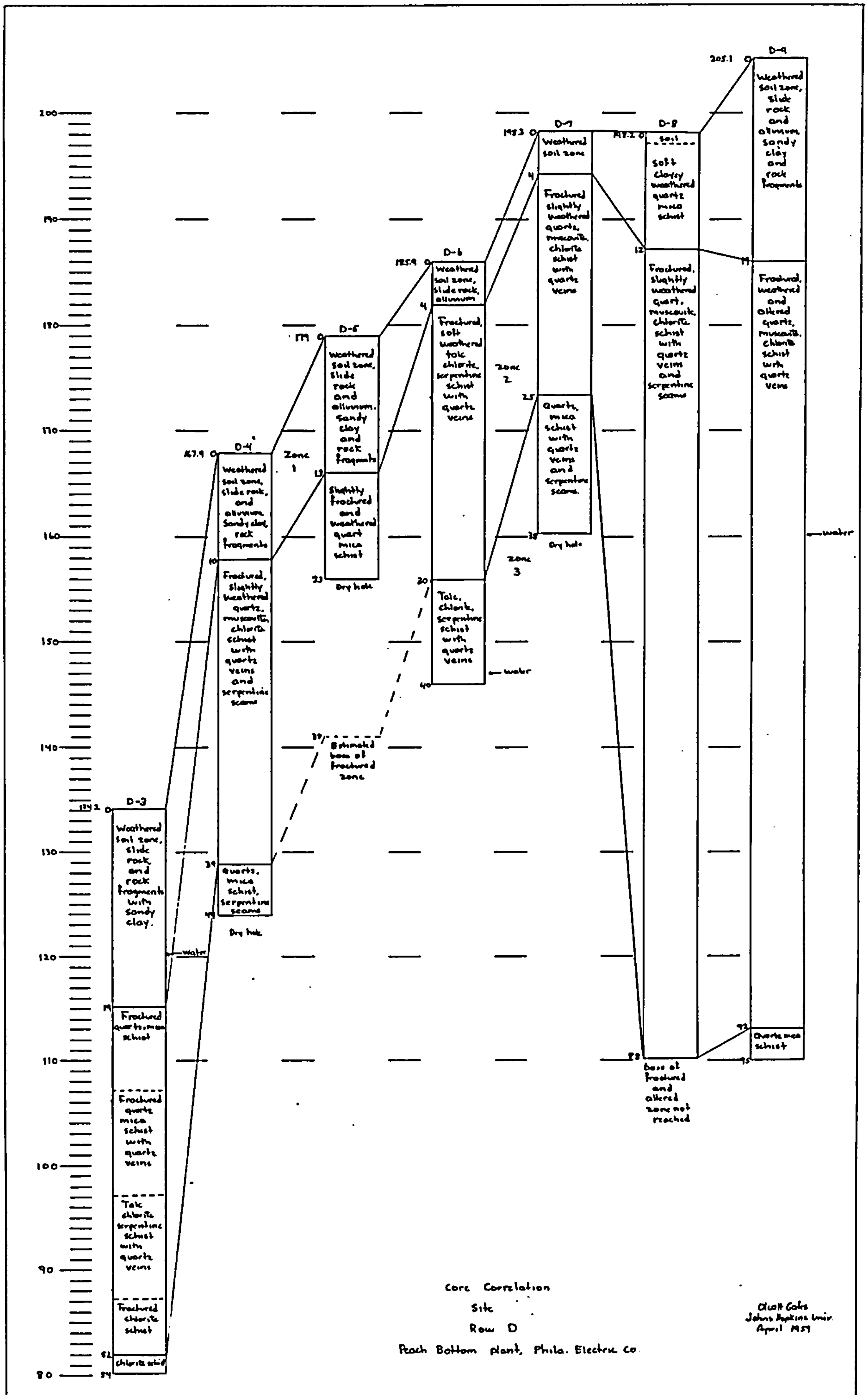

D-3
D-4
D-5
D-6
D-7
D-8
D-9
Zone 1
Zone 2
Zone 3
water
Dry hole
Core Correlation
Site
Row D
Peach Bottom plant, Phila. Electric Co.
Olcott Gates
Johns Hopkins Univ.
April 1959

FIGURE IV - 5

TABLE I-1

POPULATION DISTRIBUTION

Radius	Population	Date	Persons per Square Mile	Estimated Population 1969
0 - 3000 ft. (to property line)	0	(1963)	0	0
0 - 1 mile	120	(1959)	38	50
0 - 5 miles	5,700	(1959)	73	7,100
0 - 10 miles	25,000	(1959)	80	31,000
0 - 25 miles	385,700	(1950)	196	
0 - 50 miles	2,934,000	(1950)	374	

TABLE I-2

PEACHBOTTOM AREA

PERCENTAGE OF COUNTIES WITHIN SPECIFIED AREAS

	Total	10-Mile Radius		10-25-Mile Radius		25-50-Mile Radius	
	Sq. Mi.	Sq. Mi.	%	Sq. Mi.	%	Sq. Mi.	%
Pennsylvania							
Adams	526					215	40.9
Cumberland	555					26	4.7
Dauphin	520					160	30.8
Lebanon	363					280	77.1
Berks	864					396	45.8
Montgomery	492					4	0.8
Delaware	185					129	69.7
Chester	760	6	0.8	197	25.9	555	73.0
Lancaster	945	107	11.3	384	40.6	454	48.0
York	914	62	6.8	262	28.7	581	63.6
Maryland							
Carroll	456					383	84.0
Queen Annes	323					206	54.2
Howard	251					122	48.6
Anne Arundel	417					129	30.9
Kent	284					284	100.0
Baltimore (County)	610			182	29.8	428	70.2
Harford	448	84	18.8	339	75.7	25	5.5
Cecil	352	35	10.0	170	48.3	147	41.8
Delaware							
Kent	595					85	14.3
New Castle	437					427	97.7
New Jersey							
Gloucester	329					39	11.9
Salem	350					200	57.1

TABLE I-3
POPULATION DISTRIBUTION
PEACHBOTTOM SITE AS CENTER

Distance From Proposed Site (Miles)	Land Area Square Miles	Total Population 1950 Census	Principal Municipalities Included	Population* 1950 Census	Proposed Site (Miles)	Direction From Proposed Site
0-25	1828	385,700	Lancaster, Pa.	63,800	21	352°
			Columbia, Pa.	12,000	24	326°
25-50	5280	2,548,600	Harrisburg, Pa.	89,500	49	317°
			Steelton, Pa.	12,600	46	317°
			Lebanon, Pa.	28,200	42	347°
			Reading, Pa.	109,300	45	22°
			Pottstown, Pa.	22,600	47	42°
			Chester, Pa.	66,000	48	80°
			W. Chester, Pa.	15,200	38	65°
			Coatesville, Pa.	13,800	28	53°
			Phoenixville, Pa.	12,900	47	54°
			York, Pa.	60,000	30	302°
			Hanover, Pa.	14,000	39	276°
			Wilmington, Del.	110,400	38	89°
			Baltimore, Md.	949,700	36	212°

* To nearest hundred for municipalities over 10,000 population.

TABLE I-4

POPULATION OF URBAN PLACES BY COUNTY (1950)*

County	Population (1950)	Increase 1940 to 1950 Percent	Population 1960 (Estimated)
Delaware			
New Castle	218,879	21.9	266,500
Maryland			
Baltimore	270,273	73.4	469,000
Carroll	44,907	15.0	51,600
Cecil	33,356	26.3	42,100
Harford	51,782	47.7	76,500
Kent	13,677	1.6	13,900
Queen Annes		Not Listed	
New Jersey			
Salem	49,508	17.1	58,100
Pennsylvania			
Adams	44,197	12.1	49,600
Berks	255,740	5.7	270,000
Chester	159,141	17.3	187,000
Dauphin	197,784	11.5	220,000
Delaware	414,234	33.3	553,000
Lancaster	234,717	10.5	270,000
Lebanon	81,683	12.4	91,800
York	202,737	13.9	231,000

*According to the definition that was adopted for use in the 1950 Census, urban places comprise all incorporated and unincorporated places of 2500 inhabitants or more.

Note: Basis - Rate of growth extrapolated to 1960 using trend as indicated for 1940-50 period.

Source: "County and City Data Book" (1956)
U. S. Government Printing Office, Washington, D. C. 1957

TABLE I-5
POPULATION OF CITIES GREATER THAN 25,000

City	Population (1950) Total	Population (1950) Per Sq. Mile	Population (1950) Increase 1940 to 1950 Percent	Location with Respect to Peach Bottom: Direction In Degrees C. W. from North	Location with Respect to Peach Bottom: Distance Miles
Delaware					
Wilmington	110,356	11,261	-1.9	91	40
District of Col					
Washington	802,178	13,065	21.0	200	72
Maryland					
Baltimore	949,703	12,067	10.5	205	38
Hagerstown	36,260	5,107	11.6	261	81
New Jersey					
Camden	124,555	14,483	6.0	77	66
Trenton	128,009	17,779	2.7	66	90
Pennsylvania					
Allentown	106,756	6,714	10.2	34	71
Bethlehem	66,340	3,567	13.4	36	76
Chester	66,039	14,051	11.4	91	51
Easton	35,632	9,898	6.1	38	85
Harrisburg	89,544	14,213	6.7	316	46
Hazelton	35,491	5,915	-6.6	9	84
Lancaster	63,774	14,831	4.0	356	18
Lebanon	28,156	7,821	3.5	348	40
Norristown	38,126	10,893	-0.1	62	56
Philadelphia	2,071,605	16,286	7.3	75	63
Pittsburgh	676,806	12,487	0.8	282	204
Reading	109,320	12,423	-1.1	24	45
Scranton	125,536	5,042	-10.6	13	119
Wilkes-Barre	76,826	11,134	-10.9	9	106
York	59,953	14,275	5.7	296	26

Cities defined as 25,000 or more inhabitants in 1950

Source: "County and City Data Book" (1956) U.S. Govt. Printing Office, Washington, D. C. 1957

TABLE I-6

INDUSTRIES WITHIN 10 MILE RADIUS

INDUSTRIES

0-10 MILE RADIUS

	Approximate Employment	Product
Western Maryland Dairy	10	Milk Distributor and Bottling
Whiteford Packing Co.	10	Canning - Tomatoes and Beans
Maryland Green Marble Co.	16	Quarry
Blue Ridge Flooring Co.	40	Lumbermill (Saw mill)
Miller Chemical Co.	10	Fertilizer
Terry Togs	90	Cloth Manufacturer
Funkhouser	35	Slate Quarry & Shingling

TABLE I-7

INDUSTRIES WITHIN 10 TO 50 MILE RADIUS[a]

10-25 MILE RADIUS[b]

Industry	Employment
Food & Kindred Products	272
Textile Mill Products	132
Apparel & Related Products	265
Lumber & Wood Products	32
Chemicals & Products	102
Rubber Products	15
Fabricated Metal Products	131
Pulp, Paper and Products	110
Electrical Machinery	35
Machinery, except Electrical	111
Tobacco Manufacturers	19
Instruments & Related Products	6
Coal Products & Petroleum	11
Printing & Publishing	116

25-50 MILE RADIUS

Industry	Employment
Textile Mill Products	22
Apparel & Related Products	51
Lumber & Wood Products	6
Food & Kindred Products	44
Tobacco Products	16
Furniture & Fixtures	14
Pulp, Paper & Products	12
Printing & Publishing	10
Chemicals & Products	7
Petroleum & Coal Products	1
Rubber Products	2
Leather & Leather Goods	15
Primary Metal Industries	14
Stone, Clay and Glass Products	9
Fabricated Metal Products	24
Machinery, except Electrical	22
Electrical Machinery	7
Transportation Equipment	3
Instruments and Related Products	2
Ordnance & Accessories	No Data

(a) Number of Manufacturing establishments with 20 or more employees (1954). (Estimated from Source and Maps of Area).

(b) Includes Baltimore City

Source: 1954 Census of Manufacturers, Volume III Area Statistics, U. S. Dept. of Commerce Bureau of the Census
Source: "County and City Data Book 1956" U. S. Govt. Printing Office, Washington, D. C., 1957

TABLE I-8

EMPLOYMENT BY COUNTIES

MARYLAND COUNTIES

	Harford	Cecil
Total Population (1950)	51,782	33,356
Total Employed	17,183	11,345
Agriculture	2,630	1,783
Mining	96	24
Construction	1,383	1,083
Manufacturing	3,335	2,516
Transportation, Communications, and other public utilities	951	939
Wholesale & retail trade	2,346	1,463
Finance, Insurance	357	221
Business & personal serv.	1,493	887
Professional & related serv.	1,370	1,416

PENNSYLVANIA COUNTIES

	York	Lancaster
Total Population (1950)	202,737	234,717
Total Employed	84,465	97,509
Agriculture	6,795	11,454
Mining	434	437
Construction	5,115	6,399
Manufacturing	39,549	39,308
Transportation, Communication, and other public utilities	4,079	5,212
Wholesale & retail trade	13,255	15,333
Finance & insurance	1,435	1,678
Business & personal service	5,685	6,765
Prof. & related service	4,882	6,767

Source: 1950 Census of Population
Volume II
Characteristics of the Population
Part 20 (Maryland) and Part 38 (Pennsylvania)

Table I-9

Harford County

Present Use of Land and Estimated 1980 Requirements

	1954 Area (Acres)	1980 Area (Acres)
Urban		
Bel Air	735	1,050
Aberdeen	575	1,700
Havre de Grace	1,344	2,250
Edgewood	-	900
Total	2,654	5,900
Rural Non-Farm		
Residential	4,123	8,400
Commercial	232	336
Industrial	262	3,000
Utilities	248	420
Quasi-Public	190	500
Public Parks & Recreational Areas	439	2,000
Other Public	487	1,260
Total	5,981	15,916
Rural Miscellaneous		
Mining	584	600
Transportation	757	800
Private Recreation	2,096	3,000
Roads and Streets	3,681	4,760
Military	39,726	39,726
Farm and Woodlands	231,359	216,136
Total	278,203	265,022
Grand Total	286,838	286,838

TABLE I-10

SEISMIC HISTORY OF THE PEACH BOTTOM, PENNSYLVANIA AREA

Date	Time	Locality
November 1, 1935	01:04	Epicenter at Timiskaming, Canada (46°47' N., 79°04' W.) Felt area of 1,000,000 square miles. Intensity III and under reported at Delta and York, Pa; Annapolis, Bel Air and Havre de Grace, Md.
November 14, 1939	21:54	Epicenter in Salem County, N.J. (39°39' N., 75°13' W.) Felt Felt area 6,000 square miles. Intensity III and under at Delta and Oxford, Pa.: Bel Air, Conowingo, Havre de Grace, Perryville, and Port Deposit, Md.
September 5, 1944	00:39	Epicenter at Messena, N. Y. (44°58' N., 74°48' W.) Felt area 175,000 square miles. Intensity IV at Philadelphia, Pa. III and under at Baltimore, and Westminister, Md.

TABLE I-11

ENVIRONMENTAL RADIATION SAMPLING STATIONS

Location	Type of Sampling Stations
1. Plant Site	a. Background gamma monitoring station
	b. Airborne particulate station on exclusion site.
	c. Airborne particulate station on hillside south of site.
	d. Fallout water sampling station.
	e. Well water sampling station.
	f. Vegetation sampling station.
	g. Silt sampling station.
	h. Earth sampling station.
	i. Fish collecting station.
	j. Small game collection.
2. Conowingo Dam, Md.	a. Airborne particulate sampling station.
	b. Fallout water sampling station.
	c. Surface water sampling station.
	d. Earth collecting station.
3. Port Deposit, Md.	a. Well water collecting station
4. Chesapeake Bay Area	a. Three independent shellfish collecting stations.
5. Delta, Pa.	a. Airborne particulate sampling station.
	b. Well water sampling station.
	c. Earth sampling station.
6. Holtwood Dam, Pa.	a. Airborne particulate sampling station.
	b. Surface water sampling station.
	c. Silt sampling station
	d. Fish collecting station.
	e. Earth sampling station.
7. Hensel Vicinity, Pa.	a. Airborne particulate sampling station.
	b. Earth sampling station.

(Figure 14 shows the location of these sampling stations.)

TABLE I-12

ENVIRONMENTAL RADIATION MONITORING PROGRAM

	Type of Analysis	Equipment	Type of Sample	Sample Collection Frequency	No. of Stations	Station Location
Background Gamma Monitoring	Gamma	Victoreen Model 716A Gamma Sensing element (01-10 mr/hr) Rectiriter strip chart recorder.	Continuous recording	Chart paper collected weekly.	one	Peach Bottom Site
Airborne Particulate	Gross Beta-Gamma	Gelman pump (1/3 Hp) 2" Diameter Filter paper. (98% retention of 0.3 micron particles-AEC test)	1 CFM Continuous	Filter paper collected weekly.	six	Peach Bottom Site Hillside southeast of the Site Delta, Pa. Holtwood, Pa. Conowingo, Md. Wakefield, Pa.
Fallout Water	Gross Beta-Gamma	Rain and snow Gauge	Continuous	Monthly	two	Peach Bottom Site Conowingo, Md.
	Strontium-90	"	"	Quarterly	two	"
Surface Water (insoluble and soluble activity)	Gross Alpha Gross Beta-Gamma	One liter polyethylene bottle.	Spot "	Monthly	two	Holtwood, Pa. Conowingo, Md.
Well Water	Gross Alpha Gross Beta-Gamma Uranium	"	"	Quarterly	three	Peach Bottom Site Colora, Md. Darlington, Md.
	Strontium-90	"	"	Semi-annually	"	"

TABLE I-12

ENVIRONMENTAL RADIATION MONITORING PROGRAM (Cont.)

	Type of Analysis	Equipment	Type of Sample	Sample Collection Frequency	No. of Stations	Station Location
Shell Fish (Cont.) Tissue	Gross Beta-Gamma Potassium-40			Quarterly	three independent beds.	Tolchester, Md. Hacketts Pt., Md. Swan Pt., Md.
	Iodine-131			Semi-annually	"	"
Milk	Gross Beta-Gamma Potassium-40	1/2 gallon polyethylene container	Spot	Quarterly	four	Local Farms
	Strontium-90 Iodine-131	"	"	Semi-annually	two	Local Farms
Small Game (Rabbits)	Gross Beta-Gamma and Potassium-40 of muscle, liver, kidney and bone. 1-131 of thyroid			Semi-annually	one	Peach Bottom Site

TABLE I-12

ENVIRONMENTAL RADIATION MONITORING PROGRAM (Cont.)

	Type of Analysis	Equipment	Type of Sample	Sample Collection Frequency	No. of Stations	Station Location
Vegetation	Gross Alpha Gross Beta-Gamma Potassium-40		Stems, leaves and fruit	Spring and Fall	five	Peach Bottom Site Delta, Pa. Holtwood, Pa. Conowingo, Md. Wakefield, Pa.
	Strontium-90		"	Annually	"	"
Silt	Gross Alpha Gross Beta-Gamma	Quart Container	Spot	Semi-annually	two	Peach Bottom Site Holtwood, Pa.
	Strontium-90	"	"	Annually	"	"
Earth	Gross Alpha Gross Beta-Gamma Potassium-40	"	Sunshine Method	Quarterly	five	Peach Bottom Site Delta, Pa. Holtwood, Pa. Conowingo, Md.
	Strontium-90	"	"	Annually	two	Wakefield, Pa
Fish	Gross Alpha Gross Beta-Gamma Potassium-40 Strontium-90			Quarterly	two	Peach Bottom Site Holtwood, Pa.
Shell Fish Shell	Gross Beta-Gamma Potassium-40			Quarterly	three independent beds.	Tolchester, Md. Hacketts Pt., Md. Swan Pt., Md.

TABLE II-1

PERCENTAGE FREQUENCY OF REGIONAL WIND DIRECTION AND SPEED

A. Annual Averages

	Wind Speed (miles per hour) 1-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	>46	Total Freq.	Mean Speed
N	1.0	2.3	3.2	1.8	0.6	0.2	0.0	0.0	0.0	9.1	9.0
NE	1.0	2.2	2.8	1.4	0.4	0.1	0.0	0.0	0.0	8.0	8.6
E	1.0	3.4	3.4	1.3	0.4	0.1	0.1	0.0	0.0	9.7	8.4
SE	0.9	2.5	2.6	1.0	0.3	0.2	0.1	0.0	0.0	7.6	8.5
S	1.1	3.0	3.8	1.8	0.5	0.2	0.1	0.0	0.0	10.5	8.9
SW	1.7	4.3	4.4	2.1	0.5	0.2	0.1	0.0	0.0	13.3	8.6
W	1.8	4.9	5.5	3.1	1.4	0.6	0.2	0.0	0.0	17.5	10.1
NW	1.4	3.5	5.0	4.2	1.8	0.8	0.2	0.0	0.0	16.9	11.1
Calms										7.3	
Total	9.9	26.1	30.7	16.7	5.9	2.4	0.8	0.0	0.0		9.0 Aver.

B. Winter Averages (January-February-March)

	1-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	>46	Total Freq.	Mean Speed
N	0.8	2.1	3.1	2.2	1.0	0.3	0.1	0.0	0.0	9.6	9.8
NE	1.1	2.2	2.6	1.3	0.4	0.2	0.1	0.0	0.0	7.9	8.9
E	0.9	3.5	3.4	1.4	0.4	0.2	0.1	0.0	0.0	9.9	8.4
SE	0.9	2.1	2.2	0.9	0.4	0.3	0.1	0.1	0.0	7.0	8.8
S	0.9	2.3	2.9	1.8	0.6	0.4	0.1	0.0	0.0	9.0	9.6
SW	1.1	3.1	3.1	2.1	0.6	0.4	0.1	0.0	0.0	10.5	9.4
W	1.2	3.8	5.2	3.7	2.5	1.4	0.5	0.1	0.0	18.4	12.1
NW	1.0	3.0	5.7	6.5	3.7	1.8	0.4	0.1	0.0	22.2	13.6
Calms										5.4	
Total	7.9	22.1	28.2	19.9	9.6	5.0	1.5	0.3	0.0		10.6 Aver.

C. Spring Averages (April-May-June)

	1-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	>46	Total Freq.	Mean Speed
N	0.7	2.2	3.0	1.9	0.5	0.2	0.1	0.0	0.0	8.6	9.4
NE	0.9	2.5	3.2	1.7	0.4	0.0	0.0	0.0	0.0	8.7	9.0
E	1.0	3.9	4.2	1.8	0.4	0.0	0.0	0.0	0.0	11.3	8.9
SE	0.8	2.9	3.1	1.4	0.3	0.1	0.0	0.0	0.0	8.6	8.7
S	1.0	3.2	4.0	2.2	0.6	0.2	0.0	0.0	0.0	11.2	9.2
SW	1.5	4.3	4.7	2.3	0.6	0.2	0.1	0.0	0.0	13.7	9.0
W	1.3	4.6	5.3	3.7	1.2	0.4	0.1	0.0	0.0	16.6	10.3
NW	1.1	3.4	4.6	3.8	1.4	0.4	0.1	0.0	0.0	14.8	11.0
Calms										6.1	
Total	8.3	27.0	32.1	18.8	5.4	1.5	0.4	0.0	0.0		9.1 Aver.

TABLE II-1 (continued)

PERCENTAGE FREQUENCY OF REGIONAL WIND DIRECTION AND SPEED

D. Summer Averages (July-August-September)

Wind Speed (miles per hour)

	1-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	>46	Total Freq.	Mean Speed
N	1.1	3.1	3.4	1.2	0.3	0.1	0.0	0.0	0.0	9.2	7.7
NE	0.9	2.3	2.7	0.8	0.2	0.1	0.0	0.0	0.0	7.0	7.8
E	1.0	3.5	3.1	0.7	0.2	0.0	0.0	0.0	0.0	8.5	7.8
SE	1.0	3.0	3.1	0.8	0.2	0.1	0.0	0.0	0.0	8.2	7.8
S	1.3	3.9	5.0	1.8	0.3	0.1	0.0	0.0	0.0	12.4	8.2
SW	2.2	5.8	5.2	2.0	0.1	0.1	0.0	0.0	0.0	15.4	7.8
W	2.7	6.3	5.2	1.1	0.5	0.2	0.0	0.0	0.0	16.0	8.0
NW	1.9	4.7	4.6	1.9	0.5	0.2	0.0	0.0	0.0	13.8	8.4
Calms										9.5	
Total	12.1	32.6	32.3	10.3	2.3	0.9	0.0	0.0	0.0		7.3 Aver.

E. Autumn Averages (October-November-December)

	1-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	>46	Total Freq.	Mean Speed
N	1.3	1.9	3.1	2.0	0.5	0.2	0.0	0.0	0.0	9.0	8.9
NE	1.1	2.0	2.8	1.7	0.5	0.2	0.0	0.0	0.0	8.3	8.6
E	1.3	2.8	2.8	1.2	0.4	0.3	0.1	0.1	0.0	9.0	8.6
SE	1.0	2.0	2.0	0.8	0.3	0.3	0.1	0.1	0.0	6.6	8.5
S	1.2	2.4	3.3	1.5	0.5	0.3	0.1	0.0	0.0	9.3	8.5
SW	1.9	4.4	4.7	2.0	0.6	0.2	0.0	0.0	0.0	13.7	8.2
W	2.0	4.7	6.3	4.0	1.4	0.6	0.1	0.0	0.0	19.1	10.0
NW	1.6	2.9	5.3	4.6	1.7	0.6	0.2	0.0	0.0	16.9	11.2
Calms										8.2	
Total	11.4	23.1	30.3	17.8	5.9	2.7	0.6	0.2	0.0		8.8 Aver.

TABLE II-2

PERCENT FREQUENCY OF WIND SPEEDS AT VARIOUS HOURS THROUGH THE DAY

A. Annual Averages

Wind Speed (miles per hour)

Hour (EST)	0	1-3	4-7	8-12	13-18	19-24	25-38	>38
01	12.0	12.1	32.8	28.8	11.2	2.9	1.1	0.0
04	11.9	13.6	31.5	28.4	11.6	2.6	1.1	0,0
07	10.9	11.1	30.9	29.3	14.0	3.1	1.0	0.1
10	4.7	7.5	25.1	31.0	22.4	7.0	2.4	0.1
13	2.9	5.1	21.0	31.8	26.2	9.5	3.3	0.1
16	2.5	5.2	22.0	35.6	24.4	7.6	2.2	0.0
19	5.3	8.2	30.6	35.5	15.6	3.8	1.2	0.0
22	8.7	11.5	32.0	30.7	12.9	3.6	1.0	0.0
*Avg.	7.3	9.6	27.7	31.3	16.9	5.0	1.7	0.1

B. Winter Averages (January-February-March)

Hour (EST)	0	1-3	4-7	8-12	13-18	19-24	25-38	>38
01	7.7	8.2	27.1	32.1	16.1	6.2	2.9	0.0
04	7.2	10.3	27.7	28.5	17.7	6.1	2.8	0.1
07	7.7	9.9	25.9	29.1	18.5	6.1	2.9	0.2
10	3.6	6.9	19.7	26.7	26.8	11.1	5.7	0.1
13	2.9	5.0	17.0	25.2	28.2	14.5	6.7	0.2
16	2.9	5.4	17.1	28.9	27.7	12.2	4.9	0.0
19	4.4	6.7	25.1	32.7	21.3	7.5	2.6	0.1
22	6.9	8.4	26.5	30.7	17.7	7.5	2.6	0.1
*Avg.	5.5	7.7	23.0	29.4	21.7	8.9	3.7	0.1

C. Spring Averages (April-May-June)

Hour (EST)	0	1-3	4-7	8-12	13-18	19-24	25-38	>38
01	11.9	11.9	34.3	28.7	11.6	1.7	0.5	0.0
04	12.1	13.2	33.0	29.1	12.1	1.4	0.5	0.0
07	8.3	8.7	31.2	31.9	16.7	3.3	0.2	0.0
10	3.3	5.6	24.4	33.0	25.8	6.7	1.3	0.0
13	2.0	3.7	19.6	32.4	30.5	9.7	2.5	0.0
16	1.5	3.1	18.7	36.3	29.7	10.0	1.7	0.1
19	3.5	5.3	28.4	41.1	17.7	3.5	0.8	0.0
22	6.3	9.8	33.9	33.4	13.7	2.7	0.3	0.0
*Avg.	5.9	7.9	27.2	33.3	19.5	4.9	0.9	0.0

*Averages are computed from complete twenty-four hour record.

TABLE II-2 (continued)

PERCENT FREQUENCY OF WIND SPEEDS AT VARIOUS HOURS THROUGH THE DAY

D. Summer Averages (July-August-September)

Wind Speed (miles per hour)

Hour (EST)	0	1-3	4-7	8-12	13-18	19-24	25-38	>38
01	16.4	16.3	39.4	24.8	4.9	0.5	0.1	0.0
04	17.3	17.8	35.9	26.0	3.9	0.5	0.1	0.0
07	14.5	13.7	37.9	25.8	7.8	0.6	0.1	0.0
10	4.9	8.5	32.8	36.2	14.9	2.4	0.3	0.0
13	2.7	5.9	28.1	38.1	20.9	3.7	0.4	0.0
16	2.1	5.9	25.3	42.4	20.9	2.9	0.6	0.0
19	6.1	9.7	37.9	37.1	8.3	1.1	0.2	0.0
22	11.9	14.3	37.1	31.9	6.3	0.7	0.1	0.0
*Avg.	9.5	11.8	33.5	32.3	9.4	1.4	0.3	0.0

E. Autumn Averages (October-November-December)

Hour (EST)	0	1-3	4-7	8-12	13-18	19-24	25-38	>38
01	12.1	11.9	30.3	29.5	12.0	3.1	1.1	0.0
04	11.1	13.1	29.3	30.1	12.6	2.3	0.9	0.1
07	12.9	12.2	28.7	29.4	12.9	2.5	0.9	0.2
10	7.2	9.0	23.4	28.2	22.3	7.7	2.3	0.1
13	4.1	5.8	19.5	31.7	25.3	10.1	3.5	0.1
16	3.3	6.5	26.8	34.9	21.1	5.4	1.8	0.1
19	7.1	11.2	31.1	31.0	14.9	3.5	1.6	0.1
22	9.6	13.5	30.7	26.9	14.0	3.7	0.9	0.0
*Avg.	8.2	11.1	27.2	30.2	17.1	4.8	1.8	0.1

*Averages are computed from complete twenty-four hour record.

TABLE II-3

PERCENTAGE FREQUENCY OF OCCURRENCE OF VARIOUS INTENSITIES OF PRECIPITATION

A. Annual Averages

Precipitation (inches)

Hour of day	Trace	.01	.02-.09	.10-.24	.25-.49	.50-.99	1.00-1.99	>2.00	Total
01	6.6	2.1	4.1	1.3	0.2	0.1	0.0	0.0	14.4
04	7.1	2.1	3.8	1.5	0.3	0.1	0.0	0.0	14.7
07	8.3	2.4	3.9	1.3	0.3	0.1	0.0	0.0	16.2
10	8.3	2.0	3.5	0.9	0.2	0.1	0.0	0.0	15.0
13	7.5	1.8	3.2	0.9	0.1	0.1	0.0	0.0	13.5
16	7.9	1.8	3.5	0.9	0.2	0.1	0.0	0.0	14.5
19	7.8	2.1	3.5	1.1	0.3	0.1	0.1	0.0	15.0
22	6.9	2.1	3.6	1.3	0.3	0.1	0.0	0.0	14.3
Day*	16.3	3.3	8.8	7.[illegible]	5.8	5.2	2.2	0.5	49.2

B. Winter Averages (January-February-March)

Hour of day	Trace	.01	.02-.09	.10-.24	.25-.49	.50-.99	1.00-1.99	>2.00	Total
01	8.5	2.8	5.7	1.4	0.2	0.0	0.0	0.0	18.6
04	7.9	3.3	5.2	1.9	0.2	0.0	0.0	0.0	18.4
07	9.1	3.4	5.1	2.2	0.2	0.0	0.0	0.0	20.0
10	11.6	3.0	4.4	0.9	0.3	0.0	0.0	0.0	20.2
13	8.9	2.2	4.4	1.0	0.2	0.0	0.0	0.0	16.8
16	8.7	2.3	4.5	0.6	0.0	0.0	0.0	0.0	16.1
19	9.2	3.2	3.5	1.0	0.1	0.0	0.0	0.0	17.1
22	7.8	2.9	4.8	1.2	0.2	0.0	0.0	0.0	16.8
Day*	16.8	3.5	10.0	7.8	6.6	6.3	2.1	0.0	53.2

C. Spring Averages (April-May-June)

Hour of day	Trace	.01	.02-.09	.10-.24	.25-.49	.50-.99	1.00-1.99	>2.00	Total
01	8.3	2.5	4.4	1.6	0.1	0.2	0.0	0.0	17.1
04	8.6	2.6	5.1	1.6	0.3	0.0	0.0	0.0	18.2
07	10.3	2.9	4.7	1.2	0.1	0.0	0.0	0.0	19.2
10	8.5	2.0	4.4	0.9	0.1	0.1	0.0	0.0	16.0
13	8.1	2.1	3.5	0.9	0.1	0.1	0.0	0.0	14.8
16	10.0	2.0	3.4	1.2	0.4	0.3	0.0	0.0	17.3
19	9.4	1.3	4.4	0.9	0.4	0.3	0.1	0.0	16.7
22	8.4	2.4	3.3	1.8	0.3	0.1	0.0	0.0	16.4
Day*	18.5	3.7	9.6	8.7	7.0	5.8	3.0	0.4	56.7

*Twenty-four hour interval, midnight to midnight.

TABLE II-3 (continued)

PERCENTAGE FREQUENCY OF OCCURRENCE OF VARIOUS INTENSITIES OF PRECIPITATION

D. Summer Averages (July-August-September)

Precipitation (inches)

Hour of day	Trace	.01	.02-.09	.10-.24	.25-.49	.50-.99	1.00-1.99	>2.00	Total
01	5.0	1.3	2.2	0.8	0.0	0.1	0.0	0.0	9.4
04	5.1	1.0	1.4	0.9	0.2	0.0	0.1	0.0	8.7
07	6.0	1.6	1.8	0.8	0.2	0.1	0.1	0.0	10.6
10	5.1	1.4	2.0	0.9	0.1	0.2	0.0	0.0	9.8
13	5.6	1.2	1.6	0.7	0.2	0.0	0.0	0.0	9.2
16	5.7	1.1	2.0	0.8	0.3	0.1	0.1	0.0	10.3
19	6.0	1.6	1.8	1.3	0.6	0.1	0.1	0.1	11.6
22	5.4	0.9	2.3	1.3	0.5	0.2	0.0	0.0	10.7
Day*	14.3	3.0	8.2	6.6	4.7	3.7	1.7	1.2	43.3

E. Autumn Averages (October-November-December)

Hour of day	Trace	.01	.02-.09	.10-.24	.25-.49	.50-.99	1.00-1.99	>2.00	Total
01	4.7	2.0	3.9	1.5	0.3	0.0	0.0	0.0	12.4
04	6.7	1.4	3.6	1.4	0.4	0.0	0.0	0.0	13.6
07	7.9	0.9	4.0	0.8	0.5	0.0	0.0	0.0	15.1
10	8.0	1.7	3.0	1.0	0.2	0.0	0.0	0.0	13.9
13	7.4	1.7	3.2	1.0	0.0	0.1	0.0	0.0	13.4
16	7.4	1.7	4.1	0.9	0.2	0.0	0.0	0.0	14.3
19	6.4	2.3	4.3	1.2	0.1	0.1	0.1	0.0	14.4
22	6.0	2.3	3.9	0.9	0.2	0.1	0.0	0.0	13.4
Day*	15.6	3.0	7.4	5.1	4.8	5.0	2.0	0.7	43.4

*Twenty-four hour interval, midnight to midnight.

TABLE II-4

DISTRIBUTION OF HOURLY TEMPERATURES FOR REGION, EXPRESSED AS PERCENT FREQUENCY

Temp. Range °F	Winter*	Spring*	Summer*	Autumn*	Year
5°	0.0			0.1	0.0
5-9	0.2			0.1	0.1
10-14	1.1			0.3	0.4
15-19	2.3			1.1	0.8
20-24	4.4			2.6	1.8
25-29	9.3	0.3		5.7	3.8
30-34	18.6	0.8		11.4	7.7
35-39	21.9	2.0		13.6	9.4
40-44	17.4	4.5	0.3	13.2	8.8
45-49	11.0	8.0	1.0	12.2	8.0
50-54	6.6	11.6	2.4	11.2	8.0
55-59	4.0	14.4	5.5	11.1	8.8
60-64	1.9	14.6	10.7	7.9	8.8
65-69	0.8	14.2	17.4	4.7	9.3
70-74	0.3	11.8	22.6	2.6	9.3
75-79	0.1	8.3	17.9	1.3	6.9
80-84	0.0	5.2	12.2	0.6	4.5
85-89	0.0	2.9	6.8	0.2	2.5
90-94	0.0	1.0	2.5	0.0	0.9
95-99	0.0	0.2	0.8	0.0	0.2
100	0.0	0.0	0.1	0.0	0.0

*Winter is defined as the months of January through March; Spring, April through June; Summer, July through September; Autumn, October through December.

TABLE II-5

PERCENTAGE FREQUENCY OF WIND DIRECTION AND SPEED AT HOLTWOOD DAM

A. Annual Averages

Wind Speed (miles per hour)

	1-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	>46	Total Freq.	Mean Speed
N	7.8	5.0	2.6	1.2	0.2	0.1	0.0	0.0	0.0	16.9	5.5
NE	0.5	0.5	0.1	0.0	0.0	0.0	0.0	0.0	0.0	1.1	4.4
E	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	1.8
SE	1.5	4.0	4.0	0.7	0.1	0.0	0.0	0.0	0.0	10.3	7.2
S	19.2	9.4	3.2	0.5	0.1	0.0	0.0	0.0	0.0	32.5	3.9
SW	2.1	1.5	1.0	0.1	0.0	0.0	0.0	0.0	0.0	4.7	5.0
W	0.7	0.5	0.3	0.1	0.0	0.0	0.0	0.0	0.0	1.6	5.5
NW	5.6	9.3	8.0	5.0	2.0	0.4	0.0	0.0	0.0	30.3	8.6
Calms										2.6	
Total	37.5	30.2	19.2	7.6	2.4	0.5	0.0	0.0	0.0		6.0 Aver.

B. Winter Averages (January-February-March)

	1-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	>46	Total Freq.	Mean Speed
N	5.4	4.7	1.8	1.9	0.2	0.2	0.0	0.0	0.0	14.2	6.5
NE	0.8	0.6	0.1	0.0	0.0	0.0	0.0	0.0	0.0	1.4	3.7
E	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SE	1.7	3.2	5.4	1.3	0.1	0.0	0.0	0.0	0.0	11.6	8.1
S	16.1	8.0	2.8	0.6	0.1	0.0	0.0	0.0	0.0	27.5	4.0
SW	1.8	1.3	1.0	0.0	0.0	0.0	0.0	0.0	0.0	4.2	5.2
W	0.3	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.6	5.6
NW	4.4	9.0	10.5	9.3	4.4	1.1	0.1	0.0	0.0	38.8	11.1
Calms										1.6	
Total	30.5	27.0	21.7	13.2	4.8	1.3	0.1	0.0	0.0		7.6 Aver.

TABLE II-5 (continued)

PERCENTAGE FREQUENCY OF WIND DIRECTION AND SPEED AT HOLTWOOD DAM

C. Spring Averages (April-May-June)

Wind Speed (miles per hour)

	1-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	>46	Total Freq.	Mean Speed
N	7.8	5.7	2.6	1.0	0.2	0.0	0.0	0.0	0.0	17.2	5.2
NE	0.4	0.6	0.1	0.0	0.0	0.0	0.0	0.0	0.0	1.1	4.6
E	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	2.7
SE	1.3	4.7	4.9	0.7	0.0	0.0	0.0	0.0	0.0	11.5	7.6
S	16.8	12.7	3.8	0.8	0.1	0.0	0.0	0.0	0.0	34.3	4.5
SW	1.9	1.9	0.7	0.3	0.0	0.0	0.0	0.0	0.0	4.8	5.4
W	0.6	0.5	0.4	0.2	0.1	0.0	0.0	0.0	0.0	1.8	6.7
NW	5.2	9.8	7.4	3.8	1.6	0.3	0.0	0.0	0.0	28.1	8.5
Calms										0.9	
Total	34.2	35.9	19.9	6.8	2.0	0.3	0.0	0.0	0.0		6.1 Aver.

D. Summer Averages (July-August-September)

	1-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	>46	Total Freq.	Mean Speed
N	10.0	5.4	3.2	0.4	0.1	0.0	0.0	0.0	0.0	19.1	4.5
NE	0.4	0.5	0.2	0.0	0.0	0.0	0.0	0.0	0.0	1.0	4.9
E	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	3.7
SE	1.9	4.7	3.0	0.2	0.0	0.0	0.0	0.0	0.0	9.8	6.2
S	25.6	9.1	3.8	0.2	0.0	0.0	0.0	0.0	0.0	38.7	3.4
SW	2.4	1.8	1.0	0.0	0.0	0.0	0.0	0.0	0.0	5.3	4.7
W	0.9	0.4	0.3	0.0	0.0	0.0	0.0	0.0	0.0	1.7	4.6
NW	7.0	8.5	4.5	2.0	0.2	0.0	0.0	0.0	0.0	22.2	6.2
Calms										1.9	
Total	48.3	30.6	16.0	2.8	0.3	0.0	0.0	0.0	0.0		4.6 Aver.

TABLE II-5 (continued)

PERCENTAGE FREQUENCY OF WIND DIRECTION AND SPEED AT HOLTWOOD DAM

E. Autumn Averages (October-November-December)

Wind Speed (miles per hour)

	1-3	4-7	8-12	13-18	19-24	25-31	32-38	39-46	>46	Total Freq.	Mean Speed
N	7.8	4.4	2.8	1.3	0.4	0.2	0.0	0.0	0.0	16.9	5.8
NE	0.4	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	4.3
E	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
SE	1.2	3.5	2.8	0.5	0.0	0.0	0.0	0.0	0.0	8.0	7.1
S	18.5	7.8	2.4	0.5	0.2	0.0	0.0	0.0	0.0	29.4	3.6
SW	2.3	1.1	1.1	0.1	0.0	0.0	0.0	0.0	0.0	4.6	4.8
W	1.0	0.9	0.4	0.0	0.0	0.0	0.0	0.0	0.0	2.3	5.1
NW	5.8	9.8	9.8	4.7	1.7	0.2	0.0	0.0	0.0	32.0	8.6
Calms										5.8	
Total	37.0	27.9	19.3	7.1	2.3	0.4	0.0	0.0	0.0		5.7 Aver.

August, 1961

TABLE II-6 (A)

PERCENTAGE FREQUENCY OF WIND DIRECTION AND SPEED AT PEACH BOTTOM

(LOCATION NO. 1: LOWEST ANEMOMETER)

A. Annual Averages

Wind Speed (miles per hour)

	1-3	4-7	8-12	13-17	18-23	24-30	>31	Total Freq.	Mean Speed
N	0.8	1.0	0.4	0.0	0.1	0.0	0.0	2.2	5.1
NE	1.2	0.8	0.3	0.0	0.0	0.0	0.0	2.4	4.2
E	2.2	1.3	0.7	0.4	0.1	0.0	0.0	4.6	5.5
SE	6.2	4.3	1.1	0.0	0.1	0.0	0.0	11.7	3.9
S	0.1	0.0	0.0	0.00	0.0	0.0	0.0	0.1	3.5
SW	0.9	0.1	0.0	0.0	0.0	0.0	0.0	1.0	1.9
W	17.3	7.5	0.1	0.0	0.0	0.0	0.0	25.0	2.8
NW	5.2	9.1	8.4	2.3	0.2	0.1	0.0	25.3	7.3
Calm								27.8	
Totals	33.9	24.1	11.0	2.7	0.5	0.1	0.0		3.5 Aver.

B. Winter Averages (January-February-March)

	1-3	4-7	8-12	13-17	18-23	24-30	>31	Total Freq.	Mean Speed
N	0.6	1.6	0.7	0.0	0.2	0.0	0.0	3.1	6.1
NE	1.6	2.0	0.7	0.2	0.0	0.0	0.0	4.5	5.0
E	0.9	1.8	1.0	1.0	0.2	0.0	0.0	4.8	8.0
SE	2.9	3.2	1.5	0.0	0.2	0.0	0.0	7.7	4.8
S	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.2	6.0
SW	0.7	0.2	0.0	0.0	0.0	0.0	0.0	0.9	2.2
W	12.2	8.3	0.2	0.0	0.0	0.0	0.0	20.7	3.0
NW	3.8	12.2	14.6	4.7	0.4	0.2	0.2	36.0	8.5
Calm								22.2	
Totals	22.7	29.5	18.7	5.9	1.0	0.2	0.2		4.9 Aver

TABLE II-6 (A) (Cont'd)

PERCENTAGE FREQUENCY OF WIND DIRECTION AND SPEED AT PEACH BOTTOM

(LOCATION NO. 1: LOWEST ANEMOMETER)

C. Spring Averages (April-May-June)

	1-3	4-7	8-12	13-17	18-23	24-30	> 31	Total Freq.	Mean Speed
N	0.7	1.2	0.5	0.0	0.0	0.0	0.0	2.4	5.6
NE	0.9	0.2	0.0	0.0	0.0	0.0	0.0	1.2	2.6
E	3.0	1.4	0.9	0.5	0.2	0.0	0.0	6.1	5.6
SE	7.0	8.4	2.1	0.0	0.0	0.0	0.0	17.6	4.5
S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	---
SW	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.9	1.8
W	15.3	3.8	0.0	0.0	0.0	0.0	0.0	19.1	2.5
NW	5.2	8.4	8.4	2.1	0.5	0.0	0.0	24.6	7.4
Calm								28.2	
Totals	33.0	23.4	11.9	2.6	0.7	0.0	0.0		3.6 Aver.

D. Summer Averages (July-August-September)

	1-3	4-7	8-12	13-17	18-23	24-30	> 31	Total Freq.	Mean Speed
N	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.6	1.7
NE	1.3	0.6	0.0	0.0	0.0	0.0	0.0	2.0	2.9
E	2.8	1.5	0.4	0.0	0.0	0.0	0.0	4.8	3.6
SE	8.5	2.0	0.4	0.0	0.0	0.0	0.0	10.9	2.8
S	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.2	1.1
SW	1.1	0.0	0.0	0.0	0.0	0.0	0.0	1.1	1.1
W	22.4	5.4	0.2	0.0	0.0	0.0	0.0	28.1	2.6
NW	7.6	5.2	2.0	0.0	0.0	0.0	0.0	14.8	4.1
Calm								37.5	
Totals	44.5	14.7	3.0	0.0	0.0	0.0	0.0		1.9 Aver.

TABLE II-6 (A) (Cont'd)

PERCENTAGE FREQUENCY OF WIND DIRECTION AND SPEED AT PEACH BOTTOM

(LOCATION NO. 1: LOWEST ANEMOMETER)

E. Autumn Averages (October-November-December)

	1-3	4-7	8-12	13-17	18-23	24-30	> 31	Total Freq.	Mean Speed
N	1.1	1.0	0.4	0.0	0.0	0.0	0.0	2.6	4.3
NE	1.0	0.6	0.4	0.0	0.0	0.0	0.0	2.0	4.6
E	2.0	0.4	0.4	0.0	0.0	0.0	0.0	2.8	4.0
SE	6.4	3.7	0.3	0.1	0.0	0.0	0.0	10.5	3.5
S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	---
SW	0.8	0.1	0.0	0.0	0.0	0.0	0.0	1.0	2.7
W	19.4	12.6	0.1	0.0	0.0	0.0	0.0	32.1	3.0
NW	4.1	10.6	8.8	2.3	0.0	0.0	0.0	25.7	7.2
Calm								23.3	
Totals	34.8	29.0	10.4	2.4	0.0	0.0	0.0		3.5

Number of Observations

Winter	686
Spring	426
Summer	459
Autumn	707
Data Missing	102
Total	2380

TABLE II-6 (B)

PERCENTAGE FREQUENCY OF WIND DIRECTION AND SPEED AT PEACH BOTTOM

(LOCATION NO. 2: MIDDLE ANEMOMETER)

A. Annual Averages

Wind Speed (miles per hour)

	1-3	4-7	8-12	13.17	18.23	24-30	>31	Total Freq.	Mean Speed
N	0.8	1.2	1.0	0.4	0.1	0.0	0.0	3.7	7.8
NE	0.5	1.2	0.7	0.3	0.0	0.0	0.0	2.7	6.8
E	1.8	1.4	1.0	0.4	0.1	0.1	0.0	4.8	6.7
SE	6.3	5.3	3.5	2.1	0.2	0.0	0.0	17.4	6.2
S	1.2	0.2	0.0	0.0	0.0	0.0	0.0	1.4	2.2
SW	3.4	4.0	0.2	0.0	0.0	0.0	0.0	7.6	3.8
W	5.3	7.8	3.6	1.2	0.2	0.0	0.0	18.1	6.0
NW	2.9	4.2	8.1	5.8	1.1	0.2	0.0	22.2	10.2
Calm								22.0	
Totals	22.2	25.3	18.1	10.2	1.7	0.3	0.0		5.6 Aver.

B. Winter Averages (January-February-March)

	1-3	4-7	8-12	13.17	18.23	24-30	>31	Total Freq.	Mean Speed
N	0.8	1.8	1.7	0.4	0.0	0.0	0.0	4.8	6.9
NE	0.4	1.6	1.4	0.6	0.0	0.0	0.0	4.0	8.1
E	0.6	1.6	0.7	0.8	0.3	0.1	0.0	4.1	9.7
SE	4.5	2.8	2.5	1.4	0.1	0.1	0.0	11.6	6.4
S	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	1.0
SW	1.4	2.5	0.1	0.0	0.0	0.0	0.0	4.1	4.0
W	3.0	10.4	5.9	1.7	0.6	0.0	0.0	21.6	7.2
NW	2.4	4.0	12.4	8.6	1.8	0.1	0.0	29.4	11.2
Calm								20.3	
Totals	13.2	24.7	24.7	13.5	2.8	0.3	0.0		6.8 Aver.

TABLE II-6 (B) (Cont'd)

PERCENTAGE FREQUENCY OF WIND DIRECTION AND SPEED AT PEACH BOTTOM

(LOCATION NO. 2: MIDDLE ANEMOMETER)

C. Spring Averages (April-May-June)

	1-3	4-7	8-12	13-17	18-23	24-30	≥31	Total Freq.	Mean Speed
N	0.6	0.0	0.6	0.6	0.0	0.0	0.0	1.9	9.3
NE	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.6	3.5
E	3.1	1.6	2.2	0.6	0.0	0.3	0.0	7.8	7.3
SE	4.4	5.9	5.9	5.6	0.0	0.0	0.0	22.0	8.3
S	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.3	3.0
SW	2.8	2.2	0.3	0.0	0.0	0.0	0.0	5.3	3.5
W	5.6	5.6	4.0	1.6	0.3	0.0	0.0	17.1	6.4
NW	3.7	4.0	8.7	7.8	1.9	0.6	0.0	26.7	10.9
Calm								18.3	
Totals	20.8	19.6	21.7	16.2	2.5	0.9	0.0		6.8 Aver.

D. Summer Average (July-August-September)

	1-3	4-7	8-12	13-17	18-23	24-30	≥31	Total Freq.	Mean Speed
N	1.0	2.4	0.5	0.7	0.2	0.0	0.0	4.8	7.8
NE	0.7	2.1	0.5	0.2	0.0	0.0	0.0	3.6	5.7
E	2.1	1.9	1.0	0.0	0.0	0.0	0.0	5.0	4.5
SE	10.2	6.6	2.8	1.0	0.2	0.0	0.0	20.9	4.9
S	3.8	0.5	0.0	0.0	0.0	0.0	0.0	4.3	2.2
SW	7.1	4.3	0.5	0.0	0.0	0.0	0.0	11.9	3.5
W	7.4	6.9	0.2	0.0	0.0	0.0	0.0	14.5	3.6
NW	1.9	5.0	2.4	1.4	0.0	0.0	0.0	10.7	7.2
Calm								24.5	
Totals	34.2	29.7	7.9	3.3	0.4	0.0	0.0		3.6 Aver.

TABLE II-6 (B) (Cont'd)

PERCENTAGE FREQUENCY OF WIND DIRECTION AND SPEED AT PEACH BOTTOM

(LOCATION NO. 2: MIDDLE ANEMOMETER)

E. Autumn Averages (October-November-December)

	1-3	4-7	8-12	13-17	18-23	24-30	≥31	Total Freq.	Mean Speed
N	0.7	0.8	1.0	0.7	0.1	0.0	0.0	3.3	8.4
NE	0.7	0.7	1.0	0.3	0.0	0.0	0.0	2.6	6.9
E	1.4	0.6	0.1	0.3	0.0	0.0	0.0	2.4	4.5
SE	6.1	5.8	2.9	0.3	0.1	0.0	0.0	15.3	4.9
S	0.8	0.1	0.0	0.0	0.0	0.0	0.0	1.0	2.1
SW	2.4	6.9	0.0	0.0	0.0	0.0	0.0	9.3	4.3
W	5.1	8.1	4.2	1.7	0.1	0.0	0.0	19.2	6.2
NW	3.5	3.6	8.8	5.6	0.8	0.0	0.0	22.2	9.6
Calm								24.7	
Totals	20.7	26.6	18.0	8.9	1.1	0.0	0.0		5.1 Aver.

Number of Observations

Winter	708
Spring	322
Summer	421
Autumn	720
Data Missing	209
Total	2380

TABLE II-6 (C)

PERCENTAGE FREQUENCY OF WIND DIRECTION AND SPEED AT PEACH BOTTOM

(LOCATION NO. 3: HILL EXPOSURE)

A. Annual Averages

Wind Speed (miles per hour)

	1-3	4-7	8-12	13-17	18-23	24-30	>31	Total Freq.	Mean Speed
N	1.9	1.8	0.7	0.3	0.0	0.0	0.0	4.8	5.3
NE	3.9	2.5	0.9	0.2	0.0	0.0	0.0	7.6	4.3
E	2.9	2.4	0.6	0.6	0.0	0.1	0.1	6.7	5.5
SE	3.2	4.5	3.1	0.5	0.1	0.0	0.0	11.4	6.2
S	2.2	1.3	0.2	0.0	0.0	0.0	0.0	3.7	3.2
SW	8.5	4.8	1.2	0.2	0.0	0.0	0.0	14.7	3.8
W	7.4	8.2	2.7	1.0	0.4	0.0	0.0	19.8	5.5
NW	2.8	5.6	4.6	2.1	0.4	0.1	0.0	15.5	7.9
Calm								15.8	
Totals	32.8	31.1	14.0	4.9	0.9	0.2	0.1		4.6 Aver.

B. Winter Averages (January-February-March)

	1-3	4-7	8-12	13-17	18-23	24-30	>31	Total Freq.	Mean Speed
N	1.0	1.8	1.1	0.3	0.1	0.0	0.0	4.4	6.6
NE	4.1	5.3	2.3	0.7	0.1	0.0	0.0	12.5	5.5
E	1.0	1.3	0.8	1.0	0.1	0.3	0.0	4.6	9.2
SE	2.7	2.3	2.0	0.1	0.0	0.0	0.0	7.1	5.5
S	0.7	0.8	0.1	0.0	0.0	0.0	0.0	1.7	4.1
SW	4.4	5.7	2.0	0.3	0.0	0.0	0.0	12.4	5.0
W	5.5	8.2	4.3	1.1	0.7	0.1	0.0	20.0	6.6
NW	2.0	7.5	8.4	4.3	0.7	0.4	0.0	23.3	9.4
Calm								14.1	
Totals	21.4	32.9	21.0	7.8	1.7	0.8	0.0		6.0 Aver.

TABLE II-6 (C) (Cont'd)

PERCENTAGE FREQUENCY OF WIND DIRECTION AND SPEED AT PEACH BOTTOM

(LOCATION NO. 3: HILL EXPOSURE)

C. Spring Averages (April-May-June)

	1-3	4-7	8-12	13-17	18-23	24-30	≥31	Total Freq.	Mean Speed
N	1.3	1.6	1.1	0.3	0.0	0.0	0.0	4.3	6.2
NE	2.1	2.1	0.5	0.3	0.0	0.0	0.0	5.1	4.8
E	2.4	3.5	1.1	1.3	0.0	0.0	0.3	8.5	7.2
SE	2.7	5.6	6.1	0.8	0.3	0.0	0.0	15.5	7.5
S	1.6	1.3	0.5	0.0	0.0	0.0	0.0	3.5	3.6
SW	7.2	4.5	1.9	0.3	0.0	0.0	0.0	13.9	4.4
W	6.1	6.7	2.4	1.6	0.8	0.0	0.0	17.6	6.4
NW	3.5	4.0	6.1	2.9	0.8	0.0	0.0	17.3	8.5
Calm								14.4	
Totals	26.9	29.3	19.7	7.5	1.9	0.0	0.3		5.6 Aver.

D. Summer Averages (July-August-September)

	1-3	4-7	8-12	13-17	18-23	24-30	≥31	Total Freq.	Mean Speed
N	2.9	1.4	0.0	0.0	0.0	0.0	0.0	4.3	3.4
NE	5.3	0.7	0.0	0.0	0.0	0.0	0.0	6.0	2.2
E	5.3	3.1	0.0	0.0	0.0	0.0	0.0	8.4	2.8
SE	3.9	7.0	2.6	0.7	0.0	0.0	0.0	14.2	5.7
S	4.3	1.7	0.0	0.0	0.0	0.0	0.0	6.0	2.7
SW	14.0	2.4	0.0	0.0	0.0	0.0	0.0	16.4	2.4
W	10.8	9.2	0.5	0.0	0.0	0.0	0.0	20.5	3.4
NW	2.9	4.6	0.2	0.0	0.0	0.0	0.0	7.7	4.3
Calm								16.4	
Totals	49.4	30.1	3.3	0.7	0.0	0.0	0.0		2.9 Aver.

TABLE II-6 (C) (Cont'd)

PERCENTAGE FREQUENCY OF WIND DIRECTION AND SPEED AT PEACH BOTTOM

(LOCATION NO. 3: HILL EXPOSURE)

E. Autumn Averages (October-Novemeber-December)

	1-3	4-7	8-12	13-17	18-23	24-30	≥31	Total Freq.	Mean Speed
N	2.4	2.5	0.6	0.6	0.0	0.0	0.0	6.1	5.1
NE	4.2	1.8	0.8	0.0	0.0	0.0	0.0	6.9	3.6
E	3.0	1.8	0.4	0.0	0.0	0.0	0.0	5.2	3.6
SE	3.5	3.2	1.6	0.3	0.0	0.0	0.0	8.6	5.0
S	2.3	1.4	0.0	0.0	0.0	0.0	0.0	3.7	3.2
SW	8.5	6.6	0.8	0.1	0.0	0.0	0.0	16.1	3.8
W	7.1	8.9	3.7	1.4	0.1	0.0	0.0	21.2	5.6
NW	2.7	6.2	3.7	1.3	0.0	0.0	0.0	13.8	6.8
Calm								18.4	
Totals	33.7	32.4	11.6	3.7	0.1	0.0	0.0		4.0 Aver.

Number of Observations

Winter	704
Spring	375
Summer	415
Autumn	708
Data Missing	178
Total	2380

TABLE II-7

PERCENTAGE FREQUENCY OF REGIONAL GEOSTROPHIC WIND DIRECTION AND SPEED

(Precipitation at Time of Observation)

A. Annual Averages

	Wind Speed (miles per hour)										
	1-3	4-7	8-12	13-17	18-23	24-30	31-37	38-46	>46	Total Freq.	Mean Speed
N	0.3	0.5	1.5	2.8	1.3	1.3	1.4	0.8	1.7	11.6	27.6
NE	0.1	0.6	1.8	2.7	2.9	2.6	1.6	1.8	1.6	15.6	27.2
E	0.1	0.8	2.5	3.5	2.7	2.0	1.5	0.7	0.5	14.3	21.7
SE	0.4	0.6	1.9	3.9	3.2	2.6	1.1	0.5	0.8	15.0	22.1
S	0.1	1.9	1.7	3.3	2.9	2.2	1.8	0.7	1.8	16.5	24.5
SW	0.3	0.6	1.7	2.5	1.8	1.5	1.4	0.8	0.8	11.4	23.5
W	0.6	0.5	1.9	1.6	1.4	1.1	0.3	0.2	0.1	7.3	17.2
NW	0.0	0.8	1.3	1.6	1.6	0.8	0.6	0.6	0.8	8.2	22.7
Calm										0.0	
Total	1.9	6.3	14.3	21.9	17.8	14.1	9.7	6.1	8.1		23.8 Aver.

B. Winter Averages (January-February-March)

	1-3	4-7	8-12	13-17	18-23	24-30	31-37	38-46	>46	Total Freq.	Mean Speed
N	0.0	0.8	1.2	2.2	1.4	1.9	1.6	1.0	2.2	12.3	29.6
NE	0.0	0.6	1.8	3.0	3.0	2.2	1.6	1.6	2.0	15.8	27.6
E	0.2	0.6	1.8	3.2	2.2	1.6	1.6	1.6	0.8	13.6	24.1
SE	0.2	0.4	2.0	2.8	3.4	3.0	1.4	1.0	1.2	15.4	24.9
S	0.2	1.0	1.2	2.3	2.2	2.0	1.6	1.4	3.0	14.9	30.5
SW	0.2	0.6	0.8	1.8	1.6	1.6	2.0	1.4	1.2	11.2	28.3
W	0.4	0.4	1.2	2.0	1.2	0.8	0.4	0.2	0.0	6.6	17.7
NW	0.0	0.6	1.6	1.0	1.6	1.0	1.8	0.8	2.0	10.4	29.0
Calm										0.0	
Total	1.2	5.0	11.6	18.3	16.6	14.1	12.0	9.0	12.4		27.0 Aver.

TABLE II-7

PERCENTAGE FREQUENCY OF REGIONAL GEOSTROPHIC WIND DIRECTION AND SPEED

(Precipitation at Time of Observation)

C. Spring Averages (April-May-June)

	1-3	4-7	8-12	13-17	18-23	24-30	31-37	38-46	>46	Total Freq.	Mean Speed
N	0.8	0.6	1.3	2.7	1.0	1.1	1.5	1.0	1.3	11.3	24.4
NE	0.0	0.2	1.4	1.5	3.8	2.5	1.5	1.2	1.0	13.1	26.6
E	0.2	1.0	2.7	4.0	4.0	3.3	1.5	0.2	0.6	17.5	20.8
SE	0.2	0.6	1.9	4.2	4.2	2.3	1.0	0.6	0.2	16.2	20.2
S	0.4	2.5	1.2	3.8	3.8	1.0	0.2	0.2	1.9	15.8	22.3
SW	0.2	0.2	1.1	2.5	1.9	1.9	1.0	0.4	1.1	10.3	24.7
W	0.0	0.8	1.3	2.1	1.7	1.2	0.6	0.4	0.0	8.1	18.8
NW	0.2	0.8	1.0	1.7	2.1	1.1	0.0	0.2	0.6	7.7	20.7
Calm										0.0	
Total	2.0	6.7	11.9	22.6	22.5	15.3	8.1	4.2	6.7		22.3 Aver.

D. Summer Averages (July-August-September)

	1-3	4-7	8-12	13-17	18-23	24-30	31-37	38-46	>46	Total Freq.	Mean Speed
N	0.3	0.6	1.8	3.8	0.9	0.6	0.6	0.6	0.6	9.6	21.5
NE	0.3	1.5	2.3	4.1	2.9	2.9	1.5	0.9	0.9	17.2	21.9
E	0.0	1.2	3.2	3.8	2.9	2.6	2.0	0.3	0.0	16.1	19.6
SE	0.3	0.9	2.6	5.0	1.8	1.8	0.9	0.6	0.3	14.0	18.8
S	0.0	2.6	2.3	5.0	2.3	1.8	1.5	0.3	0.3	16.1	18.8
SW	0.6	0.3	3.2	3.2	1.8	1.5	0.6	0.0	0.0	11.1	16.6
W	1.2	0.6	2.0	1.2	1.2	1.2	0.0	0.3	0.0	7.6	15.2
NW	0.0	0.9	2.0	2.6	1.8	0.3	0.3	0.3	0.0	8.2	16.1
Calm										0.0	
Total	2.7	8.6	19.4	28.7	15.6	12.7	7.4	3.3	2.1		19.0 Aver.

TABLE II-7 (Cont'd)

PERCENTAGE FREQUENCY OF REGIONAL GEOSTROPHIC WIND DIRECTION AND SPEED

(Precipitation at Time of Observation)

E. Autumn Averages (October-November-December)

	1-3	4-7	8-12	13-17	18-23	24-30	31-37	38-46	>46	Total Freq.	Mean Speed
N	0.0	0.0	1.5	2.3	2.3	1.3	2.0	1.0	3.0	13.4	34.7
NE	0.0	0.5	1.0	2.0	2.3	3.1	1.5	3.3	2.5	16.2	32.5
E	0.0	0.2	2.3	2.8	1.8	0.8	0.8	0.8	0.7	10.2	22.3
SE	0.8	0.2	1.8	2.8	3.3	3.3	1.0	0.0	1.5	14.7	24.5
S	0.0	1.5	2.1	3.3	3.3	2.8	2.8	1.0	2.0	18.8	26.4
SW	0.3	1.3	1.8	2.5	2.0	1.0	2.0	1.3	1.0	13.2	24.4
W	0.8	0.3	2.0	1.0	1.3	1.5	0.0	0.0	0.2	7.1	17.1
NW	0.0	1.0	0.5	1.1	1.0	1.0	0.3	1.0	0.5	6.4	24.9
Calm										0.0	
Total	1.9	5.0	13.0	17.8	17.3	14.8	10.4	8.4	11.4		26.8

Season	Number of Observations
Winter	502
Spring	394
Summer	342
Fall	520
Total (Annual)	1758

TABLE II-13 (A)

PERCENTAGE FREQUENCY OF VERTICAL TEMPERATURE DIFFERENCES AT PEACH BOTTOM

(Measured between Locations 1 and 2, at 10 and 30 meters)

A. Annual Averages

Temperature Difference (°F)	Time of Observation 0100E	0700E	1300E	1900E	All Obs.
More than -2.0	0.0	0.0	1.0	0.0	0.2
-1.1 to -2.0	0.8	1.3	6.0	0.3	2.1
-0.1 to -1.0	7.3	23.3	62.0	6.3	24.7
0 to +0.9	30.6	39.9	25.2	32.6	32.1
1.0 to +1.9	19.8	18.2	2.2	21.8	15.5
2.0 to +3.9	26.0	11.4	2.6	24.8	16.2
4.0 to +5.9	12.0	4.2	0.7	10.0	6.7
6.0 to +7.9	2.8	1.3	0.2	3.7	2.0
More than +8.0	0.8	0.5	0.0	0.5	0.4
Average Temp. Difference	+ 2.0	+1.0	-1.0	+1.9	+ 1.2

B. Winter Averages (January-February-March)

Temperature Difference (°F)	0100E	0700E	1300E	1900E	All Obs.
More than -2.0	0.0	0.0	0.0	0.0	0.0
-1.1 to -2.0	0.0	0.0	1.0	0.0	0.2
-0.1 to -1.0	8.6	14.6	50.5	8.5	20.6
0 to +0.9	45.2	48.6	35.0	37.7	41.6
1.0 to +1.9	19.2	16.5	4.8	24.5	16.3
2.0 to +3.9	18.3	13.6	4.8	16.1	13.2
4.0 to +5.9	7.7	2.9	2.9	11.3	6.2
6.0 to +7.9	0.0	1.9	1.0	0.0	0.7
More than +8.0	1.0	1.9	0.0	1.9	1.2
Average Temp. Difference	+1.4	+1.2	+ 0.3	+1.6	+ 1.1

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TABLE II-13 (A)

PERCENTAGE FREQUENCY OF VERTICAL TEMPERATURE DIFFERENCE AT PEACH BOTTOM

(Measured between Locations 1 and 2, at 10 and 30 meters)

C. Spring Averages (April-May-June)

More than -2.0	0.0	0.0	3.9	0.0	1.0
-1.1 to -2.0	3.0	4.0	3.9	0.0	2.7
-0.1 to -1.0	14.8	56.4	78.5	16.8	41.6
0 to +0.9	28.7	30.7	10.8	45.5	28.9
1.0 to +1.9	21.8	7.9	1.9	11.9	10.9
2.0 to +3.9	21.8	1.0	1.0	21.8	11.4
4.0 to +5.9	6.9	0.0	0.0	3.0	2.5
6.0 to +7.9	3.0	0.0	0.0	1.0	1.0
More than +8.0	0.0	0.0	0.0	0.0	0.0
Average Temp. Difference	+1.5	+0.0	-0.6	+1.1	+0.5

D. Summer Averages (July-August-September)

More than -2.0	0.0	0.0	0.0	0.0	0.0
-1.1 to -2.0	0.0	1.2	17.8	1.2	5.0
-0.1 to -1.0	3.5	20.0	70.3	0.0	23.5
0 to +0.9	18.8	55.3	11.9	20.0	26.5
1.0 to +1.9	18.8	18.8	0.0	23.5	15.3
2.0 to +3.9	41.2	3.5	0.0	30.6	18.8
4.0 to +5.9	15.3	1.2	0.0	17.6	8.5
6.0 to +7.9	1.2	0.0	0.0	7.1	2.1
More than +8.0	1.2	0.0	0.0	0.0	0.3
Average Temp. Difference	+2.4	+0.5	-0.5	+2.7	+1.3

TABLE II-13 (A)

PERCENTAGE FREQUENCY OF VERTICAL TEMPERATURE DIFFERENCES AT PEACH BOTTOM

(Measured between Locations 1 and 2, at 10 and 30 meters)

E. Autumn Averages (October-November-December)

Temperature Difference (°F)	Time of Observation 0100E	0700E	1300E	1900E	All Obs.
More than -2.0	0.0	0.0	0.0	0.0	0.0
-1.1 to -2.0	0.0	0.0	1.1	0.0	0.3
-0.1 to -1.0	2.2	2.2	48.9	0.0	13.3
0 to +0.9	29.6	25.0	43.2	27.3	31.3
1.0 to +1.9	19.3	29.6	2.2	27.3	19.6
2.0 to +3.9	22.7	27.3	4.6	30.7	21.3
4.0 to +5.9	18.2	12.5	0.0	7.9	9.7
6.0 to +7.9	6.8	3.4	0.0	6.8	4.2
More than +8.0	1.1	0.0	0.0	0.0	0.3
Average Temp. Difference	+2.5	+2.1	+0.1	+2.2	+1.7

Number of Observations

	0100E	0700E	1300E	1900E	All Obs.
Winter	104	103	103	106	416
Spring	101	101	102	101	405
Summer	85	85	84	85	339
Autumn	88	88	88	88	352
Annual	378	377	377	380	1512

TABLE II-13 (B)

PERCENTAGE FREQUENCY OF VERTICAL TEMPERATURE DIFFERENCES AT PEACH BOTTOM

(Measured between Locations 1 and 3: 10 meter and Hillside Stations)

A. Annual Averages

Temperature Difference (°F)	Time of Observation (E.S.T.) 0100E	0700E	1300E	1900E	All Obs.
More than -2.0	0.0	0.0	0.0	0.2	0.1
-1.1 to -2.0	0.8	2.0	2.7	1.5	1.7
-0.1 to -1.0	19.3	38.6	50.8	20.0	32.2
0 to +0.9	27.7	30.0	30.7	23.4	27.9
1.0 to +1.9	18.4	15.6	8.8	17.9	15.1
2.0 to +3.9	24.9	11.1	4.0	23.5	15.9
4.0 to +5.9	7.0	1.8	1.3	10.1	5.1
6.0 to +7.9	1.4	0.7	1.2	2.7	1.5
More than +8.0	0.5	0.2	0.5	0.7	0.5
Average Temp. Difference	+1.5	+0.6	+0.3	+1.6	+1.0

B. Winter Averages (January-February-March)

Temperature Difference (°F)	0100E	0700E	1300E	1900E	All Obs.
More than -2.0	0.0	0.0	0.0	0.9	0.2
-1.1 to -2.0	0.0	1.0	1.0	0.9	0.7
-0.1 to -1.0	28.8	34.0	47.6	20.8	32.8
0 to +0.9	24.0	29.1	26.2	27.4	26.7
1.0 to +1.9	18.3	12.6	11.6	12.3	13.7
2.0 to +3.9	19.2	15.5	5.8	18.8	14.8
4.0 to +5.9	7.7	3.9	2.9	13.2	6.9
6.0 to +7.9	1.0	2.9	3.9	3.8	2.9
More than +8.0	1.0	1.0	1.0	1.9	1.2
Average Temp. Difference	+1.3	+1.1	+0.7	+1.7	+1.2

TABLE II-13 (B)

PERCENTAGE FREQUENCY OF VERTICAL TEMPERATURE DIFFERENCES AT PEACH BOTTOM

(Measured between Locations 1 and 3: 10 meter and Hillside Stations)

C. Spring Averages (April-May-June)

Temperature Difference (°F)	Time of Observation (E.S.T.) 0100E	0700E	1300E	1900E	All Obs.
More than -2.0	0.0	0.0	0.0	0.0	0.0
-1.1 to -2.0	3.0	6.9	3.9	4.0	4.4
-0.1 to -1.0	27.7	63.4	53.9	38.6	45.9
0 to +0.9	28.8	17.8	23.5	25.8	24.0
1.0 to +1.9	15.8	5.9	10.8	11.9	11.1
2.0 to +3.9	15.8	5.0	7.9	14.8	10.9
4.0 to +5.9	8.9	1.0	0.0	4.0	3.5
6.0 to +7.9	0.0	0.0	0.0	0.0	0.0
More than +8.0	0.0	0.0	0.0	1.0	0.2
Average Temp. Difference	+1.0	-0.1	+0.1	+0.7	+0.4

D. Summer Averages (July-August-September)

Temperature Difference (°F)	0100E	0700E	1300E	1900E	All Obs.
More than -2.0	0.0	0.0	0.0	0.0	0.0
-1.1 to -2.0	0.0	0.0	6.0	1.2	1.8
-0.1 to -1.0	8.2	43.5	61.8	7.1	30.2
0 to +0.9	32.9	43.5	27.4	22.3	31.5
1.0 to +1.9	22.4	13.0	4.8	22.3	15.6
2.0 to +3.9	30.6	0.0	0.0	32.9	15.9
4.0 to +5.9	5.9	0.0	0.0	13.0	4.7
6.0 to +7.9	0.0	0.0	0.0	1.2	0.3
More than +8.0	0.0	0.0	0.0	0.0	0.0
Average Temp. Difference	+ 1.6	+0.2	-0.2	+2.0	+ 0.9

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TABLE II-13 (B)

PERCENTAGE FREQUENCY OF VERTICAL TEMPERATURE DIFFERENCES AT PEACH BOTTOM

(Measured between Locations 1 and 3: 10 meter and Hillside Stations)

E. Autumn Averages (October-November-December)

Temperature Difference (°F)	0100E	0700E	1300E	1900E	All Obs.
More than -2.0	0.0	0.0	0.0	0.0	0.0
-1.1 to -2.0	0.0	0.0	0.0	0.0	0.0
-0.1 to -1.0	12.5	13.6	39.8	13.6	19.9
0 to +0.9	25.0	29.6	45.5	18.2	29.6
1.0 to +1.9	17.1	30.7	7.9	25.0	20.2
2.0 to +3.9	34.1	23.8	2.3	27.3	21.9
4.0 to +5.9	5.7	2.3	2.3	10.2	5.1
6.0 to +7.9	4.5	0.0	1.1	5.7	2.8
More than +8.0	1.1	0.0	1.1	0.0	0.5
Average Temp. Difference	+1.9	+1.3	+0.5	+ 2.1	+1.4

Number of Observations

	0100E	0700E	1300E	1900E	All Obs.
Winter	104	103	103	106	416
Spring	101	101	102	101	405
Summer	85	85	84	85	339
Autumn	88	88	88	88	352
Annual	378	377	377	380	1512

TABLE II-8

PERCENTAGE FREQUENCY OF WIND DIRECTION AND SPEED AT HOLTWOOD DAM

(PRECIPITATION AT TIME OF OBSERVATION)

A. Annual Averages

Wind Speed (miles per hour)

	1-3	4-7	8-12	13-17	18-23	24-30	31-37	38-46	>46	Total Freq.	Mean Speed
N	6.3	5.2	2.4	1.0	0.7	0.2	0.0	0.0	0.0	15.8	6.6
NE	0.4	0.9	0.7	0.0	0.0	0.0	0.0	0.0	0.0	2.0	5.5
E	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	5.0
SE	2.0	7.1	7.5	2.9	0.6	0.0	0.0	0.0	0.0	20.1	9.1
S	10.0	14.5	5.2	0.8	0.5	0.0	0.0	0.0	0.0	31.0	5.4
SW	1.6	2.7	0.7	0.0	0.0	0.0	0.0	0.0	0.0	5.0	5.1
W	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
NW	6.7	7.6	6.4	3.2	0.7	0.2	0.0	0.0	0.0	24.8	7.8
Calm										0.8	
Total	27.0	38.5	22.9	7.9	2.5	0.4	0.0	0.0	0.0		6.9 Aver

B. Winter Averages (January-February-March)

	1-3	4-7	8-12	13-17	18-23	24-30	31-37	38-46	>46	Total Freq.	Mean Speed
N	3.7	5.5	0.0	1.8	0.9	0.0	0.0	0.0	0.0	11.9	7.5
NE	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	1.0
E	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
SE	0.9	7.3	11.0	4.6	0.9	0.0	0.0	0.0	0.0	24.7	9.9
S	11.9	12.8	2.8	0.9	0.0	0.0	0.0	0.0	0.0	28.4	4.8
SW	1.8	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.6	3.8
W	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
NW	4.6	9.2	11.9	1.8	0.9	0.9	0.0	0.0	0.0	29.3	8.8
Calm										0.9	
Total	23.8	36.6	25.7	9.1	2.7	0.9	0.0	0.0	0.0		7.5 Aver

C. Spring Averages (April-May-June)

	1-3	4-7	8-12	13-17	18-23	24-30	31-37	38-46	>46	Total Freq.	Mean Speed
N	5.9	7.5	5.9	0.0	0.0	0.0	0.0	0.0	0.0	19.3	6.3
NE	0.8	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	1.7	5.5
E	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
SE	0.8	5.9	5.9	1.7	0.0	0.0	0.0	0.0	0.0	14.3	8.9
S	6.7	21.8	3.4	0.0	0.0	0.0	0.0	0.0	0.0	31.9	4.8
SW	2.5	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.2	3.6
W	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
NW	6.7	9.3	6.7	5.9	0.0	0.0	0.0	0.0	0.0	28.6	7.9
Calm										0.0	
Total	23.4	46.2	22.7	7.6	0.0	0.0	0.0	0.0	0.0		6.5 Aver

TABLE II-8(cont'd)

PERCENTAGE FREQUENCY OF WIND DIRECTION AND SPEED AT HOLTWOOD DAM

(PRECIPITATION AT TIME OF OBSERVATION)

D. Summer Averages (July-August-September)

Wind Speed (miles per hour)

	1-3	4-7	8-12	13-17	18-23	24-30	31-37	38-46	>46	Total Freq.	Mean Speed
N	10.5	3.5	1.8	0.0	0.0	0.0	0.0	0.0	0.0	15.8	3.6
NE	0.0	3.5	1.8	0.0	0.0	0.0	0.0	0.0	0.0	5.3	6.3
E	0.0	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	5.0
SE	5.3	7.0	1.8	0.0	1.7	0.0	0.0	0.0	0.0	15.8	7.2
S	17.5	12.3	3.5	0.0	0.0	0.0	0.0	0.0	0.0	33.3	4.2
SW	0.0	5.3	1.7	0.0	0.0	0.0	0.0	0.0	0.0	7.0	7.0
W	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
NW	10.5	8.8	1.7	0.0	0.0	0.0	0.0	0.0	0.0	21.0	4.3
Calm										0.0	
Total	43.8	42.2	12.3	0.0	1.7	0.0	0.0	0.0	0.0		4.9 Aver

E. Autumn Averages (October-November-December)

	1-3	4-7	8-12	13-17	18-23	24-30	31-37	38-46	>46	Total Freq.	Mean Speed
N	5.1	4.1	2.1	2.0	2.0	1.0	0.0	0.0	0.0	16.3	9.1
NE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
E	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
SE	1.0	8.2	11.2	5.1	0.0	0.0	0.0	0.0	0.0	25.5	9.7
S	4.1	11.2	11.2	2.1	2.0	0.0	0.0	0.0	0.0	30.6	8.0
SW	2.0	2.1	1.0	0.0	0.0	0.0	0.0	0.0	0.0	5.1	4.6
W	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--
NW	5.1	3.1	5.1	5.1	2.0	0.0	0.0	0.0	0.0	20.4	9.6
Calm										2.1	
Total	17.3	28.7	30.6	14.3	6.0	1.0	0.0	0.0	0.0		8.6 Aver

Season	Number of Observations
Winter	109
Spring	119
Summer	57
Fall	98
Total (Annual)	383

TABLE II-9

PERCENTAGE FREQUENCY OF REGIONAL GEOSTROPHIC WIND DIRECTION AND SPEED

A. Annual Averages

Wind Speed (miles per hour)

	1-3	4-7	8-12	13-17	18-23	24-30	31-37	38-46	>46	Total Freq.	Mean Speed
N	0.3	0.9	2.8	4.6	3.9	3.0	1.9	0.9	1.1	19.4	22.4
NE	0.1	1.4	2.6	4.2	3.5	2.2	1.1	0.8	0.5	16.4	20.9
E	0.2	0.9	2.1	2.2	1.4	0.7	0.5	0.3	0.2	8.5	17.3
SE	0.7	0.8	1.4	1.8	1.1	0.8	0.3	0.2	0.2	7.3	16.7
S	0.2	1.6	2.0	2.1	1.8	1.1	0.6	0.3	0.5	10.2	18.8
SW	0.3	1.1	2.5	3.3	2.6	1.7	0.9	0.4	0.4	13.2	19.6
W	0.7	1.3	2.4	2.4	1.8	1.3	0.6	0.2	0.1	10.8	15.9
NW	0.1	1.2	2.6	3.2	2.6	2.1	1.1	0.7	0.5	14.1	20.3
Calm										0.1	
Total	2.6	9.2	18.4	23.8	18.7	12.9	7.0	3.8	3.5		19.6 Aver

B. Winter Averages (January-February-March)

	1-3	4-7	8-12	13-17	18-23	24-30	31-37	38-46	>46	Total Freq.	Mean Speed
N	0.3	1.1	2.3	3.4	3.9	4.6	2.8	2.0	2.6	23.0	27.2
NE	0.1	1.0	1.5	3.1	2.2	1.9	1.1	1.0	0.8	12.7	23.5
E	0.3	0.7	1.6	1.8	0.9	0.7	0.5	0.6	0.3	7.4	19.2
SE	0.3	0.5	1.6	1.8	1.3	1.1	0.4	0.3	0.3	7.6	20.0
S	0.2	1.1	2.1	2.3	2.4	1.4	0.8	0.6	1.0	11.9	22.4
SW	0.1	0.6	1.7	2.9	2.3	1.5	1.4	0.7	0.6	11.8	22.9
W	0.4	1.0	1.8	2.5	1.8	1.5	0.7	0.2	0.0	9.9	17.6
NW	0.1	0.8	1.8	2.6	3.1	2.4	2.3	1.2	1.4	15.7	25.8
Calm										0.0	
Total	1.8	6.8	14.4	20.4	17.9	15.1	10.0	6.6	7.0		23.3 Aver.

C. Spring Averages (April-May-June)

	1-3	4-7	8-12	13-17	18-23	24-30	31-37	38-46	>46	Total Freq.	Mean Speed
N	0.3	0.9	2.4	4.4	3.6	2.5	1.7	0.8	0.6	17.2	21.3
NE	0.0	1.0	2.1	2.8	3.4	1.3	1.1	0.8	0.4	12.9	20.8
E	0.1	1.1	2.1	2.2	1.8	1.2	0.7	0.1	0.2	9.5	17.8
SE	0.8	0.8	1.4	2.5	1.6	0.8	0.5	0.2	0.0	8.6	16.6
S	0.3	1.3	2.1	1.8	2.2	1.2	0.6	0.2	0.5	10.2	19.2
SW	0.4	0.8	2.8	4.0	2.7	2.3	0.8	0.5	0.5	14.8	19.9
W	0.3	1.4	2.6	2.9	2.5	1.7	0.9	0.2	0.0	12.5	17.7
NW	0.0	1.2	2.5	3.1	3.4	2.6	0.9	0.3	0.3	14.3	19.9
Calm										0.0	
Total	2.2	8.5	18.0	23.7	21.2	13.6	7.2	3.1	2.5		19.4

TABLE II-9 (continued)

PERCENTAGE FREQUENCY OF REGIONAL GEOSTROPHIC WIND DIRECTION AND SPEED

D. Summer Averages (July-August-September)

Wind Speed (miles per hour)

	1-3	4-7	8-12	13-17	18-23	24-30	31-37	38-46	>46	Total Freq.	Mean Speed
N	0.4	1.3	4.1	6.6	3.9	1.8	0.7	0.1	0.1	19.0	16.5
NE	0.1	2.3	4.4	6.0	5.6	3.0	0.8	0.2	0.1	22.5	17.4
E	0.1	1.2	2.9	2.3	1.5	0.3	0.4	0.1	0.0	8.8	14.7
SE	1.2	1.8	1.4	1.4	0.5	0.3	0.2	0.1	0.1	7.0	11.8
S	0.4	2.3	1.9	2.1	1.1	0.7	0.3	0.1	0.1	9.0	14.3
SW	0.5	1.5	3.5	3.5	2.6	1.5	0.6	0.1	0.0	13.8	16.0
W	1.3	1.7	2.6	1.9	1.0	0.6	0.1	0.0	0.0	9.2	11.6
NW	0.0	1.4	3.5	3.4	1.3	0.6	0.2	0.2	0.0	10.6	14.7
Calm										0.1	
Total	4.0	13.5	24.3	27.2	17.5	8.8	3.3	0.9	0.4		15.3 Aver.

E. Autumn Averages (October-November-December)

	1-3	4-7	8-12	13-17	18-23	24-30	31-37	38-46	>46	Total Freq.	Mean Speed
N	0.1	0.4	2.3	4.1	4.2	3.1	2.0	0.9	1.2	18.3	24.4
NE	0.0	1.4	2.4	5.0	2.9	2.8	1.4	1.2	0.6	17.7	21.6
E	0.2	0.9	1.8	2.4	1.5	0.6	0.4	0.3	0.2	8.3	17.5
SE	0.5	0.4	1.3	1.5	1.1	0.9	0.2	0.0	0.3	6.2	18.4
S	0.0	1.6	1.9	2.3	1.5	0.8	0.7	0.3	0.4	9.5	19.2
SW	0.2	1.5	1.9	2.9	2.7	1.6	0.7	0.5	0.3	12.3	19.4
W	0.8	1.2	2.8	2.4	2.0	1.5	0.6	0.3	0.2	11.8	16.8
NW	0.3	1.3	2.6	3.7	2.7	2.7	0.9	1.0	0.5	15.7	20.9
Calm										0.2	
Total	2.1	8.7	17.0	24.3	18.6	14.0	6.9	4.5	3.7		20.4 Aver.

TABLE II-10

Values of K' for Selected Values of α, β

All Quantities are Non-Dimensional

$\alpha \longrightarrow$

	-10	-0.5	0.0	0.5	1.0	1.5	2.0	3.0	4.0
0.1	---	---	4.6	6.1	3.7	2.2	1.4	0.5	0.2
0.2	---	---	2.1	3.1	1.9	1.2	0.7	0.2	0.1
0.4	---	.20	.92	1.32	.98	.60	.38	.12	.04
0.8	.09	.23	.36	.45	.43	.35	.23	.08	.02
1.2	.10	.15	.20	.25	.25	.20	.16	.08	.03

TABLE II-11

CORRECTION FOR RELATIVE RAINOUT ASSOCIATED WITH PRECIPITATION OF DURATION T

"Duration" (λT)	Non-dimensional "Distance" ($\lambda x/\bar{u}$ or $\lambda y/\bar{v}$)						
	0.5	1.0	2.0	3.0	4.0	5.0	6.0
0.2	1.49*	2.5*	6.7*	18*	49*	134*	365*
0.6	1.25	2.0*	5.5*	15*	41*	111*	303*
1.0	1.15	1.7*	4.7*	13*	34*	94*	255*
2.0	1.07	1.4	3.2*	9*	24*	64*	174*
3.0	1.05	1.3	2.5	6*	17*	47*	128*
4.0	1.04	1.2	2.1	5	13*	37*	99*

*$x/\bar{u}T$ or $y/\bar{v}T \geqslant 1$

TABLE II-12

RELATIVE RAINOUT (R/Q_o) AT SITE BOUNDARY

Meteorological Condition	Rate of Precip. (in/hr)	Gas or Particulate	Relative Rainout (m^{-2})
Inversion	0.15	Iodine	3×10^{-6}
(Stable)		Strontium (1μ)	5×10^{-7}
	0.03	Iodine	10^{-6}
		Strontium (1μ)	9×10^{-8}
Lapse	0.15	Iodine	10^{-7}
(Unstable)		Strontium (1μ)	2×10^{-8}
	0.03	Iodine	5×10^{-8}
		Strontium (1μ)	3×10^{-9}

TABLE III-1 NATURAL RIVER FLOW
Susquehanna River at Conowingo

MAXIMUM

	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938
JAN.	90600	113400	9450	92400	52975	109525	184300	51175	249150	103325
FEB.	128475	179750	21125	84725	92075	17025	65275	59800	109950	92175
MAR.	254950	145375	153460	112825	189000	125625	141550	785000	62875	115250
APR.	224400	88575	130850	248775	181600	146150	135625	133950	234350	108375
MAY	177050	33950	132225	169900	110650	32625	138400	32250	149200	47500
JUNE	48525	92275	44575	16400	48250	25800	19800	19375	48750	29725
JULY	17750	19300	34200	17275	32500	21325	185325	14000	28450	32300
AUG.	6500	9275	13600	6300	303925	18100	20775	11575	74550	17925
SEPT.	8600	8125	8075	4575	117900	128150	11050	9800	36925	70725
OCT.	76600	3750	6350	65575	26500	65825	15475	20175	144125	19750
NOV.	109675	3000	7750	115250	24725	49460	105625	120725	127475	32075
DEC.	99925	9550	47950	40650	46625	264625	82250	68650	162350	127750
TOTAL										

MINIMUM

	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938
JAN.	7800	18050	3060	19850	18325	9050	12450	13625	46000	12400
FEB.	8750	16575	3875	17625	10175	6175	14750	13450	30125	36225
MAR.	42450	22300	13525	13750	20850	6375	51675	72800	24550	27775
APR.	36350	29275	25160	23400	39525	20000	30850	28500	33325	31075
MAY	42350	15050	26650	17225	33700	12150	19950	13275	28175	16700
JUNE	11250	13375	10500	9400	9550	7525	9925	8700	13200	8850
JULY	7100	4100	7000	5425	6225	4175	8000	3350	7425	8725
AUG.	2275	2075	5250	3525	5925	5125	6175	3575	6925	6225
SEPT.	3400	2725	3175	11950	17950	5050	4400	2950	6900	3600
OCT.	6425	1600	2450	2060	8925	8750	3375	4275	4375	6250
NOV.	18375	1800	2950	26450	8800	11175	11150	9075	22850	7850
DEC.	12975	1900	4860	6600	8325	19075	12125	8050	12450	13300
TOTAL										

AVERAGE

	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938
JAN.	16491	46783	5305	44744	28906	96393	44968	29456	101650	37350
FEB.	20271	35502	9659	41863	25394	11447	30717	19022	50648	58938
MAR.	102185	74910	33126	34810	78658	39341	83284	251865	39869	63380
APR.	113260	52793	72844	91303	96591	81230	66772	76978	91484	50295
MAY	74823	23472	66048	48627	56666	20796	49483	20962	55004	26658
JUNE	20334	22179	22984	12203	23113	12211	13971	12347	21496	16377
JULY	10512	10239	16417	9402	13390	6862	35202	6631	13703	15987
AUG.	4965	3274	2137	4777	44848	7425	12506	6509	20511	11151
SEPT.	5334	4101	5372	2845	39124	28152	6932	5095	14711	16596
OCT.	27365	2794	3988	21819	14047	19658	5058	9745	32680	9778
NOV.	34025	2830	4362	54357	15562	26065	38111	29563	52878	13900
DEC.	35145	4628	17204	18244	23370	54365	36016	37110	41821	46130
~~Total~~ Yearly	38727	23630	20423	32075	38308	29496	30376	42107	44705	30296

TABLE III-1

TABLE III-1 NATURAL RIVER FLOW (continued)
Susquehanna River at Conowingo

MAXIMUM	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	
JAN.	33,750	19,250	138,850	34,350	455,150	61,475	71,825	173,225	87,050	35,550	JAN.
FEB.	213,500	33,850	34,975	44,750	144,700	47,325	157,700	29,425	99,250	118,075	FEB.
MAR.	153,725	199,125	87,925	223,200	188,500	187,425	259,275	216,025	120,400	267,175	MAR.
APR.	128,175	465,200	253,925	110,775	263,700	151,875	101,475	42,025	209,950	323,775	APR.
MAY	39,500	75,675	22,125	315,200	167,025	204,875	166,550	487,650	135,250	93,050	MAY
JUNE	15,550	66,425	49,700	50,550	81,875	52,175	60,900	204,850	85,600	47,575	JUNE
JULY	10,850	22,275	17,500	68,825	17,400	28,150	52,475	39,275	59,075	31,425	JULY
AUG.	9,275	12,500	13,300	72,200	9,575	9,475	40,900	32,950	24,825	15,775	AUG.
SEPT.	6,725	41,300	8,925	34,500	7,100	9,200	85,950	18,925	26,325	6,475	SEPT.
OCT.	15,900	14,600	4,200	69,325	89,900	20,325	71,125	47,775	6,475	9,900	OCT.
NOV.	21,350	44,225	11,200	88,875	178,375	19,050	170,925	30,875	47,975	57,125	NOV.
DEC.	29,125	152,150	115,200	358,050	20,775	54,875	161,225	15,325	23,700	167,250	DEC.
TOTAL											TOTAL
MINIMUM	**1939**	**1940**	**1941**	**1942**	**1943**	**1944**	**1945**	**1946**	**1947**	**1948**	
JAN.	10,225	5,925	15,375	9,500	27,400	8,400	9,275	17,450	21,625	7,400	JAN.
FEB.	43,800	6,150	13,275	14,575	21,400	7,575	9,875	12,175	10,450	7,725	FEB.
MAR.	38,300	14,650	16,050	19,975	30,250	24,025	61,825	48,675	10,250	30,375	MAR.
APR.	42,125	68,700	24,275	22,325	26,300	38,625	27,675	14,150	43,700	50,600	APR.
MAY	13,800	23,425	8,550	16,100	41,150	28,125	46,875	12,050	48,475	48,725	MAY
JUNE	8,250	12,575	7,400	13,725	13,750	14,600	21,600	26,600	17,050	15,600	JUNE
JULY	3,875	8,275	5,025	7,850	7,275	5,700	11,375	9,575	14,700	12,000	JULY
AUG.	2,975	4,750	3,875	11,474	5,400	3,650	9,450	9,225	11,500	7,175	AUG.
SEPT.	2,125	7,300	1,825	6,675	2,575	3,450	9,000	5,275	6,375	3,400	SEPT.
OCT.	3,625	6,000	1,775	12,325	3,300	4,575	18,975	8,975	4,000	4,025	OCT.
NOV.	6,225	7,675	4,450	22,425	21,525	6,275	22,950	9,750	5,775	4,775	NOV.
DEC.	5,950	14,000	6,125	10,525	6,700	13,950	16,100	9,575	9,900	15,975	DEC.
TOTAL											TOTAL
AVERAGE	**1939**	**1940**	**1941**	**1942**	**1943**	**1944**	**1945**	**1946**	**1947**	**1948**	
JAN.	19,930	10,091	36,935	20,031	83,346	19,050	24,805	55,145	46,998	16,945	JAN.
FEB.	87,799	15,097	20,278	25,701	56,674	19,272	38,843	19,314	32,406	40,292	FEB.
MAR.	84,639	53,711	43,743	87,694	84,227	82,356	152,845	95,331	49,240	104,332	MAR.
APR.	74,261	212,656	82,737	68,560	74,747	74,934	53,655	22,651	75,694	102,792	APR.
MAY	21,982	41,983	13,999	59,842	91,886	67,339	83,624	85,326	88,050	71,542	MAY
JUNE	10,687	29,597	17,236	23,070	36,404	29,050	34,560	77,967	46,614	28,235	JUNE
JULY	6,968	14,581	9,636	18,514	10,700	10,852	25,217	20,536	35,508	18,210	JULY
AUG.	5,627	7,015	7,460	22,312	7,014	5,052	19,829	17,327	17,174	12,097	AUG.
SEPT.	3,214	15,548	4,581	11,528	4,371	5,478	29,930	8,009	12,504	5,165	SEPT.
OCT.	6,484	8,983	3,013	35,598	15,460	9,451	37,590	21,111	5,170	6,556	OCT.
NOV.	12,527	24,881	7,169	41,451	43,154	10,102	63,944	15,167	23,717	25,287	NOV.
DEC.	11,338	41,175	23,552	51,607	12,581	24,029	53,393	12,406	17,593	37,615	DEC.
Yearly	28,788	39,610	22,528	39,242	43,797	29,749	51,319	37,762	* 37,575	39,068	

TABLE III-1 (Cont'd)

TABLE III-1 NATURAL RIVER FLOW (continued)
Susquehanna River at Conowingo

MAXIMUM	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	
JAN.	234,000	141,175	133,475	218,075	170,750	57,725	152,075	24,300	124,500	72,600	JAN.
FEB.	102,150	125,225	172,650	137,800	95,650	106,575	98,700	101,975	61,500	116,900	FEB.
MAR.	68,775	300,825	103,675	343,550	225,900	234,525	180,225	336,900	95,900	152,600	MAR.
APR.	91,025	226,325	269,975	196,850	100,150	117,325	72,725	221,900	255,600	284,400	APR.
MAY	53,450	63,475	49,400	171,375	129,050	158,525	57,050	98,000	62,500	185,000	MAY
JUNE	28,100	73,450	83,875	65,075	170,600	52,175	29,700	42,300	19,400	44,100	JUNE
JULY	23,425	16,825	33,075	22,000	13,700	10,025	8,250	40,400	14,600	32,900	JULY
AUG.	9,375	36,150	12,850	14,100	10,100	7,750	123,875	55,500	6,100	28,500	AUG.
SEPT.	13,600	49,200	15,425	46,225	8,800	9,875	19,350	22,300	6,200	25,300	SEPT.
OCT.	11,875	68,075	7,375	6,825	6,800	43,350	264,500	32,900	7,600	26,300	OCT.
NOV.	17,925	430,025	33,325	177,025	18,525	42,475	125,725	144,100	16,000	36,500	NOV.
DEC.	77,500	297,350	73,875	204,925	45,775	79,275	35,050	133,000	136,700	35,600	DEC.
TOTAL											TOTAL

MINIMUM	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	
JAN.	37,950	27,675	22,900	34,350	18,600	4,025	8,025	9,175	10,300	13,800	JAN.
FEB.	32,875	27,875	51,425	20,150	31,750	10,825	7,625	15,350	22,700	10,100	FEB.
MAR.	24,525	10,900	56,825	21,025	36,925	34,250	53,050	51,300	37,200	41,300	MAR.
APR.	31,475	37,250	43,700	49,350	43,525	30,325	28,925	48,400	41,600	73,400	APR.
MAY	16,300	29,700	15,500	28,475	37,450	18,425	9,450	23,800	17,700	20,600	MAY
JUNE	7,100	12,525	11,725	9,350	11,475	9,200	7,700	17,300	9,300	14,500	JUNE
JULY	6,575	10,800	12,475	6,925	5,500	3,400	2,925	15,800	4,900	10,300	JULY
AUG.	4,325	4,475	5,250	6,675	3,375	3,400	2,500	9,700	3,200	9,900	AUG.
SEPT.	4,725	7,600	3,650	5,575	2,650	3,150	3,875	10,300	2,600	5,700	SEPT.
OCT.	6,025	7,100	3,450	4,000	3,050	3,050	8,300	9,500	3,900	6,900	OCT.
NOV.	7,500	12,650	9,475	3,675	3,725	7,825	28,150	17,000	4,200	14,900	NOV.
DEC.	10,325	16,400	14,500	19,550	10,525	16,075	8,900	16,300	7,300	10,900	DEC.
TOTAL											TOTAL

AVERAGE	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	
JAN.	94,809	60,907	71,649	93,910	64,433	14,826	41,751	14,366	37,684	37,623	JAN.
FEB.	62,086	55,354	91,358	56,384	49,443	43,151	31,255	51,056	38,150	23,368	FEB.
MAR.	41,334	76,879	75,547	94,203	76,886	67,445	104,589	101,758	55,552	78,890	MAR.
APR.	55,788	90,644	90,294	95,460	64,520	53,887	42,253	102,113	105,260	140,150	APR.
MAY	34,927	43,733	25,977	71,523	68,586	56,727	20,454	53,023	30,600	74,297	MAY
JUNE	12,464	24,334	28,825	22,797	44,892	23,213	15,068	24,457	12,677	25,353	JUNE
JULY	11,059	13,754	18,684	14,010	9,197	6,650	5,443	26,165	7,823	19,613	JULY
AUG.	6,215	12,811	8,679	5,699	6,263	5,010	24,233	21,513	4,451	14,945	AUG.
SEPT.	7,170	20,048	6,270	13,755	5,076	5,618	9,011	16,673	4,133	11,380	SEPT.
OCT.	8,135	20,828	5,296	5,447	4,125	10,945	57,728	16,777	5,187	12,639	OCT.
NOV.	11,135	72,423	22,347	27,875	8,388	19,278	52,547	36,328	8,993	23,400	NOV.
DEC.	32,948	92,252	39,743	53,692	25,895	34,842	19,[illegible]43	61,752	43,552	18,832	DEC.
[illegible]	31,365	49,404	40,389	46,563	35,625	28,466	35,089	43,832	29,505	40,041	[illegible]

TABLE III-1 (Cont'd)

TABLE III-2

MINIMUM AVERAGE 7-DAY FLOWS AT CONOWINGO

FOR THE VARIOUS MONTHS OF THE YEAR

(with 1 day overlap into adjacent month)

Month	Year of Minimum	Period of Minimum	Minimum 7-Day Natural River Flow at Conowingo, c.f.s.
January	1931	January 22 to 28	4,604
February	1931	February 5 to 11	5,136
March	1901	February 28 to March 6	7,840
April	1946	April 25 to May 1	15,468
May	1941	May 26 to June 1	9,150
June	1921	June 23 to 29	6,970
July	1955	July 25 to 31	3,325
August	1930	August 21 to 27	2,807
September	1932	September 24 to 30	2,043
October	1930	October 21 to 27	2,371
November	1930	November 25 to December 1	2,520
December	1930	November 30 to December 6	2,918

Note: October and November:

These dates mutually agreed upon with representatives of Pennsylvania Water and Power Co. Others will show slightly lower values (October 18 to 24 - 2,293 c.f.s., November 24 - 30 - 2,489 c.f.s.)

TABLE III-3

DAMS AND RESERVOIRS ON TRIBUTARIES OF THE SUSQUEHANNA RIVER

Name of Dam	Name of Tributary	Purpose	Owner	Drainage Area Sq. mi.	Flood Storage Acre feet	Height Dam ft.	(1) Stage Reduction at Harrisburg 1936 peak flow feet
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	COMPLETED AND IN OPERATION						
Indian Rock	Cadorus Cr.	Flood C.	USA	94	28,000	83	
Stevenson	First Fork Cr.	Flood C.	Penn.	243	78,950	167	
Almond	Canacadea	Flood C.	USA	56	14,800	90	
Arkport	Canisteo R.	Flood C.	USA	31	7,900	113	
Whitney Pt.	Otselio R.	Flood C.	USA	255	86,440	95	
East Sidney	Ouleout Cr.	Flood C.	USA	102	33,500	146	
		Sub-totals		781	249,590		
	BEING DESIGNED OR UNDER CONSTRUCTION						
Kettle Creek	Kettle Cr.	Flood C.	USA	229	74,000	170	
Curwensville	West Branch	Flood C.	USA	368	118,500	129	
Stillwater	Lackawanna R.	Flood C.	USA	37	11,935	55	
Blanchard	Eagle Cr.	Flood C.	USA	352	113,000	95	
	Sub-totals for all above			1,767	567,025		1.5
	AUTHORIZED BUT NO FUNDS FOR DETAILED PLANNING						
Cowanesque	Cowanesque R.	Flood C.	USA	299	95,700	145	
Tioga	Tioga R.	Flood C.	USA	280	130,000	125	
Hammond	Crooked Cr.	Flood C.	USA	120		107	
Copes Corner	Butternut Cr.	Flood C.	USA	118	37,900	75	
Davenport Center	Charollete Cr.	Flood C.	USA	164	52,500	100	
Genegantslet	Genegantslet Cr.	Flood C.	USA	95	30,195	104	
S. Plymouth	Canasawacta	Flood C.	USA	58	18,500	125	
West Oueouta	Otega Cr.	Flood C.	USA	108	34,500	86	
	Sub-totals for all above			3,009	966,320		2.5
	UNDER STUDY BUT NOT AUTHORIZED						
Keating	West Branch	Multiple	USA	1,574	420,000	(2)	1.9
Raystown	Raystown Bra.	Multiple	USA	960	256,000	(2)	1.1
	Total of all above			5,543	1,624,320		7.0

(1) Estimates based on Corps of Engineer values for other combinations.
(2) Undecided because of multiple-purpose nature of project.

TABLE III-4

WATER QUALITY AT CONOWINGO DAM

	Turbidity mg/l	pH	Alkalinity mg/l as $CaCO_3$	Manganese mg/l	Hardness mg/l as $CaCO_3$
Average	5	7.3	33	0.1	70
Maximum	85	8.1	48	0.34	120
Minimum	2	6.7	16	0.00	31

TABLE III-5

HYDRO-ELECTRIC PLANTS

ON THE LOWER SUSQUEHANNA RIVER

Plant Name (1)	Miles above tide water (2)	First yr. in operation (3)	No. of Units (4)	Head feet (5)	Max. discharge sec. ft. (6)	Effective plant capacity (7)kw
Conowingo	4	1928	7	89	45,000	252,000
Holtwood	19	1910	10	51	32,000	104,000
Safe Harbor	27	1931	7	55	65,000	230,000
York Haven	50	1904	20	20	18,000	20,000

TABLE III-6

RELATIVE CONCENTRATIONS (m^{-3}) IN CONOWINGO POND

Ratio of the Concentration (curies/m^3) to the Amount of Activity (Curies) Released, in a Relatively Short Period into the Condenser Discharge or into the Pond at the Site.

(Note: y = lateral distance and x' = relative longitudinal distance from center of diffusing volume; i.e., x' = x - Ut.)

t (days)	y(m)	x'(m): 0	5×10^2	10^3	1.5×10^3	2×10^3	2.5×10^3	3×10^3	5×10^3	7×10^3	10×10^3	15×10^3
	10^3	5×10^{-15}	2×10^{-16}	5×10^{-17}								
0.5	5×10^2	1×10^{-8}	2×10^{-11}	1×10^{-16}								
	0	2×10^{-6}	1×10^{-8}	3×10^{-15}								
	-5×10^2	2×10^{-8}	4×10^{-11}	2×10^{-16}								
	10^3	5×10^{-9}	2×10^{-9}	1×10^{-12}	5×10^{-14}							
1	5×10^2	5×10^{-8}	2×10^{-8}	1×10^{-9}	5×10^{-14}							
	0	5×10^{-7}	5×10^{-8}	3×10^{-9}	2×10^{-13}							
	-5×10^2	2×10^{-7}	4×10^{-8}	2×10^{-9}	5×10^{-14}							
	10^3	4×10^{-8}	4×10^{-8}	3×10^{-8}	2×10^{-8}	1×10^{-8}	5×10^{-9}	3×10^{-9}	3×10^{-10}	2×10^{-13}		
5	5×10^2	4×10^{-8}	4×10^{-8}	3×10^{-8}	2×10^{-8}	1×10^{-8}	5×10^{-9}	3×10^{-9}	3×10^{-10}	3×10^{-13}		
	0	4×10^{-8}	4×10^{-8}	3×10^{-8}	2×10^{-8}	1×10^{-8}	5×10^{-9}	3×10^{-9}	3×10^{-10}	3×10^{-13}		
	-5×10^2	4×10^{-8}	4×10^{-8}	3×10^{-8}	2×10^{-8}	1×10^{-8}	5×10^{-9}	3×10^{-9}	3×10^{-10}	2×10^{-13}		
	10^3											
10	5×10^2											
	0	1.3×10^{-8}	--	1.2×10^{-8}	--	9×10^{-9}	--	6×10^{-9}	2×10^{-9}	--	5×10^{-11}	5×10^{-15}
	-5×10^2											

TABLE III-6

TABLE III-7

THE RATIO C/Q_r FOR A CONTINUOUS RELEASE OF ACTIVITY INTO THE CONDENSER DISCHARGE FOR STEADY STATE CONDITIONS

(Note: Origin is at condenser discharge outfall; x = longitudinal distance downstream; y = lateral distance from west shore (-5×10^{-2}m) to east shore ($+10^{3}$m)

	x(m)					
y(m)	10^{3}	2×10^{3}	4×10^{3}	6×10^{3}	8×10^{3}	10×10^{3}
10^{3}	1.2×10^{-2}	1.6×10^{-2}	1.4×10^{-2}	1.1×10^{-2}	8.9×10^{-3}	7.6×10^{-3}
5×10^{2}	1.9×10^{-2}	1.9×10^{-2}	1.5×10^{-2}	1.1×10^{-2}	9.1×10^{-3}	7.7×10^{-3}
0	3.4×10^{-2}	2.2×10^{-2}	1.6×10^{-2}	1.2×10^{-2}	9.1×10^{-3}	7.7×10^{-3}
-5×10^{2}	2.9×10^{-2}	2.4×10^{-2}	1.5×10^{-2}	1.1×10^{-2}	9.0×10^{-3}	7.6×10^{-3}

TABLE III-8

THE RATIO C/ζ_o FOR THE CASE OF WASHOUT OF ACTIVITY FROM UNDER AN ATMOSPHERIC INVERSION, AS A FUNCTION OF TIME (t) AND RELATIVE LONGITUDINAL COORDINATE x - UT

t (days) x (meters)	0	2×10^{3}	4×10^{3}	6×10^{3}	8×10^{3}	10×10^{3}
1	5.0×10^{-1}	2.8×10^{-1}	4.9×10^{-2}	2.7×10^{-3}	4.7×10^{-5}	-
5	6.4×10^{-2}	-	2.5×10^{-2}	7.7×10^{-3}	-	1.6×10^{-4}
10	2.4×10^{-2}	-	1.4×10^{-2}	7.4×10^{-3}	-	8.9×10^{-4}

TABLE III-8

TABLE III-9

SILT DEPOSITION IN CONOWINGO POND

Traverse No.	Dist. fr. Conowingo ft.	Average Depth below Elevation 108.5 ft. MSL 1936	1941	1957*	Ave. Deposition 1941-1957	Deposition Rates ft. per year 1936-41	1941-57
3	1,200	83.3	81.6	75.5	6.1	0.34	0.38
2	3,500	73.8	70.1	68.0	2.1	0.74	0.13
9	13,700	--	64.5	54.5	10.0	--	0.62
8	22,500	--	52.6	39.5	13.1	--	0.82
4	36,500	32.2	29.4	16.0	12.4	0.76	0.77
1	40,000	22.1	22.5	14.5	8.0	-0.05	0.50
Peach Bottom	45,000	--	--	--	--		
5	49,000	18.8	17.0	14.5	2.5	0.36	0.16
6	54,700	17.2	14.2	12.0	2.2	0.60	0.14
7	60,700	15.3	13.5	13.0	0.5	0.36	0.03
Unweighted Ave.			40.5	34.2	6.3	0.44	0.40

* Depths taken from chart showing data for Fathometer survey made May and June 1957. Depths assumed to be below elevation 108.5 ft. MSL.