ENVIRONMENTAL PROTECTION AGENCY

OFFICE OF ENFORCEMENT

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Water Quality Study

St. Andrew Bay, Florida

NATIONAL ENFORCEMENT INVESTIGATIONS CENTER

DENVER, COLORADO

AND

REGION IV-ATLANTA GEORGIA

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ENVIRONMENTAL PROTECTION AGENCY

OFFICE OF ENFORCEMENT

WATER QUALITY STUDY
ST. ANDREW BAY, FLORIDA

June 1975

NATIONAL ENFORCEMENT INVESTIGATIONS CENTER - Denver, Colorado
and
REGION IV - Atlanta, Georgia

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I. INTRODUCTION

The St. Andrew Bay estuarine system at Panama City on the northern Gulf coast of Florida consists of four coastal plain bays: East, West, North and St. Andrew Bays [Fig. 1]. The entire estuarine system is shallow and has little freshwater inflow.

International Paper Company (IPC) operates a Kraft process pulp and paper mill at Panama City on the north shore of St. Andrew Bay adjacent to Watson Bayou [Fig. 1]. Until 1974, process and cooling wastewaters from the mill were discharged to the north side of St. Andrew Bay following primary treatment. In mid-1974, all wastewaters from the mill were reportedly connected to an aerated lagoon operated by Bay County on Tyndall Air Force Base land across St. Andrew Bay from the mill.

A number of environmental problems have allegedly been caused by the IPC wastewater discharges both before and after completion of the lagoon. In January 1974, a fish kill occurred in Watson Bayou. The State of Florida filed suit against IPC, charging that the company was responsible for the fish kill and that pollution was continuing. A court hearing will be held in the near future.

Areas of East Bay are closed to shellfish harvesting because of the presence of high bacterial levels. The IPC wastewaters discharged from the Bay County lagoon reportedly contain excessive levels of coliform bacteria and were suspected of being a major contributor to the unsatisfactory water quality conditions in East Bay.

A National Pollutant Discharge Elimination System (NPDES) permit has been issued to Bay County for the lagoon discharge. The permit

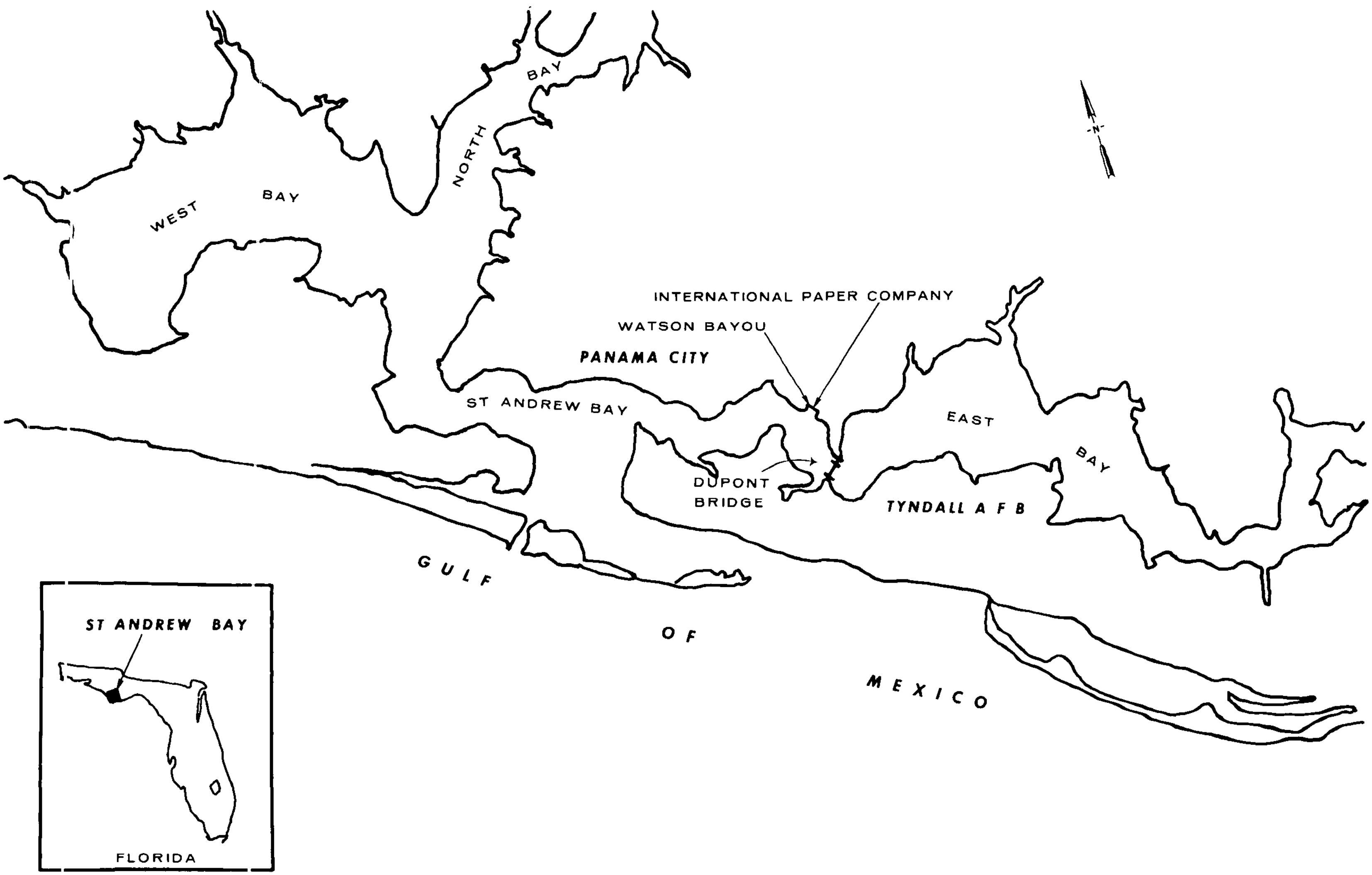

Figure 1. St Andrew Bay Estuarine System

conditions have been appealed by IPC. The lagoon effluent does not presently meet the permit limitations. An adjudicatory hearing will be held in the near future to review the appeal.

On 14 Feb. 1975 the National Enforcement Investigations Center was requested by the Enforcement Division, EPA Region IV, Atlanta, Ga. to conduct a study of the estuary near the IPC mill. The study was to determine if IPC wastewater discharges were contributing to violations of water quality standards in East Bay and the associated closure of shellfish harvesting areas. The results of the study would provide technical data for both the State and Federal enforcement actions.

Allegedly the primary violations of water quality standards occurring in this case were excessive coliform bacteria concentrations; therefore, a bacteriological survey of the receiving waters was planned. A water quality (chemical-physical conditions) study and a remote sensing study also were planned to correlate coliform bacterial densities with dispersion patterns of the mill discharge.

Objectives of the joint bacteriological, water quality and remote sensing investigations of the estuarine waters of St. Andrew and East Bays were as follows:

1. Define the dispersion characteristics of the discharge of International Paper Company wastewaters from the Bay County Wastewater Treatment Plant (aerated lagoon) and determine the extent to which this discharge is dispersed into the East Bay by tidal action.

2. Assess the chemical and bacteriological quality of the waters overlying shellfish beds in East Bay to determine if violations of water quality standards are occurring.

3. Through correlation of observed wastewater dispersion patterns and bacterial levels, evaluate the contribution of International Paper Company to the observed water quality problems.

4. Determine the distribution of commercially harvestable shellfish in East Bay and estimate the economic impact of closure of shellfish areas to harvesting.

II. SUMMARY AND CONCLUSIONS

A nine-day field investigation of the St. Andrew estuarine system was conducted from 19-27 Mar. 1975 to determine the presence and source of water quality standards violations. The study area was limited to the eastern portion of St. Andrew Bay between Redfish Point and the DuPont Bridge (U. S. Hwy 98) and East Bay from the bridge to Little Oyster Bay Point [Fig. 2]. Water samples were collected from 12 stations [Table 1], 169 samples for bacteriological analysis and 218 for chemical analysis. Remote sensing data were collected by reconnaissance aircraft on 19-20 Mar. during the field investigation and also on 3 Apr. 1975.

Bacteriological analyses of water samples showed that estuarine waters in the study area were in violation of quality standards for such beneficial uses as water contact recreation and shellfish harvesting. Two Locations in Watson Bayou (Stations 7 and 8) contained fecal coliform bacterial densities that exceeded State of Florida limits established for these Class III recreational waters. Three locations in areas of East Bay contained coliform bacteria densities that exceeded the State of Florida and Food and Drug Administration standards for shellfish propagation and harvesting.

Aerial imagery showed that International Paper Company wastewater was dispersed eastward about 10 km (6 mi) into East Bay. Concurrent sampling and analyses of water collected from this area revealed bacterial contamination violating State and Federal Water Quality Standards.

Effluent samples collected from the Bay County aerated lagoon contained a geometric density of 1,200 fecal coliform bacteria/100 ml and a maximum of 3,300/100 ml. This violates the NPDES permit limitations specifying a daily maximum of 400 fecal coliform bacteria/100 ml.

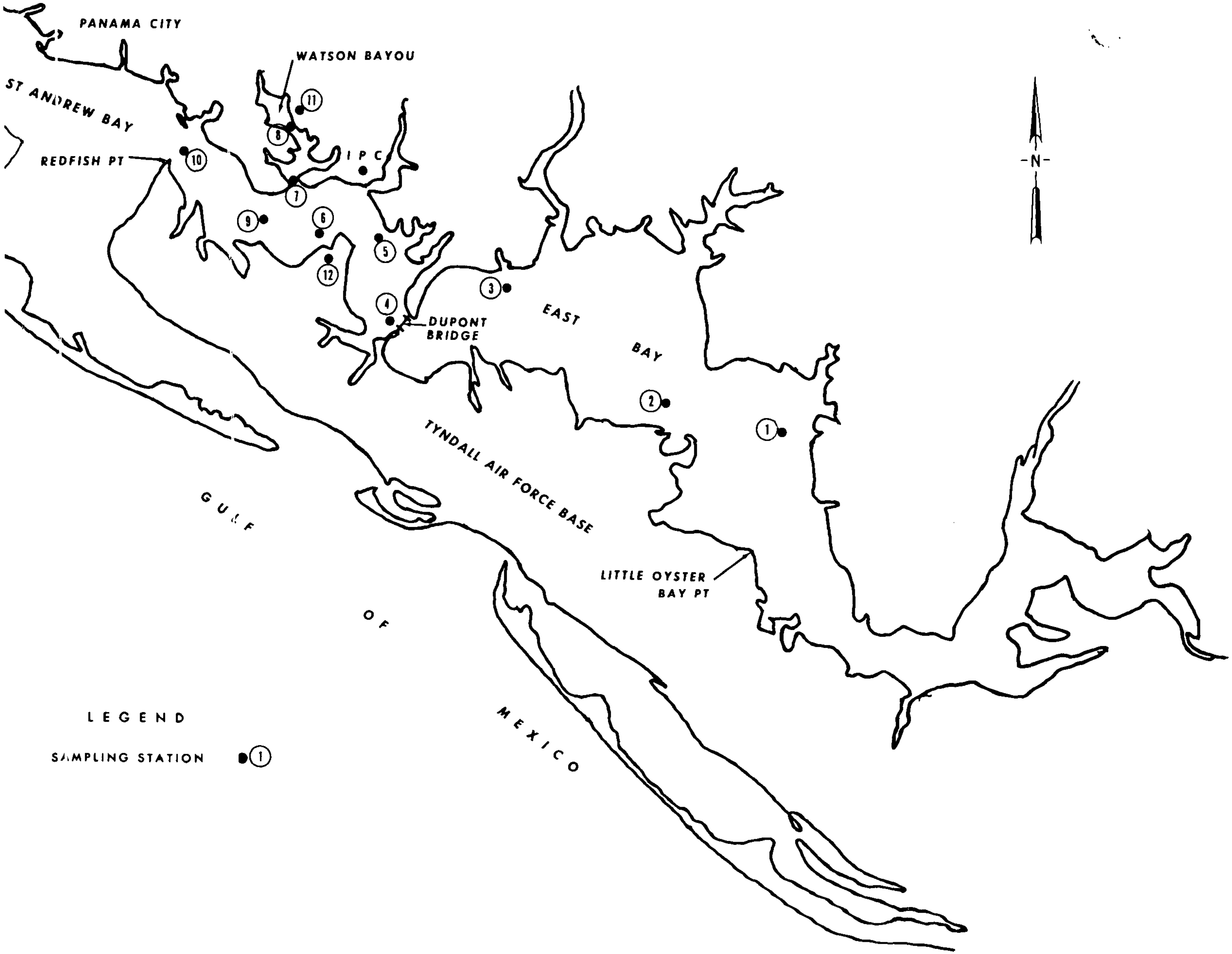

Figure 2. Water Sampling Locations, St Andrew Bay, Florida
19—27 March 1975

Table 1

SAMPLING LOCATIONS

Station	Station Description
1	2,000 m (2,200 yd) 40° NE of Buoy 35 Fl 4 Sec
2	Buoy 40 Fl R
3	1,100 m (1,200 yd) 60° NE of Buoy 45 Fl 4 Sec
4	C Buoy 3
5	Day Beacon 29
6	International Paper Company discharge 270 m (300 yd) offshore in line with the westernmost border of the International Paper Company lagoon
7	Mouth of Watson Bayou
8	Millville WWTP discharge in Watson Bayou
9	Buoy 24 Fl R
10	Buoy 17 Fl
11	Effluent from Millville WWTP
12	Effluent from Bay County WWTP

Although it was reported that only industrial wastes from IPC were discharged into the lagoon, pathogenic bacteria (Salmonella enteritidis ser Carrau) were found in the lagoon effluent, indicating that the International Paper Company wastewaters were contaminated with sewage.

Improvement in the bacteriological quality of St. Andrew and East Bays concurrent with the temporary shutdown of the paper mill (23 Mar.-6 Apr. 1975) provided additional evidence that the mill was a major contributor to the bacterial contamination of the St. Andrew Bay estuarine system.

Bacteriological studies indicated that the Millville Wastewater Treatment Plant discharges contributed to the poor bacterial quality of Watson Bayou. Despite the potential health hazards resulting from the high bacterial concentrations in Watson Bayou (St. Andrew Bay) and East Bay, water contact sports and shellfish harvesting occurred during the March 1975 survey.

On 23 Mar. 1975, dissolved oxygen levels in a portion of St. Andrew Bay (Station 9) were depressed to 3.5 mg/l. This is a violation of the State of Florida dissolved oxygen criterion for Class III waters. The cause of this single violation was not determined. At other times during the survey, dissolved oxygen concentrations were low in St. Andrew Bay (at Stations 6 and 10) but did not violate the applicable criterion. Other physical and chemical changes observed in the St. Andrew-East Bay waters during this survey appeared to be closely related to weather, hydrographic, or other natural conditions in the estuarine system. Effects of industrial wastes on salinity, temperature, pH, and lignin-tannin content of the Bay waters were not detected.

On 19-20 Mar. and 3 Apr. 1975 aerial infrared imagery indicated a thermal discharge from International Paper Company which would violate the mill NPDES permit limitations. Infrared imagery also strongly indicated that IPC wastewater seeped into St. Andrew Bay through leaks in the treatment lagoon dike.

The Bay County aerated lagoon was designed for the future connection of municipal sewage from Tyndall Air Force Base and the communities of Callaway, Cedar Grove, Parker and Springfield. Construction of a force main across St. Andrew Bay and a treatment plant next to the lagoon would be required before these wastewaters could be treated in the lagoon. By the end of 1975, all air base wastewaters will go to land disposal. No construction on the necessary municipal facilities has been initiated.

III. RECOMMENDATIONS

1. St. Andrew Bay east of Redfish Point, and East Bay should be declared water quality limiting with respect to total and fecal coliform bacteria for the purpose of establishing National Pollutant Discharge Elimination System (NPDES) permit limitations. A comprehensive sanitary survey of the St. Andrew Bay estuarine system should be conducted to determine if other water quality limiting areas or parameters exist.

2. To alleviate potential public health problems associated with bacterial contamination in Watson Bayou and East Bay, these areas should be properly posted and patrolled until bacterial quality meets State of Florida standards for body contact recreation and shellfish propagation and harvesting.

3. The sources of sewage contamination of the International Paper Company wastewaters treated in the Bay County aerated lagoon should be determined and eliminated. A field inspection of the Bay County lagoon system should be made to evaluate the significance of reported leaks.

4. Future plans to discharge treated sewage to the Bay County Wastewater Treatment Plant which treats paper mill wastes prior to discharge of these wastewaters into St. Andrew Bay, should be reconsidered. The potential health hazards as documented in this report indicate that such a plan could increase pollution in the St. Andrew Bay estuarine system.

5. International Paper Company should submit a revised NPDES permit application showing actual wastewater sources, characteristics and discharges, as well as a proposed compliance schedule to connect these discharges to the Bay County Wastewater Treatment Plant.

6. A complete evaluation of process and wastewater treatment systems at International Paper Company should be conducted to determine the sources and characteristics of the wastewater discharge from Outfall 016.

7. An evaluation of the Millville Wastewater Treatment Plant should be conducted to determine if operational procedures or design problems result in reduced treatment efficiency or contribute to the bacterial pollution of Watson Bayou.

IV. BACKGROUND INFORMATION

ESTUARINE SYSTEM

The St. Andrew Bay estuarine system consists of four coastal plain bays on the northern Gulf coast of Florida [Fig. 1]. The estuary includes East, West, North and St. Andrew Bays and covers about 233 km^2 (90 mi^2).

St. Andrew Bay forms the estuary's central portion and is the only bay in the system directly linked to the Gulf. The entire bay system is shallow; St. Andrew Bay has a mean depth of 5 m (17 ft) while the mean depths of East, North, and West Bays are 2.2, 1.8 and 2.1 m (7.0, 5.7, 6.7 ft), respectively.[1] East Bay, the longest bay in the system opens into St. Andrew Bay and extends about 32 km (20 mi) to the southeast where it heads in Wetappo Creek. The creek, East Bay and other adjoining bays are dredged, buoyed and maintained as part of the Florida Intracoastal Waterway System.

Panama City and adjacent small communities on the north shore of St. Andrew Bay and the smaller city of Lynn Haven on North Bay are the only significant population centers. Much of the area next to the bays is swampland, limiting the area that can be developed. International Paper Company on St. Andrew Bay and the Gulf Power Company powerplant on West Bay are the only large water-using industries in the area.

The study area was limited to the eastern portion of St. Andrew Bay between Redfish Point and the DuPont Bridge (U.S. Hwy 98) and East Bay from the bridge to Little Oyster Bay Point [Fig. 2]. The eastern portion of Panama City, including the Millville area and the communities of

Calloway, Cedar Grove, Parker and Springfield, occupy the north shoreline of St. Andrew Bay in the study area. Also, the International Paper Company is on the north shoreline of St. Andrew Bay. Tyndall Air Force Base property lies along the south shorelines of St. Andrew and East Bays. Most of the remaining shoreline in the study area is uninhabited swampland.

SOURCES OF POLLUTION

There are about 30 known point sources of pollution that discharge municipal, industrial and commercial wastewaters to the St. Andrew Bay estuarine system. Most of these are minor discharges. Fourteen of the sources are in the study area, and all but two are on St. Andrew Bay. The two East Bay sources are very small. The characteristics of these fourteen sources of pollution are summarized in Table 2; locations are shown in Figure 3.

The largest wastewater discharge in the study area originates from the Bay County Wastewater Treatment Plant (WWTP), an aerated lagoon across St. Andrew Bay from IPC, which treats process wastes from the International Paper Company. IPC also discharges minor volumes of miscellaneous wastewaters from 15 outfalls and an unknown volume of wastewater from an outfall reportedly discontinued. Details of wastewater treatment and disposal practices at the International Paper Company mill and the Bay County WWTP are discussed in the following section.

With the exception of the Bay County and Millville WWTP's, the other sources of pollution listed in Table 2 discharge minor volumes of wastewater. Until 1975, the Capehart housing area at Tyndall Air Force Base was served by a secondary treatment facility that discharged effluent to Pearl Bayou. This facility has been abandoned and the wastewaters have been diverted to land disposal. The main base area is served by a secondary treatment plant with effluent discharged to the

Table 2

SOURCES OF POLLUTION

Map†	Source	Treatment	Type Waste	Volume (m^3/day	mgd)
		ST. ANDREW BAY			
1	Bay County WWTP	Aerated Lagoon	Pulp and Paper	105,560	28.0
2	International Paper Company	Settling or none	Miscellaneous (15 outfalls)	4,700	0.6
		Unknown	Unknown (1 outfall)	---	---
3	Capehart WWTP	Secondary and Land Disposal	Municipal	1,885	0.5
4	Millville WWTP	Secondary	Municipal	7,918	2.1
5	Oil Terminals (Bulk)	---	Oil Seepage	---	---
6	Panama City	None	Storm drainage	---	---
7	Springfield	None	Storm drainage	---	---
8	Parker	None	Storm drainage	---	---
9	McLemore Trailer Park	Extended aeration	Domestic	52.78	0.014
10	Morris Manor Trailer Park	Extended aeration	Domestic	15.08	0.004
11	Parkway Apts.	Extended aeration	Domestic	30.16	0.008
12	Parker Elementary School	Extended aeration	Domestic	15.08	0.004
		EAST BAY			
13	GKMZ Corp.	Extended aeration	Laundry	56.55	0.015
14	Pines Mobile Home Park	Extended aeration	Domestic	22.62	0.006

† *See Fig. 3 for source locations.*

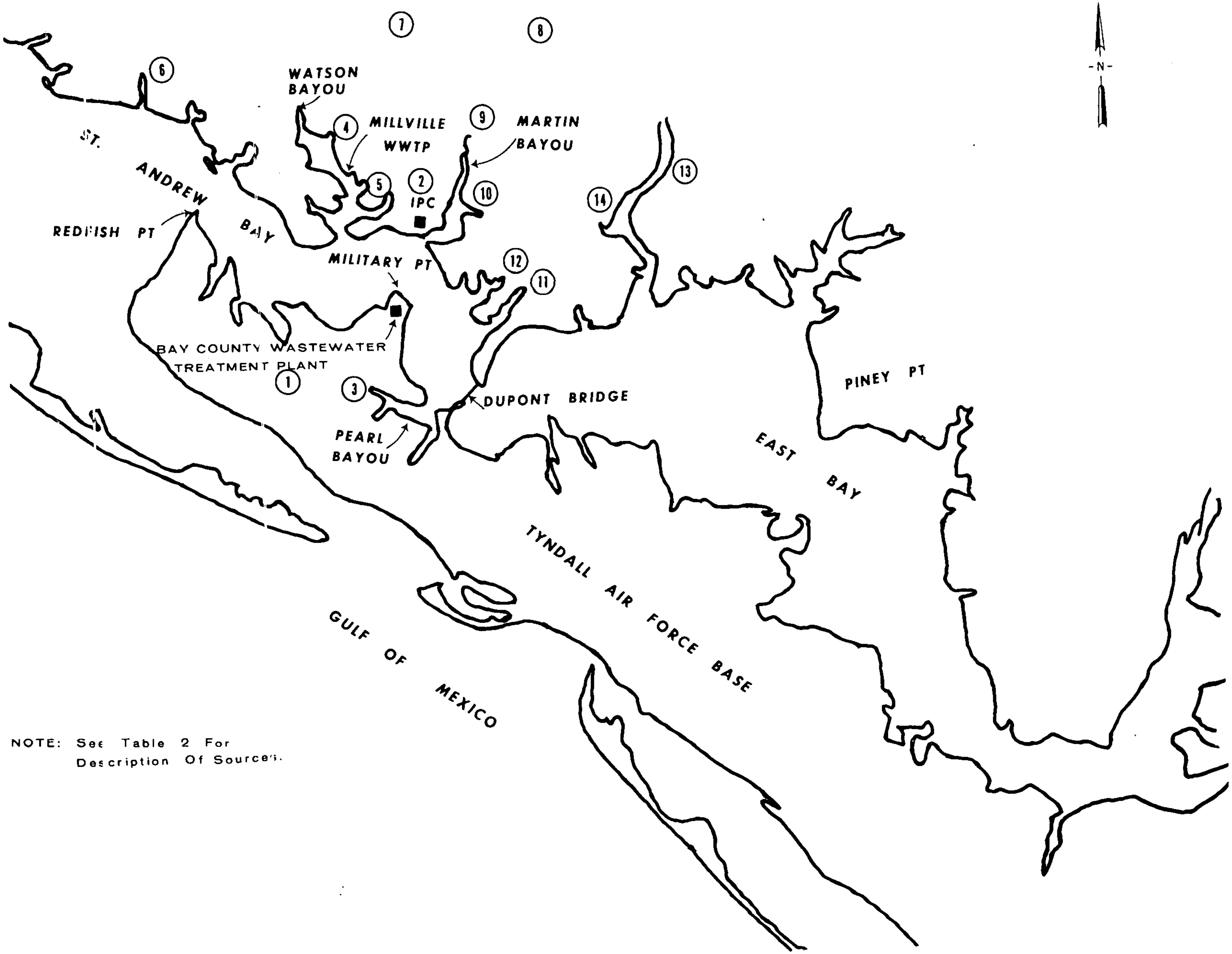

Figure 3. Sources Of Pollution In Study Area

Gulf of Mexico. Additional treatment facilities are under construction to divert this effluent to land disposal.

In addition to the sources of pollution listed in Table 2, surface runoff from agricultural areas adjacent to Calloway Bayou and residential areas on the north side of the study area may contribute pollution.

Millville Wastewater Treatment Plant

The Millville municipal WWTP serves the eastern portion of the Panama City urban area and treats domestic sewage from this area and from IPC. The facility is a standard high-rate trickling filter plant, reportedly designed for a hydraulic loading of 11,310 m^3/day (3 mgd) but currently treating about 7,900 m^3/day (2.1 mgd).[18] Treatment units include an influent structure containing a bar screen and grit chamber, two primary clarifiers, two trickling filters, two secondary clarifiers, chlorination facilities, sludge digesters and sludge drying beds. Disinfection of the effluent is provided by chlorination of the influent to the secondary clarifiers. Plant effluent is discharged into Watson Bayou through a short, near-surface outfall.

Examination of the remote sensing data indicated that both trickling filters were in use on 19 and 20 Mar., but the south filter was not operating on 3 Apr. Biological growth was present on the surface of both filters. Markings were present on the surface of the south filter that indicated that this filter has been operated with the distributor arm in a fixed position on several occasions.

An NPDES permit was issued for the Millville facility on 13 Dec. 1974. The permit limits effluent BOD to a monthly average of 30 mg/l or 340 kg (748 lb)/day and a weekly average of 45 mg/l or 510 kg (1,124 lb)/day).

Total suspended solids are limited to a monthly average of 50 mg/l or 567 kg (1,250 lb)/day and a weekly average of 75 mg/l or 850 kg (1,874 lb)/day. Fecal coliform bacteria are limited to a monthly geometric mean of 200/100 ml and a weekly geometric mean of 400/100 ml.

Self monitoring data submitted for the period November 1974 through March 1975 showed that because of the low flow relative to design flow, the plant effluent easily meets allowable load limits. In four out of five months, however, the monthly average BOD concentration exceeded the allowable limit of 30 mg/l. These violations occurred in November (33 mg/l), December (45 mg/l), February (37 mg/l) and March (31 mg/l).[19] Concentrations of other parameters were in compliance with allowable limits. Low fecal coliform levels were reported.

V. INTERNATIONAL PAPER COMPANY

The Southern Kraft Division of International Paper Company operates a mill in the Millville area of eastern Panama City on the north shore of St. Andrew Bay between Watson and Martin Bayous [Fig. 3]. Using the Kraft sulphate process, the mill produces pulp from various hardwoods and pine. Average production is 1,360 m. tons (1,500 tons)/day which is about equally divided between bleached pulp and unbleached liner board, the two primary products.[15]

The mill began operation in 1931 and has undergone several expansion and modernization programs including air and water pollution control improvements. The mill employed 1,150 people in 1971,[2] although the current employment may be about 900 people.

In addition to the pulp and paper mill, a water treatment plant and a tall oil byproducts plant are located at the mill site. Raw water purchased from Bay County is processed in the water treatment plant for use in the mill. The tall oil facility is operated by Arizona Chemical Company. Process units include tall oil, rosin treating, semicommercial, crude tall oil, terpene rosin, soap and ester, pinene, anethole and synthetic pine oil plants. The main raw material is a tall oil byproducts stream from IPC.

All three industrial operations produce wastewaters that are discharged into St. Andrew Bay or adjoining Watson Bayou. These wastewaters and associated treatment and control measures are discussed in the following sections.

PHYSICAL DESCRIPTION OF FACILITIES

The general layout of the IPC mill site is shown in Figure 4; Figure 5 is an aerial photograph of the mill site taken on 19 Mar. 1975. The water treatment plant is north of the pulp and paper mill next to an eastern arm of Watson Bayou. Treatment provided by the facility includes clarification, filtration and demineralization. Process facilities include a large storage reservoir, a backwash pond, clarifiers, sand filters, demineralizers and other associated equipment. Nine miscellaneous wastewater streams originate at this plant.

The wood receiving and storage yard is south of the mill. Wood is received either as cord wood or chips by both railroad cars and by trucks. The cord wood is either unloaded onto large storage piles or directly onto mechanical conveyors that move the logs into the pulping facilities. Chips are unloaded directly onto conveyors. The only source of pollution from this area appears to be surface runoff from the storage yard.

Arizona Chemical Company facilities are northeast of the mill with associated wastewater treatment ponds adjacent to U. S. Highway 98.

The main IPC wastewater treatment facilities are between the mill and the highway. To the east of the highway next to Martin Bayou are ash and sludge lagoons. In 1971 there were reportedly only two wastewater discharges from the mill, Arizona Chemical Company, and the area east of the mill.

WASTEWATER TREATMENT AND CONTROL PRACTICES, PRE-1974 CONDITIONS

In 1971 International Paper Company filed a Refuse Act Permit Program (RAPP) application describing all reported wastewater discharges from its Panama City mill complex. The volume and type of wastewater

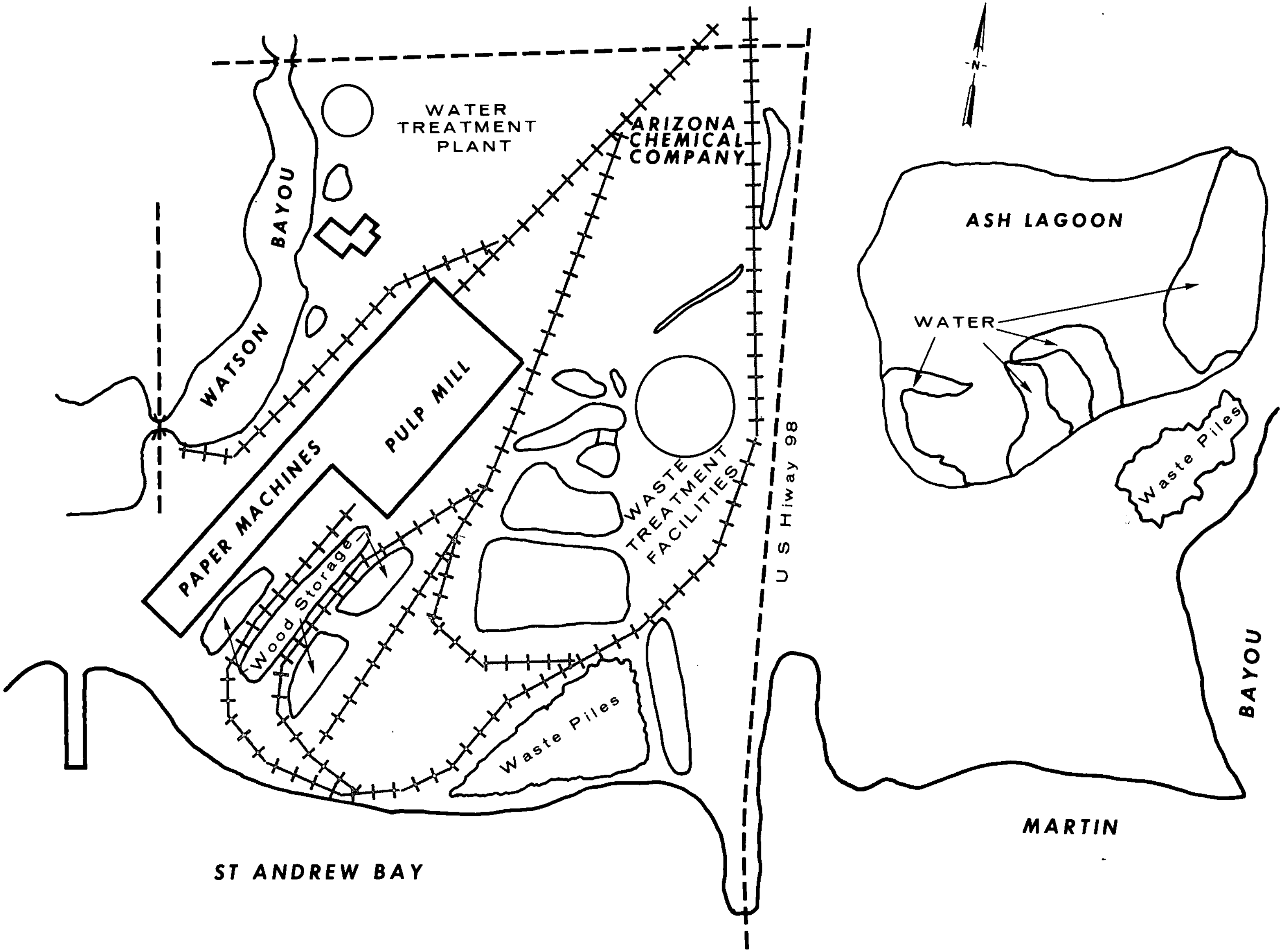

Figure 4. International Paper Company Mill Site

Figure 5. Aerial Photograph Of
International Paper Company Mill Site

discharged from the 17 sources identified are summarized in Table 3. Most of the discharges were minor in terms of both pollution potential and volume. The 15 discharges originating from the water treatment plant and the west side of the mill complex had a total flow rate of 2,270 m^3/day (0.6 mgd) and discharged into Watson Bayou [Fig. 4]. Sanitary sewage was reportedly discharged to the municipal sewerage system for treatment at the Millville WWTP. In contrast to these minor discharges, the two wastewater discharges to St. Andrew Bay totalled more than 170,000 m^3/day (45 mgd) and contained major pollution loads.

An engineering study completed in 1971 documented waste treatment and control practices associated with the two major discharges and provided information on the sources of the wastewaters.[15] Figure 6 shows wastewater treatment facilities used in 1971. Average wastewater flows and BOD loads for the 11-month period, Dec. 1969 to Oct. 1970, are shown in Table 4. In late 1970 a once-through saltwater cooling system was used in conjunction with an evaporator system. The evaporator wastes added a major BOD load averaging 14,700 kg (32,400 lb)/day to this waste stream with an average flow rate of 90,800 m^3/day (24 mgd). This wastewater stream was discharged to St. Andrew Bay without treatment. The discharge [Fig. 6, point #1] flowed in ditches along the west and south edges of the waste pond, and then was discharged through a pipe to the saltwater ditch designated as Outfall 016. Heated outflow from the ditch entered St. Andrew Bay as a surface discharge.

A recirculating cooling system was completed in 1971 that substantially modified this discharge. The system cools the evaporator and thus eliminates once-through saltwater cooling. Blowdown from the system was expected to average 6,400 m^3/day (1.7 mgd). The cooling tower was expected to reduce the BOD load from the evaporator by 40%, leaving 9,900 kg (21,900 lb)/day of BOD in the blowdown. As discussed below, this discharge is reportedly combined with other wastewaters for

Table 3

INTERNATIONAL PAPER COMPANY WASTEWATER DISCHARGE

Outfall	Type Wastewater	Volume (mgd)	Volume (m^3/day)	Receiving Water
001	Reservoir Seepage	0.058	220	Watson Bayou
002	Reservoir Seepage	0.007	26	Watson Bayou
003	Surface Drainage	0.036	136	Watson Bayou
004	Water Treatment Backwash Pond Drain	0.072	270	Watson Bayou
005	Sand Filter Drainage	0.036	136	Watson Bayou
006	Demineralizer Drainage	0.014	53	Watson Bayou
007	Boiler Water Reservoir	0.001	4	Watson Bayou
008	Raw Boiler Water Overflow	0.014	53	Watson Bayou
009	Coal Filter Drainage	0.072	271	Watson Bayou
010	Water Treatment Plant Drain	0.072	271	Watson Bayou
011	Storm Drain	0.072	271	Watson Bayou
012	Paper Machine Basement Drain	0.036	136	Watson Bayou
013	Cooling Water and Condensate	0.036	136	Watson Bayou
014	Storm Drain	0.036	136	Watson Bayou
015	Storm Drain	0.014	53	Watson Bayou
016	Evaporator Cooling Water	20.1	75,800	St. Andrew Bay
017	Primary Treatment Effluent	25.2	95,000	St. Andrew Bay
-	Sanitary Sewage	0.03	113	Millville WWTP

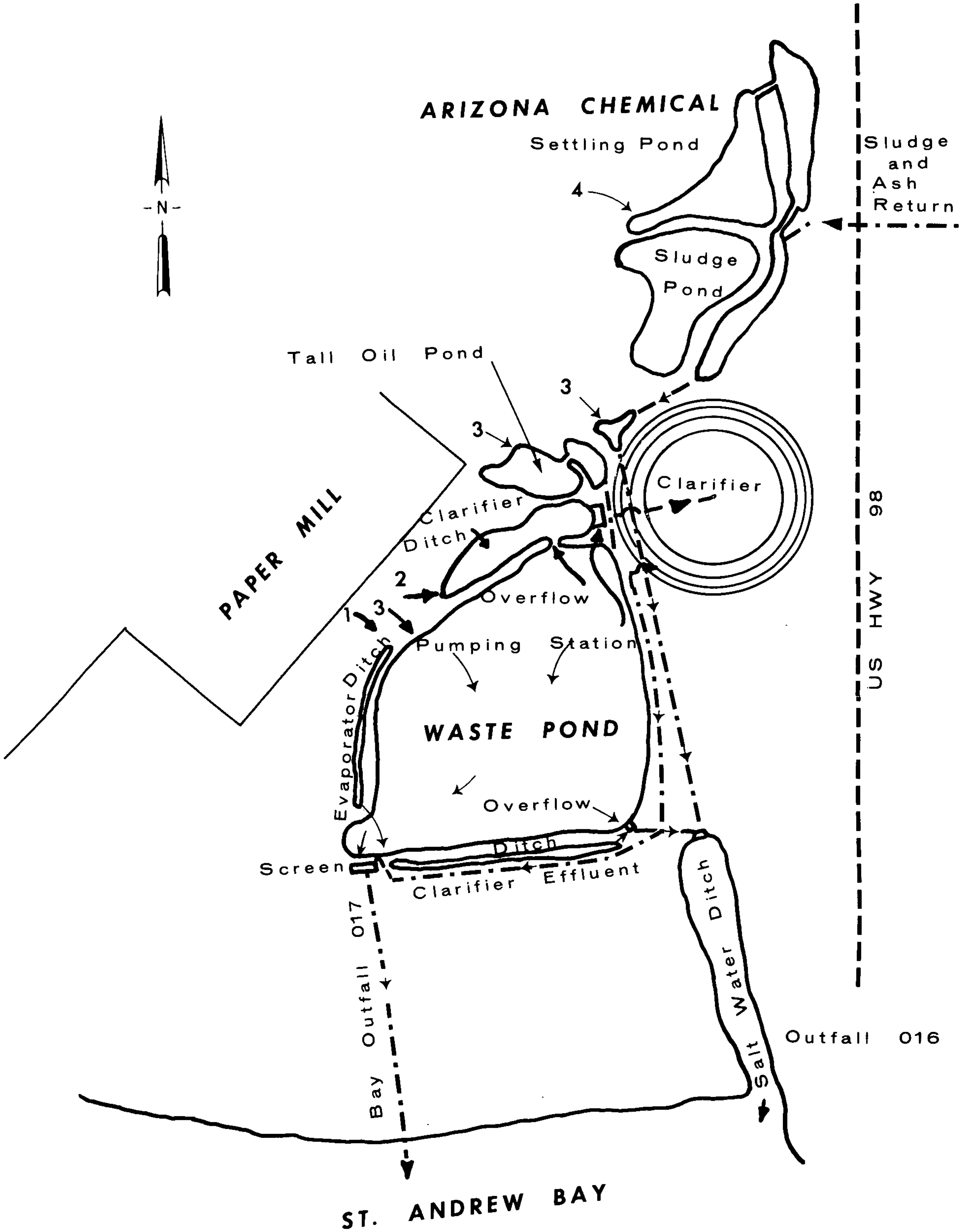

Figure 6. 1971 Wastewater Treatment Facilities
International Paper Company

Table 4

UNTREATED WASTE MATERIAL BALANCE[15]
[*11 Month Averages for IPC; Dec. '69 - Oct. '70*]

No.†	Sewer	Flow		BOD_5	
		(m^3/day)	(mgd)	(kg/day)	(lb/day)
1	Evaporator Wastes	6,435	1.7	14,710	32,400
1††	Saltwater - Evaporator Condensing Water	90,840	24.0	--	--
2	Fiber Bearing Process Sewers - To Clarifier	95,382	25.2	18,432	40,600
3	Non-Fiber-Bearing Process Sewers - Bypass Clarifier	1,893	0.5	272	600
4	Arizona Chemical	4,920	1.3	136	300
	Total Waste Existing	199,470	52.7	33,550	73,900
	††Total Waste to Proposed Treatment Facilities	108,630	28.7	33,550	73,900
	Purchased and Well Water Consumption	113,172	29.9		

† *See Figure 6 for discharge location*

†† *Evaporators in use before 1971 used direct condensing with 90,840 m^3/day (24 mgd) saltwater that exited the mill mixed with the evaporator waste. The mill converted to a recirculating cooling tower in 1971 which eliminated saltwater condensing water from waste flow.*

secondary treatment and the actual wastewater volume and characteristics are not reported to EPA.

The second major source of pollution was the fiber-bearing process wastewaters with an average flow rate and BOD load of 95,400 m^3/day (25.2 mgd) and 18,400 kg (40,600 lb)/day, respectively. These wastewaters entered the clarifier ditch [Fig. 6, point #2] and were then pumped to the center of a 122 m (400 ft) diameter primary clarifier. With a center depth of 7.3 m (24 ft), and 10 hr detention at design flow, the clarifier achieved a 10% BOD reduction. Sludge was mechanically removed, dewatered, and incinerated in the mill. The clarifier effluent flowed through a buried pipeline to a screen structure at the southwest corner of the waste pond, then through a submerged outfall to St. Andrew Bay (Outfall 017). An overflow on the clarifier ditch provided an alternate flow path through the waste pond to the Bay outfall, completely bypassing the clarifier.

Minor volumes of non-fiber-bearing wastewaters were discharged to the waste treatment system at three points [Fig. 6, points #3]. Wastewaters discharged at the point adjacent to the clarifier flowed directly to the saltwater ditch and St. Andrew Bay. Wastewaters discharged to the tall oil pond flowed through an additional small pond and into the waste pond. The third discharge of this type wastewater entered the waste pond directly on the northwest side. Waste pond effluent flowed to St. Andrew Bay through either the screen structure and the Bay outfall or an overflow at the southeast corner connected to the saltwater ditch.

Wastewaters from Arizona Chemical Company passed through an API separator, a settling pond, and two smaller ponds (total area, 6 hectares or 15 acres) north of the clarifier before direct discharge to the saltwater ditch. An unspecified volume of supernatant return from the ash lagoons east of the highway was also discharged to the Arizona Chemical Company ponds. Apparently the ash lagoons were also previously used for sludge disposal.

PROPOSED CHANGES

As a result of the engineering study, various changes and waste treatment improvements described below were recommended in 1971.[15]

1. Divert the evaporator cooling system blowdown to the clarifier ditch.

2. Divert the clarifier effluent and all other wastewater discharges to an emergency primary clarifier constructed by diking off the north end of the waste pond.

3. Construct a pumping station and force main to convey all wastewater discharges across St. Andrew Bay to Military Point for further treatment.

4. Construct a 34 hectare (69 acre) aerated lagoon to provide secondary treatment of all wastewaters.

5. Construct a deepwater outfall and diffuser from the lagoon to St. Andrew Bay.

As discussed in the following sections, the changes listed above in Nos. 3, 4, 5 were completed as proposed. Whether No. 1 has been completed is questionable. Modifications similar to No. 2 were made but not all discharges have been intercepted.

NPDES PERMIT LIMITATIONS

Based on the 1971 RAPP application data and the scheduled diversion of the two major wastewater discharges to the aerated lagoon under construction, EPA issued an NPDES permit to IPC in January 1974. Effluent limitations, to be met by 15 Aug. 1974, were based on existing flow volumes and wastewater characteristics. The permit required no additional controls on the 15 minor miscellaneous discharges to Watson Bayou. For the two major discharges, the permit prescribed no effluent limitations but indicated the discharges were to be connected to the lagoon by 1 Jan. 1974.

The aerated lagoon system which serves IPC is owned and operated by Bay County. A RAPP application for the proposed lagoon discharge was thus filed by Bay County in 1972.[2] The application indicated that the lagoon influent would consist of 6,400 m^3/day (1.7 mgd) of cooling water (the cooling system blowdown) and 107,000 m^3/day (28.2 mgd) of process wastes (the clarifier effluent and other miscellaneous process wastes).

An NPDES permit for the lagoon effluent was issued to Bay County on 1 Apr. 1974. The permit limited average daily and maximum daily BOD* loads to 3,270 and 3,760 kg (7,200 and 8,300 lb) respectively. Corresponding total suspended solids limits were 4,340 and 6,780 kg (9,560 and 14,952 lb). Fecal coliform bacteria were limited to a daily average of 200/100 ml and a daily maximum of 400/100 ml.

International Paper Company appealed the permit limitations but was denied an adjudicatory hearing. On 27 June 1974, EPA notified IPC that it would consider modifying the permit; a modified permit was issued on 8 Jan. 1975. The new permit increased the daily average

* *The BOD limitations are based on the Florida requirements for 90% removal of BOD and are more stringent than effluent guidelines for the pulp and paper industry.*

limits for BOD to TSS to the values prescribed as daily maximums in the original permit. New daily maximum limits were set at 5,647 kg (12,450 lb)/day of BOD and 10,206 kg (22,500 lb)/day of TSS. The fecal coliform limit is effective only when sanitary sewage is discharged to the system for treatment.

The modified permit conditions were appealed by IPC. On 14 Mar. 1975, EPA granted the IPC request for an adjudicatory hearing; the hearing date has not yet been set.

1974 OPERATING CONDITIONS

On 15 July 1974, the Bay County Wastewater Treatment Plant (aerated lagoon) began treating wastewaters from International Paper Company. The 34 hectare (69 acre) lagoon is unlined except for asphalt erosion protection on the dikes. Water depth is 3.7 m (12 ft) with 1 m (3 ft) freeboard; detention time is 8 to 9 days; aeration is provided by 23 75-hp mechanical surface aerators.

The lagoon is near Military Point on land leased from Tyndall Air Force Base. Ultimate plans call for the lagoon to receive domestic sewage from the Capehart housing and main base areas at Tyndall and from the municipalities of Callaway, Cedar Grove, Parker and Springfield. These municipalities currently are served by septic tanks. Two secondary treatment plants serve the base. To date no construction has begun to connect the municipal sewage to the lagoon system.

A number of environmental problems have been blamed on the lagoon. On 20 Dec. 1974, the Commander of Tyndall Air Force Base sent a memorandum to Air Defense Command Headquarters describing these problems.[17] Odors in the lagoon vicinity had affected personnel working there. Dry foam from the lagoon surface had become airborne in strong winds and reportedly had fallen in various directions over habitations up to several kilometers away from the lagoon. These foam particles allegedly have caused allergy problems for personnel living on the air base and in Panama City. Trees were reportedly dying on the west side of the lagoon. Three leaks in the dike were observed during Nov. 1974 but two of these had stopped by the 21st of the month.

The lagoon has not achieved expected levels of BOD reduction. To meet the Florida requirements for 90% reduction of raw waste BOD, the lagoon was designed to produce an effluent containing not more than 3,760 kg (8,300 lb)/day of BOD. Effluent data indicates that for the three-month period Dec. 1974 to Feb. 1975, the effluent BOD averaged 5,040 kg (11,100 lb)/day, or 34% above design.[19] Total suspended solids averaged 9,950 kg (21,940 lb)/day for the same period. Much higher loads were discharged during the previous three months, but operational changes were made at the IPC mill that reduced raw wasteloads to the lagoon with a corresponding effluent load reduction.

1975 OBSERVED CONDITIONS

Bay County Wastewater Treatment Plant

The lagoon was observed on several occasions using remote sensors, and during field trips to the lagoon to collect effluent samples. Odors were noticeable at the lagoon but were judged by several observers to be weaker and less offensive than odors near the IPC mill.

A foam layer a few centimeters thick covered essentially the entire surface of the lagoon on most occasions. On 27 Mar. 1975, observed foam conditions were at their worst. Winds from the north and northeast with gusts to 45 km/hr (24 kn) caused a foam layer about 6 m (20 ft) wide and 20-25 cm (8-10 in) thick to accumulate along the southern edge of the lagoon.

Air and wastewater temperatures were well below summer maximums during the study. Winds were also adequate to substantially dilute odors. Ambient conditions were thus not favorable to produce severe odor and foam problems.

Observed foam conditions were substantially less severe than reported in the past. IPC reportedly adds a chemical (Dixielub anti-foam) to its wastewater disharged to the lagoon for foam control. If observed conditions are typical of current foam production, this approach may have eliminated the airborne foam problem.

Examination of low altitude color photographs of the lagoon vicinity indicated several leaks along the west, east, and north sides of the dike. Thermal infrared imagery obtained at night on 19 Mar. showed three probable leaks. A positive print of the thermal image is presented in Figure 7. Light areas in this image are warmer than dark areas.

The warm wastewaters in the lagoon are the lightest, indicating they are substantially warmer than St. Andrew Bay. In fact, field measurements showed the lagoon contents averaged 6.5°C (11.7°F) warmer than the Bay during the March 1975 survey. The dark U-shaped patterns are cool lines of surface foam blown eastward from each aerator by a west wind. Note that one of the 23 aerators was not operating. The wastewater plume from the submerged diffuser in St. Andrew Bay is visible offshore north of the west edge of the lagoon. The small area of the plume indicates only a small volume of wastewater was reaching the surface directly.

Three probable leak locations indicated by warm (light) spots near the dikes are shown by arrows on Figure 7. The largest spot is halfway between the northwest corner of the lagoon and the bay shoreline. A

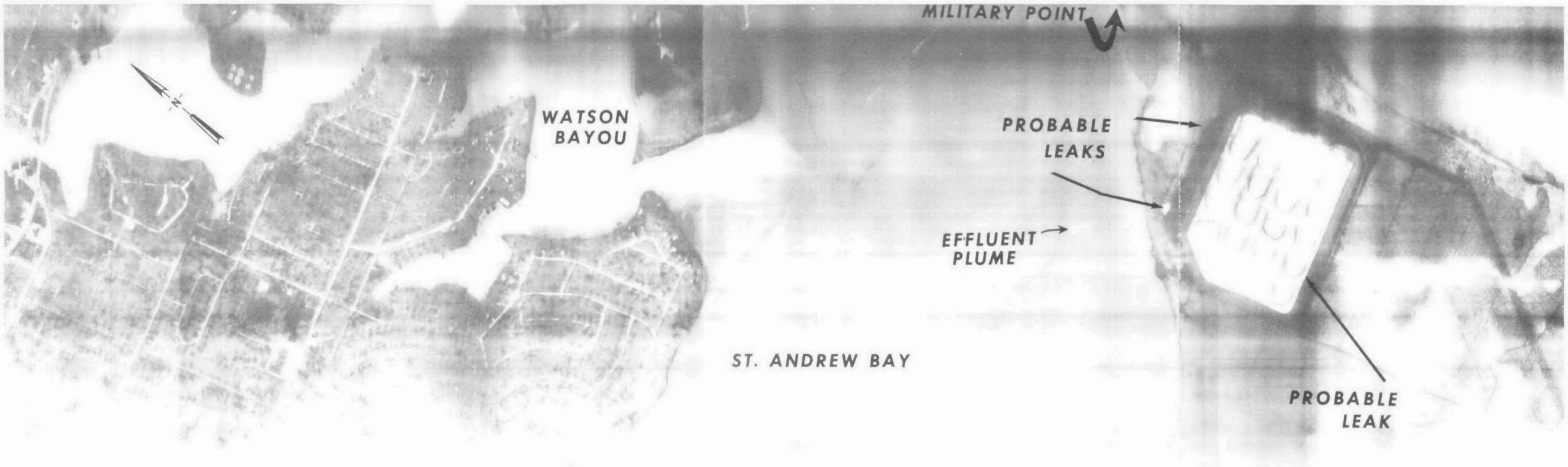

Figure 7. Thermal Map Of Bay County Aerated Lagoon

second smaller warm spot indicates a small flow into the swamp on the north of the lagoon at a point about 1/3 of lagoon length from the east. The third spot is a small warm flow into the swamp south of the lagoon.

An IPC staff member indicated an interest in thermal imagery of the lagoon as a means of detecting short circuiting. The broken thermal pattern produced by the aerators and foam lines precluded such an evaluation.

International Paper Company

The aerial imagery revealed several differences between present wastewater treatment and control practices and the system proposed in 1971 (previously discussed). The most significant finding was that, contrary to information supplied by IPC for the NPDES permit, wastewaters appeared to be discharged from Outfall 016 into St. Andrew Bay.

Existing wastewater facilities are shown in Figure 8; a comparison with Figure 6 shows the changes that have been made since 1971. Moving north to south, the large Arizona Chemical settling pond has been filled in to make room for storage tanks. The sludge pond is now occupied by a large pile of waste materials. The large waste pond has been divided into three sections. A pumping station has been built between the clarifier ditch and the small north section. The middle section is an aeration basin with one mechanical surface aerator. The large south section is almost dry. The screen structure to Outfall 017 has been diked off from the waste pond and was not in use.

The largest wastewater flow observed (assumed to be the fibre-bearing process wastes) enters the west end of the clarifier ditch at

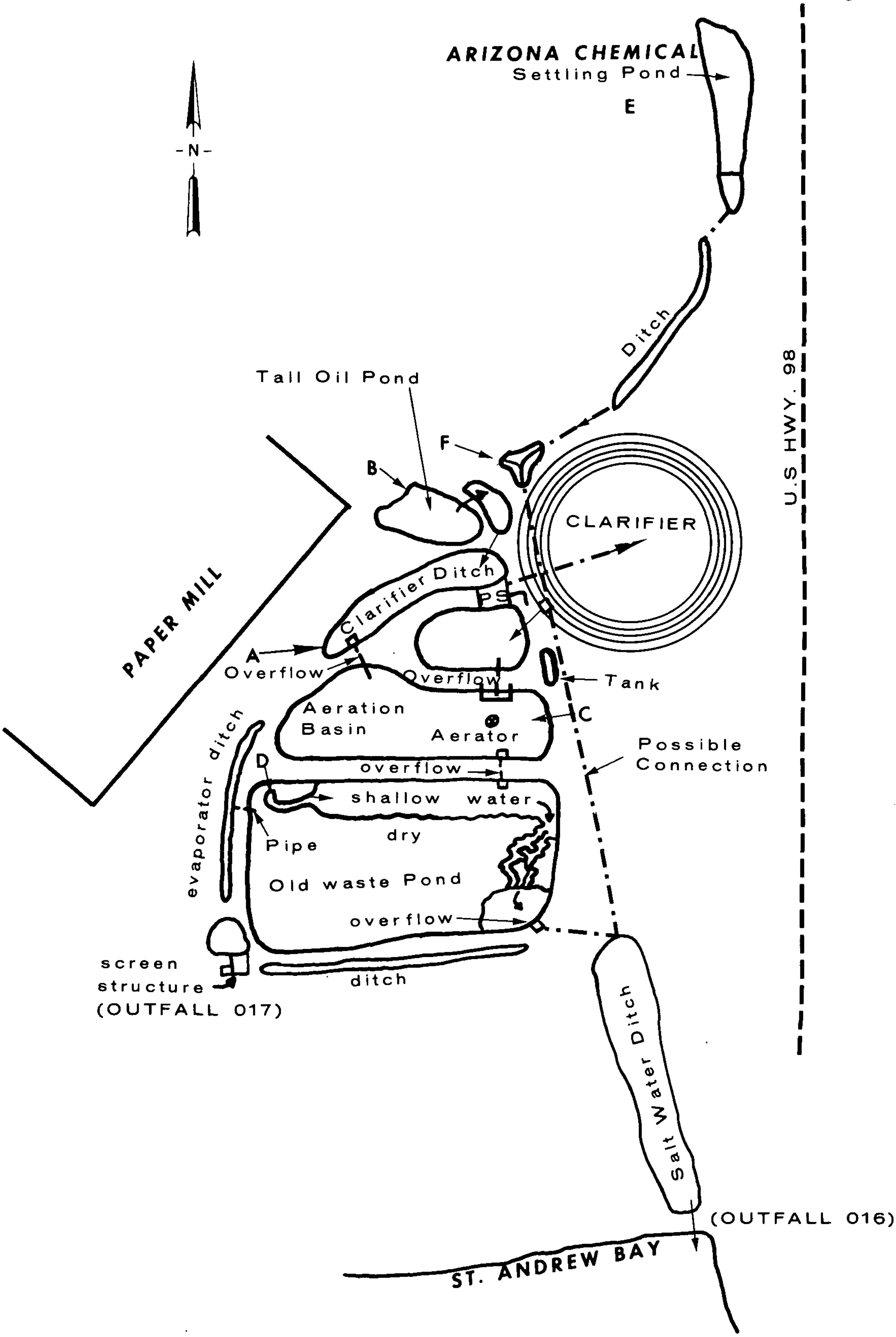

Figure 8. International Paper Company
1975 Wastewater Treatment Facilities

point A and flows to the pumping station. Three pumps lift this flow (and a small volume of wastewater that enters the tall oil pond at point B) into the clarifier. Flow from the outer effluent channel of the clarifier is conveyed to a small basin on the south side of the pumping station. Four larger pumps lift the clarifier effluent into a force main that is assumed to lead across St. Andrew Bay to the lagoon. An elongated tank near the pumping station may be for anhydrous ammonia, used as a source of nutrients for the lagoon. On 3 Apr., the discharge at point A was inactive, but a small discharge was entering the clarifier ditch from the tall oil pond.

It appeared that in the case of the extended pumping station failure, the process wastewater stream could be bypassed to St. Andrew Bay. Overflow structures are situated to allow the clarifier ditch to overflow into the aeration basin which, in turn, overflows into the old waste pond. Overflow from this pond goes to the saltwater ditch and the Bay. Detention time before an overflow to the Bay would occur is not known, although the large waste pond would provide little detention at observed overflow conditions.

A discharge into the east end of the aeration basin was observed at point C; the source of the discharge was not observed. An overflow structure connects the aeration basin with the small basin south of the pumping station. The aeration basin effluent apparently goes to the pumping station, but an active discharge could not be detected. The aerator was operating on 19 and 20 Mar. but not on 3 Apr. during the mill shutdown. A small discharge from point C was observed on 3 Apr.

It appears that more than one wastewater stream contributes to the observed discharge from Outfall 016. This discharge could not be defined in the aerial photographs because the pipe through the dike at the mouth of the saltwater ditch is submerged and water color is similar in the ditch and Bay. Because of its warm temperature, however, the discharge was clearly visible in the thermal imagery. Figure 9 is a thermal image of the area recorded at about 8 p.m. on 19 Mar. Note that a thermal plume (light area) extends south from the ditch for almost 490 m (1,600 ft) before dispersing.

During all aerial observations including the one on 3 Apr. during the mill shutdown, a pipe at point D [Fig. 8] in the northwest corner of the old waste pond was discharging dark wastewater. The flow rate was estimated to be in the range of 3,800-7,600 m^3/day (1-2 mgd). The discharge ponded in a narrow strip along the north dike and then trickled in several shallow channels leading to the overflow structure. On 19 and 20 Mar., the bottom of the saltwater ditch could not be defined. Foam patterns indicated surface movement from north to south. On 3 Apr., the bottom of the north third of the ditch was exposed, indicating a lower water level. A dark wastewater stream similar in volume to the discharge at point D was flowing from the north end of the ditch toward Outfall 016. In 1971, the waste pond overflow discharged at this point. The area of ponded water in the old waste pond did not change size between any of the aerial observations, indicating storage was not changing. It thus can be concluded that the wastewater discharged at point D ultimately was discharged to St. Andrew Bay through Outfall 016. On 3 Apr., it appeared to be the only source of this discharge.

Since the water level in the saltwater ditch is higher than in the Bay, the drop in water level between 20 Mar. and 3 Apr. was more likely the result of a decrease in inflow to the ditch rather than tidal fluctuations. Since the discharge at point D did not visibly change volume, a second source must have been discharging to the ditch on 19 and 20 Mar. but not on 3 Apr. Examination of the imagery for these three days showed that discharges at points E and F [Fig. 8] were active in March but not in April.

Figure 9. Thermal Map Of International Paper Company

In 1971, Arizona Chemical Company discharged wastewater to a settling pond at point E that then flowed to the long narrow pond adjacent to the highway. The settling pond has been filled in, but the long pond is still used. Although an actual discharge to the pond was not observed, on 19 and 20 Mar. there was flow in the effluent ditch leading to a small triangular depression near point F. This flow is presumed to be from Arizona Chemical. A disharge was also active at point F in March. This discharge was described in 1971 as non-fiber-bearing wastewaters. In April, no discharges were visible at points E and F.

The ultimate discharge point for the flows leaving the confluence at points E and F could not be defined from the remote sensing data. In 1971, however, these flows were connected to the saltwater ditch. The March and April observations strongly indicate that this connection is still in operation.

Close examination of the thermal imagery recorded the night of 19 Mar. [Fig. 9] indicates that heated discharges were originating from points D, E, and F at the same time the thermal plume was recorded originating from Outfall 016.

The source of the discharge at point D could not be defined from the remote sensing data. The discharge point is very close, however, to the 1971 discharge point for the evaporator condensor water. The volume of the discharge is consistent with the expected evaporator cooling system blowdown; the color suggests contamination with black liquor. The data thus indicate the possibility that the cooling system blowdown has not been connected to the lagoon system but instead is being discharged without further treatment. If the Outfall 016 discharge consists of the cooling system blowdown, the Arizona Chemical Company discharge and a small non-fiber-bearing process wastewater stream, then this discharge would have a flow rate of about 12,100 m^3/day (3.2 mgd), containing a BOD load of more than 9,980 kg (22,000 lb)/day based on the 1971 engineering report.[15] This is more than 2.5 times the allowable wasteload for the entire mill prescribed by the Florida water quality standards.

In addition to the active wastewater discharges described above, there are several other potential sources of pollution from the IPC mill. All storm drains included in the 1971 RAPP application are located on Watson Bayou on the northwest edge of the mill site. A ditch south of the wood yard, draining part of the wood storage yard and some waste piles, discharges to St. Andrew Bay. A large area between the waste pond and St. Andrew Bay is occupied by waste piles of undetermined makeup [Fig. 4]. Surface runoff and seepage from this area enters St. Andrew Bay at several points. The area south of the ash lagoons, east of the highway and next to Martin Bayou, contains piles of waste materials and small ponds of water of a variety of colors [Fig. 4]. Surface runoff from this area enters Martin Bayou. No discharge points in this area are included in the permit application.

VI. ENVIRONMENTAL AND WATER QUALITY CONDITIONS

WEATHER CONDITIONS[5]

Temperature

Air temperatures were considered seasonal during the survey (19-27 Mar. 1975) with an average high of 24°C (75°F) and an average low of 13°C (56°F). Relatively low temperatures during the first days of the survey were associated with a front which passed through the area; temperatures were warmer the second half of the survey.

Wind

Recorded wind velocities during the survey never exceeded 46 km/hr (25 kn). Moderate winds, ranging from 19-28 km/hr (10-15 kn), usually occurred in the afternoon. The more consistently stronger winds blew from the NNE at 28-37 km/hr (15-20 kn).

Winds blew from every sector except easterly. The first two days, the winds accompanied weather fronts which approached from the west. The following four days, the winds shifted to southerly between SE and SW with moderate velocities. The remaining days, the winds gradually swung to the northern sector blowing from a steady NNE direction.

Precipitation

Before the survey there were scattered showers in the Panama City area, including a rainfall of 4.8 cm (1.89 in) on 18 Mar. 1975. No precipitation was recorded by the weather bureau for the St. Andrew Bay watershed during the remainder of March.

HYDROLOGY

Along the northern Gulf coast, including the St. Andrew Bay area, diurnal tides usually consist of a single high and low stage. The mean tidal range is small and under ordinary conditions is from 30-60 cm (1-2 ft).[6] Surface currents in the St. Andrew Bay system are slow with maximum velocities about 2 km/hr (1 kn).[1]

The combination of shallow water, small tidal range and a daily tide in this bay system produces a condition in which the disturbing effect of the wind on the tides is quite pronounced.[12] Strong northerly winds that occur principally during the winter depress the water surface as much as 1.2 m (3.5 ft) below mean low water.

Drainage into the East, North, West and St. Andrew Bays is small but generally positive -- that is, evaporation is less than drainage inflow. As a result, ebb currents endure longer than flood currents.[1] Vertical differences in temperature are reportedly small, even during the summer months. Surface temperatures vary slightly during a 24 hr period due to surface heating and cooling and tidal currents.

As discussed in the following sections, wind, surface runoff and tidal conditions all exerted a significant influence on observed water quality conditions and dispersion patterns for the IPC effluent during the study period.

EFFLUENT DISPERSION CHARACTERISTICS

The dispersion pattern of IPC wastewater discharged from the Bay County WWTP was not known before the survey. A remote sensing study was made to define the dispersion pattern and to determine the spatial extent of IPC wastewaters dispersing into East Bay. This information was needed to assist in the interpretation of the bacteriological and chemical conditions observed during the study and to determine if a cause and effect relationship existed between the IPC discharge and East Bay conditions.

Remote sensing data consisted of photographic imagery recorded in the ultraviolet, visible (blue through red) and the near-infrared regions of the optical spectrum and thermal infrared imagery. (Data collection and analysis methods are discussed in Appendix A). The data used for this part of the study were recorded in early afternoon on 19 and 20 Mar. 1975. Aerial imagery was recorded over the study area from which water quality samples were taken. Also, for comparison, imagery was recorded over the eastern portion of East Bay and limited areas of the Gulf of Mexico and West Bay.

Examination of the true-color photographs (imagery recorded in the visible part of the optical spectrum) showed the entire St. Andrew Bay system to contain waters with dark gray-brown color in sharp contrast to the clear blue-green waters of the Gulf of Mexico [Figs. 10, 11]. The dark color levels in the estuary made it impossible to define a specific discharge plume resulting from the IPC submerged discharge. When the IPC wastewaters and various areas of the estuary were characterized optically, a definite correlation existed between the wastewater discharge and estuarine color [App. A].

Since most creeks and bayous which feed the estuarine system drain swamp areas, they had high color levels (light red-brown) characteristic of swamp drainage. Optical characterization of the bayous, the IPC wastewater, and the waters of St. Andrew Bay showed that the characteristic dark gray-brown color in most of St. Andrew Bay and the western portion

Figure 10. Color Boundary Between The Water Of St Andrew Bay And Water Of The Gulf Of Mexico 19 March 1975

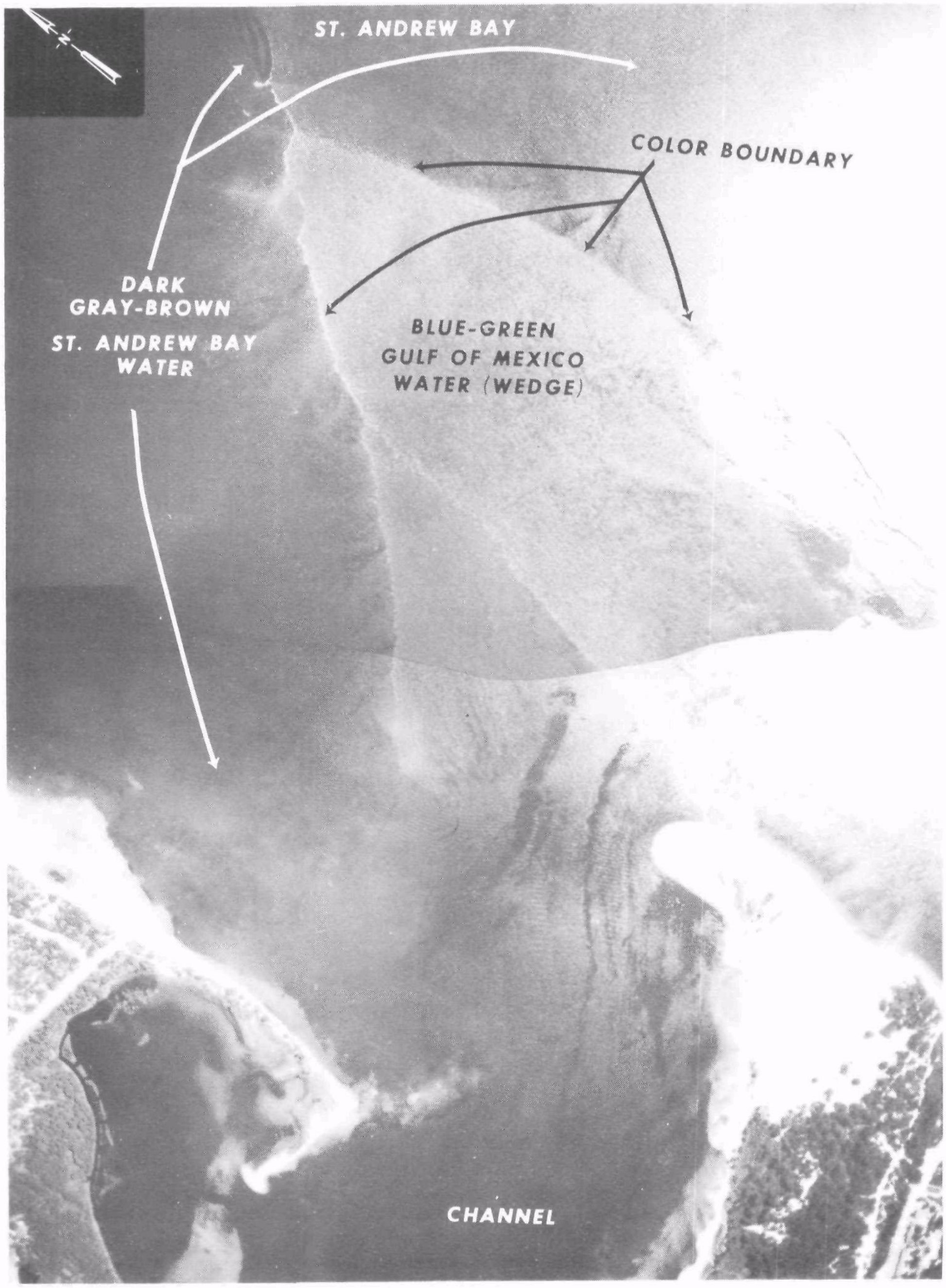

Figure 11. Color Boundary Between The Water Of St Andrew Bay And Water Of The Gulf Of Mexico
20 March 1975

of East Bay was directly related (color characteristics) to the IPC lagoon wastewater. Also, the dark gray-brown water differed significantly in optical characteristics from the waters of the various bayous.

On 19 Mar. the dark gray-brown waters containing IPC wastewaters extended about 10 km (6 mi) east from the discharge point near Military Point into East Bay to near Piney and Goose Points [Fig. 12]. A definite color demarcation was observed with the characteristic dark gray-brown waters to the west of the demarcation and light red-brown sediment laden waters to the east [Fig. 13]. This sediment apparently was from Wetappo and Sandy Creeks. Similar conditions were observed on 20 Mar. [Fig. 14].

The low tidal range and limited freshwater flow into the estuarine system apparently result in long residence times for substances discharged into the estuary. The color characterization indicates that IPC wastewaters disperse through a major portion of St. Andrew and East Bays. They are slowly flushed from the system resulting in relatively uniform color levels throughout the affected area. When wind conditions are favorable, such as during the remote sensing study, estuarine waters containing IPC wastewaters are displaced several miles eastward into East Bay.

CHEMICAL CONDITIONS

Applicable Water Quality Regulations[7]

The State of Florida has designated the waters of St. Andrew Bay to be used for recreation, and propagation and management of fish and wildlife (Class III waters). East Bay is classified for shellfish

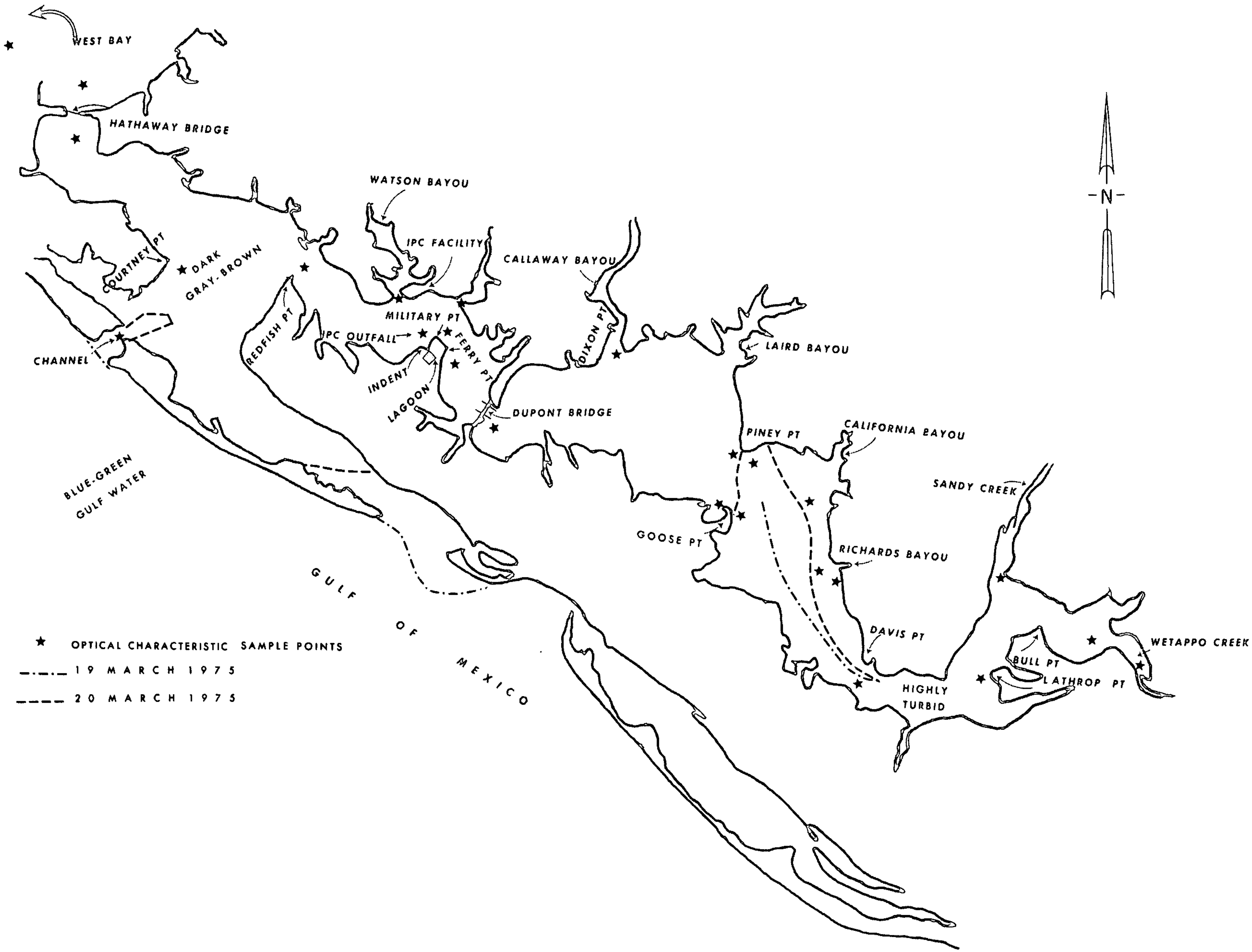

Figure 12. Water Color Demarkation 19—20 March 1975

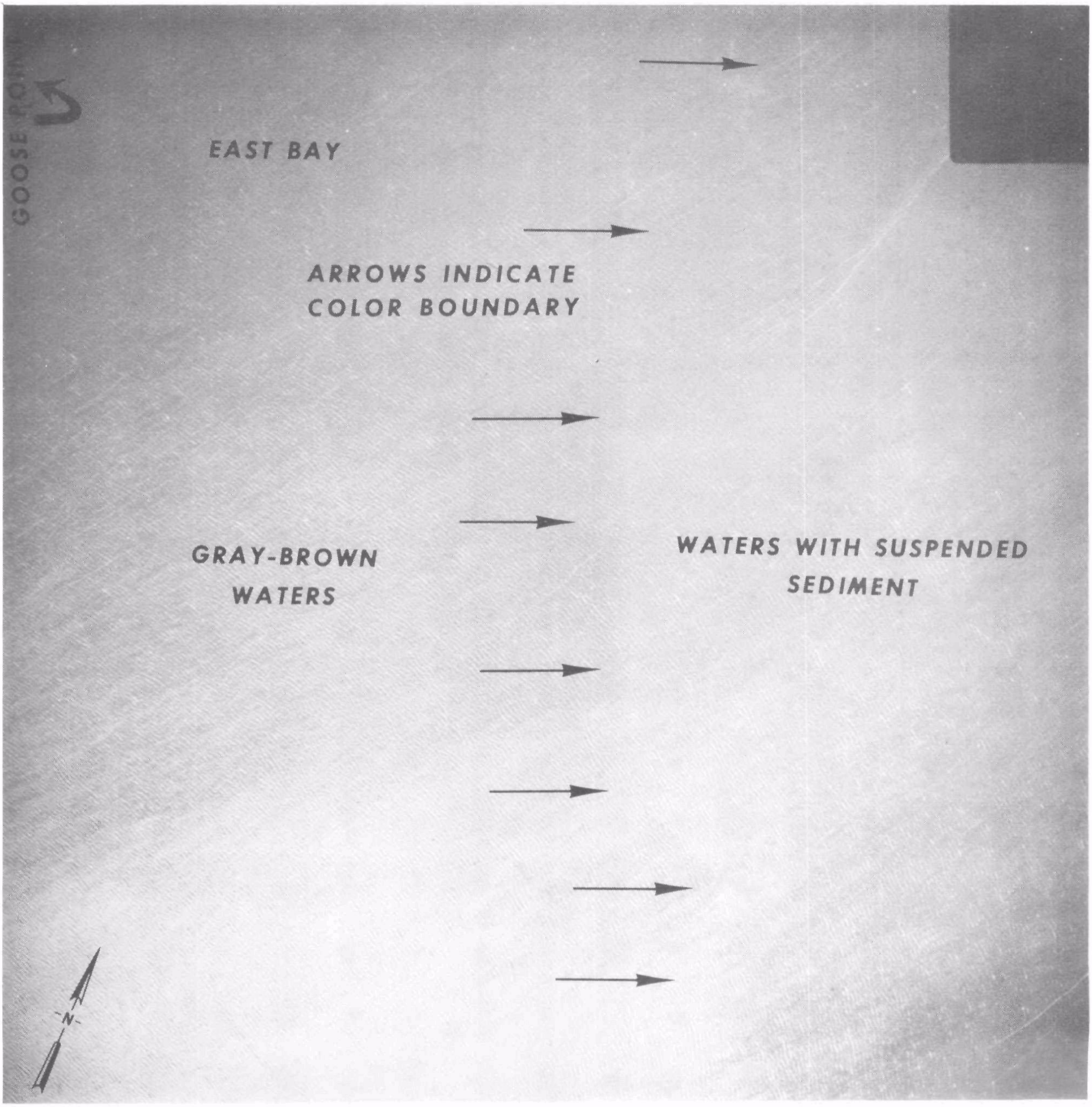

Figure 13. Color Boundary Between Two Water Quality Types In East Bay
19 March 1975

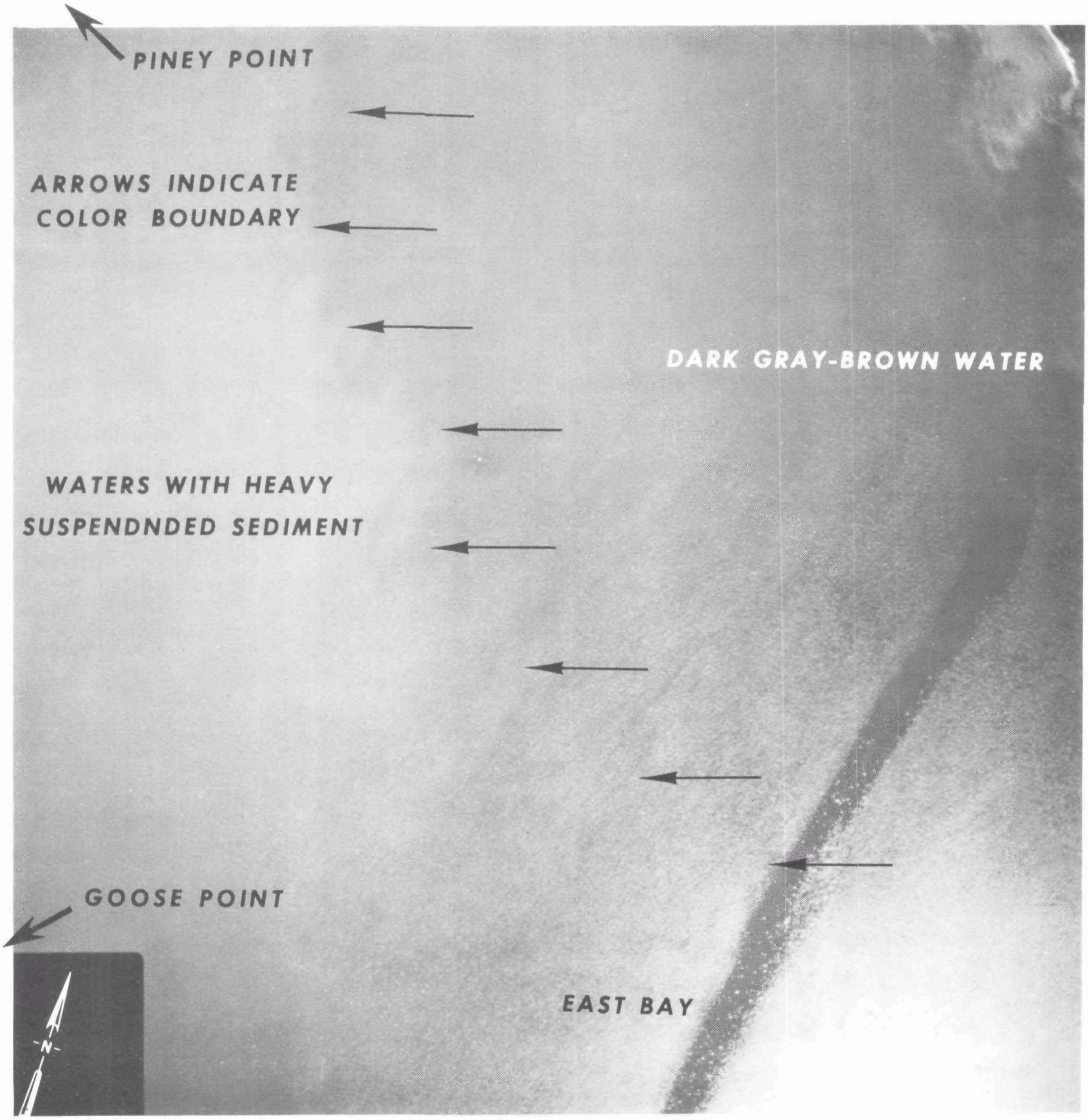

Figure 14. Color Boundary Between Two Water Quality Types In East Bay
20 March 1975

harvesting (Class II waters). The following physical and chemical criteria are common to both Class II and Class III waters.

- Sewage, industrial wastes, or other wastes shall be effectively treated by the latest modern technological advances as approved by the regulatory agency.
- The pH of receiving waters shall not be caused to vary more than one (1.0) unit above or below normal pH of the waters; and the lower value shall be not less than six (6.0), and the upper value not more than eight and one-half (8.5). In cases where pH may be due to natural background or causes outside limits stated above, approval of the regulatory agency shall be secured prior to introducing such material in waters of the State.
- Dissolved oxygen concentration in all surface waters shall not average less than 5 mg/l in a 24 hr period and never less than 4 mg/l. Normal daily and seasonal fluctuations above these levels shall be maintained. Dissolved oxygen concentrations in estuaries and tidal tributaries shall not be less than 4.0 mg/l except in naturally dystrophic waters. In those cases where background information indicates prior existence under unpolluted conditions of lower values than required above, lower limits may be utilized after approval by the regulatory uthority. Sampling shall be performed according to the methods approved by the Florida Pollution Control Board.
- Receiving waters shall be free from substances attributable to municipal, industrial, agricultural or other discharges in concentrations or combinations which are toxic or harmful to human, animal or aquatic life.

Class III waters to be used for recreational purposes, including such body contact activities as swimming and water skiing, and for the maintenance of a well-balanced fish and wildlife population have these additional physical or chemical criteria:

- Receiving waters shall be free from materials attributable to municipal, industrial, agricultural, or other discharges producing color, odor or other conditions in such degree as to create a nuisance.
- Turbidity shall not exceed fifty (50) Jackson units as related to standard candle turbidimeter above background.

Class II waters used for shellfish propagation and harvesting have one additional criterion:

- The threshold odor number is not to exceed 24 at 60°C (140°F) as a daily average.

Survey Findings

A total of 218 water samples were collected from 12 locations for physical-chemical analysis [Table 5]. Field measurements of salinity, dissolved oxygen, water temperature and pH were made for each sample collected in St. Andrew and East Bays. Also, water samples were sent to the NEIC laboratories in Denver for lignin-tannin determinations and analysis of optical properties. Data were compiled on the basis of results obtained from 20-23 Mar. and 23-27 Mar. 1975. These dates corresponded with the temporary closure on 23 Mar. of International Paper Company. Consequently, physical-chemical conditions in the St. Andrew estuary could be compared during the paper mill operation and shutdown. Daily fluctuations and overall survey trends for various parameters are graphically presented in Figure 15.

Table 5

SUMMARY OF CHEMICAL ANALYSIS
WATER QUALITY STUDY OF ST. ANDREW BAY, FLORIDA
20-27 Mar. 1975

Station	Station Description		Salinity	Dissolved Oxygen	Temperature	pH	Lignin-Tannin Tannic Acid
			(o/oo)	(mg/l)	(°C)		(mg/l)
				CLASS II WATERS			
1	2,010 m (2,200 yd) 40° northeast of buoy 35 Fl 4 Sec.	Range Average	5.0-12.9 8.8	7.5-11.5 8.9	15.0-22.0 19.4	7.1-7.8	0.54
2	Buoy 40 Fl R	Range Average	4.9-12.7 10.2	5.1-10.3 8.6	16.6-22.2 19.4	7.3-7.8	0.39
3	1,100 m (1,200 yd) 60° northeast of buoy 45 Fl 4 Sec.	Range Average	7.0-14.6 10.7	7.4-11.9 8.6	15.5-22.2 19.6	7.4-7.8	0.14-0.36
				CLASS III WATERS			
4	C Buoy 3	Range Average	10.7-17.4 12.7	7.0-9.5 8.5	15.5-22.0 19.3	7.8-7.9	0.25
5	Day Beacon 29	Range Average	13.1-18.4 14.3	7.1-12.0 8.3	16.0-21.5 19.4	7.8-8.0	0.21-0.32
6	I.P.C. discharge: 270 m (300 yd) offshore in line with the westernmost border of the Bay County WWTP	Range Average	14.1-20.2 16.7	5.3-8.9 7.6	16.3-21.2 19.6	7.9-8.1	0.14-0.21
7	Mouth of Watson Bayou	Range Average	13.5-19.8 15.5	6.0-10.0 8.0	16.5-22.4 19.9	7.9-8.1	0.21-0.29
8	Millville WWTP discharge in Watson Bayou	Range Average	11.4-14.8 13.1	5.0-11.0 9.3	18.3-23.0 20.8	7.5-8.4	0.36
9	Buoy 24 Fl R	Range Average	13.0-20.5 16.4	3.5-9.4 7.4	16.5-21.8 19.6	7.8-8.2	0.07-0.18
10	Buoy 17 Fl B	Range Average	14.1-22.3 17.0	4.3-9.6 7.7	16.5-21.8 19.3	8.0-8.1	0.07-0.18
11	Millville WWTP after chlorination prior to discharge	Range Average					
12	Bay County WWTP† prior to discharge	Range Average			24.5-27.5 26.1		35.0

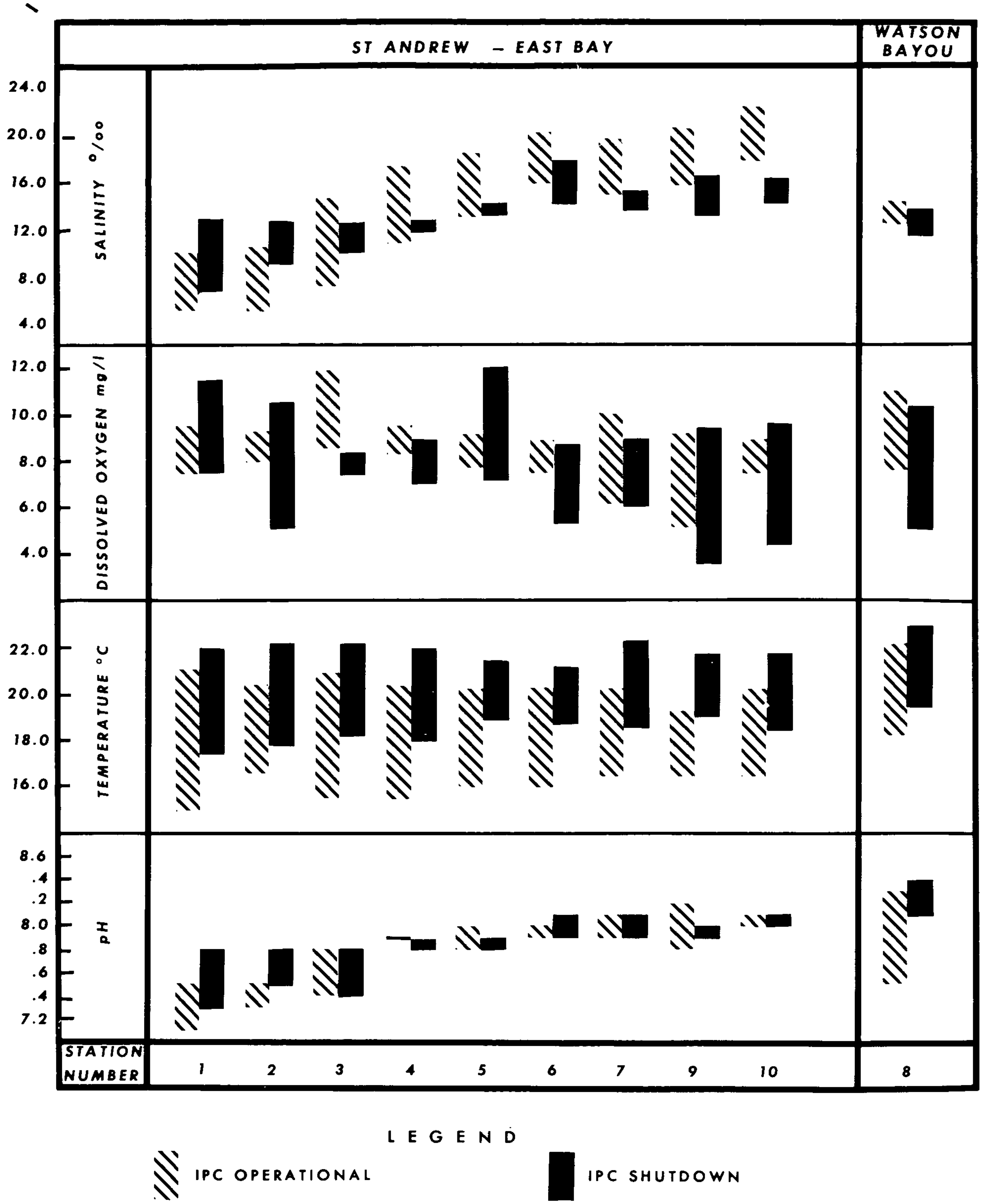

Figure 15. Physical and Chemical Data
St Andrew Bay Florida
20—27 March 1975

Initially an east to west salinity gradient ranging from 5-23 parts per thousand was observed in the St. Andrew-East Bay study area. This was attributed to a 4.8 cm (1.89 in) rainfall recorded on 18 Mar. Lower salinities occurred in areas normally receiving the most drainage. From 20-27 Mar., freshwater intrusion slowly diffused into the western region of East Bay and into St. Andrew Bay. This was reflected in a gradual increase of salinity in the eastern reaches (Stations 1, 2, 3) and a concomitant decrease in salinity in the western reaches (Stations 9, 10) of the Bay. This diffusion rate was retarded by prevailing SSW winds through 25 Mar. There was no indication that significant changes in salinity occurred at any of the stations from 18-25 Mar. due to tidal exchange.

The pH values also reflect the influence of the freshwater intrusion. In general, pH was slightly lower immediately following the rain on 18 Mar. A slight upward pH gradient existed from the eastern to western section of the Bay.

Dissolved oxygen (DO) levels fluctuated erratically. No apparent geographical pattern for DO levels was established. A single grab sample collected at the surface of St. Andrew Bay (Station 9) on 23 Mar. contained a DO concentration of 3.5 mg/l. This is in violation of the DO criterion for these State of Florida Class III waters; however, the cause of this single violation was not determined. At other times during the survey, dissolved oxygen levels in St. Andrew Bay at Stations 6 and 10 approached but did not violate the applicable criterion.

Surface water temperatures at any given station differed as much as 5°C (9°F) in a 24 hr period. However, such fluctuations were constant throughout the bay and no isolated variance was noted. Daily fluctuations appeared due to wind and solar changes rather than tidal exchange.

Lignin- and tannin-like compounds were found to exist throughout the survey area. In general, higher levels were observed in the East Bay area. However, the concentrations of these materials were low, ranging from 0.07 mg/l (as tannic acid) at Stations 9 and 10 to the maximum of 0.54 mg/l at Station 1.

In summary, the physical and chemical changes in the St. Andrew and East Bay waters during this survey appeared to be closely related to weather, hydrographic, or other natural conditions in the estuarine system. Effects of industrial wastes on salinity, temperature, pH, and lignin-tannin content of the Bay waters were not detected.

BACTERIOLOGICAL CONDITIONS

Applicable Water Quality Regulations[7]

The study area in the St. Andrew estuarine system has two bacteriological criteria currently in effect. The State of Florida has designated East Bay as Class II waters for shellfish harvesting. The State complies with standards adopted by the National Shellfish Sanitation Program (NSSP) for classification of waters in areas which either actually or potentially can support recreational or commercial shellfish propagation and harvesting. Bacteriological standards for Class II waters require that the median total coliform bacteria MPN (Most Probably Number) cannot exceed seventy (70) per one hundred (100) ml and not more than ten (10) % of samples exceed an MPN of two hundred and thirty (230) per one hundred (100) ml in those portions of areas most probably exposed to fecal contamination during most unfavorable hydrographic and pollutional conditions.[7]

The State of Florida has designated St. Andrew Bay as Class III waters, which must be of a suitable quality to be used for recreational purposes and to maintain a well-balanced fish and wildlife population.

With respect to bacteriological quality this classification includes: waters designated for body contact recreation such as swimming and water skiing; and water not normally used for body contact recreation. The Florida Department of Pollution Control has assigned the latter classification to the Class III waters in the study area.[4] The following bacteriological criteria apply to these Class III waters:

- Fecal coliform bacterial densities shall not exceed a monthly average of 500/100 ml of sample, nor exceed 750 fecal coliform bacteria per 100 ml of water in 10% of the samples. Monthly averages shall be expressed as geometric means based on a minimum of 10 samples taken over a 30 day period.

Survey Findings

A total of 169 water samples were collected from 12 sampling locations for bacteriological analyses during a 9-day sampling period. Effluent samples were collected once daily from the Millville Wastewater Treatment Plant (Station 11) and from the Bay County aerated lagoon treating wastewater from International Paper Company. Surface water samples were collected twice daily from 10 locations in Watson Bayou, St. Andrew Bay and East Bay [Fig. 2].

Chlorinated effluent samples collected at the Millville Wastewater Treatment Plant (Station 11) contained fecal coliform (FC) bacteria densities ranging from an MPN of <2 to 940/100 ml [Table 6]. The average FC density was 9 (median) or 10 (geometric mean). These values are in compliance with effluent limitations. Water samples collected in the receiving waters of Watson Bayou, adjacent to the Millville plant discharge (Station 8) contained much higher FC densities, ranging from 11 to 1,700/100 ml. Of the samples, 27% contained more than 750 fecal

Table 6

SUMMARY OF BACTERIAL DENSITIES
WATER QUALITY STUDY OF ST. ANDREW BAY, FLORIDA
19-27 Mar. 1975

Station	Station Description	Number of Samples	Total Coliforms (MPN/100 ml)				% Samples	Fecal Coliforms (MPN/100 ml)				% Samples
			Maximum	Minimum	Median	Geometric Mean	> 230	Maximum	Minimum	Median	Geometric Mean	> 750
						CLASS II WATERS						
1	2,010 m (2,200 yd) 40° northeast of buoy 35 Fl 4 Sec.	15	230,000	33	330†	500	67	1,700	5	49	68	
2	Buoy 40 Fl R	15	230,000	22	130†	240	27	790	<2	49	30	
3	1,100 m (1,200 yd) 60° northeast of buoy 45 Fl 4 Sec.	16	1,300	23	150†	170	38	490	2	35	28	
						CLASS III WATERS						
4	C Buoy 3	16	17,000	23	140	170		3,300	2	23	23	6
5	Day Beacon 29	16	2,300	11	79	83		140	<2	14	11	0
6	Bay County WWTP discharge 270 m (300 yd) offshore in line with the westernmost border of the Bay County lagoon	16	2,300	9	48	64		490	2	23	19	0
7	Mouth of Watson Bayou	15	110,000	23	310	510		11,000	8	33	55	13††
8	Millville WWTP Discharge into Watson Bayou	15	33,000	80	2,300	1,300		1,700	11	460	160	27††
9	Buoy 24 Fl R	15	330	23	50	73		79	2	13	16	0
10	Buoy 17 Fl B	15	13,000	17	49	73		7,900	<2	13	14	7
11	Millville WWTP after chlorination prior to discharge	8	1,300	20	360	160		940	<2	9	10	
12	Bay County WWTP††† prior to discharge	7	79,000	790	11,000	7,500		3,300	230	1,700	1,200	

† *Violation of USPHS (State of Florida Class II Waters) Standards for Shellfish Waters for Total Coliforms*
†† *Violation of State of Florida Class III Waters (10% of samples shall not exceed 750 fecal coliforms/100 ml)*
††† *Salmonella enteritidis ser Carrau isolated*

coliform bacteria per 100 ml, which is a violation of the State of Florida standards for Watson Bayou (Class III water classification standards). Although the Millville Wastewater Treatment Plant discharge collected immediately after chlorination (Station 11) was of relatively good bacteriological quality, the poorer quality of the discharge in the bayou (Station 8) is apparently the result of bacterial resuscitation in the presence of organic material as the chlorine becomes diluted.[8] Bacteriologically polluted water was also recorded at the mouth of Watson Bayou (Station 7). Fecal coliform bacteria densities ranged from 8 to 11,000/100 ml and 13% of the samples contained more than 750 FC/100 ml, which is in violation of State standards. Probable sources of bacterial contamination at Stations 7 and 8 include the combined contribution of International Paper Company, the Millville Wastewater Treatment Plant, water-craft sewage disposal, and seepage from septic tanks located in the area.

Effluent samples collected from the Bay County aerated lagoon treating wastewaters from International Paper Company (Station 12) contained geometric mean densities of 7,500 total and 1,200 fecal coliform bacteria per 100 ml [Table 6]. The fecal coliform bacteria density is a violation of the NPDES permit for the lagoon which limits fecal coliform densities to a daily maximum of 400 per 100 ml. These results indicate that wastewater discharges from the paper mill, and subsequently from the lagoon, contributed to the bacteriological degradation of the St. Andrew estuarine system. Additionally, pathogenic *Salmonella enteritidis* ser Carrau were isolated from the lagoon (Station 12). The presence of these pathogens constitutes a serious health hazard to anyone coming in contact with these waters, as well as a serious public health threat to anyone consuming shellfish collected from receiving waters contaminated by this discharge.

Wastewaters from the Bay County lagoon are discharged into St. Andrew Bay adjacent to Military Point (Station 6) [Fig. 3]. St. Andrew Bay is defined by the State of Florida as waters not normally used for body contact recreation (Class III), and bacteriological limitations previously discussed in *Applicable Water Quality Regulations* apply. Despite the potential health hazards described above, water contact sports such as swimming and water skiing are practiced in St. Andrew Bay near the IPC wastewater discharge.

Based on State regulations, no bacteriological water quality violations were evident for Stations 4, 5, 6, 9 and 10 in St. Andrew Bay. Nevertheless, it is important to note that a marked change in coliform densities occurred in St. Andrew Bay when comparing samples collected 19-22 and 23-27 Mar. This change toward improved water quality corresponded with the shutdown of International Paper Company on 23 Mar., as is graphically shown in Figure 16.

St. Andrew Bay connects with East Bay which is classified for shellfish harvesting (Florida Class II waters). Three sampling sites were established in East Bay. Bacteriological analyses of water samples collected from these areas on 19-22 Mar. showed that all were in violation of State and Federal Food and Drug Administration bacteriological limitations for shellfish harvesting waters. The dates of these violations corresponded with the operation of International Paper Company and its discharge of about 105,500 m^3/day (28 mgd) of wastewater into St. Andrew Bay.

On 23 Mar. the mill ceased operation for two weeks. The shutdown substantially reduced direct discharges and reduced mill discharges from the Bay County lagoon to 30,200 m^3/day (8 mgd) or less. Bacteriological analyses of water samples from East Bay collected 23-27 Mar. showed a marked improvement in water quality [Fig. 16]. Only one of the three

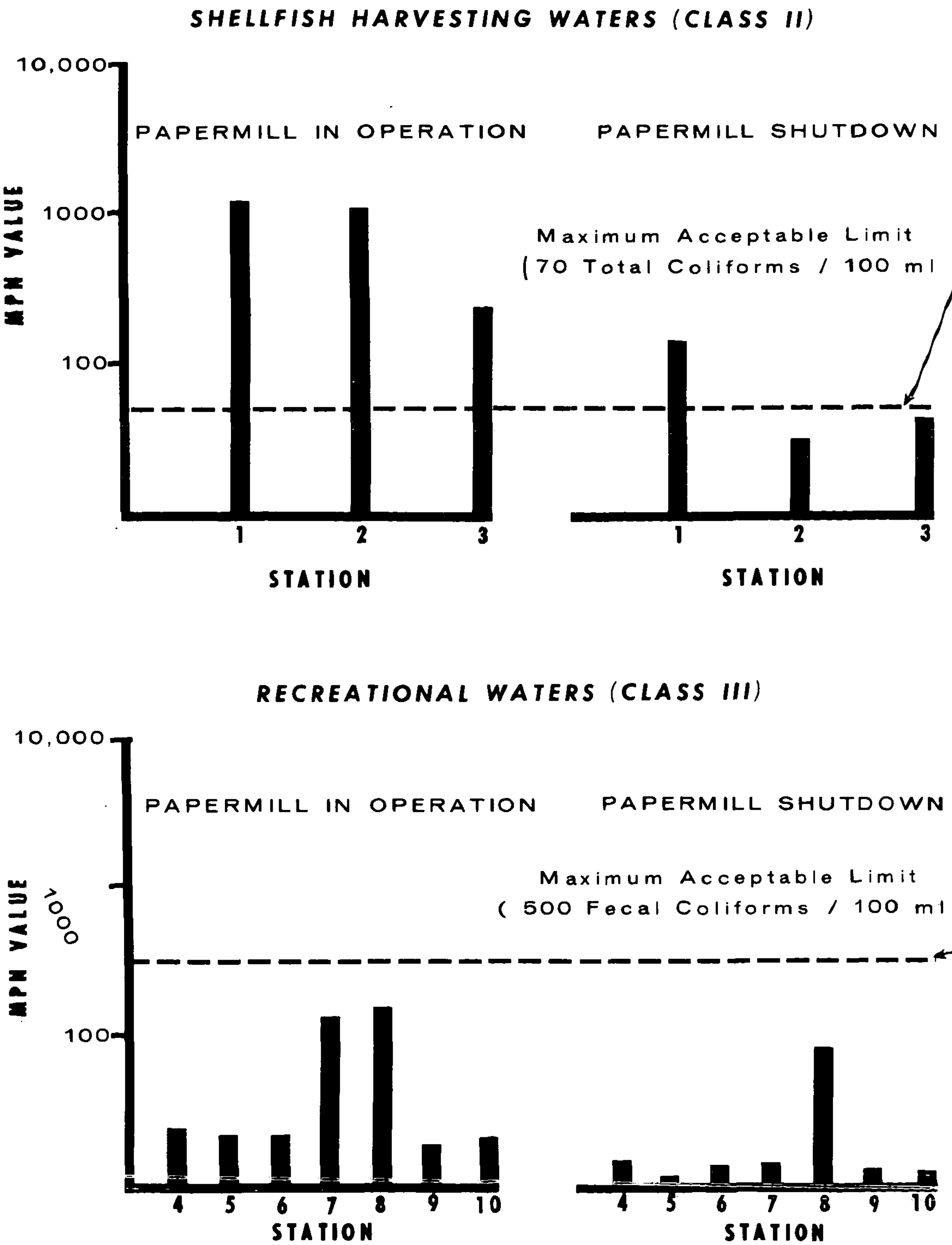

Figure 16. Comparison of Bacteriological Quality in the St Andrew Estuarine System During International Paper Company Operation and Shutdown March 1975

sampling sites remained in violation of the bacteriological limits for shellfish waters and this area showed an 85% reduction in bacterial contamination.

The improvement in water quality in St. Andrew and East Bays concurrent with the shutdown of the paper mill strongly indicates that the mill contributes to bacteriological degradation of the St. Andrew estuarine system.

VII. ST. ANDREW BAY FISHERIES

SHELLFISHERIES

Two commercial types of shellfish are found in the waters of the St. Andrew Bay system. The eastern oyster Crassostrea virginica is indigenous to the area and, being a sessile mollusk, spends its entire life on the substrate. The second type of shellfish is the shrimp, which uses the waters basically as a nursing ground. In this group are the pink shrimp Penaeus duorarum, brown shrimp P. aztecus, and white shrimp P. setiferus. The most commercially used shellfish are shrimp, followed by the oyster which borders between a commercial and sportsfishery. A third edible shellfish the bay scallop Aequipecten sp., occurs sparsely.

Oysters

Oysters are found in most sections of the St. Andrew estuary, but the moderate abundance limits their entry into a steady commercial trade. Another limiting factor is the restriction of harvesting to either handgathering or tonging. Handgathering appears to be the more common method because oysters are distributed mostly in the shallow shoreline areas. Private culture is being practiced in East Bay on leased grounds. The total area currently under cultivation is less than 0.6 km^2 (150 acres). The remainder of the oysters in the bay are classified as wild or uncultivated and are found in small clumps on the bottom or attached to bridge abutments, dolphins, or stone retaining walls.

Surveys on the distribution of oysters have established that in East Bay approximately 2.7 km^2 (673 acres) contained scattered oyster populations; in West Bay the total amounted to 4 km^2 (1,028 acres); while in North Bay only 0.3 km^2 (61 acres) were populated.[9] Approximately 3% of the total Bay is populated by oysters with an estimated value of $225,000 dockside.

A factor preventing increased exploitation of the oyster is the diminishing number of areas remaining suitable for the safe harvest of this shellfish. Industrial growth, accompanied by a population increase, has placed a stress on the Bay System which is evidenced by an increase in the volume of water overlying shellfish beds contaminated either by industrial or domestic wastes. The effects of these detrimental discharges have not been confined to any particular section of the bay and appear to be steadily spreading into each branch of the complex [Table 7].

Shrimp

Panama City, on the north shore of St. Andrew Bay, is not considered one of the larger fishing ports in the Gulf. It does, however, serve as a landing area for considerable quantities of shrimp. Over the past several years the annual catch (heads-on) fluctuated around 450 m. tons (1 million lb). Nearly all of the shrimp catch is taken in the Gulf along the west Florida coast, but a small portion of the commercial catch is harvested in the St. Andrew Bay estuarine system by smaller day-trip shrimp boats. Their contribution to the total catch is at this time unknown.

Table 7

ACREAGE CHANGES IN THE SHELLFISH HARVESTING WATERS of ST. ANDREW BAY, FLA. 1965-1975

Location	Status	Year 1965	1971	1975
West Bay				
	Open	16,656	16,656	16,656
	Closed	2,102	2,102	2,102
North Bay				
	Open	6,416	1,826	1,826
	Closed	0	4,590	4,590
St. Andrew Bay	Open	4,287	0	0
	Closed	16,593	20,880	20,880
East Bay				
	Open	17,452	14,361	14,361
	Closed	255	3,346	3,346
	TOTAL	63,761	63,761	63,761

The majority of the local shrimping activity is conducted in East Bay and, consequently, this section is considered the most productive. Limited nighttime shrimping is done predominately in North, West and St. Andrew Bays. Because of poor bottom conditions adjacent to the International Paper Company plant, this section of St. Andrew Bay is not usually used by shrimp fishermen.

Sportfishing for shrimp is also a very popular activity in this area. The fact that most of it takes place in East Bay further attests to the great productivity of the estuary.

Another source of shrimp to the Panama City commercial market is a privately-owned mariculture farm on the shores of West Bay. Shrimp are raised from eggs to various market sizes in 1.2 km^2 (300 acres) of earthen ponds. In 1971 this pond culture operation realized a commercial yield of shrimp of about 225 m. tons (500,000 lb).

RECREATIONAL FIN-FISHING

St. Andrew Bay, like many other estuaries along the nation's coasts, is being more fully used by more people as a result of the relatively easy acquisition of small pleasure boats and the increased availability of leisure time. To evaluate the use of this estuarine complex and its use-value to the surrounding communities, the National Marine Fisheries Laboratory in Panama City studied in 1973 the actual use of the Bay by recreational fishermen.[10]

The study revealed that East Bay was considerably less used for recreational fin-fishing than any other sub-estuary in the complex. The possible reasons advanced for this underutilization were related to aesthetic values resulting from the International Paper Company activities, such as paper mill odor in the air, color and foam in the adjacent waters, and the occasional reports of fish kills. Another important and obvious reason is the very limited access to the Bay by shore fishermen. This restriction occurs essentially along the southern shore where Tyndall Air Force Base property extends to the water and the northeast shore of the Bay, which is remote and generally inaccessible by car or walking.

To arrive at a monetary value for this estuarine system, the Marine Fisheries service economists used $13 a day for each person using the Bay for recreational fin-fishing. Using their estimates and observations for a year, the Bay area was estimated to be worth from three to four million dollars annually. Estimates for the individual Bays are as follows:[10]

Location	Millions of Dollars		
North and West Bays	0.6	to	0.9
East Bay	0.3	to	0.4
St. Andrew Bay	0.9	to	1.4
Panama City Coastal Area	0.9	to	1.4
Total	2.7	to	4.1

Boating on the Bay in the form of sailing and powerboat pleasure cruising has not been estimated, but its annual use-value to the Bay would, no doubt, increase the overall total substantially.

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APPENDIX A
REMOTE SENSING TECHNIQUES

Aircraft and Sensor Data
Data Interpretation and Analysis
Data Aquisition
Error Analysis
Film Spectral Sensitivity Data
Optical Filter Transmittance Data
Development Process for Reconnaissance Films
Focal Length, Angle of View

REMOTE SENSING TECHNIQUES*

AIRCRAFT AND SENSOR DATA

Aircraft and Flight Data

A high-performance aircraft, specifically designed and equipped for aerial reconnaissance work, was used for the remote sensing flights. The aircraft was used for day and night flights over Saint Andrew Bay.

The flight parameter data that specify the values of the aerial reconnaissance variables are summarized in Table A-1. These variables are important at the time the mission is flown and during the analysis of the airborne data. With rare exception, the airspeed variations are automatically processed in the aircraft computer system and, combined with aircraft altitude, are used to calculate the amount of photographic stereoscopic overlap.

Cameras

Three cameras and an infrared line scanner (IRLS) were the sensors on board the aircraft. The cameras were KS-87B aerial framing cameras equipped with 152 mm (6 in.) focal length lens assemblies. They were mounted in the aircraft in their respective vertical positions as shown in Figure A-1.

The viewing angle of the KS-87B framing cameras was 41° centered about the aircraft's nadir as shown in Figure A-2. A diagram of a typical framing camera is shown in Figure A-3.

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* *Mention of equipment and/or brand names in this report does not constitute endorsement or recommendation by the Environmental Protection Agency.*

Table A-1

Flight Parameter Data
St. Andrew Bay

Parameter	Date 19 March 1975	Date 20 March 1975
Duration of Flight (hours, CDT)	(Day) 1412 to 1557 (Night) 1927 to 2147	(Day) 1211 to 1329
Air Speed	360 kn	360 kn
Altitude Above Ground Level	(Day) 1,830 m (6,000 ft) (Day) 457 m (1,500 ft) (Night) 457 m (1,500 ft)	1,830 m (6,000 ft) 457 m (1,500 ft) --
Sensors	(Day) All (Night) IRLS	(Day) All --

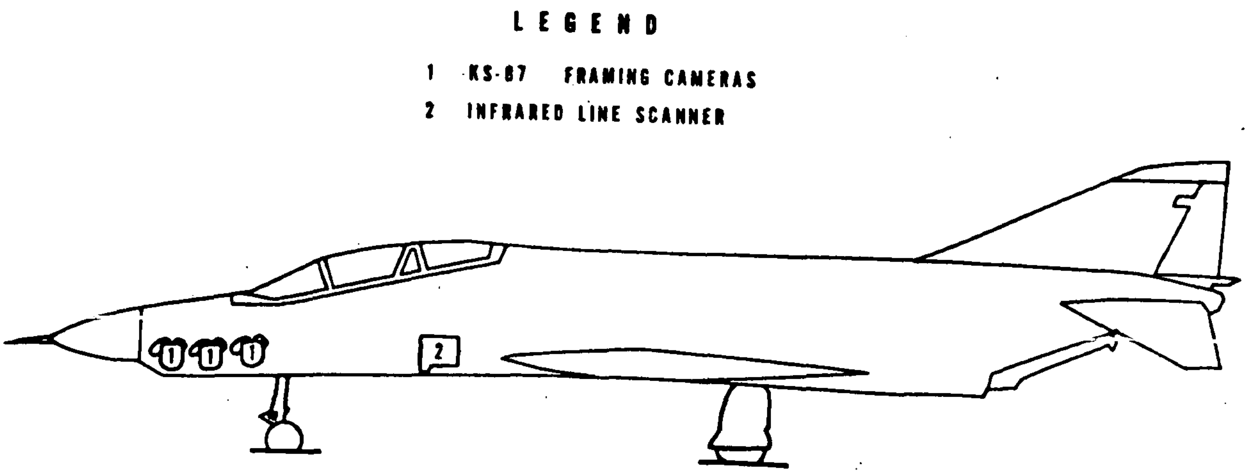


Figure A-1. Aircraft Sensor Locations

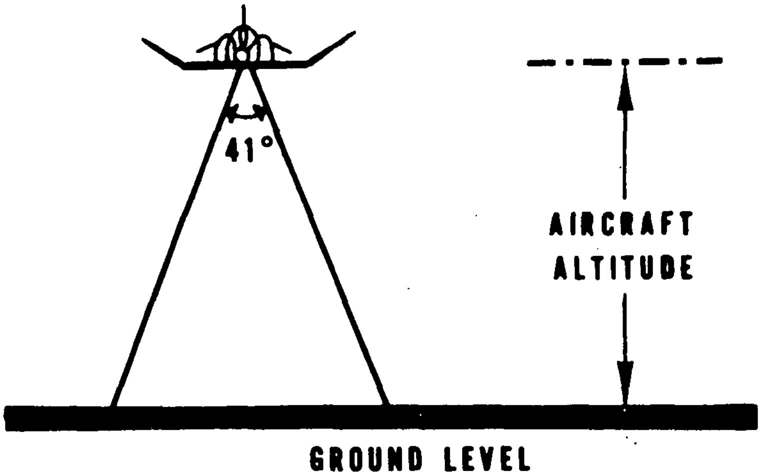
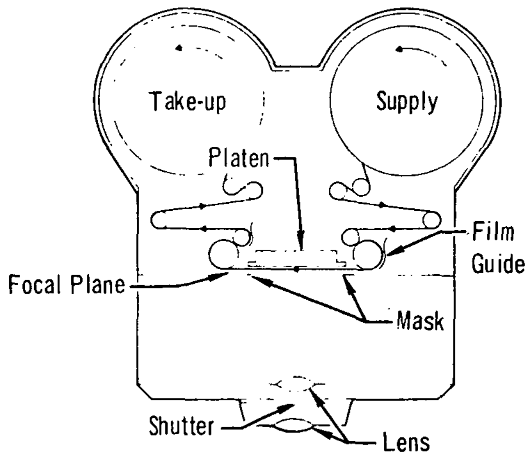


Figure A-2. Viewing Angle of Framing Camera



Film Advances Frame by Frame

Figure A-3. Framing Camera

Films and Filters

The cameras were loaded with the following film and optical filter combinations:

Camera Station 1 -- Kodak SØ-397 Aerographic Ektachrome Film (127 mm; 5 in.) with a Wratten HF-3/HF-5 gelatin optical filter combination. The film provides a true color transparency 114 mm sq (4.5 in. sq). The filter combination prevents ultraviolet light from reaching the film and eliminates the effects of atmospheric haze.

Camera Station 2 -- Kodak 2402 Aerographic Film with a Wratten 39 glass optical filter. This provides a black and white negative 114 mm sq (4.5 in. sq) which was exposed to ultraviolet and deep blue light.

Camera Station 3 -- Kodak 2443 Aerochrome Infrared Film (127 mm) with a Wratten 16 gelatin optical filter. The film provides color transparencies 114 mm sq.

The Wratten 16 filter (deep orange in color) transmits a portion of the visible optical spectrum (i.e., deep green, yellow, orange, and red) as well as the near-infrared energy from 0.7 to 1.0 μm. The film presents a modified-color or false-color rendition in the processed transparency unlike the more familiar true-color films. It has an emulsion layer that is sensitive to the near-infrared in addition to the red and green layers, whereas the true-color ektachrome films have red, green, and blue sensitive layers. (Every color film has various combinations of red, green, and blue dyes similar to the red, green and blue dots on the front of a color television picture tube.) The modified or false-color rendition comes into play when the exposed image on the infrared film is processed. In the finished transparency, the scene objects (trees, plants, algae) producing infrared exposure appear red, while red and green objects produce green and blue images, respectively. Most important, this film records the presence of various levels of chlorophyll in terrestrial and aquatic plant growth. The leaves on a healthy tree will record bright red rather than the usual green; unhealthy foliage will appear brownish-red. The orange filter keeps all blue light from reaching the film to prevent unbalance in red, green, and blue.

Infrared Line Scanner

The aircraft was equipped with an AN/AAS-18 Infrared Line Scanner (IRLS) which images an area along the flight path of the aircraft. The width of the image area depends upon aircraft altitude; the area is encompassed by a 120° field-of-view in crosstrack, or perpendicular to the flight path [Fig. A-4].

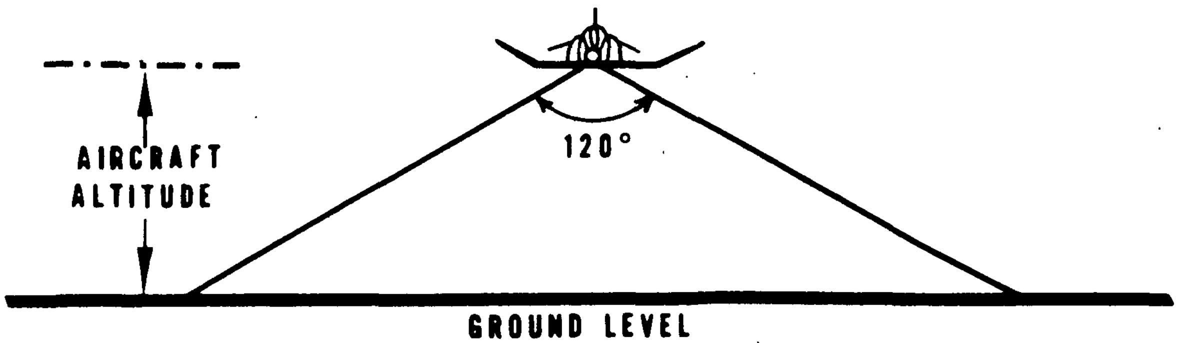


Figure A-4. Field of View of IRLS

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 [Fig. A-5].

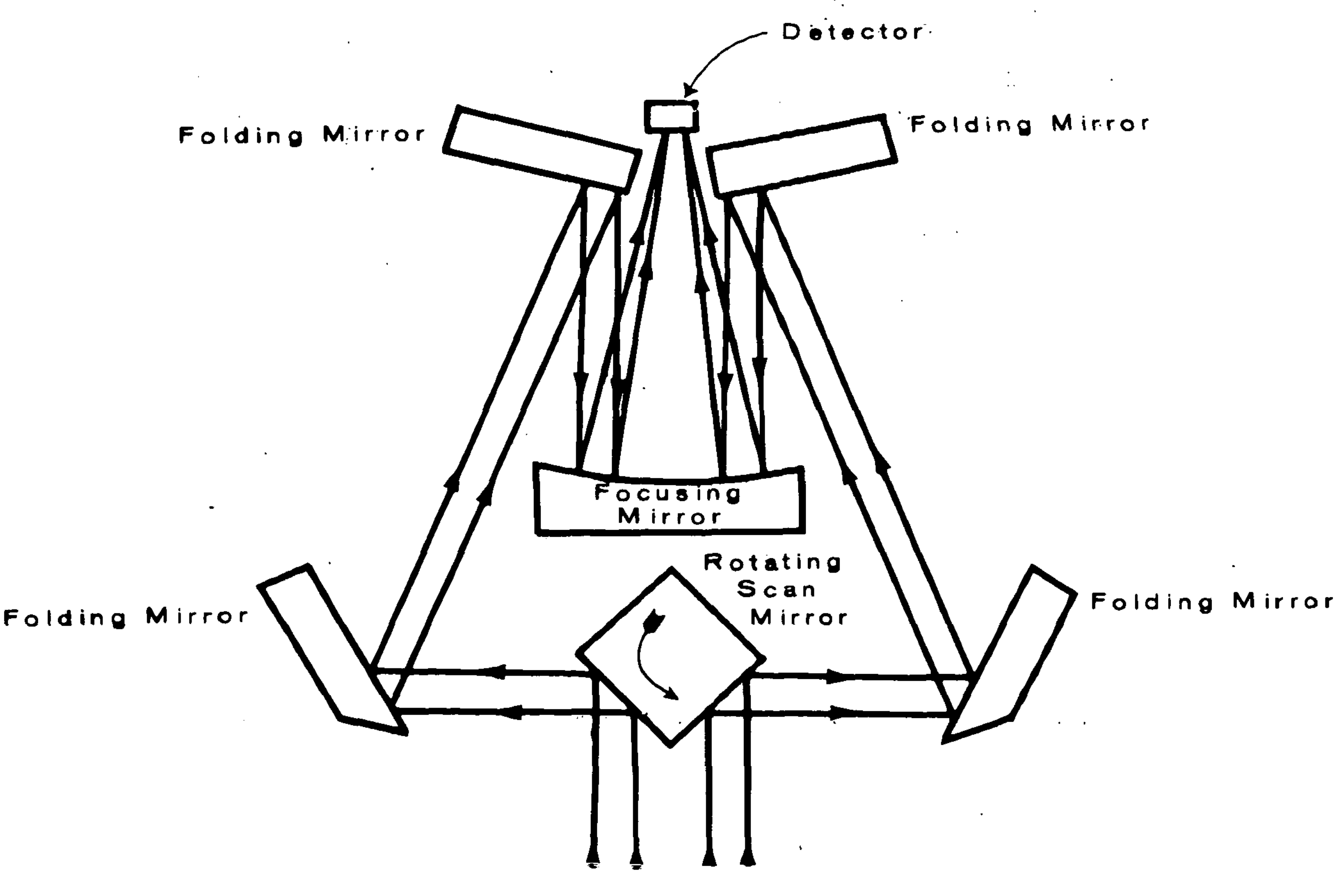


Figure A-5. IRLS optical Collection System

The detectors, cyrogenically cooled to 26° K, 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 recorded on ordinary 127 mm (5 in.) RAR black-and-white film. The recorded thermal map is 100 mm (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 μm, the so-called thermal band of the electromagnetic spectrum. Applying Wien's Displacement Law, this represents a temperature band from -66° to 89° C. The system has an instantaneous field-of-view of 1 mrad sq. The total field-of-view is achieved by the rotating mirror in the optical collection system, which is 120° x 1 mrad. 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.

DATA INTERPRETATION AND ANALYSIS

Data is interpreted and analyzed on the original photographic and Infrared Line Scanner (IRLS) films; prints and duplicated transparencies degrade the image in scale and color balance. The original films are true color transparencies, false color infrared transparencies, black-and-white ultraviolet negatives and the IRLS thermal image black-and-white negatives.

Standard image analysis techniques were employed in the reduction of distances/areas and stereoscopic analysis of areas displaying topographic gradients on land and in the water. The reduced data were subsequently plotted on U. S. Geological Survey 7.5 minute topographic maps (scale 1:24,000) and U. S. Coast Guard and Geodetic Survey Nautical Charts (scale 1:10,000). To evaluate scale consistency, the map scales were compared to the imagery empirical scales derived from the optical focal length of each sensor and the altitude of the aircraft above water level.

A Macbeth TD-203AM Densitometer was employed during the analysis of the color films to measure film densities as a function of the three cardinal colors -- red, blue and green. This system measures film densities with an accuracy of 0.02 density units and a measurement repeatability of 0.01 density units.

Temperature levels are represented on black-and-white IRLS film by various shades of gray in the negative. Areas of low density (clear film) represent cooler temperatures, and as the temperature of a particular target becomes warmer the density of gray in the film also increases. Positive prints presented in this report reflect the reverse of the negative film. Cool areas are dark while the warm areas are light gray.

It is important to note that 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 waters.

DATA ACQUISITION

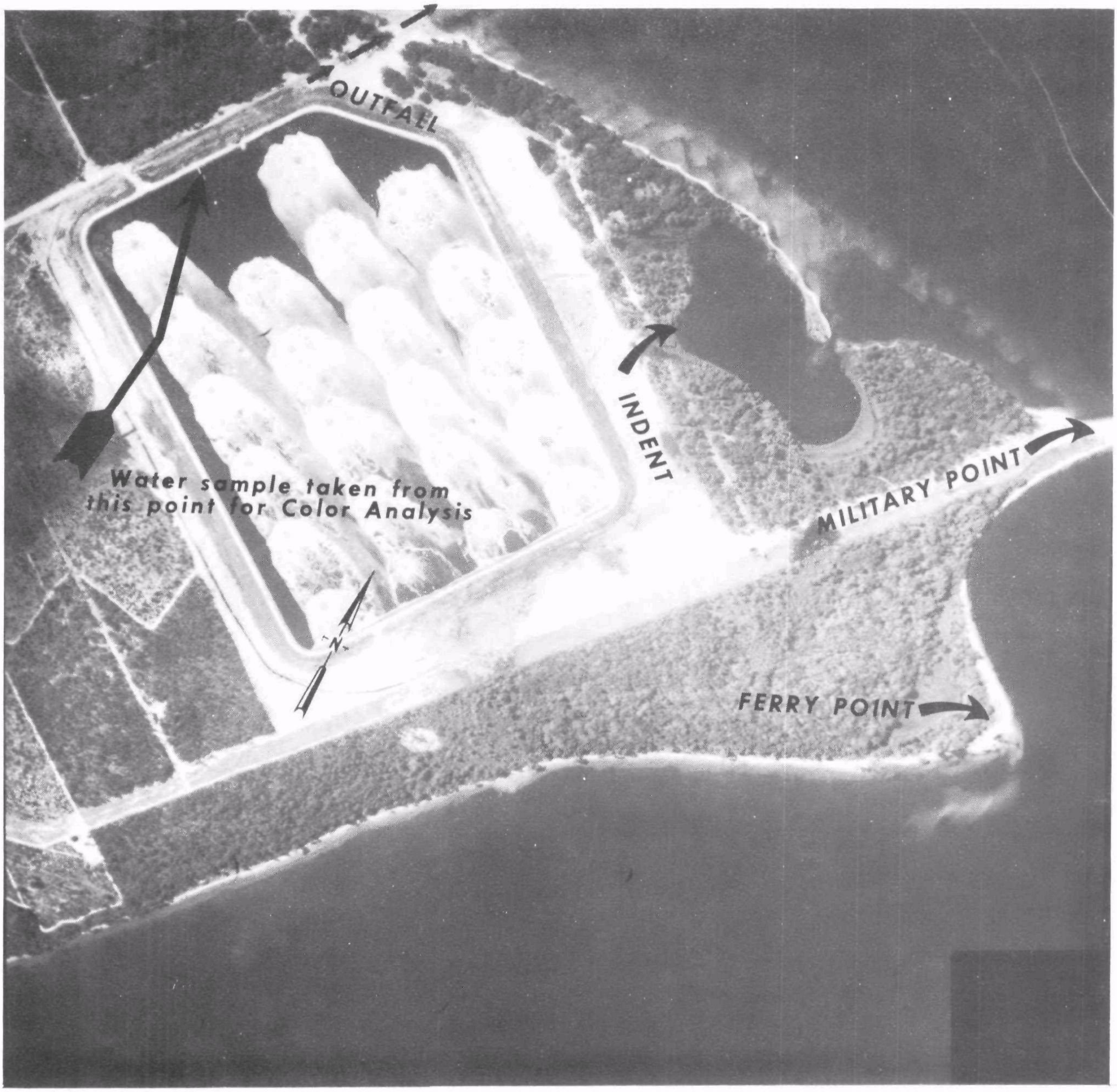
During the day missions, three aerial cameras and an infrared (thermal) line scanner (IRLS) were flown over the study area, while only the IRLS was used at the time of the night flights. The three cameras recorded photographic imagery in the ultraviolet, visible (blue through red) and the near infrared regions of the optical spectrum.

At the time of the flight, samples of the IPC wastewater were obtained from the Bay County WWTP [Fig. A-6] and from the 10 biological sampling stations in the Bay. These samples were subsequently subjected to optical fingerprint testing in the NEIC Environmental Physics Laboratory. The results of these lists were used to calibrate and normalize the data derived from the chromaticity analyses of the airborne imagery. The optical fingerprint of the Kraft Mill effluent is shown in Figure A-7.

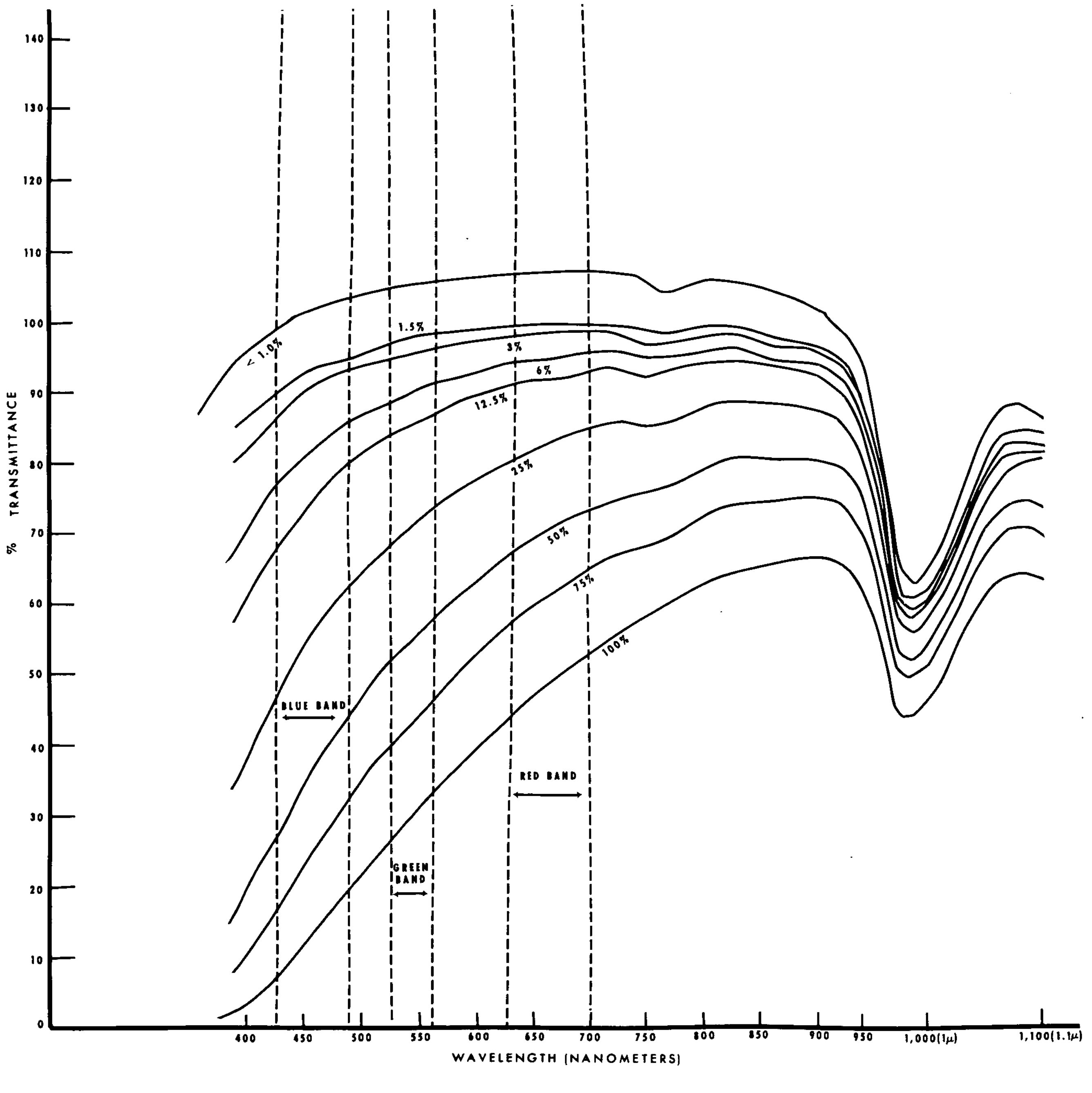
These data were obtained from sample transmittance lists performed in a Beckman DK-2A spectrophotometer. The test cell used for the sample had a 1 cm (0.4 in) optical path length. A tungsten light source was used with a lead sulfide (PbS) detector. An empty cell optically matched to the one containing the sample was placed in the reference optical path to differentially remove any effects imposed by the glass medium.

The optical fingerprint was plotted from 400 nanometers (nm) in the violet region of the visible spectrum through the red region 700 nm into the near-infrared stopping at 1.1 microns (1,100 nm). The "100% curve" is the spectral transmittance curve for the full-strength or undiluted effluent. The remaining curves are the transmittance curves for effluent concentrations ranging from 75% of full strength to less than 1%. As the sample was further diluted, the transmittance curve approached the 100% transmittance level in the blue, while in the red it doubled in value into a condition of minor fluorescence which is characteristic of water in this spectral band.

The regions marked blue, green and red are the spectral bands used by the laboratory densitometry equipment to carry out chromaticity measurements in the aerial imagery. The laboratory densitometer provided film (imagery) transmittance data in density units defined as $D=\log\left(\frac{1}{T}\right)$ where D, T are film density and film transmittance, respectively. As the film density increases, the film transmittance decreases, indicating the target area is becoming darker.



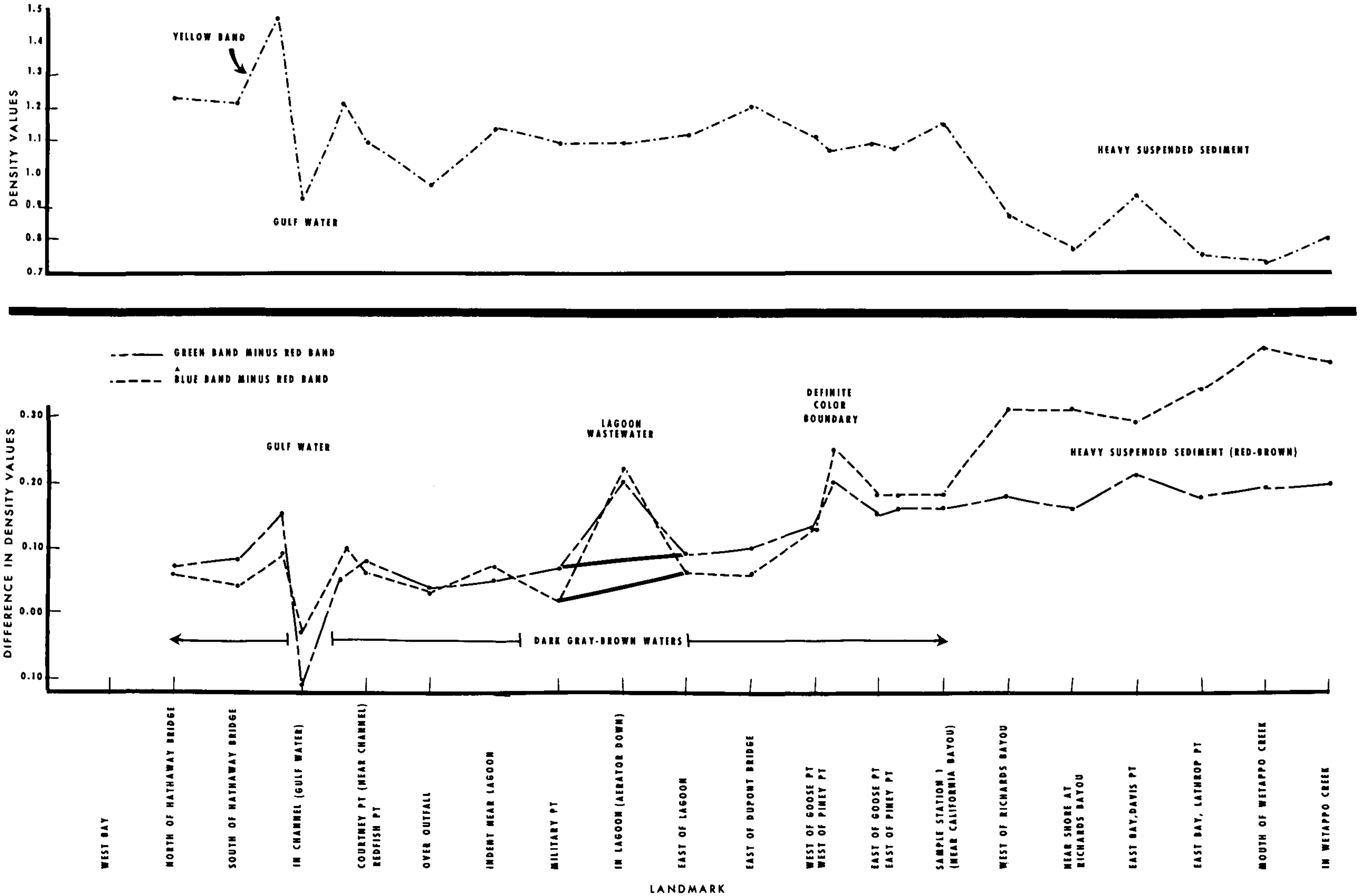
A-6. Bay County WWTP Lagoon Containing IPC Wastewater



A-7. Optical Fingerprint Of IPC Kraft Mill Effluent

As an indication of coloration in the St. Andrew Bay area, the color parameters "green minus red", and "blue minus red" were obtained from the respective optical testing locations in the imagery, having been chosen from the analysis of the blue, green and red regions of the optical fingerprint [Fig. A-7]. The fingerprint depicts the relationship between the red, green and blue transmittance values as a function of sample concentration carefully controlled in the laboratory. The "green minus red" and "blue minus red" parameters provide the relative variations in target color without having to consider the absolute (radiometric) levels of light recorded by the camera which were reflected from the target area. The aforementioned parameters, called color difference factors, were plotted as a function of predetermined landmarks within the overall target area, yielding a so-called "color difference diagram". The color difference diagram of this target area for the 19 Mar. 1975 flight is shown in Figure A-8. The diagram begins in the area north of the Hathaway Bridge extending eastward through St. Andrew Bay and East Bay into the Wetappo Creek Basin, with color analysis points included for the Gulf water and the IPC lagoon (Bay County WWTP) wastewater. The color profile of "blue-red" and "green-red" is nearly constant from the Hathaway Bridge to Military Point and then to the waters in the vicinity of Station 1 near California Bayou in the East Bay.

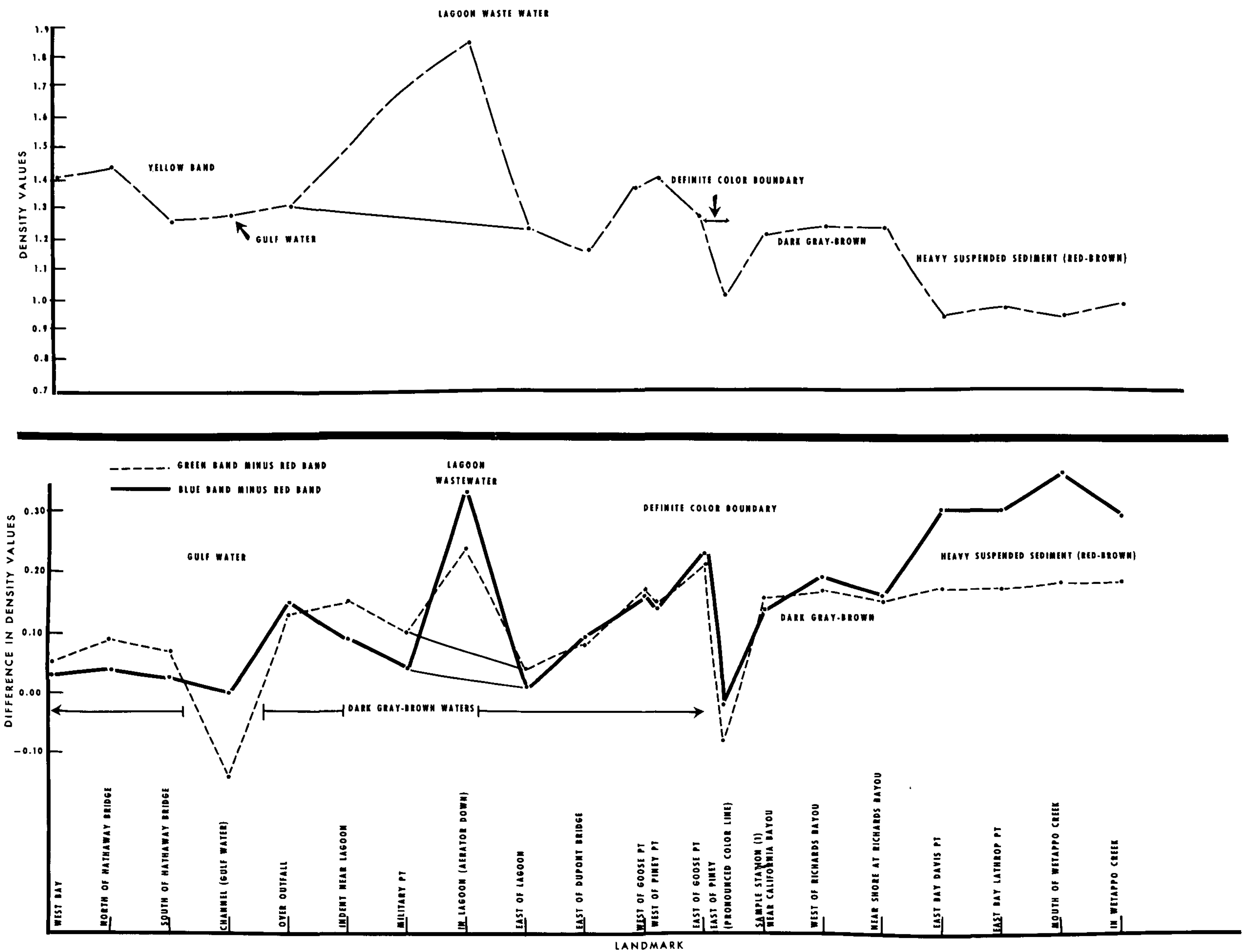
There was a marked change in color between the dark gray-brown Bay water and the blue-green Gulf water as indicated in the aerial imagery and by the dip of the color difference curve in Figure A-8. The lagoon wastewater produced a positve peak in the curve as would be expected because of the full-strength undiluted wastewater. The dark gray-brown effect in the East Bay waters peaked in the vicinity of Piney Point and Goose Point, most probably a result of tidal action and induced currents imposed by the northeasterly winds before and during the flight. A definite color demarcation appeared in the imagery between the west and east side of Station 1 [text Fig. 13]. To the east, the waters were



A-8. Color Diagram For St Andrew Bay 19 March 1975 heavily laden with suspended sediment from Wetappo and Sandy Creeks having a light red-brown color. West of the line, the water was dark gray-brown as in St. Andrew Bay. This caused the blue density value in the diagram to increase significantly (red scenes lack blue, thus causing the blue density to increase while the green region is closer to the red and was influenced to a much lesser degree). In summary, the St. Andrew and East Bay waters from Hathaway Bridge to Station 1 had a characteristic color directly related to the color of the IPC wastewater in the Bay County WWTP.

To verify the absolute levels of film exposure by the aerial cameras based on the scene reflectance directly below the aircraft, a broad band yellow or visual diagram was plotted [Fig. A-8]. It depicts that the light level at the water's near-surface region was nearly constant from the north side of Hathaway Bridge to Station 1. By exception, the water south of Hathway Bridge was darker gray-brown causing an increase in film density, while the Gulf water was significantly lighter in color causing the dip in film density. In the area of heavy suspended sediment, the light level increased due to scattering of sunlight by the suspended particles, giving rise to film densities considerably lower than those from the St. Andrew Bay waters.

A daylight mission was flown on 20 Mar. 1975 over the study area as before, this time including a small area of West Bay. These data were also subjected to the aforementioned chromaticity analysis. The "difference color diagram" for this mission is shown in Figure A-9. This diagram begins in West Bay extending through the area of the Hathaway bridge, St. Andrew Bay and East Bay into the Wetappo Creek basin, with color analysis points included for the Gulf Water and the IPC lagoon wastewaters. This color profile of "blue-red" and "green-red" shows some variation in the characteristic dark gray-brown color of the St. Andrew Bay area. It was nearly constant from West Bay into St. Andrew Bay.

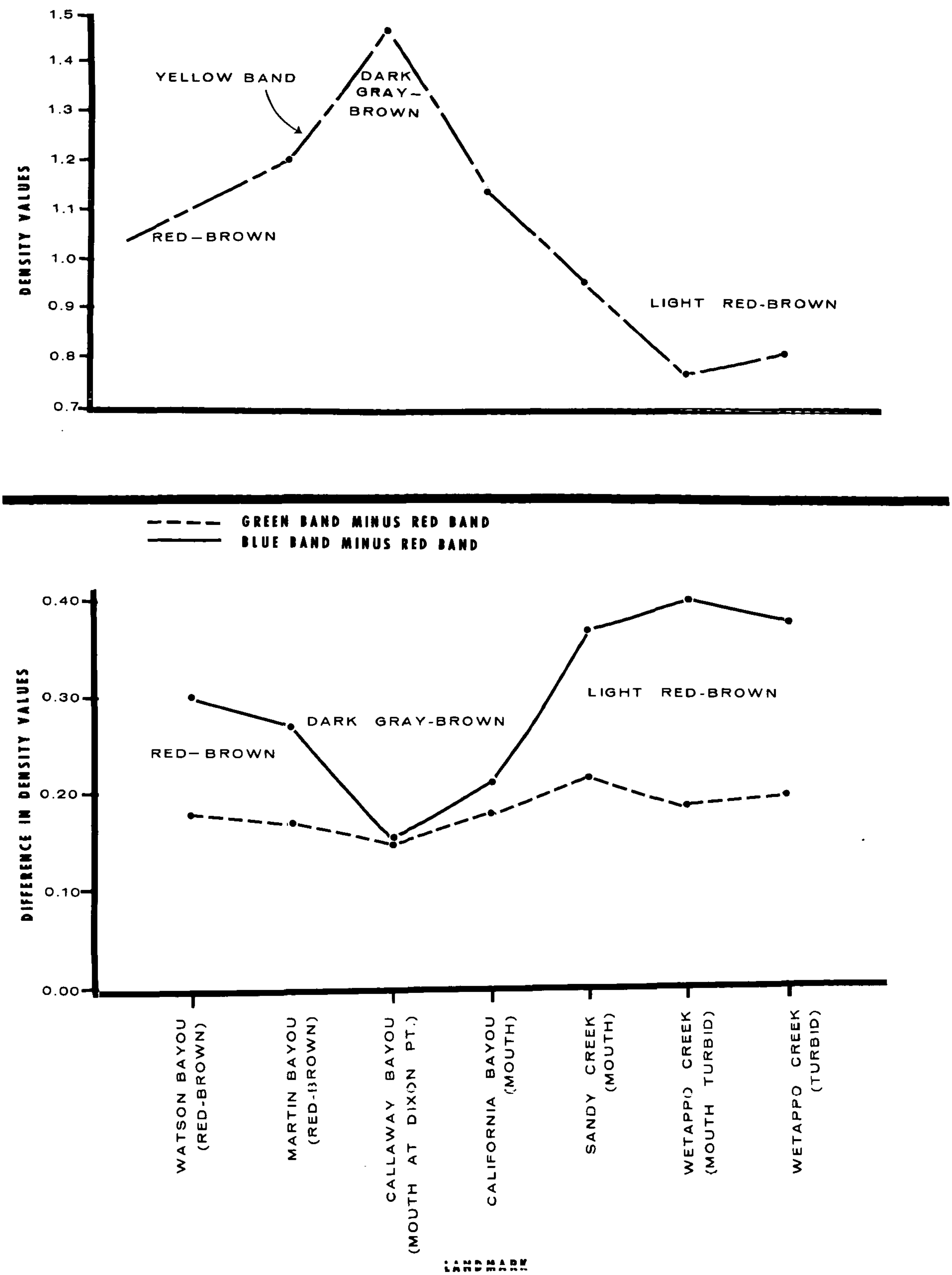


A-9. Color Diagram For St Andrew Bay 20 March 1975

The dark gray-brown effect increased over the location of the submerged outfall while decreasing to the previously mentioned levels around Military Point into East Bay near Ferry Point. From just east of Ferry Point to the Goose Point-Piney Point area of East Bay the color levels (dark gray-brown) increase gradually to the sharp or distinct color boundary that existed between these waters and the waters (west of Piney Point) heavily laden with suspended sediment. The waters from the area near Richards Bayou eastward in East Bay into Wetappo Creek were likewise heavily laden with suspended sediment as indicated by the spatially separated curves. The color of these waters was light red-brown which caused the blue film density ("minus red" condition as previously explained) to increase substantially. As an overall picture, the waters of West Bay, St. Andrew Bay waters from north of the Hathaway Bridge to East Bay and East Bay eastward to Piney Point-Goose Point displayed a characteristic color directly related to the color of the undiluted IPC wastewater present in the Bay County WWTP lagoon. The turbid waters in East Bay originated from Wetappo and Sandy Creeks.

A yellow film density diagram was plotted for the 20 Mar. flight [Fig. A-9]. It shows a decrease in film density (increase in target light level) from West Bay to the location over the submerged discharge. The density greatly increased (decrease in light level in the lagoon as compared to St. Andrew Bay to approximately 30% of that of the Bay) in the IPC lagoon water. Film density decreased significantly in the areas of Ferry Point and the Dupont Bridge, indicating greater reflectance of light from the water; it increased proceeding eastward in East Bay to the color line at which it dropped again. The water near California and Richards Bayous were dark gray-brown. From Davis Point eastward into Wetappo creek the yellow film density decreased to a nearly constant value. In this area the heavy suspended sediment increased the solar scattering induced by the suspended particles yielding greater light levels which were recorded by the airborne cameras.

The chromaticity analysis established that the dark gray-brown color found in West Bay, St. Andrew Bay and East Bay was directly related to that recorded in the IPC (Bay County WWTP) lagoon. The influent waters from the various creeks showed color characteristics different from this characteristic color. The imagery of several creeks was analyzed for respective color profiles, the results of which are plotted in Figure A-10 for 19 Mar. 1975. All included points show spatially separated curves with the exception of that obtained in East Bay near Dixon Point in the vicinity of Calloway Bayou. Waters in this area were dark gray-brown, again directly related to that of the lagoon. Similar results were achieved for the 20 Mar. 1975 flight.



A-10. Color Diagram For Various Creeks 19 March 1975

DEVELOPMENT PROCESSES FOR BLACK-WHITE AND COLOR RECONNAISSANCE FILMS

The film was processed in Eastman Kodak Company processors. The infrared and true-color Ektachrome films were processed in the Ektachrome RT Processor, Model 1811, Type M, Federal Stock Number 6740-109-2987PK, Part Number 460250. This machine uses Kodak EA-5 chemicals. The temperature of the respective chemicals in the processor and the film process rate, in ft/min, are the important parameters. Their values were specified as follows:

Prehardner	115°F
Neutralizer	115°F
First Developer	115°F
First Stop Bath	115°F
Color Developer	120°F
Second Stop Bath	120°F
Bleach	125°F
Fixer	120°F
Stabilizer	120°F

The film process rate was 9 ft/min. The nine chemical baths, mentioned above, comprise the EA-5 process used for the color films. The temperature and pressure of the fresh water supplied to the processor was 120°F and 45 psi minimum, respectively. The fresh water is used to wash the film immediately before entering the dryers.

FILM SPECTRAL SENSITIVITY DATA
OPTICAL FILTER TRANSMITTANCE DATA

The spectral curves for each film and optical filter used during this reconnaissance program are provided on the following pages:

SO-397 with HF3/HF5 filter combination
2443 with 16.

To obtain the optical band width B (λ) of each film-filter combination let $F(\lambda)$ be the transmittance function of the respective filter and $S(\lambda)$ be the spectral sensitivity function for the particular film. Then:

$$B(\lambda) = \int_{\lambda 1}^{\lambda 2} S(\lambda)\ F(\lambda)\ d\lambda.$$

APPENDIX B

BACTERIOLOGICAL AND CHEMICAL METHODS OF ANALYSIS

BACTERIOLOGICAL METHODS OF ANALYSIS

Bacteriological analyses of total and fecal coliform bacteria were performed according to standard techniques.[11] Using aseptic techniques, all samples were collected in sterile bottles prepared by the accepted procedure.

Salmonella sampling involved placement of several sterile gauze pads at the sampling site for 5 days. The pads were retrieved aseptically, placed in sterile plastic bags, chilled, and transported to the laboratory within 6 hr for analyses. There is no standard procedure for detection of *Salmonella* in surface waters. The method employed by NEIC is the elevated temperature technique of Spino[14] with modifications. Selective enrichment media included dulcitol-selenite broth and tetrathionate broth. Incubation temperatures were 35 and 41.5°C (95 and 107°F). On each of four successive days the growth in each of the enrichment media containing the pads was streaked onto selective plating media that consisted of brilliant-green and xyloselysine-deoxycholate agars. After a 24 hr incubation period at 35°C, colonies with characteristics typical of *Salmonella* were picked from the plates and subjected to biochemical and serological identification.

CHEMICAL METHODS OF ANALYSIS

Field analyses were performed twice daily on four parameters: dissolved oxygen, water temperature, pH, and salinity. Except for dissolved oxygen these analyses were performed at the sampling sites.

Dissolved oxygen samples were fixed at the sampling stations and titrated by the Winkler method within 2 hr. All analytical procedures were as defined in Standard Methods.[11]

Samples for lignin-tannin determination were sent to the chemical laboratory NEIC-Denver. Analysis was performed spectrophotometrically as prescribed in Standard Methods.[11]

Color analysis was performed on duplicate samples both in the field (using a Bausch and Lomb Mini-Spec 20) and with a Beckman DK-2A spectrophotometer at the Remote Sensing Laboratory, NEIC.