ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF ENFORCEMENT

REMOTE SENSING STUDY OF STEAM-ELECTRIC POWER PLANT THERMAL DISCHARGES TO LAKE ERIE AND THE DETROIT AND ST. CLAIR RIVERS OHIO AND MICHIGAN

NATIONAL FIELD INVESTIGATIONS CENTER-DENVER
DENVER, COLORADO
AND
REGION V
CHICAGO, ILLINOIS

March 1974

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont.)

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES (Cont.)

LIST OF FIGURES (Cont.)

GLOSSARY OF TERMS

acre	- Area = 43,560 square feet
cfs	- Flow rate given in cubic feet per second = 0.0283 cubic meters per second or 28.3 liters per second
cm	- Length in centimeters = 0.3937 in. or 0.03281 ft.
gpm	- Flow rate in gallons per minute - 0.0631 liters per second
hectare	- Area = 2.47 acres
km	- Distance in kilometers = 0.621 miles
km^2	- Area in square kilometers = 100 hectares or 0.3861 square miles
knot	- Velocity in nautical miles per hour = 1.15 statute miles per hr = 1.845 kilometers per hour
l	- Volume in liters = 0.2642 gallons
m	- Length in meters = 3.281 feet or 1.094 yards
MWe	- Electrical generating capacity in million watts
m^3/day	- Flow rate in cubic meters per day = 0.000264 million gallons per day
m^3/sec	- Flow rate in cubic meters per sec = 22.8 million gallons per day = 35.3 cubic feet per sec
mgd	- Flow rate in million gallons per day = 3,785 cubic meters per day
mm	- Length in millimeters = 0.1 centimeter
ppm	- Concentration given in parts per million parts
°C	- Temperature in degrees Centigrade = 5/9 (°F-32)
°F	- Temperature in degrees Farenheit

I. INTRODUCTION

An airborne remote sensing study of thermal discharges to Lake Erie and the Detroit and St. Clair Rivers was conducted on 9 July 1973. The study was undertaken at the request of the Enforcement Division, Region V, Environmental Protection Agency, Chicago, Illinois.

The study area [Figure I-1] encompassed the southern shore of Lake Erie from about 5 km (3 mi) east of Ashtabula, Ohio, to Toledo (Maumee Bay), Ohio, and the western shore of Lake Erie from Toledo to the mouth of the Detroit River. The western shores of the Detroit and St. Clair Rivers were also included in the study area. Eight power plants in Ohio and ten power plants in Michigan discharge thermal effluents to these waters. Eleven thermal effluents from industrial facilities were also observed in the study area.

Thermal infrared imagery of the entire study area was obtained using infrared line scanners mounted in high performance reconnaissance aircraft. Ground measurements of water temperatures were made at most of the power plants. This imagery and the ground truth water temperature data were used to characterize the observed thermal fields or plumes.

The results of this study will be used in the preparation of National Pollutant Discharge Elimination System (NPDES) permits for each of the 18 steam-electric power plants. The data will also add to the baseline data for future compliance monitoring of these discharges.

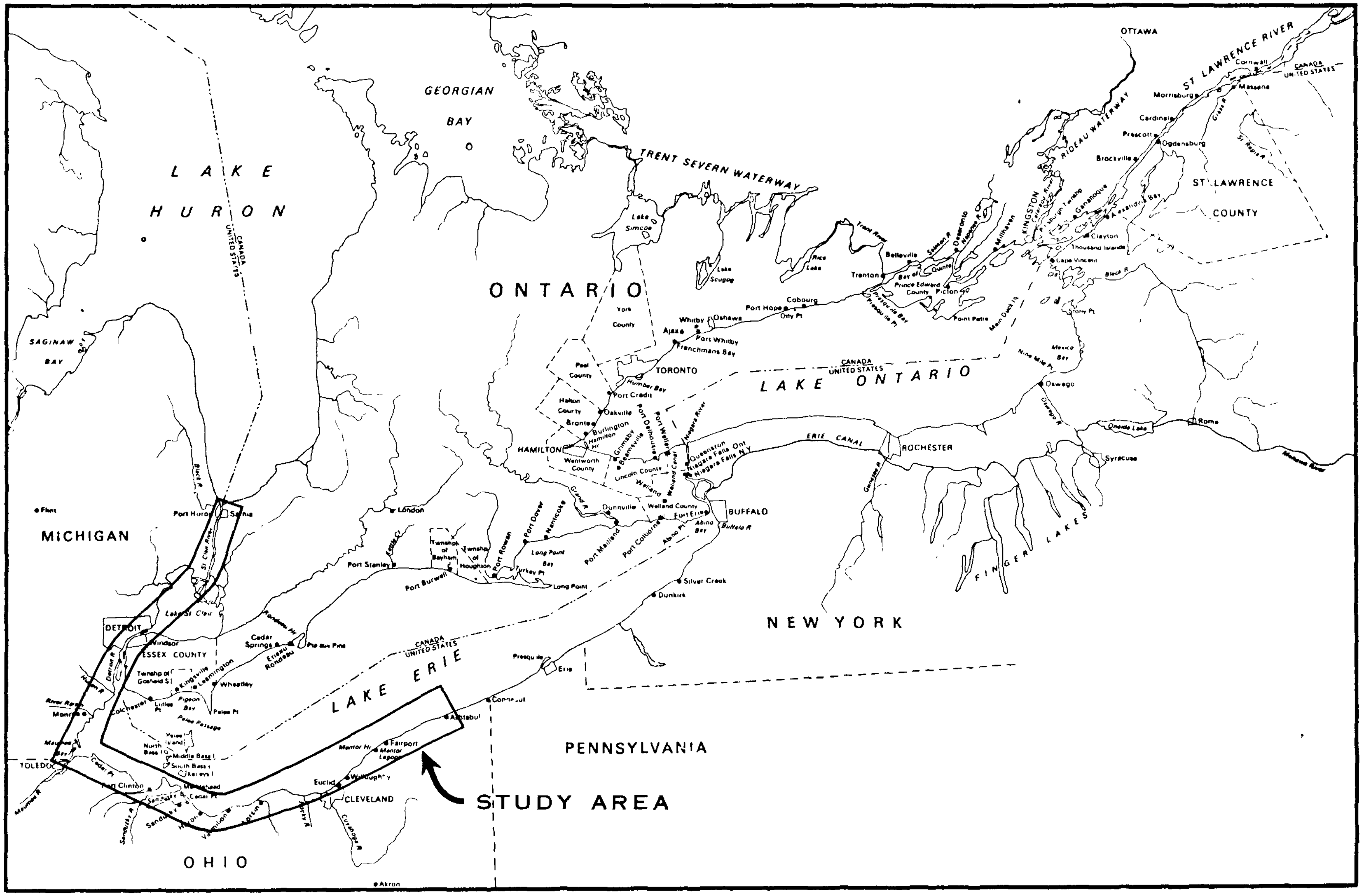


Figure I-1. Location Map

II. SUMMARY AND CONCLUSIONS

Airborne thermal infrared sensors were used to record the characteristics of thermal discharges from 18 (17 conventional and 1 nuclear-fueled) steam-electric power plants located along Lake Erie's southern and western shores and the western shores of the Detroit and St. Clair Rivers. This investigation was conducted on 9 July 1973 in warm weather during a period of near-peak power demand and warm receiving water temperatures. Ground truth, in the form of surface water temperature measurements at various locations in the vicinity of each plant's thermal effluent (including the discharge point), was obtained by field crews at the time of flight.

Isarthermal* maps depicting areas of equal surface water temperature were prepared from the infrared imagery. Actual temperatures of the isartherms were determined from the ground measurements. The isarthermal maps characterized the behavior of the thermal field under known weather conditions.

Water temperature criteria applicable to Lake Erie have not been approved by EPA. Ohio and EPA have proposed different criteria but agreement has not been reached on a single set of criteria that could be used as a basis for evaluating the water temperatures observed during this study. In addition, remote sensing techniques record only surface water temperatures. Some of the proposed criteria apply at

---

* Isarthermal is used to mean an <u>area</u> of the water surface displaying an essentially constant temperature, as contrasted with isothermal which means a <u>line</u> of constant temperature.

the 1 m (3 ft) depth. It was thus not possible to compare the observed temperatures with these criteria.

To provide a basis for comparison, the Ohio water temperature criteria applicable to inland lakes were used. These criteria limit water temperatures outside a mixing zone to an increase above natural temperatures of less than 1.7°C (3°F). The size of the mixing zone is limited to 5 hectares (12 acres) or less. In addition, maximum temperatures in the mixing zone must not exceed 8.3°C (15°F) above natural background temperatures.

The location, name, company ownership, generating capacity and water use for each plant studied are summarized in Table II-1. Observed thermal discharge characteristics are summarized in Table II-2. All of the Ohio plants and the first three Michigan plants are located on Lake Erie. The St. Clair and Marysville plants are located on the St. Clair River and the other four Michigan plants are on the Detroit River.

The observed temperature differences [Table II-2] between the heated effluent at the discharge point and the ambient receiving water temperature were determined from ground measurements in most cases. Note that these temperature differences vary from essentially zero to more than 12°C (21°F). The discharge temperature at seven of the plants was more than 8.3°C (15°F) warmer than ambient temperatures, the Ohio maximum limit for discharge to inland lakes.

The observed thermal field sizes were taken from the thermal infrared imagery. The dimensions given in Table II-2 are the maximum observed length and width of the thermal plume. The actual shape of

TABLE II-1.

SUMMARY OF POWER PLANT CHARACTERISTICS

Reported Power Plant Characteristics					
Location	Power Plant	Company[a/]	Capacity (MWe)	Cooling Water Use (1,000 m^3/day)	Cooling Water Use (mgd)
		OHIO			
Ashtabula	Ashtabula A&B	CEIC	456	1,530	403
Ashtabula	Ashtabula C	CEIC	160	651	172
Painesville	IRC Fibers Co.	--	21	65	17
Eastlake	Eastlake	CEIC	577	1,900	1,030
Cleveland	Lake Shore	CEIC	518	2,400	631
Avon Lake	Avon Lake[b/]	CEIC	595	2,700	720
Avon Lake	Avon Lake[c/]	CEIC	--	1,300	341
Lorain	Edgewater	OEC	193	420	110
Toledo	Bay Shore	TEC	636	2,800	746
		MICHIGAN			
Erie	J.R. Whiting	CPC	342	1,200	308
Monroe	Monroe	DEC	1,600	7,600	2,016
Lagoona Beach	Enrico Fermi No. 1	DEC	150	940	249
Trenton	Trenton Channel	DEC	1,119	5,200	1,380
Wyandotte	Wyandotte	WMSC	42	--	--
River Rouge	River Rouge	DEC	860	2,400	644
Detroit	Delray	DEC	375	3,100	810
Detroit	Conners Creek	DEC	628	3,500	930
Belle River	St. Clair	DEC	1,842	5,600	1,472
Marysville	Marysville	DEC	300	2,800	750

a/ Company Codes
- CEIC - Cleveland Electric Illuminating Company
- OEC - Ohio Edison Company
- TEC - Toledo Edison Company
- CPC - Consumer Power Company
- DEC - Detroit Edison Company
- WMSC - Wyandotte Municipal Service Commission

b/ Avon Lake Outfall 001
c/ Avon Lake Outfall 003

TABLE II-2.

SUMMARY OF THERMAL DISCHARGE CHARACTERISTICS

Location	Power Plant	Observed Thermal Discharge Characteristics: Temp. Diff.[a/] (°C)	Temp. Diff.[a/] (°F)	Thermal Field Size[b/] (km)	Thermal Field Size[b/] (1,000 ft)	Plume Area[c/] (hectares)	Plume Area[c/] (acres)
				OHIO			
Ashtabula	Ashtabula A&B	6	10	3.4x0.7	11x2	16	40
Ashtabula	Ashtabula C	10	18	d/	d/	30	74
Painesville	IRC Fibers Co.	10	18	0.6x0.2	1.8x0.5	32	80
Eastlake	Eastlake	9	16	1.3x0.6	4.2x1.8	100	250
Cleveland	Lake Shore	4	7	0.8x0.7	2.5x2.2	49	120
Avon Lake	Avon Lake[e/]	6	11	3.7x1.0	12.1x3.2	100	250
Avon Lake	Avon Lake[f/]	2	4	0.2x0.1	0.6x0.3	0	0
Lorain	Edgewater	9	16	1.2x0.3	4.2x1.1	360	890
Toledo	Bay Shore	6	11	1.6x1.4	5.3x4.2	380	940
				MICHIGAN			
Erie	J.R. Whiting	9	16	1.4x0.7	4.2x2.1	70	170
Monroe	Monroe	12	21	3.9x1.4	12.6x4.2	460	1,130
Lagoona Beach	Enrico Fermi No. 1	8	14	1.1x1.0	3.7x3.2	300	750
Trenton	Trenton Channel	10	17	0.6x0.1	1.8x0.3	g/	g/
Wyandotte	Wyandotte	0	0	0	0	0	0
River Rouge	River Rouge	9	16	0.6x0.2	1.8x0.6	g/	g/
Detroit	Delray	0	0	0	0	0	0
Detroit	Conners Creek	8	14	1.0x0.2	3.2x0.5	g/	g/
Belle River	St. Clair	2	4	-	-	0	0
Marysville	Marysville	0	0	0	0	0	0

a/ Temperature difference between discharge temperature and ambient receiving water temperature.
b/ Overall maximum dimensions of the thermal field.
c/ Area of the thermal plume that was at least 1.7°C (3°F) warmer than ambient receiving water temperatures.
d/ The discharges from Ashtabula Plants A, B & C formed one thermal field.
e/ Avon Lake Outfall 001
f/ Avon Lake Outfall 003
g/ Thermal plume areas were not computed for river locations.

the field and the direction of drift in each case are documented in Section V. Note that the distances the plumes travelled before dispersing varied substantially and were not necessarily related to the plant generating capacity or cooling water use.

The area of the thermal plume with surface water temperatures more than 1.7°C (3°F) above ambient was determined from the isarthermal sketches for all plants located on Lake Erie. Note that for all of the Lake Erie plants, the observed areas were larger than the allowable mixing zone for inland lakes. The heated areas ranged from 3 to 92 times larger than the specified mixing zone limit of 5 hectares (12 acres).

A thermal plume area was not determined for the plants located on rivers as the factor of concern here is the amount of the cross-sectional area of the stream that is occupied by the heated effluent. Due to the large volume of flow in the Detroit and St. Clair River, the thermal plumes occupied only a small fraction of the rivers cross-section as indicated by the observed surface thermal plume widths. In the case of four plants, essentially no thermal plume was observed.

The eleven Lake Erie power plants were in substantial non-compliance with the Ohio water quality criteria for inland lakes used for comparative purposes indicating that reductions in heat loads discharged to Lake Erie may be necessary if similar criteria are approved for Lake Erie.

III. DESCRIPTION OF STUDY AREA

PHYSICAL DESCRIPTION

Lake Erie is situated between Lake Huron and Lake Ontario in the Great Lakes chain [Figure I-1]. The Lake receives its major inflow from Lake Huron through the St. Clair and Detroit Rivers. Outflow is over Niagra Falls to Lake Ontario. This study covered the Ohio (southern) shoreline of Lake Erie from east of Ashtabula, Ohio, to Toledo, Ohio, and the western shorelines of Lake Erie, the Detroit River, and the St. Clair River between Toledo and Lake Huron.

With a length of 390 km (240 mi) and maximum width of 80 km (50 mi), Lake Erie has a surface area of about 25,700 km^2 (9,940 mi^2) and a volume of 470 km^3 (113 mi^3). It is the second smallest of the Great Lakes in terms of area and smallest in volume as a result of its shallow depth.

Topographically, Lake Erie is divided into three basins [Figure III-1]. The small western basin (about 12 percent of the Lake surface area) is very shallow with average and maximum depths of 7 and 19 m (24 and 63 ft), respectively. This basin is separated from the central basin by a chain of rocky islands. The shallow Maumee Bay is situated at the west end of the lake where the Maumee River enters at Toledo. The Detroit River enters the basin from the north. Along the south and west shorelines, the bottom slope is small with the 6 m (20 ft) depth located several km offshore.

About two-thirds of the surface area of the Lake is located in the central basin. This basin is broad and flat bottomed, with average and

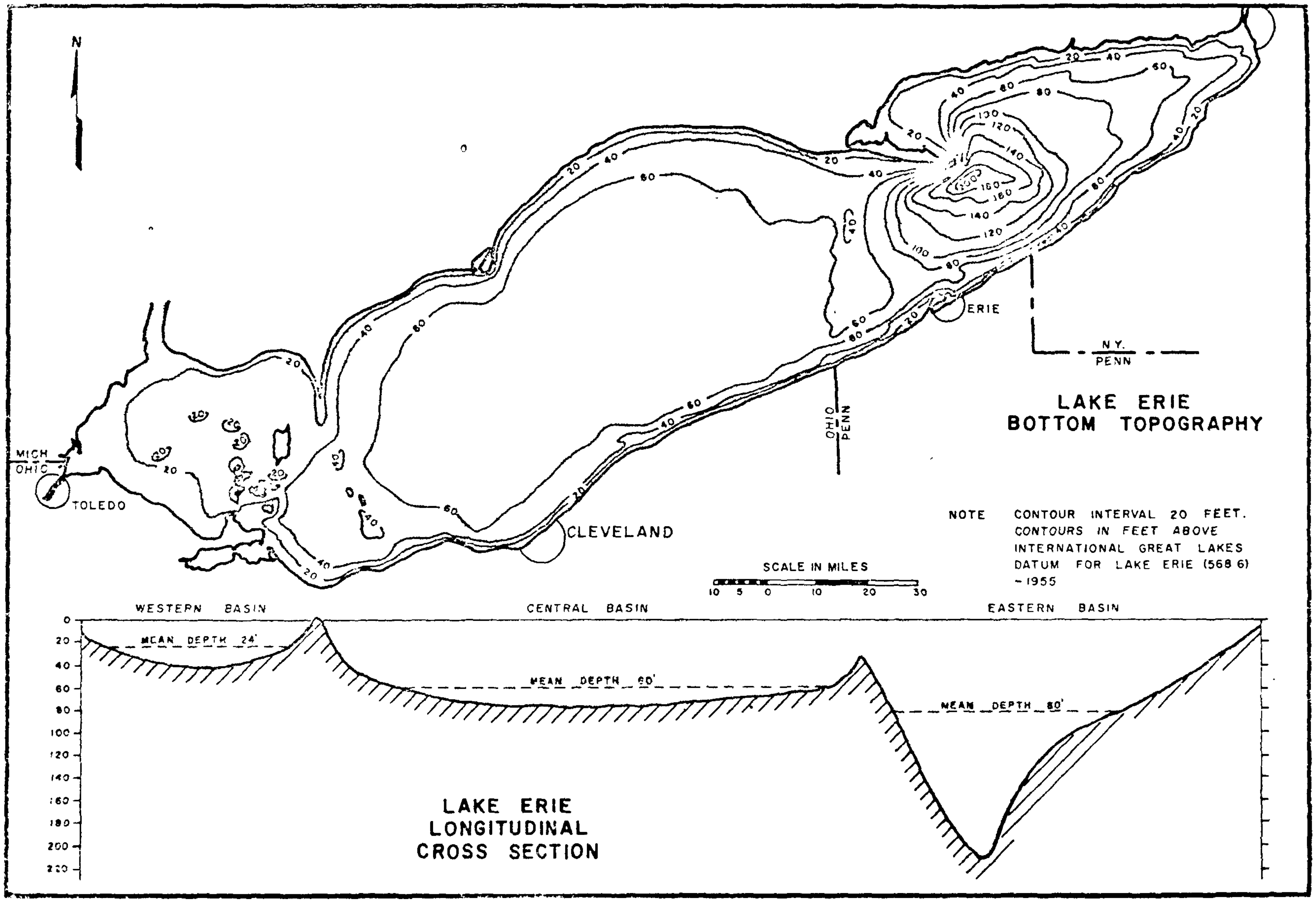


Figure III-1. Lake Erie Topography

maximum depths of 18 and 25 m (60 and 80 ft), respectively. The south shore slopes steeply to depths of more than 10 m (33 ft) in most areas.

The east basin is separated from the central basin by a low bar. Average and maximum water depths are 25 and 67 m (80 and 216 ft), respectively. The east basin is east of the study area and exerts little effect on water movements or thermal conditions in the area of interest.

The Detroit and St. Clair Rivers are essentially channels connecting Lake Huron and Lake Erie. Almost the entire flow in the rivers is outflow from Lake Huron. Lake St. Clair is located between the two rivers. The lake has a surface area of 2,000 km^2 (490 mi^2) and average depth of 3 m (10 ft).

CLIMATE

The climate of the Lake Erie area is temperate, humid-continental with the chief characteristic of rapidly changing weather. Average annual temperatures at land stations range between 8 and 11°C (47 and 51°F). The highest average monthly temperatures occur in July, ranging between 21 and 23°C (70 and 74°F). Recorded temperature extremes are -29 and 38°C (-20 and 100°F).

Average annual precipitation in the study area ranges between 790 mm (31 in.) near Lake St. Clair and 915 mm (36 in.) along the Ohio shore.

Southwesterly winds prevail over Lake Erie in all months. Northwesterly storm winds occur frequently during fall and winter while northeasterly storm winds may occur in the spring.

HYDROLOGY

About 80 percent of the inflow to Lake Erie enters through the Detroit River. Annual outflow from Lake Huron through the St. Clair River averages 5,300 m^3/sec (187,500 cfs). Highest flows occur during July or August and average 5,600 m^3/sec (199,000 cfs). Smaller tributaries are usually at low flow during July.

Average annual flows of tributary streams of interest because of proximity to power plants include: Maumee River, 136 m^3/sec (4,794 cfs); Raisin River, 20 m^3/sec (714 cfs); Black River 8.6 m^3/sec (302 cfs); and Ashtabula River 5 m^3/sec (169 cfs).

Lake levels fluctuate as the result of storms, seiches, and long-term precipitation changes. Orientation of the long axis of the lake in the same direction as storm tracks results in substantial, rapid lake level variations. Usually, levels decrease in the west end and increase in the east during storms. Fluctuations as high as 4 m (13 ft) have been recorded although most level changes are less than 1 m (3 ft).

Seiches resulting from the passage of storms may cause cyclic, small fluctuations in lake levels for several days. Longer term, gradual fluctuations are produced by variations in annual precipitation in the upstream Great Lakes drainage area. Maximum variations in long-term lake levels over the last 100 years have been less than 2 m (6 ft).

Winds, variations in lake levels, and variations in tributary inflows all affect surface water movements and, hence, movement of thermal plumes from power plants. Dominant summer surface water movement patterns are shown in Figure III-2. Surface movements may differ from these general patterns in localized areas, especially in the western basin.

Lake Erie is the warmest of the Great Lakes. Mid-lake surface water temperatures reach an average maximum of 24°C (75°F), usually early in August. Occasionally the summer temperature of mid-lake surface water rises above 27°C (80°F). Nearshore water normally reaches a maximum along the south shore of 27°C (80°F) or more. Water temperatures in the western basin also average slightly higher than at mid-lake.

APPLICABLE WATER QUALITY REGULATIONS

Water temperature criteria for Lake Erie in Ohio have not been approved by EPA. Both the State of Ohio and EPA have proposed criteria but agreement has not been reached on a single set of criteria that could be used for evaluating the water temperatures observed during this study. In addition, some of the proposed criteria apply at a 1 m (3 ft) depth but remote sensing techniques record only surface temperatures. To provide some basis for comparing the observed temperatures with water quality standards, the EPA approved Ohio water quality criteria for inland lakes were used.

The Ohio standards provide that lake water temperatures outside mixing zones shall not exceed by more than 1.7°C (3°F) the water temperature which would occur if there were not temperature change of such waters attributable to human activities. In addition, the maximum temperature outside the mixing zone shall not exceed 32.2°C (90°F) during the months of June, July, August and September.

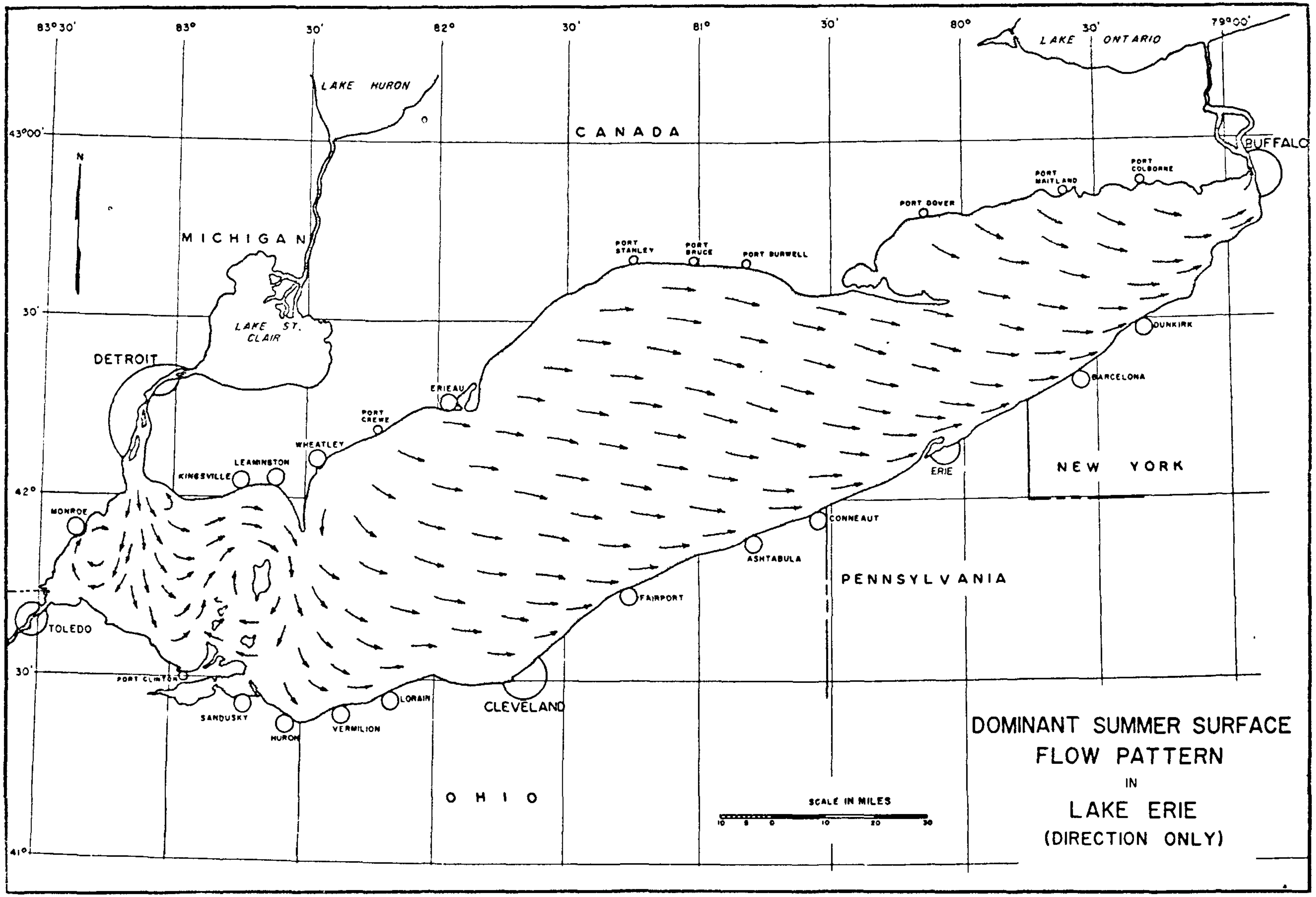


Figure III-2. Dominant Summer Surface Water Movement

Mixing zones are limited to a surface area of less than 5 hectares (12 acres). Water temperatures within the mixing zone at any depth shall not exceed natural water temperatures outside the mixing zone by more than 8.3°C (15°F) during the months of May, June, July and August.

IV. STUDY TECHNIQUES FOR THERMAL DISCHARGES

AIRCRAFT AND FLIGHT DATA

This remote sensing mission was carried out by two high performance aircraft specifically designed and equipped for aerial reconnaissance work. The two aircraft independently flew each target area to provide primary and backup coverage. They were spaced about 30 seconds apart in flight time. Both aircraft carried the sensors discussed below.

The flight parameter data listed below provide the specific values of the aerial reconnaissance variables.

Date of Flight: 9 July 1973

Time of Flight: 1410 to 1510 Hours EDT

Target Areas: Southern and western shores of Lake Erie, western shores of the Detroit and St. Clair Rivers

Air Speed of Aircraft: 660 to 740 km/hr (360 to 400 knots)

Average Aircraft Altitude Above Water Level: 760 m (2,500 feet) and 920 m (3,000 feet)

Sensors Used: Infrared Line Scanner

SENSOR DATA

An AN/AAS -18 Infrared Line Scanner (IRLS) was the sensor used for this study. The sensor is located on the underside of the aircraft as shown in Figure IV-1. While in operation, it images an area along the flight path of the aircraft. The width of the imaged area is dependent upon aircraft altitude and is encompassed by a 120° field-of-view in cross-track or perpendicular to the flight path [Figure IV-2].

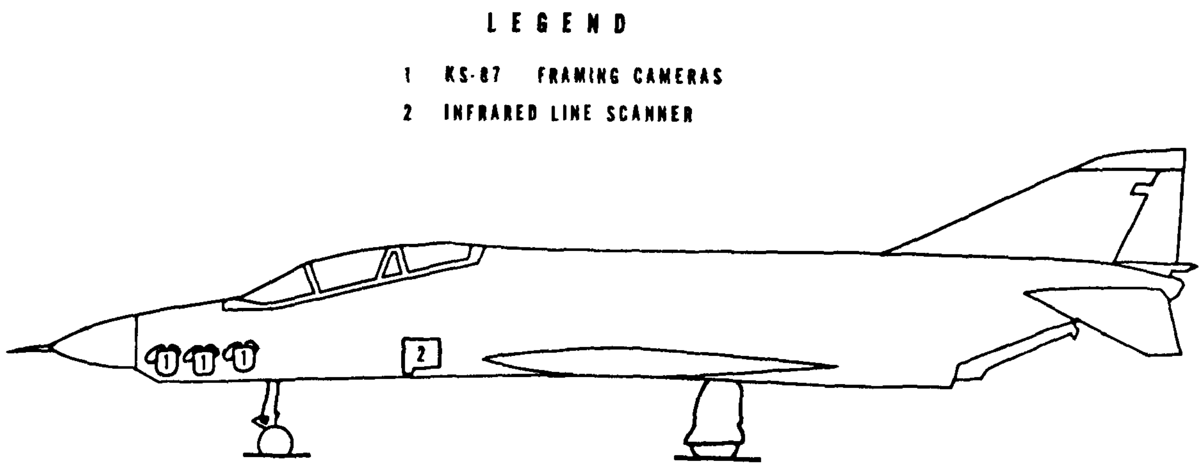


Figure IV-1. Aircraft Sensor Locations

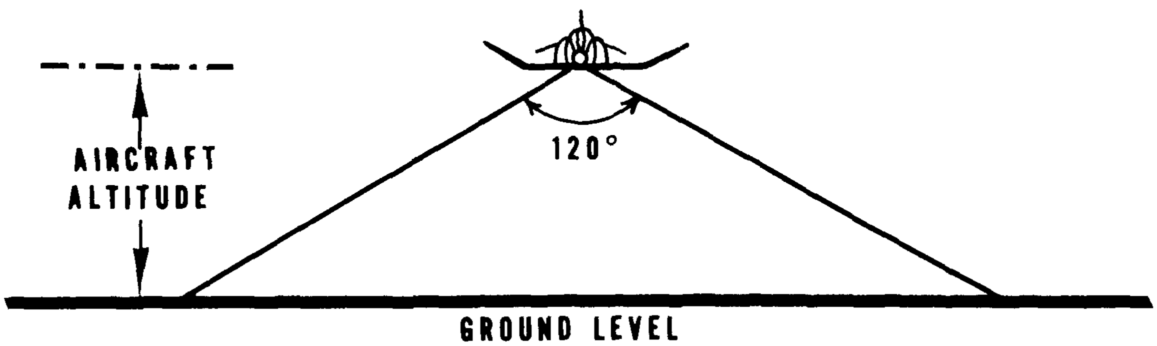


Figure IV-2. Field of View of IRLS

An IRLS converts variations in infrared energy emissions from objects of different temperatures into a thermal map. The three basic parts of an IRLS are the scanner optics, a detector array, and a recording unit. The scanner optics collect the infrared emissions from ground and water areas and focus them on the detectors [Figure IV-3].

The detectors, cryogenically cooled to 26° Kelvin, convert the infrared energy collected by the scanner optics into an electronic signal. This signal is processed electronically and subsequently transformed into visible light through a cathode ray tube. This light is then recorded on ordinary RAR black-and-white film measuring 12.6 cm (5 in.) in width. The recorded thermal map is 10 cm (4 in.) wide and its length depends upon the length of a particular line of flight being imaged.

The IRLS has a sensitivity bandwidth from 8 to 14 microns, the so called thermal band of the electromagnetic spectrum. Applying Wien's Displacement Law, this represents a temperature band from -66°C to 89°C. The system has an instantaneous field-of-view of 1 milliradian by 1 milliradian. The total field of view is achieved by the rotating mirror in the optical collection system, which is 120° by 1 milliradian. The measured noise equivalent temperature (N.E.T.) of the IRLS is 0.32°C with 100 percent probability of target detection. This represents an effective measurement of the temperature resolution of the system.

GROUND TRUTH

The Surveillance and Analysis Division, Region V, EPA, obtained near-surface (about 10 cm depth) water temperature measurements simultaneously with the time-of-flight. The water temperatures were

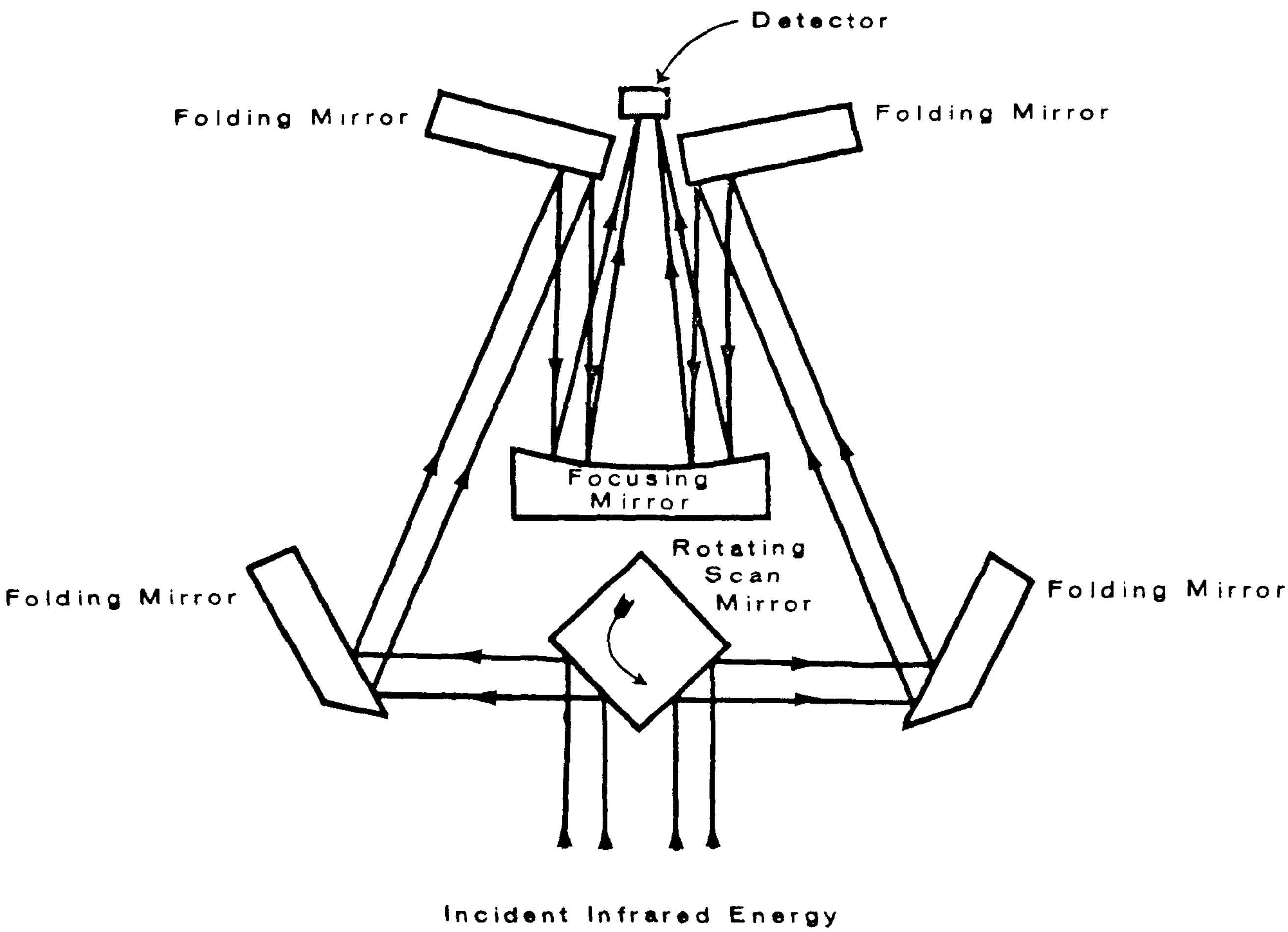


Figure IV-3. IRLS Optical Collection System measured at discrete points in the vicinity of each thermal discharge including each discharge point and ambient or background surface water locations. Four to 8 other data points were selected at each location, usually within the warmer area of the thermal field.

The accuracy of the contact instrumentation used to obtain the surface water temperatures was $\pm$ 0.1°C. It is estimated that the precise location of the discrete water-temperature data points was known to within $\pm$ 30 meters with the exception of the location of data points within the discharge itself. The position accuracy of the latter was 1 to 3 meters.

DATA INTERPRETATION AND ANALYSIS

All data interpretations and analyses were made on the original black and white film negative used to record the infrared data aboard the aircraft. Photographic prints were not used because of the added errors of an additional image generation.

Each thermal plume image or map, associated with the power plant discharges under study, was plotted with respect to U.S. Department of Commerce Nautical Charts (Scale 1:10,000) or U.S. Geological Survey 7.5 minute maps (Scale 1:24,000) to determine the infrared image scale. To evaluate consistency this scale was compared to the empirical scale derived from the effective focal length of the IRLS and the altitude of the aircraft above water level. The respective image scale is included on each thermal map in this report.

In the black-and-white IRLS film, temperature levels are represented by various shades of gray in the negative format or rendition. Areas of low density (clear film) represent cooler temperatures and areas of higher density (darker gray) represent higher temperatures. Positive prints presented in this report reflect the reverse of the negative film. Cool areas are dark while the warm areas are light gray.

A Spatial Data 704 Image Analyzer was used to convert the infrared images into isarthermal maps. Isarthermal maps delineate areas with the same temperature (isartherms). The Image Analyzer uses a technique called density slicing to divide the density range on a given infrared image into 12 increments. Each increment thus represents a particular density of gray on the image and a narrow temperature range closely approximating an isotherm. The density value of each increment is accurate to within 0.03 density units over a range of 0 to 2 (density). Each density increment is displayed on the Image Analyzer screen in a particular color. An isarthermal map was prepared by tracing directly from the color rendition on the Analyzer display screen.

The actual temperature of each isartherm on the map was determined by first comparing it with a physical plot of the water temperature data obtained in the field at flight time. Each density value or increment represents a particular water temperature. These are derived from calibration curves obtained empirically from the gray density levels on the negative corresponding to the locations of the ground truth water temperatures. These curves were used to interpolate temperatures for isartherms in areas where no ground truth data points were located. They covered a rather large temperature differential (6 to 11°C or 10 to 20°F) between the power plant effluents and the background or ambient receiving waters. From the calibration curves the absolute temperature of each isartherm (colored increment) delineated by the Image Analyzer was determined.

An important factor must be mentioned at this point. The IRLS will only record water surface temperatures since water is opaque in this region of the infrared spectrum. The maximum depth penetration in either fresh or salt water is 0.01 cm. Therefore, a submerged thermal discharge can be detected from an aircraft with an IRLS only if the warm wastewater reaches the surface of the receiving body of water. The isarthermal maps developed by this study represent surface temperatures only and not subsurface temperature distributions.

ERROR ANALYSIS

Limitations can be placed on the accuracy or uncertainty of the absolute value of water temperatures represented by the isarthermal maps developed by this study. The three significant sources of error affecting the data are the resolution of the IRLS, the accuracy of the Image Analyzer, and the accuracy of the instrumentation used in obtaining ground truth. These sources have the following error values:

(1) $\Delta t_1 = \Delta t_{IRLS} = \pm 0.32°C$ (measured system N.E.T.)

(2) $\Delta t_2 = \Delta t_{Image\ Analyzer} = \pm 0.10°C$ (film density accuracy)

(3) $\Delta t_3 = \Delta t_{ground\ truth\ inst.} = \pm 0.10°C$ (accuracy of instrument)

By using the method of root-sum-squares, the magnitude of the total possible error range can be estimated as follows:

$$\Delta t_{total} = \pm \left[\sum_{i=1}^{3} (\Delta t_i)^2\right]^{\frac{1}{2}}$$

$$= \pm \left[(0.32)^2 + (0.10)^2 + (0.10)^2\right]^{\frac{1}{2}}$$

$$\Delta t_{total} = \pm 0.35°C \approx \pm 0.4°C \ (\pm 0.7°F)$$

Reported temperature values are thus accurate to within ±0.4°C (0.7°F) with the exception of the locations in the isarthermal maps designated as areas of degraded thermal data. In these areas the solid lines separating the various isartherms were extrapolated by dashed lines to provide continuity throughout the map. Neither the above reported nor the consistant error introduced by assuming a constant temperature within an isartherm applies to these areas.

No atmospheric corrections were applied to these thermal data under the assumption that the atmospheric effect was constant and would not induce a significant effect since the film was directly calibrated by the water temperatures measured during the time of flight. Any influence of the air column between the aircraft and the water surface would be taken into account by the calibration process, assuming a constancy of the entire air column in the target area.

V. RESULTS AND EVALUATION OF THERMAL DATA ANALYSIS

This section presents the results of the analysis of the water temperature data obtained by aerial reconnaissance and ground surveys. Weather conditions existing at the time of flight are summarized. Power plant descriptions and cooling water discharge characteristics reported in Refuse Act Permit Program appplications submitted in 1971 are also presented. The observed thermal plumes are evaluated with respect to the reported discharge characteristics and recorded weather conditions.

Water quality standards specifying water temperature criteria for Lake Erie in Ohio have not received EPA approval. The State of Ohio and EPA have proposed different criteria. In the following discussion, observed water temperatures are compared with EPA approved Ohio water temperature criteria for inland lakes. Until Lake Erie water temperature standards are promulgated, however, it will not be possible to evaluate compliance with water quality standards for the power plants studied.

The power plants are discussed by location proceeding westward along the Ohio shore of Lake Erie to Toledo and then northward along the western shore of Lake Erie, the Detroit River and the St. Clair River to Lake Huron in Michigan. Power plant locations are shown in Figure V-1 (inside back cover).

ASHTABULA, OHIO

Description of Power Plants

The Cleveland Electric Illuminating Company operates three power plants (A, B and C) in this location on the south shore of Lake Erie. Plants A and B, with a combined generating capacity of 456 MWe, are essentially one facility with common intake and discharge channels. The cooling water intake is a walled channel extending about 460 m (1,500 ft) offshore to a water depth of 2 m (6 ft). Cooling water is discharged through a 310 m (1,000 ft) long walled channel extending northeastward from the plant nearly parallel to shore. The discharge has an initial direction along shore corresponding to prevailing summer surface water movements. Average cooling water use (Outfall 001) was reported as 1,530,000 m^3/day (403 mgd) in 1971 with average summer intake and discharge temperatures of 22 and 28°C (72 and 83°F), respectively.

The smaller Plant C (160 MWe) is located about 0.8 km (0.5 mi) to the east of Plants A and B. This plant was formerly operated by the Union Carbide Company. The cooling water supply is obtained through dual pipelines extending offshore on the lake bottom to deep water. Heated effluent is discharged through a tunnel terminating near shore. The outlet orientation produces a northeastward velocity vector similar to Plants A and B. Average cooling water use (Outfall 002) was reported as 651,000 m^3/day (172 mgd) in 1971 with average summer intake and discharge temperatures of 19 and 27°C (66 and 80°F), respectively.

Observed Thermal Conditions

Using the techniques discussed in Section IV, thermal imagery of Lake Erie in the vicinity of the two thermal discharges was recorded from an altitude of 740 m (2,430 ft) above water level. The resultant thermal map, in the form of a positive print of the infrared imagery, is shown in Figure V-2. As this is a positive print, the dark areas are cool and the light gray or white areas are warm. The dark bands across the thermal map are the result of degraded IRLS data as discussed in Section IV. Based on the flight altitude, the map has an approximate scale of 1:25,300.

As shown in Figure V-2, the thermal fields resulting from the two discharges were combining and moving or dispersing along shore in an easterly direction. The thermal plume resulting from Discharge 002 was larger than the plume from Discharge 001 even though the reported flow rate from 001 is more than twice the discharge from 002. This direction of movement and the combining of the two thermal fields into one were partially the result of the 10 knot wind blowing from the northwest (315°) at flight time. The combined thermal field was dispersing to the extent that it was no longer detectable about 3.4 km (2.1 mi) to the east of Outfall 002. Water depths in the area covered by the thermal field are generally less than 2 m (6 ft).

With the aid of the thermal map and the ground truth obtained at the time of flight, the thermal fields were analyzed for areas of equal temperature and isarthermal maps were prepared [Figures V-3, V-4] using

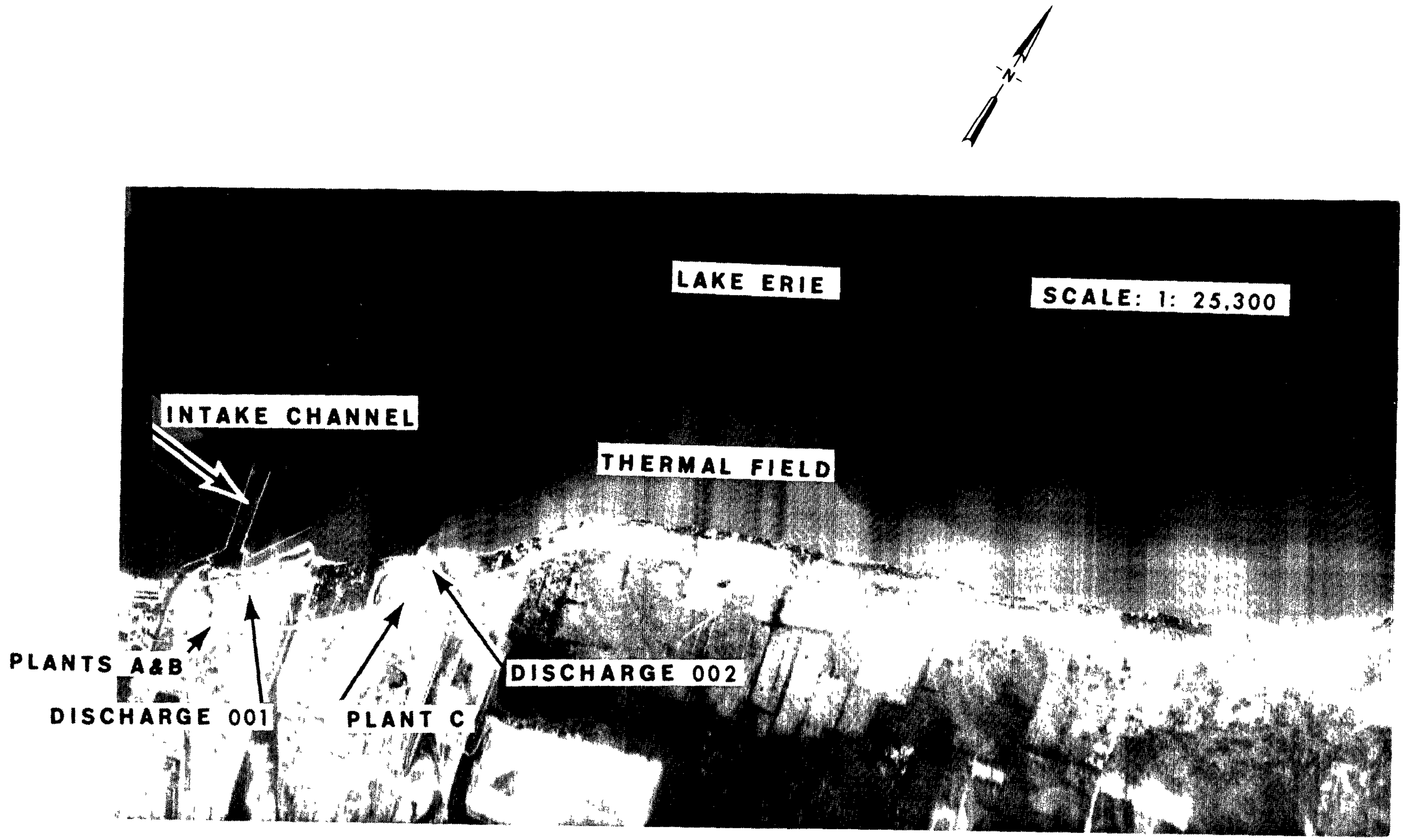
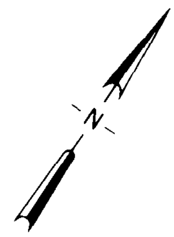
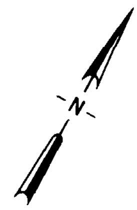


Figure V-2 Thermal Map of Ashtabula Power Plant Discharges



L E G E N D

1.	30.8° C
2.	30.1° C
3.	29.5° C
4.	28.8° C
5.	28.2° C
6.	27.6° C
7.	26.9° C
8.	26.3° C
9.	25.6° C
10.	25° C
11.	24.4° C



LEGEND

1.		35° C
2.		34° C
3.		33° C
4.		32° C
5.		31° C
6.		30° C
7.		29° C
8.		28° C
9.		27° C
10.		26° C
11.		25° C
12.		24° C

analytical techniques discussed in Chapter IV. Areas of constant temperature (isartherms) are depicted by a particular color on the isarthermal maps. The color scheme goes from dark red representing the warmest temperature through several lighter shades of red and several light shades of blue to a dark blue color representing the coolest temperature. Figure V-3 has 11 temperature gradient steps and Figure V-4 has 12 steps. The difference in the number of thermal increments is directly related to the set-up procedures for the density slicing - techniques and to the total temperature difference between the warmest area in the thermal field and the background cool water.

As mentioned above, the thermal maps have small linear areas that were the result of degraded thermal information recorded in the Infrared Line Scanner. These areas are clearly depicted in the isarthermal maps. The isartherms in these areas are represented by dashed lines indicating that the solid lines were extrapolated to provide continuity.

A maximum near-surface water temperature of 29.5°C (85°F) was recorded by the ground survey crew at the lake end of the discharge channel receiving effluent from Outfall 001. A corresponding background water temperature of 25°C (77°F) was recorded offshore and away from the influence of the thermal field. The isarthermal map [Figure V-3] of the thermal field indicated several areas both in and near the discharge channel were as warm as 30.8°C (87°F), about 6°C (10°F) warmer than ambient conditions. Temperature differences between isartherms in Figure V-3 are 0.6°C (1.1°F). About 16 hectares (40 acres) of the water surface in Figure V-3 had a temperature more than 1.7°C (3°F) above ambient temperatures, the maximum allowable temperature rise specified by the Ohio Water Quality Standards for lake waters outside designated mixing zones.

The effluent from Outfall 002 was considerably warmer with a reading of 35°C (95°F), 10°C (18°F) above ambient, recorded in the lake near the discharge point by the ground crew. About 30 hectares (74 acres) of the thermal field in Figure V-4 were 1.7°C (3°F) warmer than ambient conditions. Both the maximum temperature rise and the surface area of the plume exceeded allowable limits specified in the Ohio water temperature criteria used for comparison purposes in this study.

PAINESVILLE, OHIO

Description of Power Plant

A small (21 MWe) power plant is operated at this location by IRC Fibers Company as part of their industrial facility on the south shore of Lake Erie. Cooling water use is reported as 65,000 m^3/day (17.3 mgd).

Observed Thermal Conditions

The thermal field resulting from this discharge is shown in the thermal map recorded by the IRLS [Figure V-5]. Because no ground truth was obtained for this power plant, water temperature data recorded for the Ashtabula power plants about 32 km (20 mi) to the east were used to derive an isarthermal map. Background lake temperatures would be expected to be the same at both locations. Based on the Ashtabula data, the

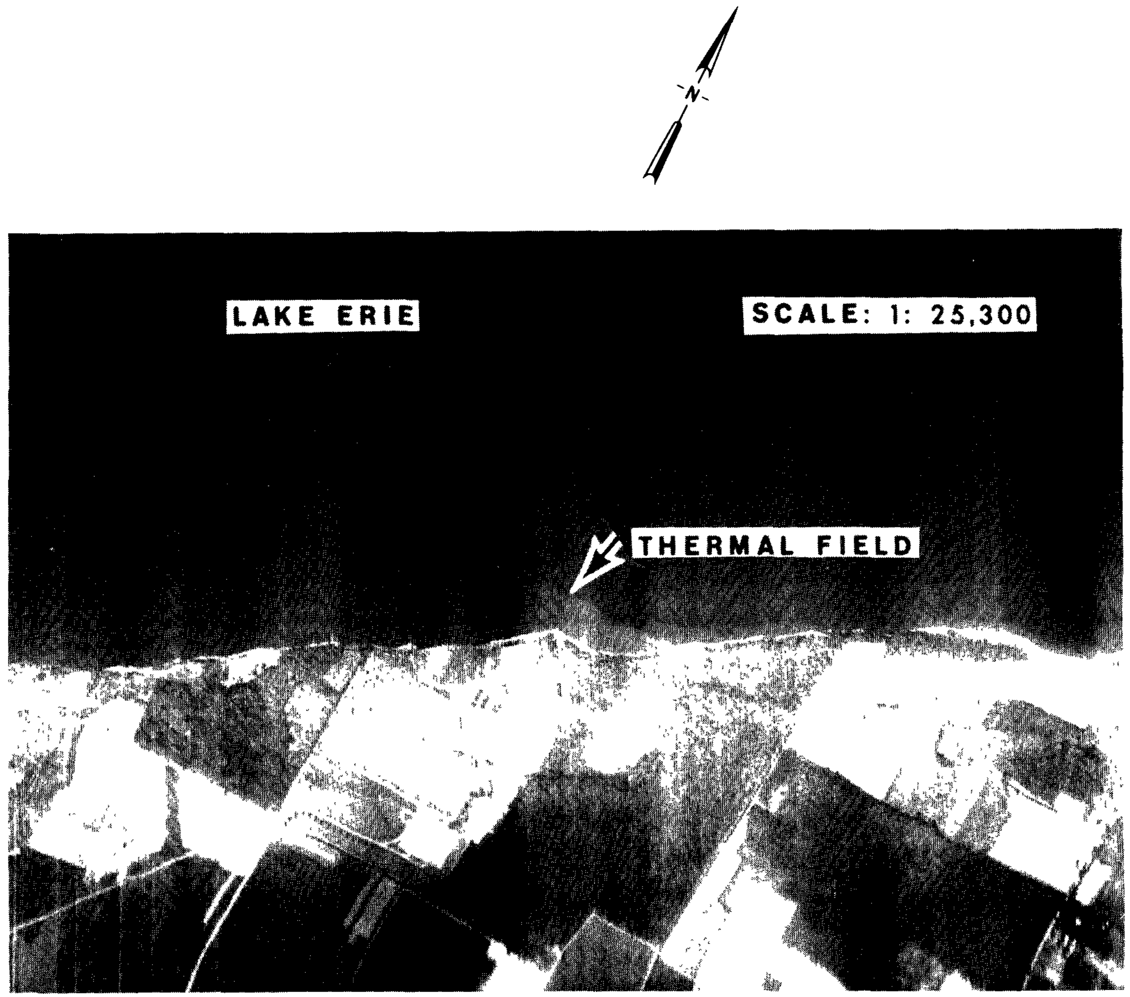


Figure V-5 Thermal Map of I.R.C. Fibers Company Discharge

isarthermal map [Figure V-6] was calibrated with temperature increments of 1.0°C (1.8°F). This calibration yielded an estimated water temperature of 35°C (95°F) at the discharge point, 10°C (18°F) above ambient (background) water temperatures of 25°C (77°F). A 10 knot wind from the northwest at flight time was blowing essentially perpendicular to the shore line and was causing the thermal field to disperse along shore. With maximum dimensions of 570 m (1,850 ft) along shore and 150 m (500 ft) out from shore, the field was small in comparison to most of the other power plant discharges to Lake Erie discussed in this report. About 32 hectares (80 acres) of the water surface were more than 1.7°C (3°F) above ambient conditions. Both the maximum temperature rise and the thermal plume area were not in compliance with the Ohio temperature criteria used for comparison.

EASTLAKE, OHIO

Description of Power Plant

The Cleveland Electric Illuminating Company operates a 577 MWe plant at this location on the south shore of Lake Erie on the east edge of the Cleveland metropolitan area. Cooling water use was reported as 3,900,000 m^3/day (1,030 mgd) in 1971. Average summer intake and discharge temperatures were reported as 23 and 30°C (73 and 86°F), respectively, with a maximum discharge temperature of 34°C (93°F). The cooling water intake is a walled channel extending about 400 m (1,300 ft) offshore to a water depth of 4 m (13 ft). Heated effluent is discharged through a walled channel about 300 m (1,000 ft) long and exits in a northeasterly direction parallel to shore.

Observed Thermal Conditions

The thermal field [Figure V-7] created by this plant's effluent was drifting in a northeasterly direction along shore. At the time of the flight the wind was blowing out of the north at 10 knots in partial opposition to the drift direction of the field indicating the presence of a significant internal counter-clockwise current in this area. The maximum dimensions of the thermal field were 1.3 km (0.8 mi) along shore and 550 m (1,800 ft) perpendicular to shore.

A maximum near-surface water temperature of 33°C (91°F) was recorded by the ground crew at a point in the lake end of the discharge channel. Background water temperatures of 26°C (79°F) were recorded. The isarthermal map [Figure V-8] indicated the maximum temperature at the upstream end of the discharge channel was 35°C (95°F). A significant area along shore was about 34°C (93°F). The area of the thermal field with surface temperatures more than 1.7°C (3°F) above ambient was about 100 hectares (250 acres). Water depths in the thermal field are about 2 to 3 m (6 to 10 ft). The area of the thermal plume exceeding the temperature rise criteria was 20 times the size of the allowable mixing zone used for comparison purposes.

CLEVELAND, OHIO

Description of Power Plants

The Lake Shore Power Plant of the Cleveland Electric Illuminating Company is located on the south shore of Lake Erie in Cleveland. With a generating capacity of 518 MWe, the plant has a reported cooling water use of 2,400,000 m^3/day (631 mgd). Summer average cooling water intake and discharge temperatures are reported as 24 and 28°C (75 and 82°F),

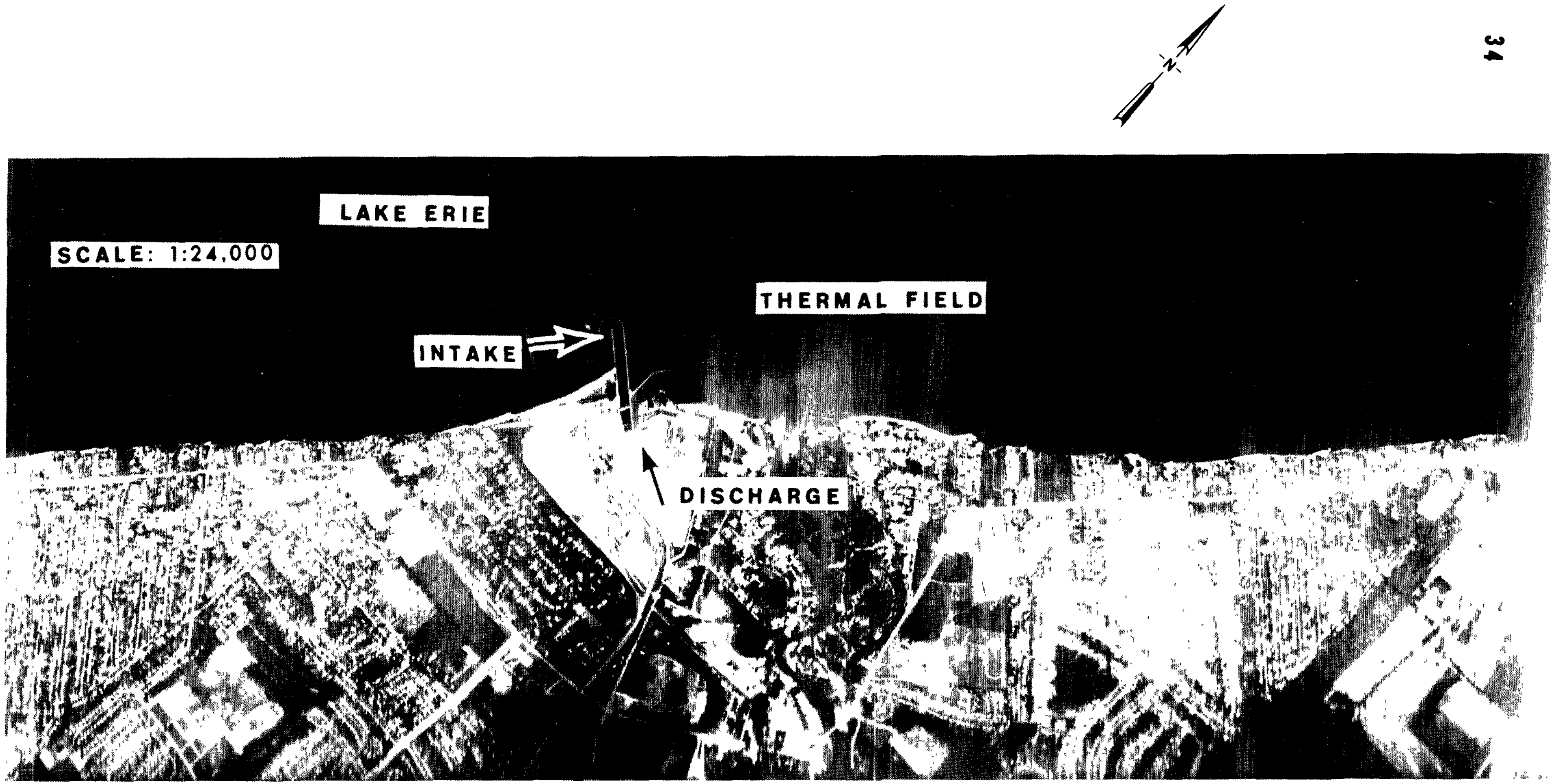
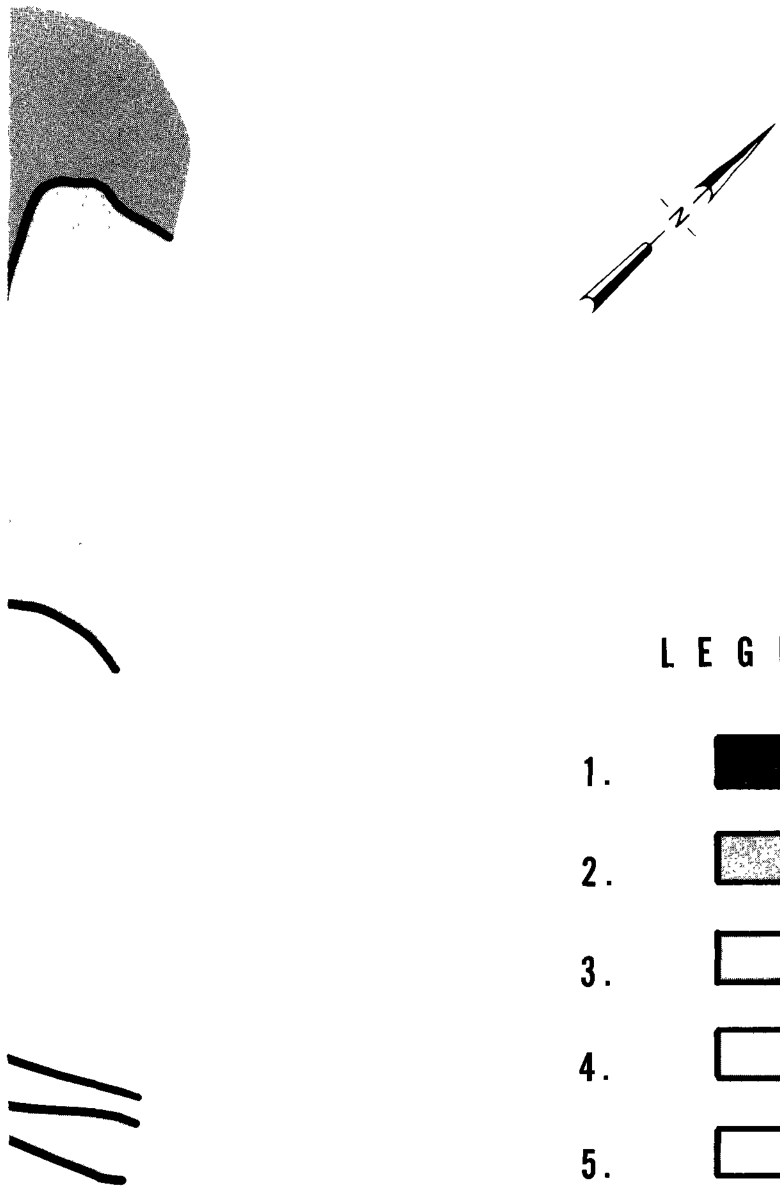


Figure V-7 Thermal Map of Eastlake, Ohio , Shoreline



LEGEND

1.		35° C
2.		34° C
3.		33° C
4.		32° C
5.		31° C
6.		30° C
7.		29° C
8.		28° C
9.		27° C
10.		26° C

4469

"Remote Sensing Study of Steam-Electric Power Plant Thermal Discharges to Lake Erie, Detroit and St. Clair Rivers OHIO AND MICHIGAN"

National Field Investigations Center-Denver
March 1974

respectively, with a maximum temperature of 34°C (93°F). The cooling water intake is a walled channel extending about 200 m (700 ft) offshore to a water depth of 5 m (16 ft). Effluent is disharged through a short channel with a deflector that diverts the flow along shore to the northeast.

Observed Thermal Conditions

The thermal field resulting from this power plant is shown in Figure V-9. The warm surface waters were moving northeast of the discharge along shore for about 760 m (2,500 ft) before turning in a counter-clockwise direction and moving to the northwest out about 690 m (2,200 ft) into the lake. The wind was blowing from the north at 10 knots at flight time. A small amount of the heated surface water was also observed recirculating back into the intake channel.

A maximum temperature of 31°C (88°F) was recorded at the discharge point by ground crews, 4°C (7°F) above the ambient water temperature of 27°C (81°F). The isarthermal map of the discharge is shown in the Figure V-10. About 49 hectares (120 acres) of the water surface had a temperature exceeding 29°C. This area is 10 times the size of the allowable mixing zone. Water depths in the thermal field average 6 to 10 m (19 to 32 ft).

AVON LAKE, OHIO

Description of Power Plant

The Cleveland Electric Illuminating Company operates the Avon Lake Power Plant on the south shore of Lake Erie to the west of Cleveland. The cooling water intake is a walled channel extending about 300 m

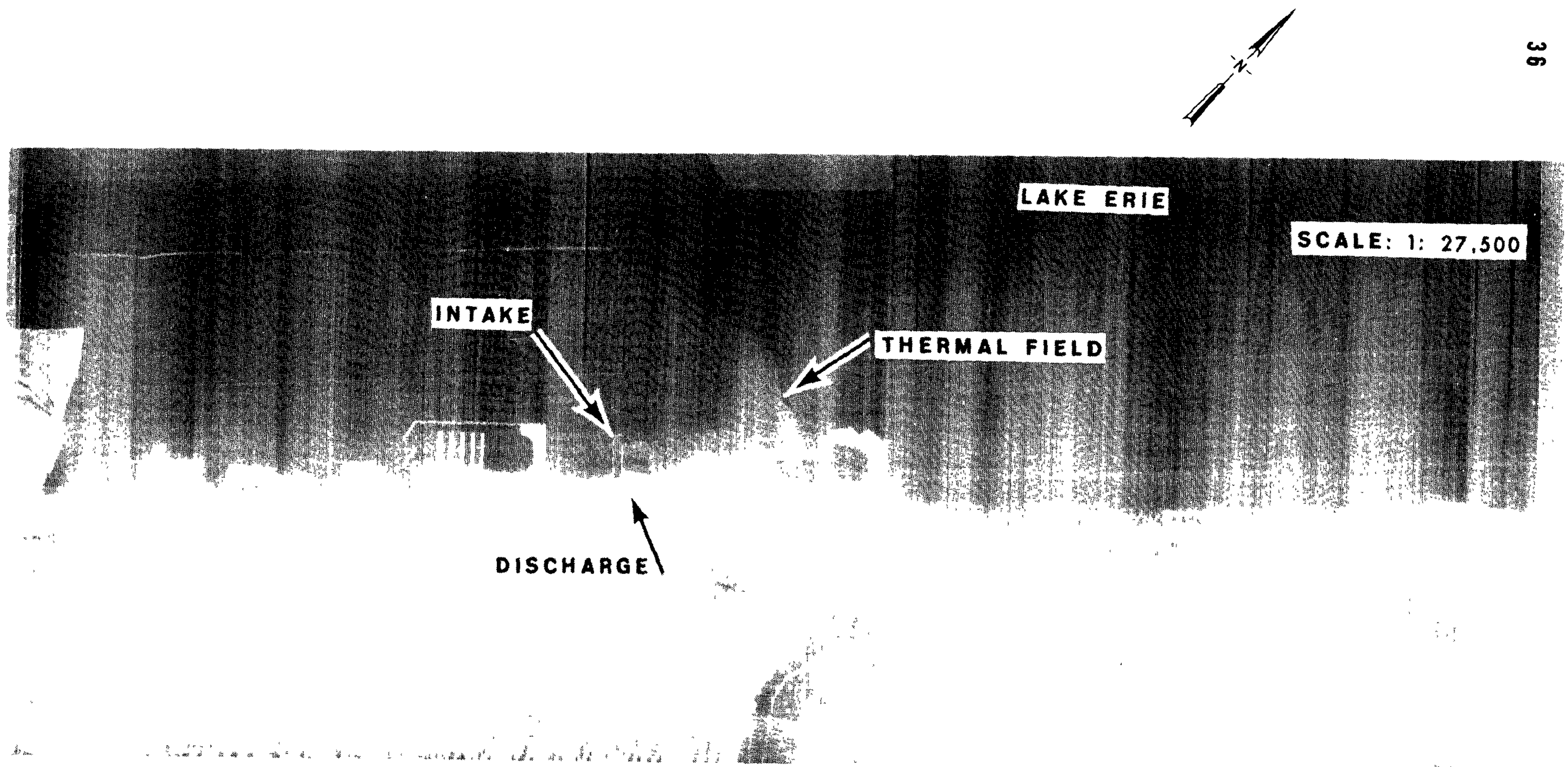


Figure V-9 Thermal Map of Lakeshore Power Plant Discharge

LEGEND

1.		31° C
2.		30° C
3.		29° C
4.		28° C
5.		27° C
6.		26° C
7.		25° C

Plant Discharge

(1,000 ft) offshore to a water depth of 2 m (6 ft). The plant has two cooling water discharges. Discharge 001, with a reported flow rate of 2,700,000 m^3/day (720 mgd) flows through a walled channel adjacent to intake channel and, about 150 m (500 ft) offshore, is diverted to the southwest back toward shore [Figure V-11]. The second discharge is from Outfall 003 with a reported flow rate of 1,300,000 m^3/day (341 mgd). This thermal effluent enters the lake from a pipeline terminating at the shoreline and is diverted by a baffle to the northeast along shore in shallow water.

The reported average summer intake temperature was 23°C (74°F). For Discharge 001, the average and maximum summer temperatures were reported as 31 and 33°C (87 and 92°F), respectively. Corresponding values for Discharge 003 were 26 and 29°C (79 and 84°F).

Observed Thermal Conditions

A map of the thermal fields resulting from the two power plant discharges is shown in Figure V-11. The large thermal field from Discharge 001 was dispersing along shore in a west-southwesterly direction. The thermal field was detectable for about 3.7 km (2.3 mi) to the west of the discharge and extended about 1.0 km (0.6 mi) offshore at its widest point. At the time of flight, the wind was blowing from the northwest at 5 knots. For several hours prior to this time period, however, the wind had been blowing out of the east-northeast at 4 to 8 knots, accounting for the westward drift of the heated effluent.

The small thermal field produced by Discharge 003 was dispersing within 200 m (650 ft) off shore.

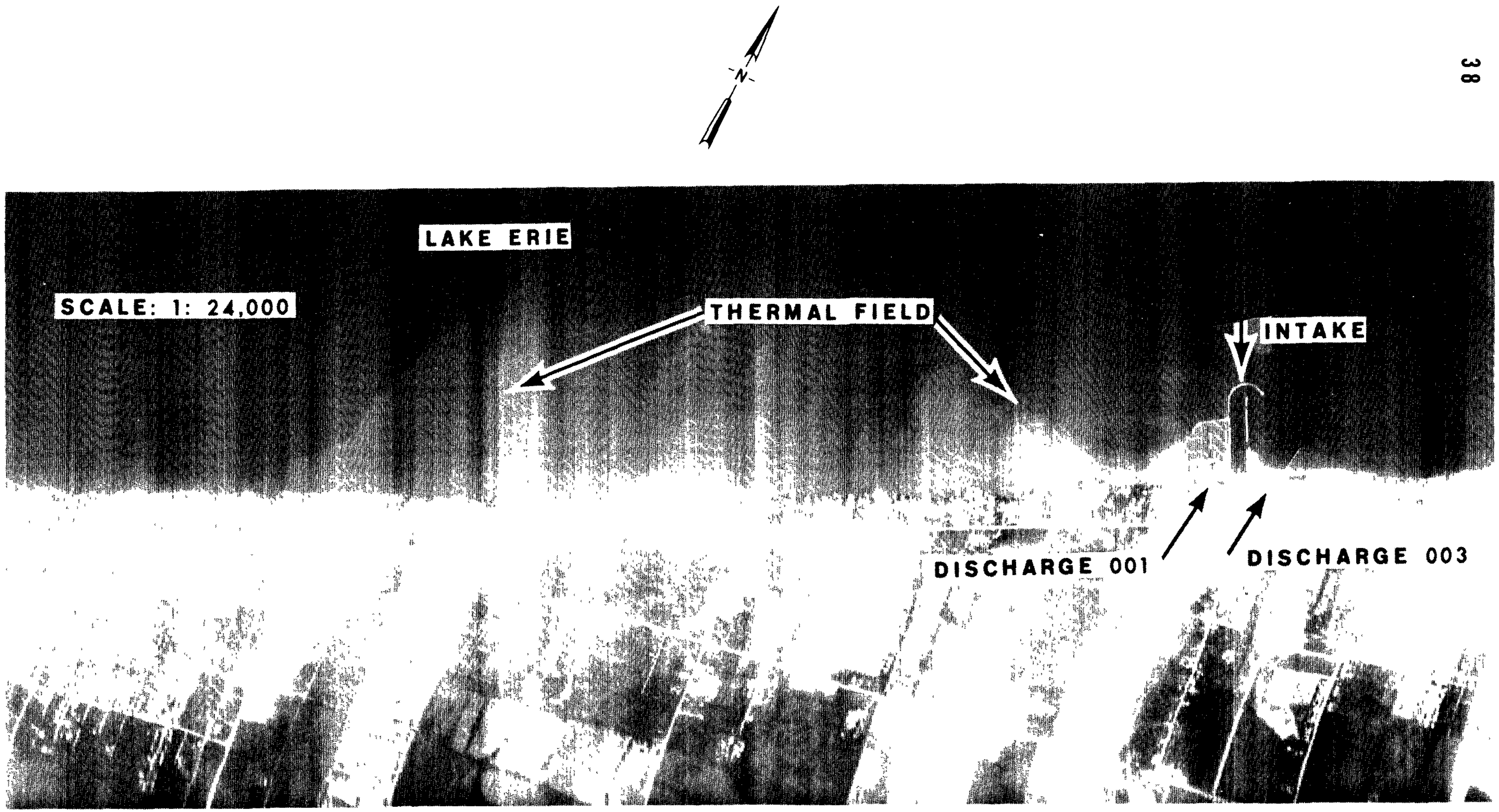


Figure V-11 Thermal Map of Avon Lake Power Plant Discharge

A maximum temperature of 28°C (82°F) was observed by the ground crew in the lake near the discharge point of Outfall 001. Ambient temperatures of 26°C (79°F) outside the thermal plume were recorded. The isarthermal map [Figure V-12] indicated that temperatures as high as 31°C (88°F) occurred in the discharge channel and 30°C (86°F) occurred at several near-shore locations on the lake. Background temperatures about 0.8 km (0.5 mi) offshore were 25°C (77°F). About 100 hectares (250 acres) of the water surface heated by the effluent from Outfall 001 exceeded background water temperatures by more than 1.7°C (3°F). This area is more than 25 times the size of the allowable mixing zone.

Figure V-13 is an isarthermal map of the thermal plume from Outfall 003. No area in the plume exceeded 28°C (83°F).

LORAIN, OHIO

Description of Power Plant

The Ohio Edison Company operates the Edgewater Power Station located on the south shore of Lake Erie at the mouth of the Black River in Lorain. This 193 MWe plant has a reported average cooling water use of 420,000 m^3/day (110 mgd). Average summer intake and discharge temperatures were reported as 24 and 30°C (75 and 86°F), respectively, and maximum discharge temperature as 40°C (104°F).

The plant is located in the harbor area separated from the open lake by breakwaters. The Black River, with an average flow of 300 cfs, discharges to the protected harbor area. The cooling water intake is a narrow surface channel extending into the harbor area. Heated effluent is discharged to an adjacent boat slip. It is probable that heated water is recirculated for the discharge channel to the intake within the harbor.

Observed Thermal Conditions

As indicated by the thermal map [Figure V-14] recorded of this area, the thermal plume from the power plant was moving out of the area enclosed by the breakwaters in a southwesterly direction along shore and was nearly completely dispersed about 1.2 km (0.8 mi) from the discharge. This direction of dispersion was influenced by a 12 knot wind from the north-northeast. The thermal field extended only 330 m (1,100 ft) offshore.

Ground observers recorded a maximum temperature of 36°C (97°F) at the discharge point, 9°C (16°F) above ambient lake temperatures of 27°C (81°F). As indicated by the isarthermal map [Figure V-15], the entire area within the breakwaters was quite warm. About 360 hectares (890 acres) of the area in Figure V-15 were 1.7°C (3°F) warmer than ambient Lake Erie temperatures. At least half of this heated area can be directly attributed to the power plant discharge indicating the size of the thermal plume is many times larger than the allowable mixing zone.

TOLEDO, OHIO

Description of Power Plant

The Toledo Edison Company operates the Bay Shore Power Station on the south shore of Maumee Bay at the west end of Lake Erie. The 636 MWe plant is just east of the mouth of the Maumee River in the Toledo metropolitan area.

Cooling water averaging 2,800,000 m^3/day (746 mgd) is obtained through a dredged channel intersecting the Maumee River channel as it enters Maumee Bay. Heated effluent is discharged through a short channel to a shallow area of Maumee Bay. Average summer cooling water intake and discharge

LEGEND

1.	31° C
2.	30° C
3.	29° C
4.	28° C
5.	27° C
6.	26°C
7.	25° C

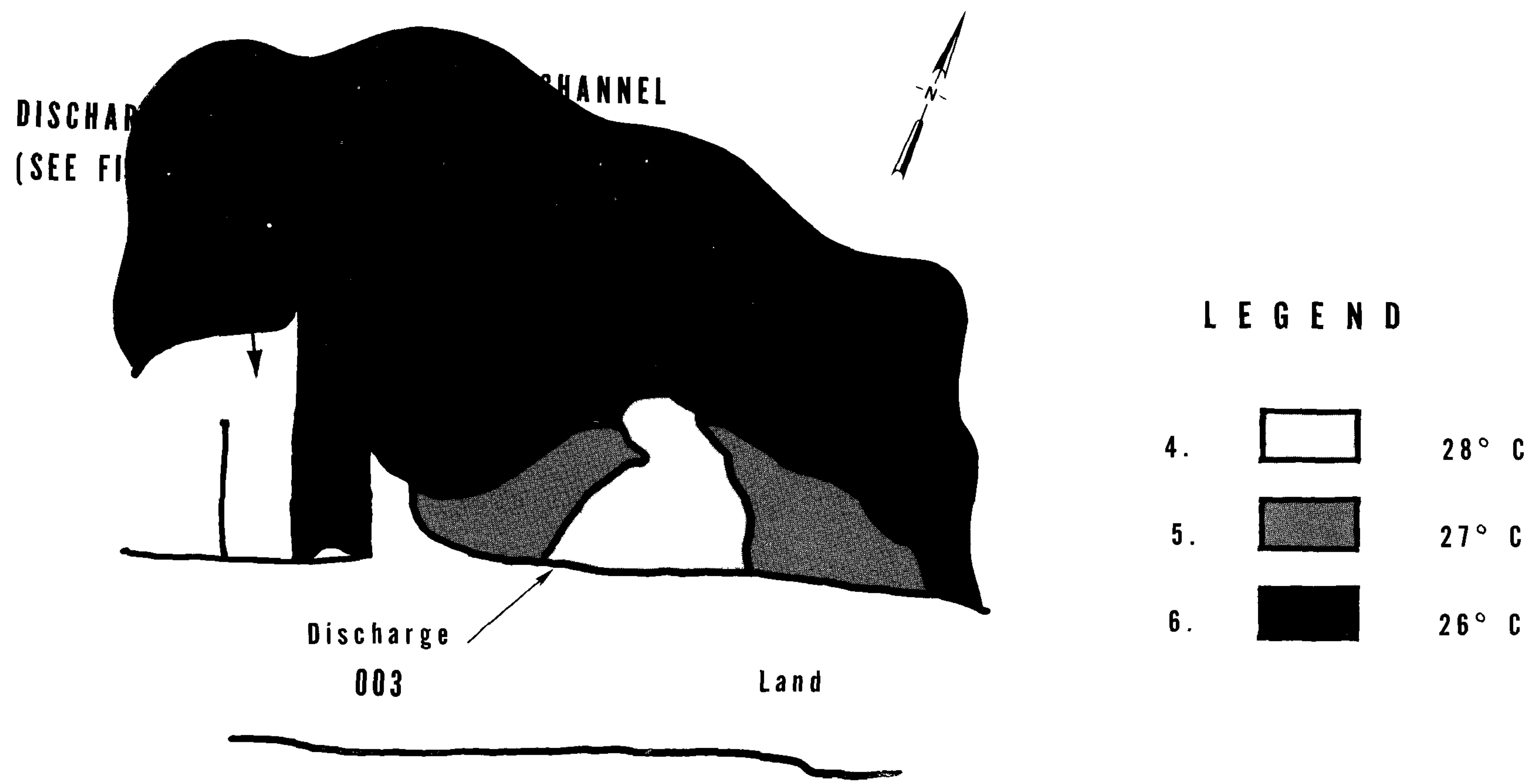


Figure V-13 Isarthermal Map of the Avon Lake Power Plant Discharge 003

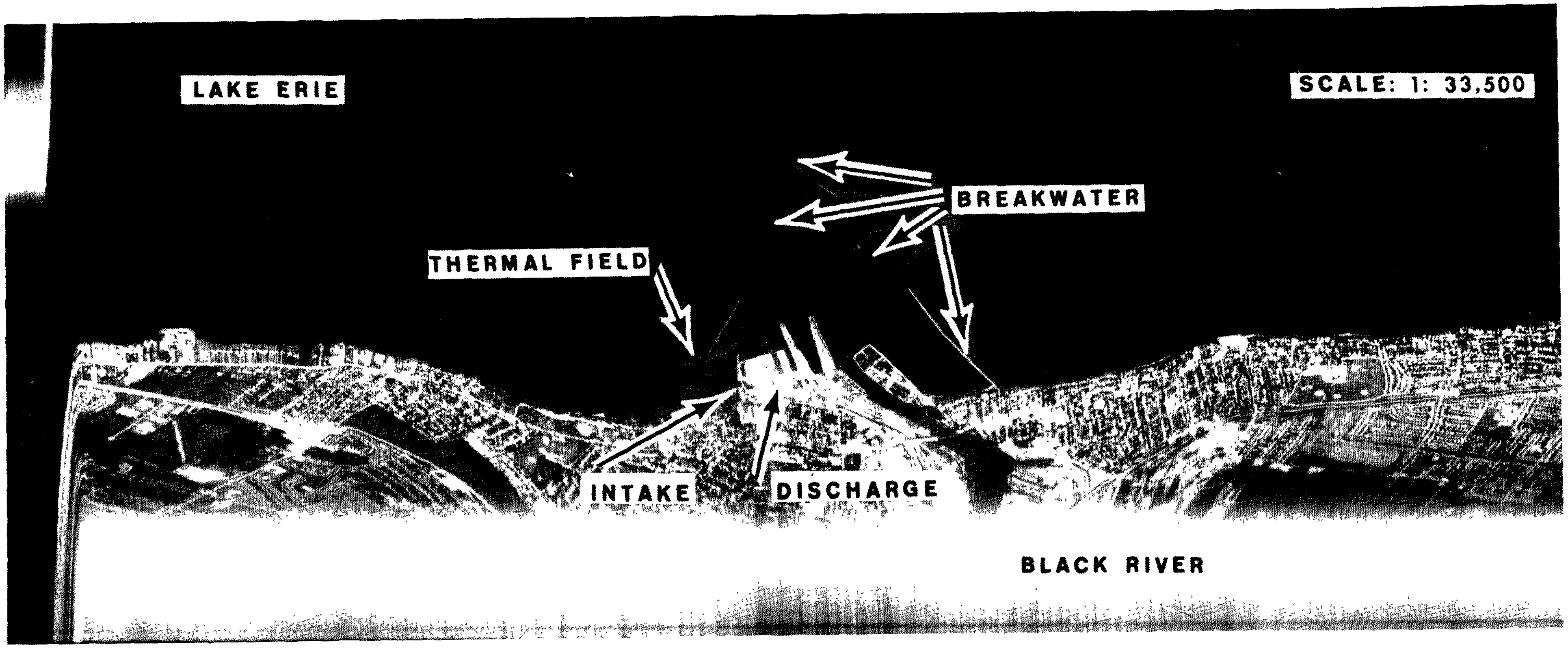


Figure V-14 Thermal Map of Lorain, Ohio , Harbor Area

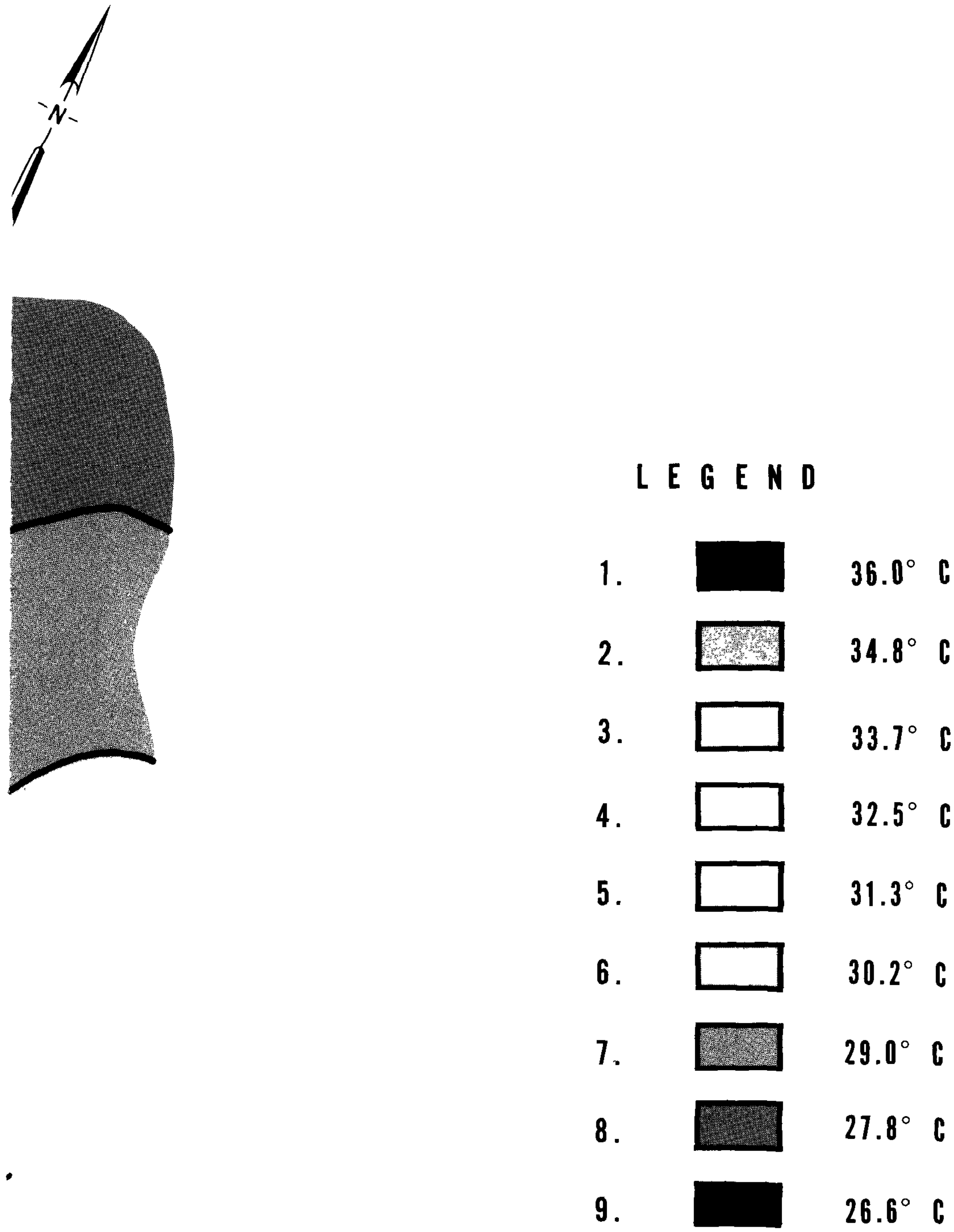
temperatures are reported as 24 and 29°C (76 and 85°F), respectively, with a maximum temperature of 31°C (88°F).

With an average discharge of about 140 m^3/sec (3,190 mgd) the Maumee River would be expected to influence water temperatures and circulation in the vicinity of the power plant.

Observed Thermal Conditions

The thermal field [Figure V-16] extended from Bay Shore Station about 1.4 km (0.8 mi) along shore and nearly 1.6 km (1 mi) out into Maumee Bay and was rotating in a counter-clockwise direction. This rotation was influence by a 7 knot wind from the northeast at flight time. Ground observers recorded an intake temperature of 25°C (77°F) and a maximum temperature in the discharge canal of 31°C (88°F), a difference of 6°C (11°F). As indicated in the isarthermal map [Figure V-17], several areas in the thermal field were also at this maximum temperature. About 380 hectares (940 acres) of the area in Figure V-17 had a surface temperature 1.7°C (3°F) above ambient. The thermal plume from the plant accounted for at least half of this area indicating that the plume is many times larger than an allowable mixing zone.

A smaller thermal plume was visible to the west of the Bay Shore Station [Figure V-16]. The plume emanates from a ditch entering the Maumee River from the south and is probably from an industrial source. A thermal map of the mouth of the Maumee River clearly shows this thermal field [Figure V-18]. An isarthermal map of the area [Figure V-19] shows that most of the River in this area is several degrees warmer than ambient conditions in Maumee Bay.


N
LEGEND
1. 36.0° C
2. 34.8° C
3. 33.7° C
4. 32.5° C
5. 31.3° C
6. 30.2° C
7. 29.0° C
8. 27.8° C
9. 26.6° C

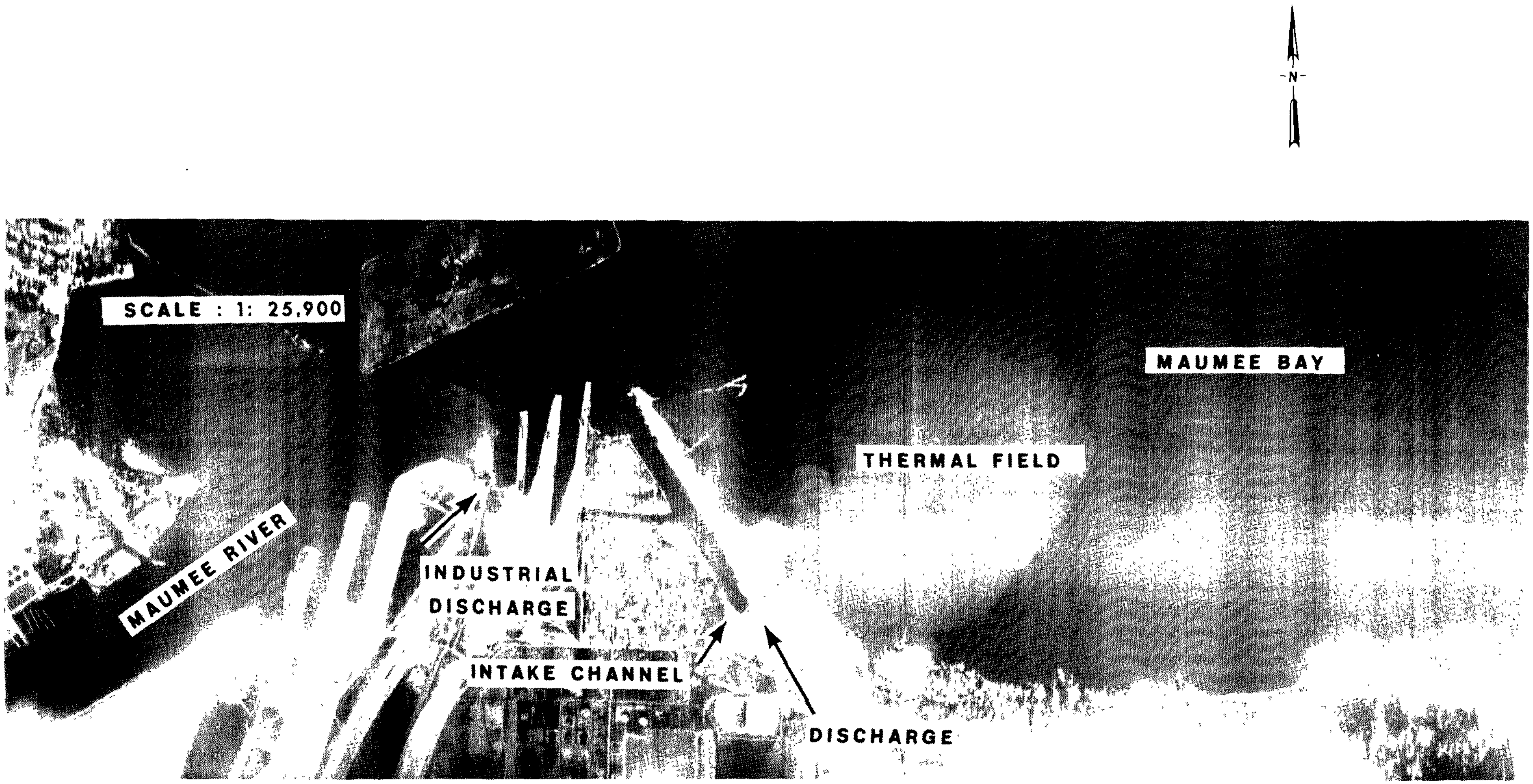
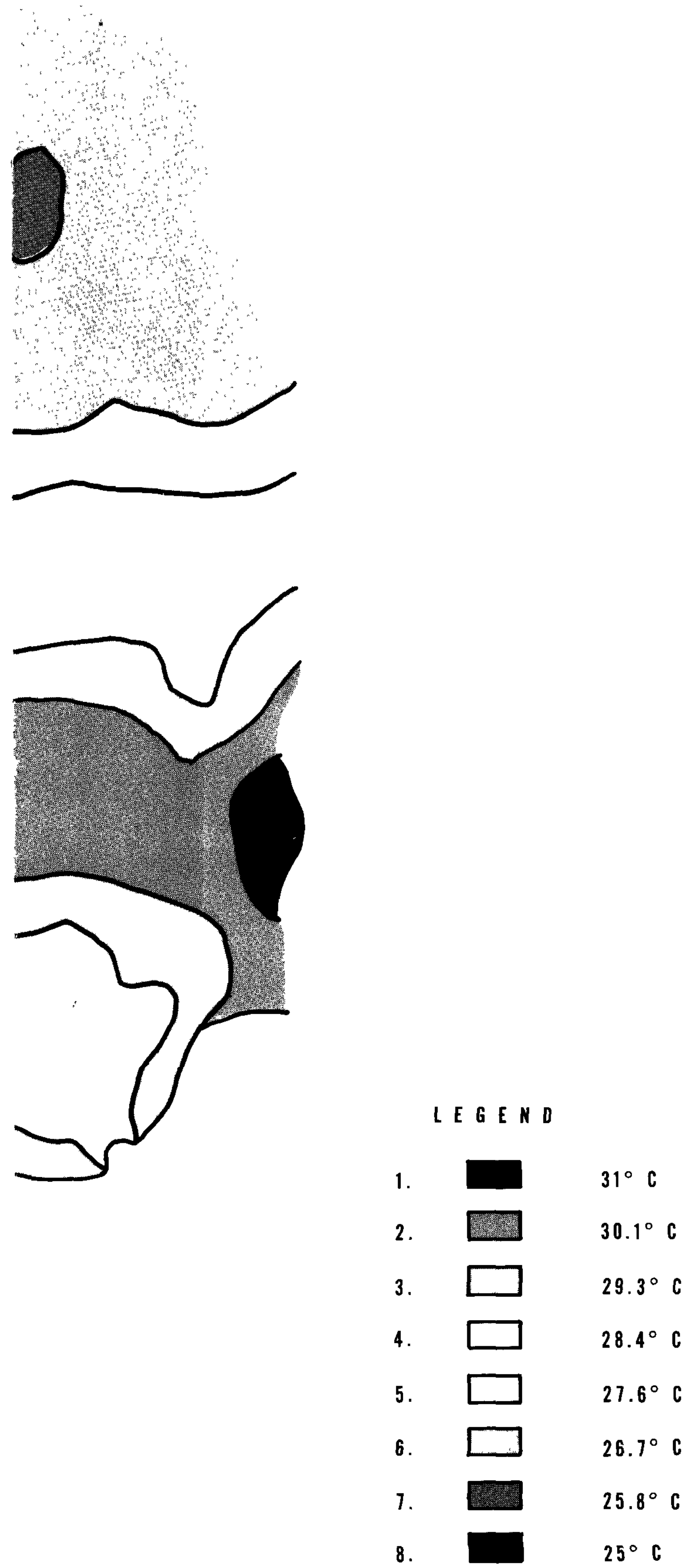
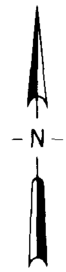


Figure V-16 Thermal Map of Bay Shore Power Plant Discharge

Figure V-18 Thermal Map of the Mouth of the Maumee River


LEGEND
1. 31° C
2. 30.1° C
3. 29.3° C
4. 28.4° C
5. 27.6° C
6. 26.7° C
7. 25.8° C
8. 25° C



LEGEND

2.	30.1° C
3.	29.3° C
4.	28.4° C
5.	27.6° C
6.	26.7° C
7.	25.8° C
8.	25.0° C

er

ERIE, MICHIGAN

Description of Power Plant

The Consumer Power Plant operates the J. R. Whiting Power Plant at Erie, Michigan on the west shore of Lake Erie just north of Toledo, Ohio. An average cooling water use of 1,200,000 m^3/day (308 mgd) was reported for this 342 MWe plant.

Observed Thermal Conditions

Figure V-20 is a thermal map showing the thermal plume produced by this plant. An isarthermal map of the plume is given in Figure V-21. The thermal field extended about 650 m (2,100 ft) out into Lake Erie and was moving along shore in a southerly direction for about 1.4 km (0.8 mi). The wind was out of the northeast (as recorded at Toledo) at 7 knots contributing to this dispersion pattern. The plant reported intake and discharge temperatures of 25.6 and 34.4°C (78 and 94°F) at flight time, a difference of 8.8°C (16°F). Note that the maximum temperature extended well out into Lake Erie. About 70 hectares (170 acres) of the lake surface were more than 1.7°C (3°F) warmer than ambient conditions. Both the maximum temperature rise and the size of the thermal field were not in compliance with the water quality criteria used for comparative purposes.

MONROE, MICHIGAN

Description of Power Plant

The Monroe Power Plant is operated by the Detroit Edison Company at Monroe on the west end of Lake Michigan. The plant will ultimately have four 800-MWe coal-fired units for a total generating capacity of 3,200 MWe.

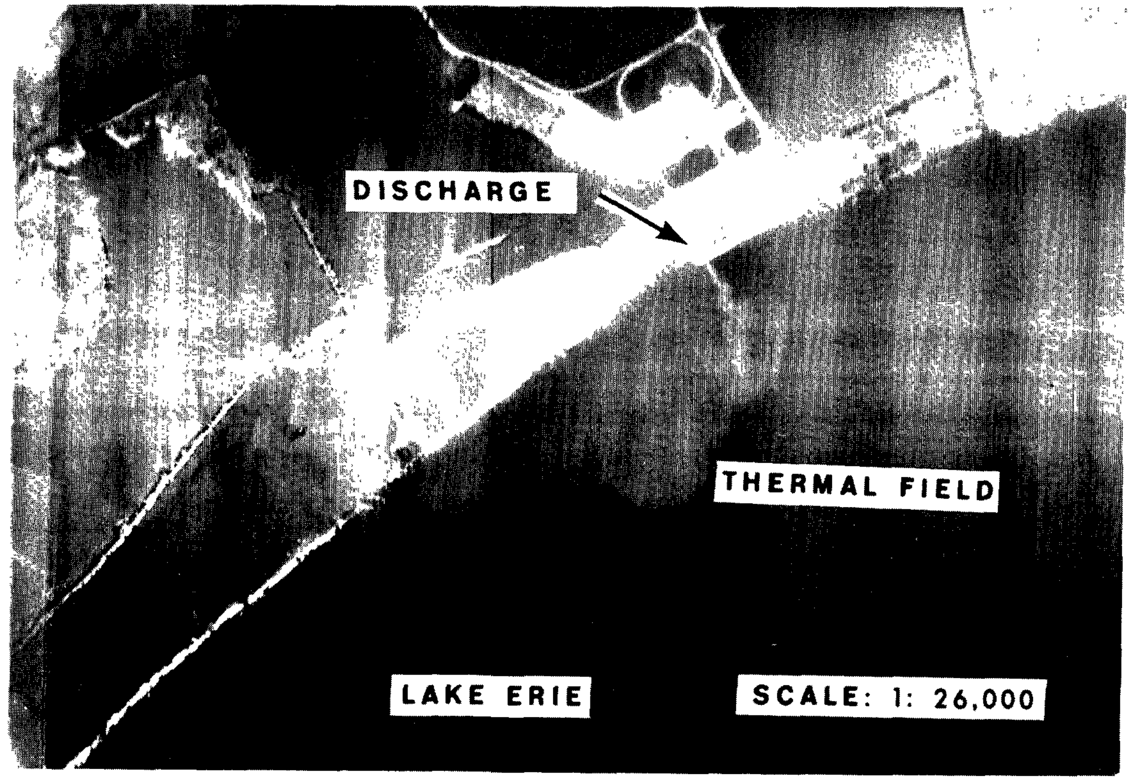
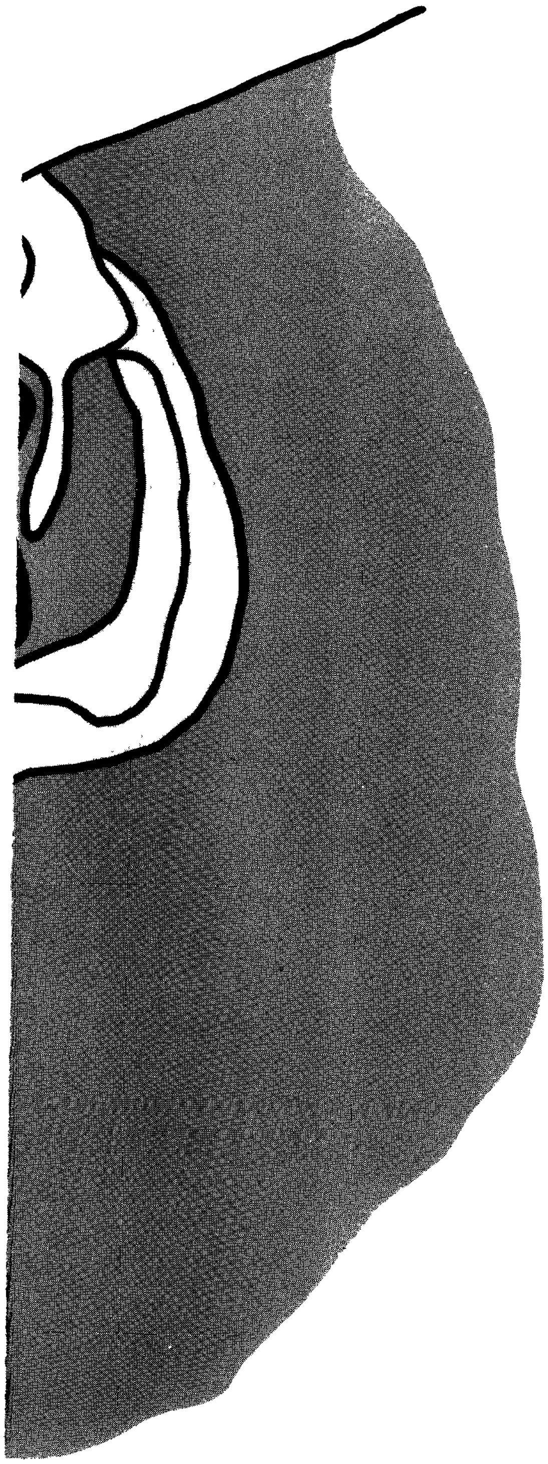


Figure V-20 Thermal Map of J.R. Whiting Power Plant Discharge



LEGEND

1.	34.4° C
2.	32.6° C
3.	30.9° C
4.	29.1° C
5.	27.4° C
6.	25.6° C

ing Power Plant Discharge

Units Nos. 1 and 2 were operational at flight time. Units Nos. 3 and 4 were scheduled for completion in 1973 and 1974 respectively. Ultimate cooling water use will be about 7,600,000 m^3/day (2,016 mgd). The cooling water discharge at flight time was estimated to be about half this amount.

The cooling water supply is obtained from a natural stream channel about 600 m (2,000 ft) inland from Lake Erie. Heated effluent is discharged to a large dredged channel about 1.8 km (1.2 mi) long. The lower half of this channel is a deepened section of the Raisin River channel as it enters Lake Erie.

Observed Thermal Conditions

The effluent from this power plant produced a thermal plume about 3.9 km (2.4 mi) long that moved out into Lake Erie from the mouth of the Raisin River about 1.4 km (0.8 mi) and was dispersing in a southerly direction [Figure V-22]. The direction of movement was influenced by a 6 knot wind from the northeast. Temperature patterns in the thermal field were quite complex [Figure V-23]. The maximum temperature observed in the discharge channel was 11.7°C (21°F) above the ambient lake temperature of 23°C (73°F). At the mouth of the Raisin River, the thermal field was still more than 6°C (11°F) warmer than the lake. About 460 hectares (1.130 acres) of the surface area of the thermal field were more than 1.7°C (3°F) warmer than ambient temperatures.

LAGOONA BEACH, MICHIGAN

Description of Power Plant

At a location on the west shore of Lake Erie midway between Detroit, Michigan, and Toledo, Ohio, the Detroit Edison Company operates the nuclear-fueled Enrico Fermi Power Plant No. 1. A second nuclear-fueled facility,

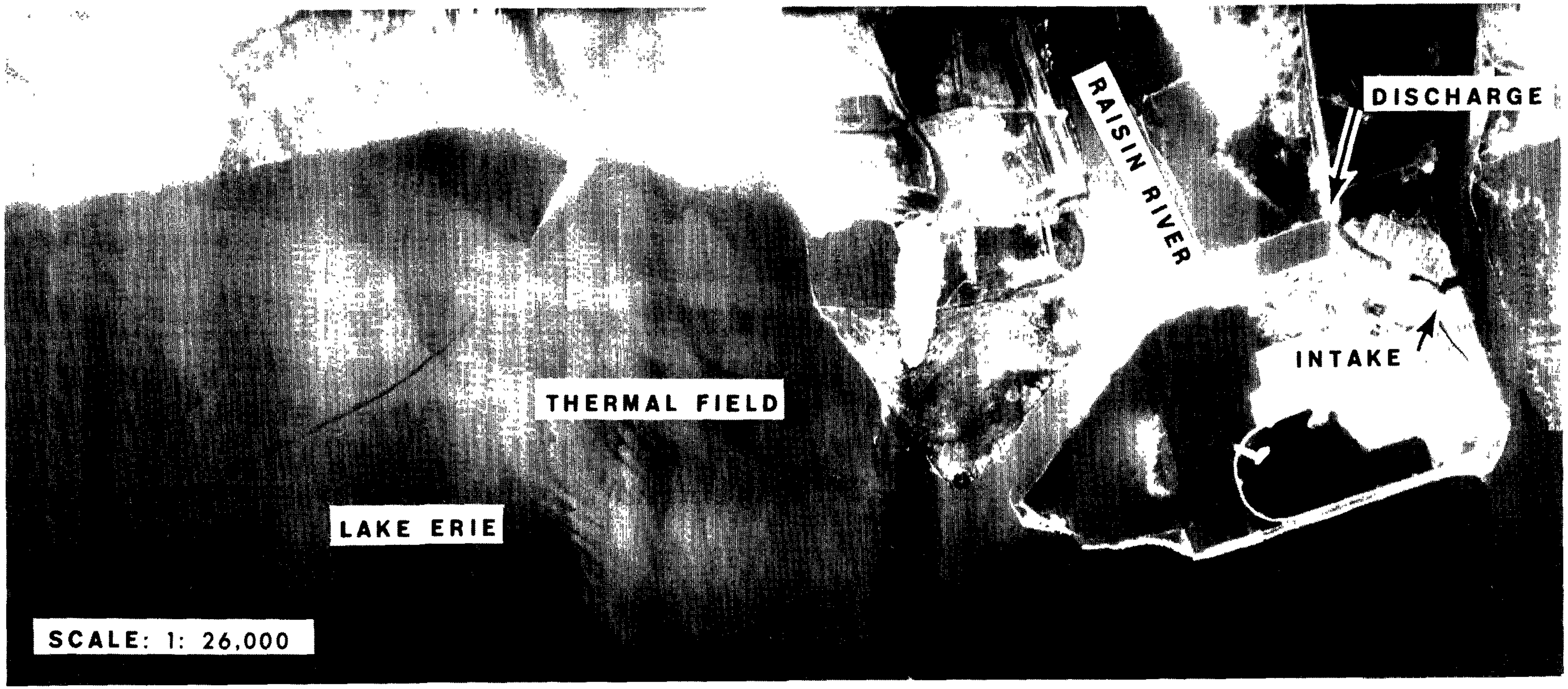
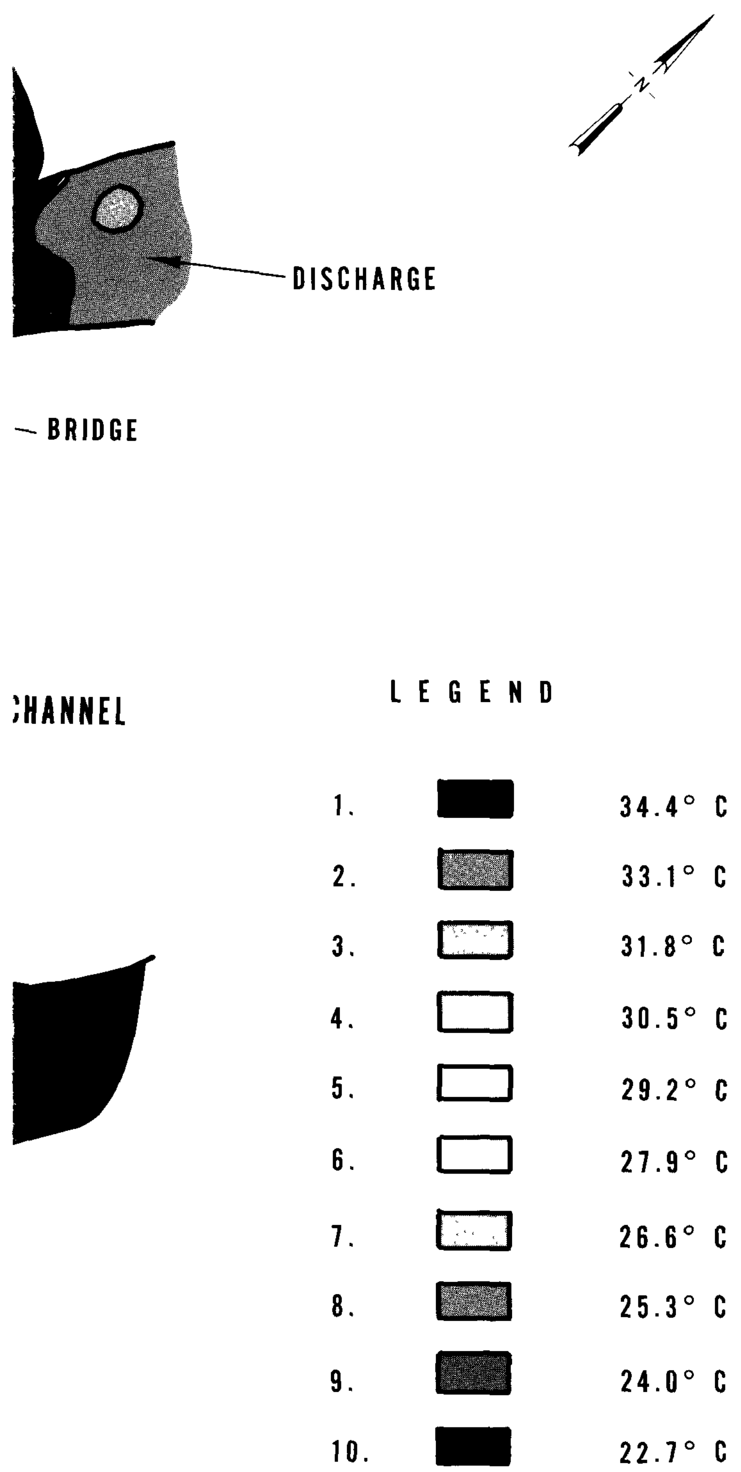


Figure V-22 Thermal Map of Monroe Power Plant Discharge


N
DISCHARGE
BRIDGE
:HANNEL
LEGEND
1. 34.4° C
2. 33.1° C
3. 31.8° C
4. 30.5° C
5. 29.2° C
6. 27.9° C
7. 26.6° C
8. 25.3° C
9. 24.0° C
10. 22.7° C

the Enrico Fermi Power Plant No. 2, is under construction at the same location. These plants are about 13 km (8 mi) north of the Monroe Power Plant discussed above. Unit No. 1 is only 150 MWe while Unit No. 2 will be 1,150 MWe.

Cooling water from both plants is obtained from Lake Erie through a short walled and dredged channel. Unit No. 1 discharges about 940,000 m^3/day (249 mgd) of heated effluent to a narrow dredged channel that will ultimately extend to Swan Creek about 1.6 km (1.0 mi) north of the plant. The effluent would then flow about 0.8 km (0.5 mi) in Swan Creek to Lake Erie. At present, part of the effluent flows through a swamp and lagoon to Lake Erie and part goes to Swan Creek.

Unit No. 2 will employ a recirculating cooling system with two large natural-draft cooling towers and a 23-hectare (50-acre) residual heat removal pond. Blowdown from the system will be discharged from the pond directly to Lake Erie. Construction of the pond will direct all Unit No. 1 heated effluent to Swan Creek.

Observed Thermal Conditions

A thermal map of Lake Erie adjacent to the two plants is shown in Figure V-24. The plant temporarily ceased operation at 1124 EDT while the thermal map was recorded at 1440 EDT. Thus, the thermal field had been disipating for more than 3 hours when observed.

An isarthermal map of the area [Figure V-25] was prepared based on water temperature data for the Monroe Power Plant as ground truth was not obtained for the Fermi location. This map shows that the discharge canal

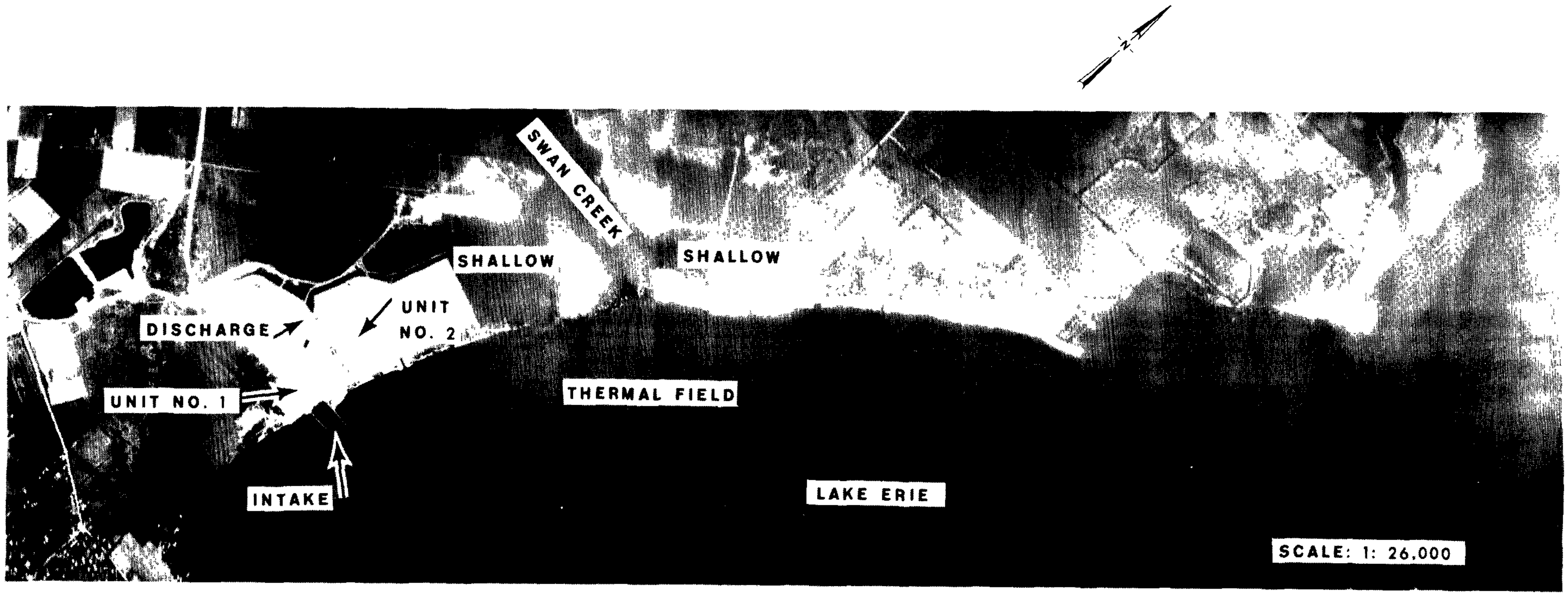
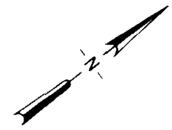


Figure V-24 Thermal Map of Enrico Fermi Power Plant Discharge



LEGEND

1.	31.8° C
2.	30.7° C
3.	29.7° C
4.	28.7° C
5.	27.7° C
6.	26.7° C
7.	25.7° C
8.	24.7° C
9.	23.7° C
10.	22.7° C

contained cool water only 2 to 3°C (3 to 5°F) warmer than ambient Lake Erie water. Significant areas of warm water were noted in the shallow water areas. This warm water was slowly dispersing into Lake Erie. The thermal field in Lake Erie measured about 1.1 km (0.7 mi) along shore and extended about 1.0 km (0.6 mi) out into the lake. About 300 hectares (750 acres) of the thermal field in the shallow water and Lake Erie were more than 1.7°C (3°F) warmer than ambient lake temperatures.

TRENTON, MICHIGAN

Description of Power Plant

The Detroit Edison Company operates the large (1,119 MWe) Trenton Channel Power Plant on the Detroit River at Trenton, Michigan. Cooling water use is reported as 5,200,000 m^3/day (1,380 mgd). Cooling water is obtained from the River with heated effluent returned to the River through a short channel.

Observed Thermal Conditions

As indicated in the thermal map [Figure V-26], the thermal plume from the plant was rapidly dispersing downstream as a result of the large flow in the Detroit River. It occupied only a small percentage of the stream cross section. The plume was only 90 m (300 ft) wide and extended 550 m (1,800 ft) downstream.

The discharge temperature was 33°C (92°F) while the warmest area recorded in the thermal plume as shown in the isarthermal map [Figure V-27] was 31.3°C (88°F). This was 9.7°C (17°F) above background River temperatures.

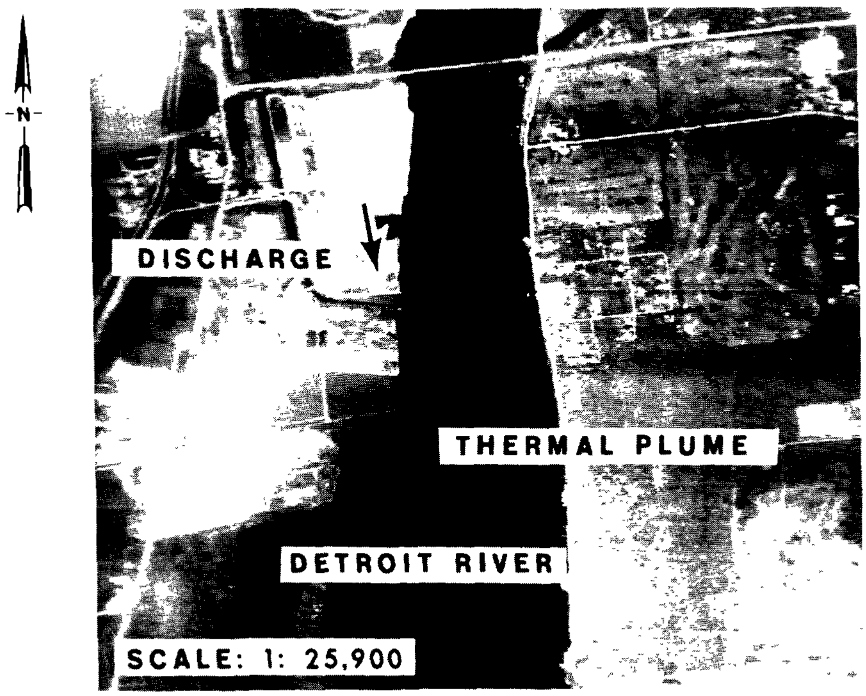
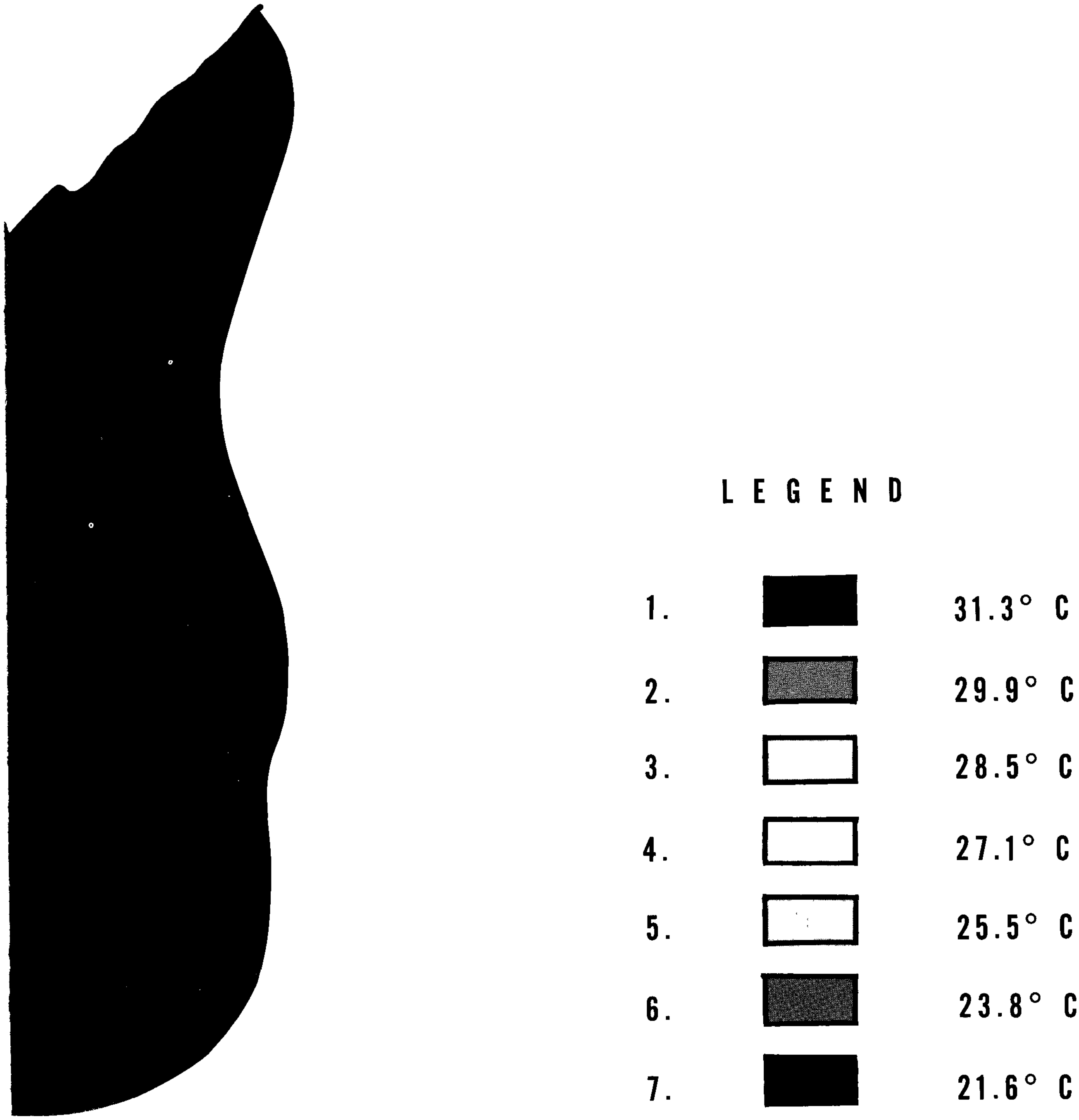


Figure V-26 Thermal Map of
Trenton Channel Power Plant Discharge



n Channel Power Plant Discharge

WYANDOTTE, MICHIGAN

Description of Power Plant

The Wyandotte Municipal Service Commission operates a small (41.5 MWe) power plant on the Detroit River. Cooling water is obtained from and discharged to the River.

Observed Thermal Conditions

No thermal plume from the plant was recorded in the thermal map of the area [Figure V-28]. The ground truth data indicated that surface water temperatures near the discharge were within 0.4°C (0.7°F) of being in an isothermal state.

Four other thermal discharges were recorded in the thermal map. The three labeled "a", "b", and "c" were too small to analyze for isarthermal characteristics and dispersed quickly in the River. The thermal plume labeled "d" was somewhat larger but a calibrated isarthermal map could not be constructed because of a lack of ground truth.

RIVER ROUGE, MICHIGAN

Description of Power Plant

The Detroit Edison Company operates the River Rouge Power Plant on the Detroit River just south of Detroit. Cooling water use is reported as 2,400,000 m^3/day (644 mgd) for this 860 MWe facility. Cooling water is obtained from and discharged to the Detroit River.

Observed Thermal Conditions

As indicated in the thermal map [Figure V-29], the thermal plume from the plant was rapidly dispersing downstream in the River. The plume had a maximum width of 185 m (600 ft) and extended 560 m (1,800 ft) downstream. It occupied only a small part of the stream cross section.

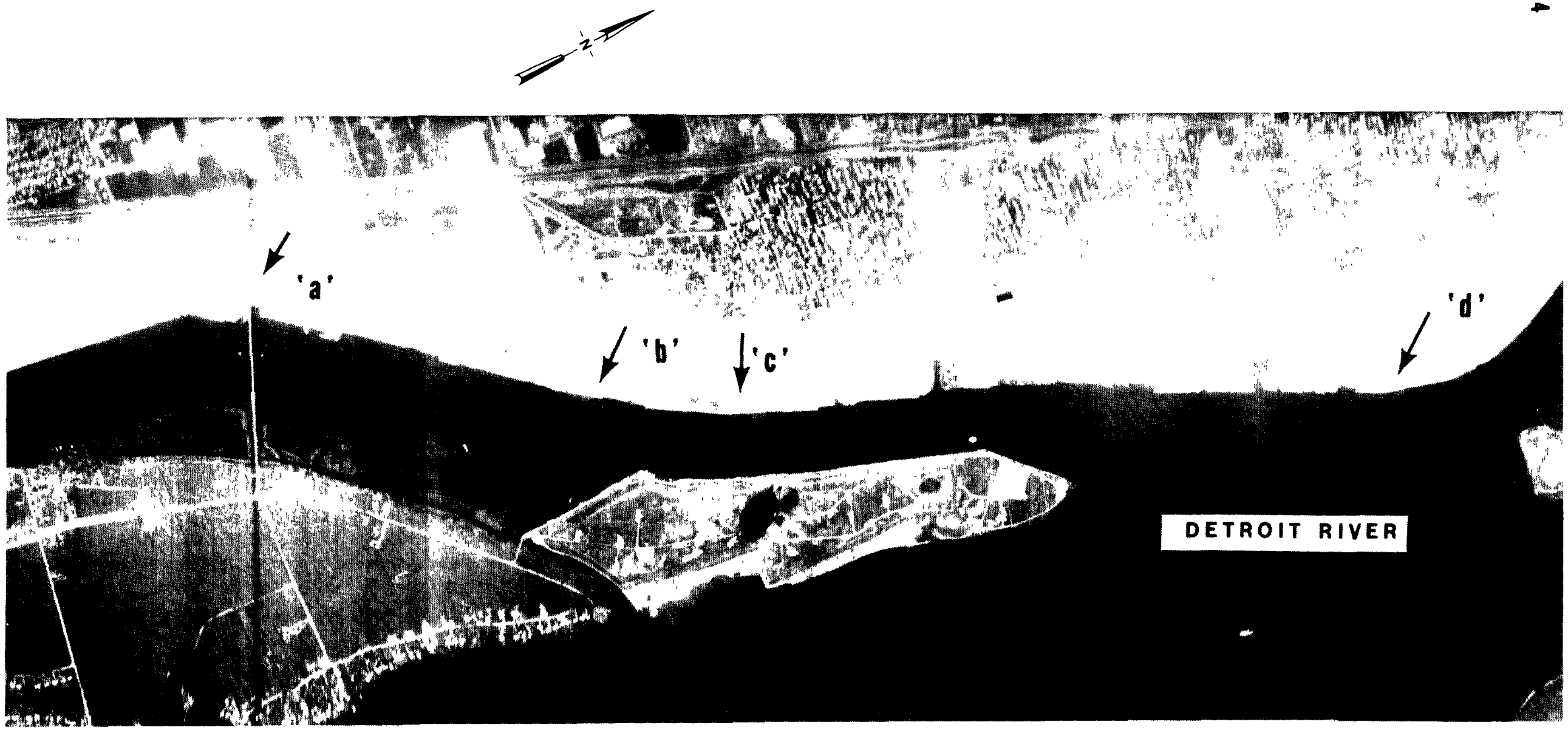


Figure V- 28 Thermal Map of Detroit River at Wyandotte, Michigan

Figure V-29 Thermal Map of River Rouge Power Plant Discharge

The isarthermal map [Figure V-30] indicates a temperature difference of 8.9°C (16°F) between the discharge point and ambient River temperatures.

Four additional small thermal discharges upstream of the power plant were recorded on the thermal map [Figure V-29].

DETROIT, MICHIGAN

Description of Power Plants

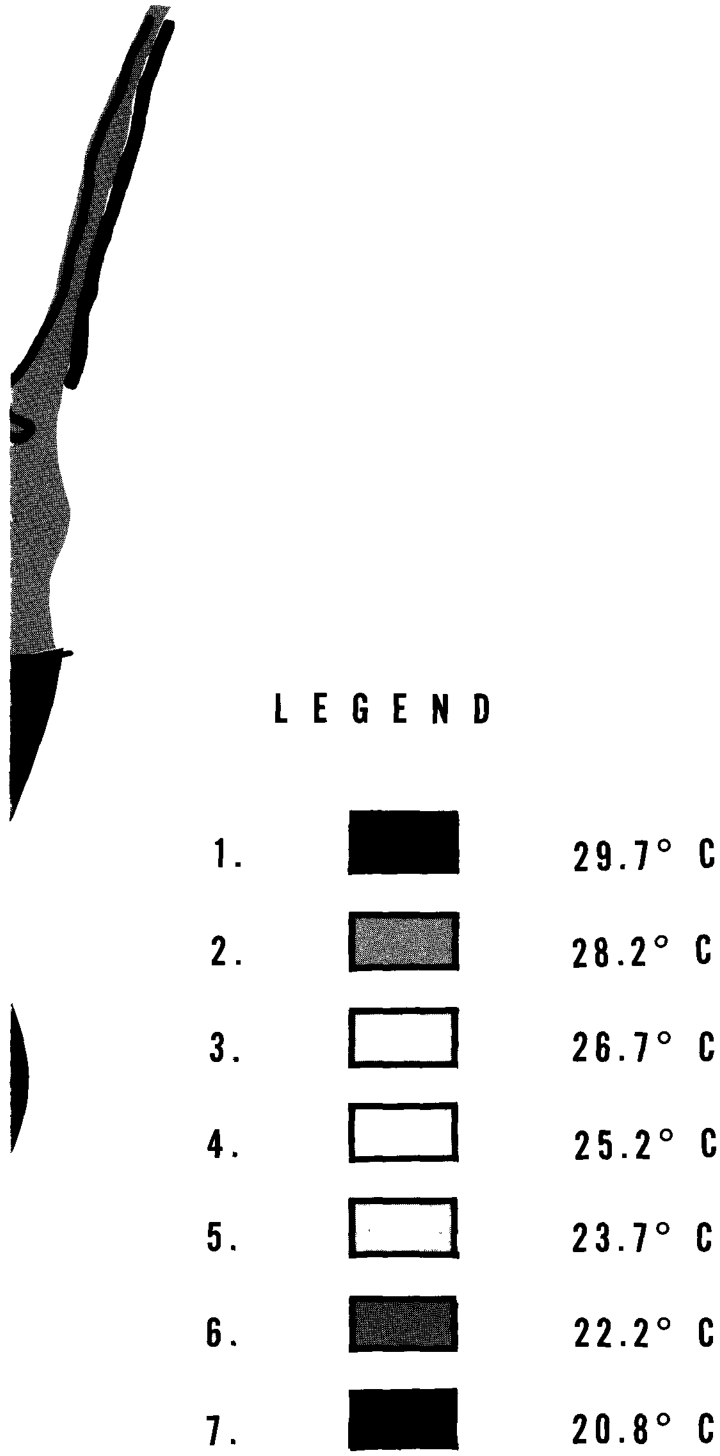
Two power facilities, the Delray and Conners Creek Power Plants, are operated by the Detroit Edison Company on the Detroit River in the Detroit metropolitan area. The Delray plant is a 375 MWe facility with a reported cooling water use of 3,100,000 m^3/day (810 mgd). Cooling water is obtained from and returned to the River.

The Conners Creek plant is a 628 MWe facility with a reported cooling water use of 3,500,000 m^3/day (930 mgd). Cooling water is obtained from and discharged to the River through dredged channels.

Observed Thermal Conditions

The thermal data recorded by the two aircraft flying 30 seconds apart did not contain any indication of a thermal discharge from the Delray power plant. The discharge canal had a surface temperature equal to that of the Detroit River.

The Conners Creek plant was discharging heated effluent to the upper end of the Detroit River. The thermal field extended 155 m (500 ft) out into the River and about 1 km (0.6 mi) downstream before achieving complete dispersion [Figure V-31]. The discharge temperature was about 8°C (14°F) above background River temperatures as shown in the isarthermal map [Figure V-32].


LEGEND
1. 29.7° C
2. 28.2° C
3. 26.7° C
4. 25.2° C
5. 23.7° C
6. 22.2° C
7. 20.8° C

LEGEND

1.	29.4° C
2.	28.0° C
3.	26.6° C
4.	25.3° C
5.	23.9° C
6.	22.6° C
7.	21.2° C

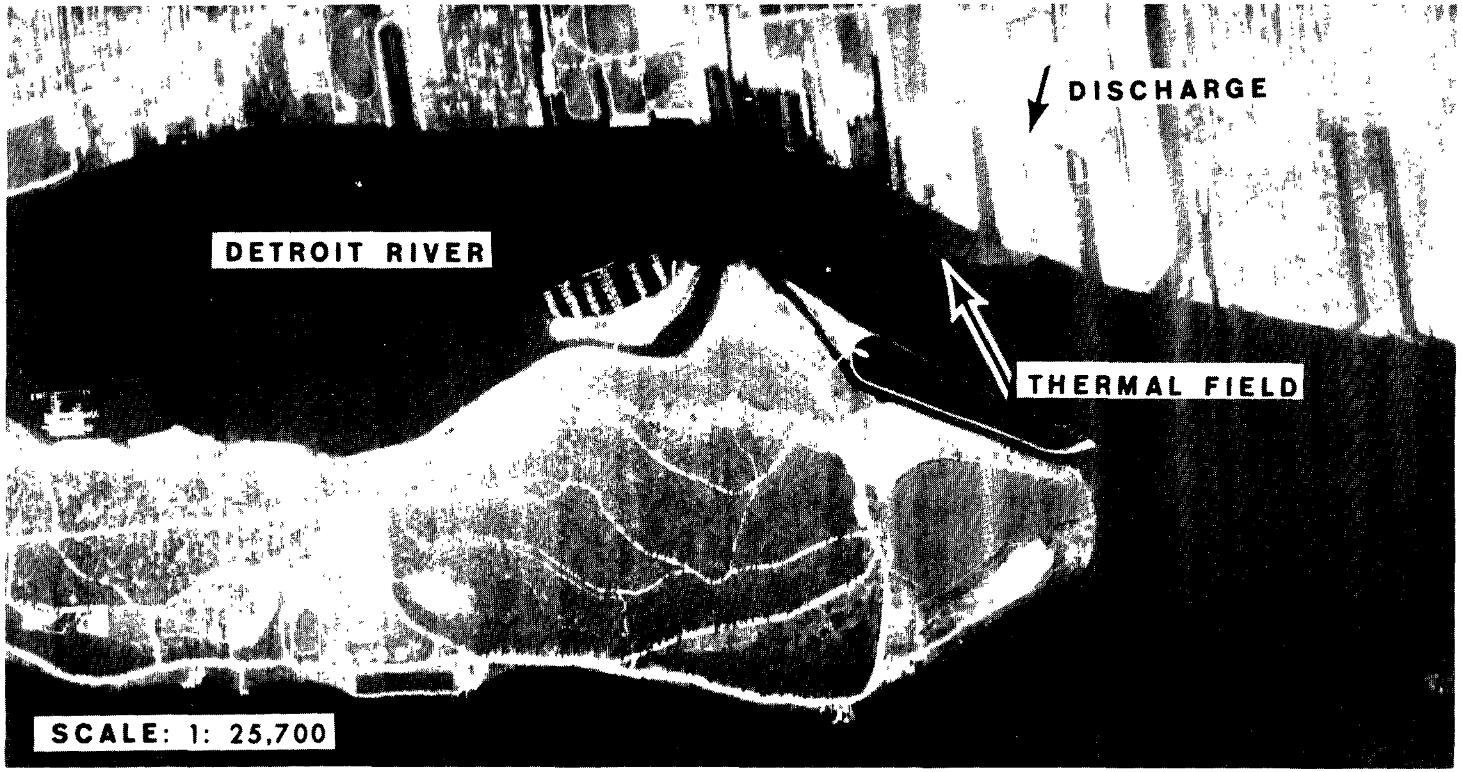


Figure V-31 Thermal Map of the Conners Creek Power Plant Discharge

BELLE RIVER, MICHIGAN

Description of Power Plant

The Detroit Edison Company operates the St. Clair Power Plant on the St. Clair River between Lake Huron and Lake St. Clair. The plant is a 1,842 MWe facility with a reported cooling water use of 5,600,000 m^3/day (1,472 mgd).

Observed Thermal Conditions

The thermal plume from the plant, as shown in the thermal map [Figure V-33] and isarthermal map [Figure V-34] of the discharge, was dispersing over a substantial distance downstream. However, the plume was estimated to be only 1 to 3°C (2 to 5°F) warmer than background River temperatures. No ground truth was obtained for the St. Clair River precluding the calibration of the isarthermal map.

A small thermal plume from a warm creek outflow was recorded downstream from the power plant [Figure V-33]. The thermal plume from Ontario Hydro's Lambton Power Plant (2,000 MWe) is also visible.

MARYSVILLE, MICHIGAN

Description of Power Plant

The Detroit Edison Company operates the Marysville Power Plant on the St. Clair River. This 300 MWe facility has a reported cooling water use of 2,800,000 m^3/day (750 mgd).

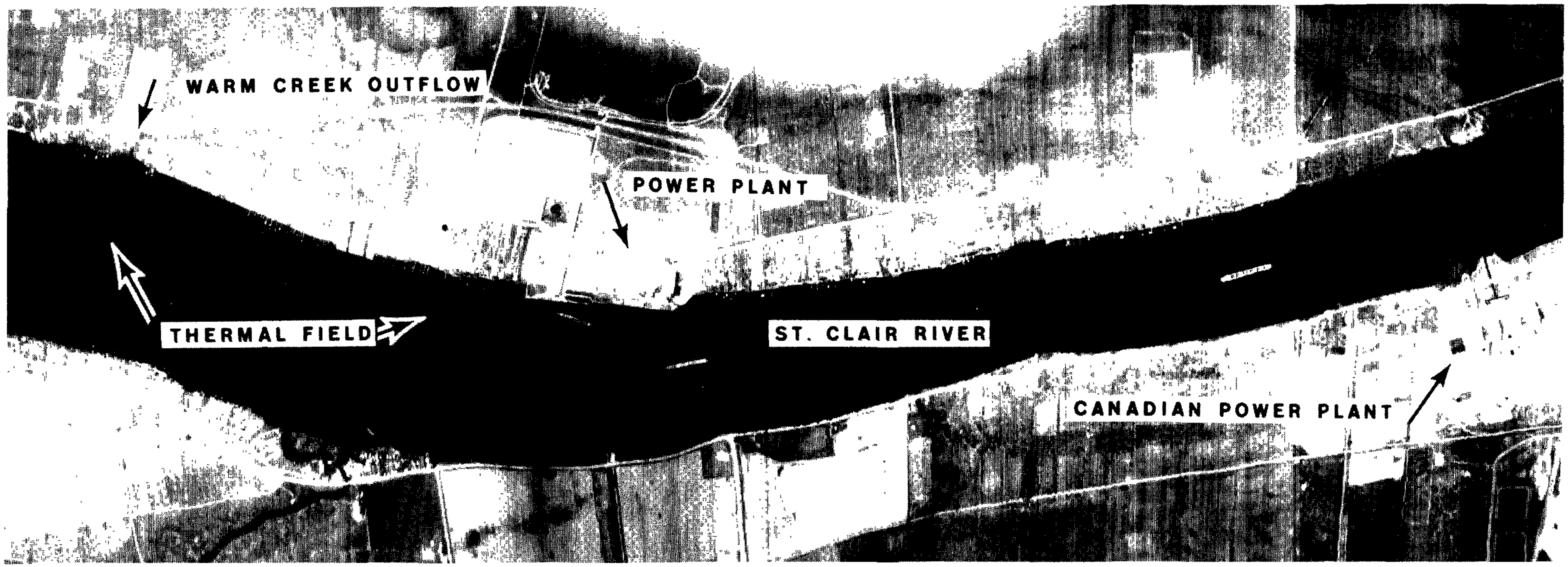
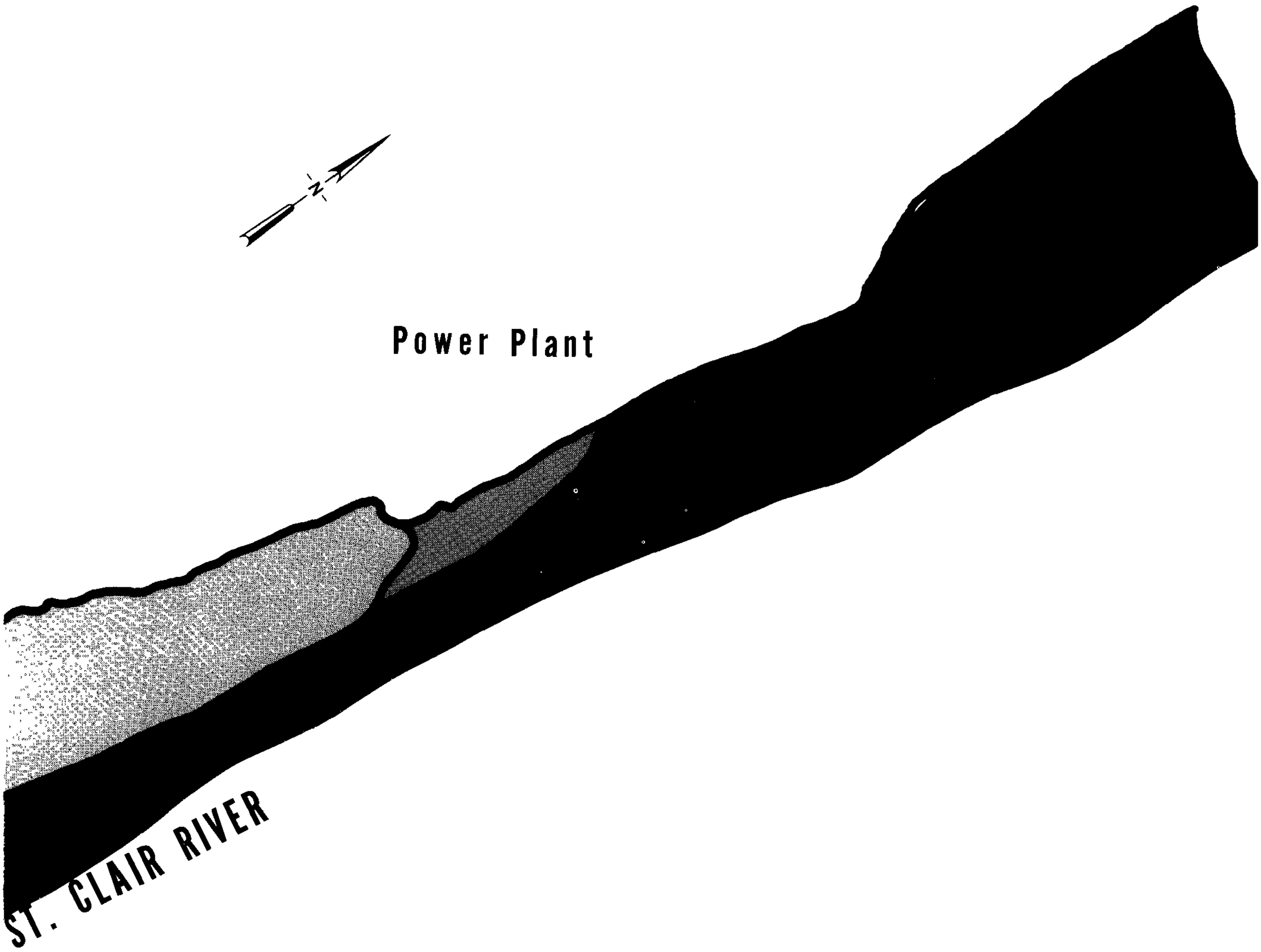


Figure V-33 Thermal Map of the St. Clair Power Plant Discharge

Observed Thermal Conditions

Neither of the two aircraft recorded the presence of a thermal discharge associated with this facility. The only thermal indication recorded was a warm creek effluent on the Canadian shore south of the power plant [Figure V-35].



f the St Clair Power Plant Discharge

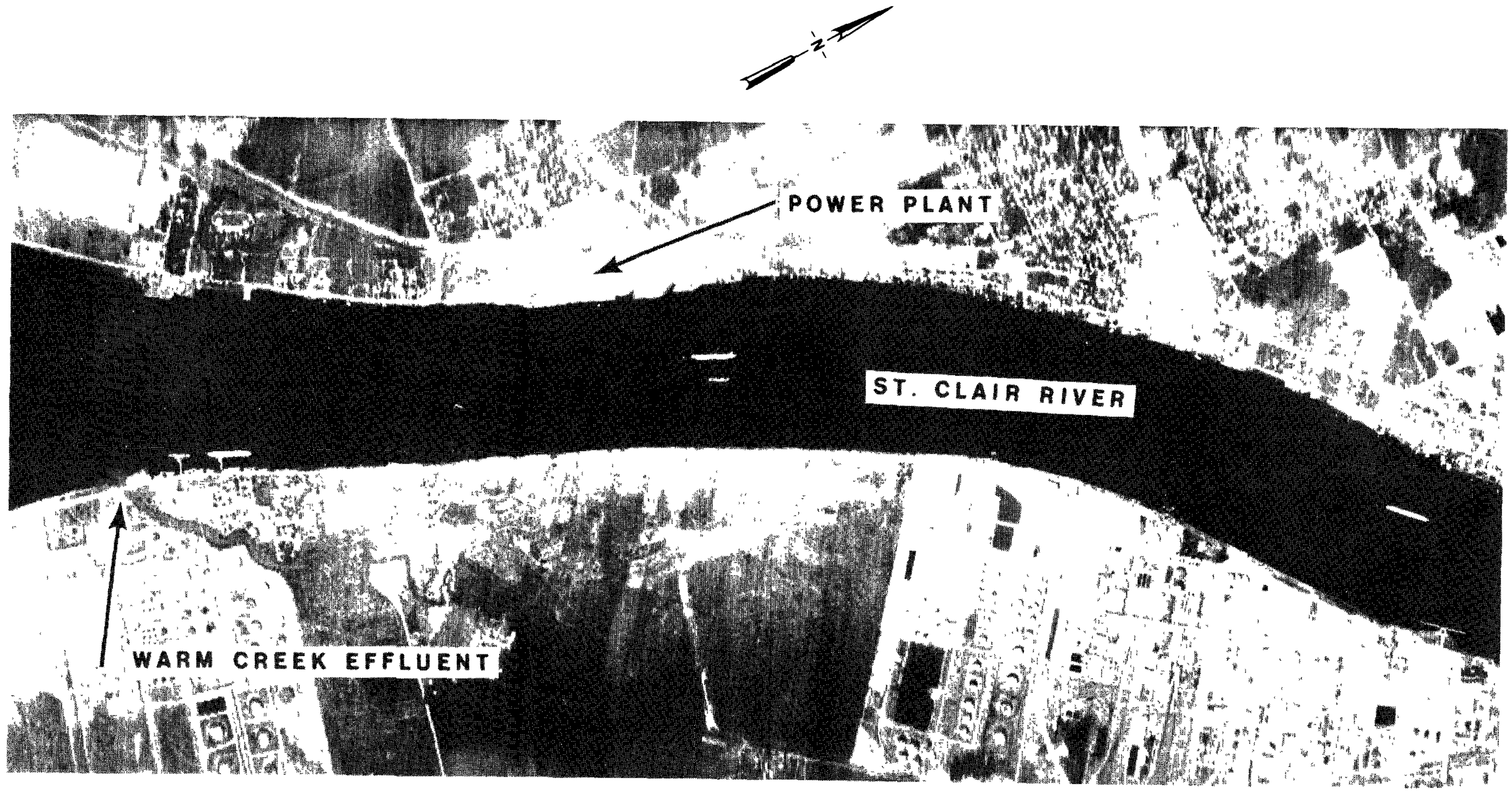
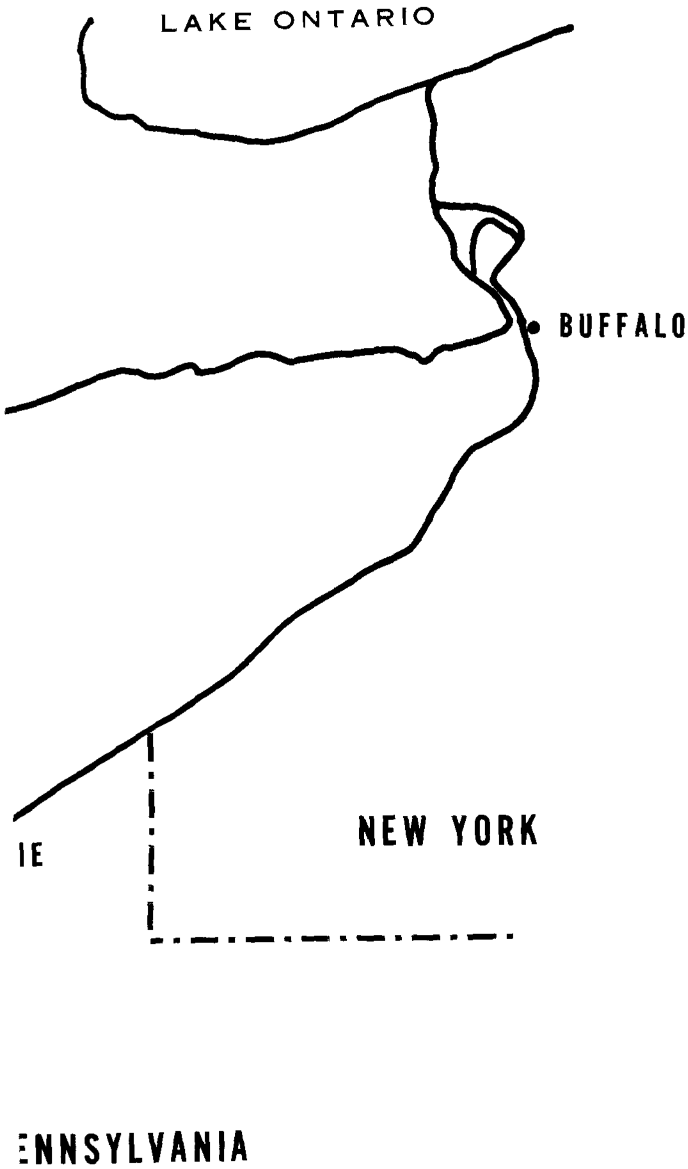


Figure V-35 Thermal Map of the St. Clair River at Marysville, Michigan


LAKE ONTARIO
BUFFALO
NEW YORK
IE
ENNSYLVANIA