NASA TECHNICAL MEMORANDUM

NASA TM X-74005

NASA TM X-74005

A SUMMARY OF THE TEST PROCEDURES AND OPERATIONAL DETAILS OF A DELAWARE RIVER AND AN OCEAN DUMPING POLLUTION MONITORING EXPERIMENT CONDUCTED AUGUST 28, 1975

By

Warren D. Hypes and Craig W. Ohlhorst

February 1977

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

LANGLEY RESEARCH CENTER, HAMPTON, VIRGINIA 23665

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NASA TM X-74005		

4. Title and Subtitle	5. Report Date
A Summary of the Test Procedures and Operational Details of a Delaware River and an Ocean Dumping Pollution Monitoring Experiment Conducted August 28, 1975	February 1977
	6. Performing Organization Code 65.300
7. Author(s) Warren D. Hypes and Craig W. Ohlhorst	8. Performing Organization Report No.
	10. Work Unit No. 176-30-31-05
9. Performing Organization Name and Address National Aeronautics and Space Administration Langley Research Center Hampton, VA 23665	11. Contract or Grant No.
	13. Type of Report and Period Covered Technical Memorandum
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, D.C. 20546	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

On August 28, 1975, two remote-sensor evaluation experiments were conducted. One experiment was conducted at the DuPont acid dump site off the Delaware coast. The second was conducted at an organic waste outfall in the Delaware River. The operational objective of obtaining simultaneous sea-truth sampling with remote-sensor overpasses was met. Descriptions of the test sites, sensors, sensor platforms, flight lines, sea-truth data collected, and operational chronology are presented.

17. Key Words (Suggested by Author(s)) (STAR category underlined)	18. Distribution Statement
Pollution Monitoring, Remote Sensing, Ocean Acid Dumping, River Industrial Waste Dumping, Multispectral Scanner, Spectrometer, Camera System 43	Unclassified - Unlimited

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price*
Unclassified	Unclassified	41	$4.00

*Available from The National Technical Information Service, Springfield, Virginia 22151

A SUMMARY OF THE TEST PROCEDURES AND OPERATIONAL DETAILS OF A DELAWARE RIVER AND AN OCEAN DUMPING POLLUTION MONITORING EXPERIMENT CONDUCTED AUGUST 28, 1975

Warren D. Hypes and Craig W. Ohlhorst
Langley Research Center

SUMMARY

On August 28, 1975, two remote-sensor evaluation experiments were conducted by the National Aeronautics and Space Administration and the University of Delaware, College of Marine Science. One experiment was conducted at an acid dump site off the Delaware Coast. Remote sensors flown over the test site included a Bendix Multispectral Scanner (M^2S) and a Hasselblad camera aboard a Cessna 310 aircraft; a Tektronix Rapid Scanning Spectrometer (RSS) and a Hasselblad camera aboard a Huey UH1-B helicopter; a Multichannel Ocean Color Sensor (MOCS); a Precision Radiation Thermometer (PRT-5); a four Hasselblad camera system aboard a C-54 aircraft; another M^2S and an Airborne Multispectral Photographic System (AMPS) aboard a P3-A aircraft; and a radiometer aboard the Landsat II spacecraft. The operational objective of obtaining simultaneous sea-truth sampling with overpasses of the instruments aboard the Cessna 310 and the UH1-B helicopter was met. Data from nine sea-truth stations were collected concurrent with overpasses of the Cessna 310, and five sea-truth stations were collected concurrent with overpasses of the UH1-B.

A second experiment was conducted at an organic waste outfall in the Delaware River. Remote sensors flown over this site included those aboard the Cessna 310 and P3-A aircraft. The operational objective of accomplishing an overpass of the Cessna 310 during the period of river-truth sampling was met. Thirteen river-truth stations were established during the 1-hour period immediately prior to the overflight and eight were established during the 1/2-hour period immediately after the overflight.

All sensors were operational; however, channel 1 of the M^2S sensor aboard the Cessna 310 and four of the channels of the M^2S sensor aboard the P3-A produced poor digital data.

Descriptions of the test sites, sensors, sensor platforms, flight lines, sea-truth data collected, and operational chronology are presented.

INTRODUCTION

The Environmental Protection Agency (EPA) and the National Aeronautics and Space Administration (NASA) approved an Interagency Agreement[1] that established an effort to develop techniques for monitoring the dumping and discharging of chemical pollutants into coastal zone waters. Subsequently, the NASA issued a grant[2] to the University of Delaware (UD) College of Marine Sciences, to assist NASA in the planning, conducting, and analysis of field tests of selected remote sensors which are candidates for monitoring instruments. On August 28, 1975, two remote-sensing experiments were conducted by NASA, UD, and cooperating commercial firms. Simultaneous with the overflights of aircraft and spacecraft platforms carrying remote sensors, sea-truth samples were taken to support the calibration and analysis of the remote-sensor data.

The purpose of this report is to document the operations of the two experiments and provide a reference of factual data to be used by scientists during experimental data analysis.

PART I - OCEAN/ACID DISPOSAL

Material and Location

The material disposed was an acid waste product resulting from a titanium dioxide production plant operated by DuPont at Edgemoor, Delaware. Chemically, the material was hydrochloric acid with a high concentration of iron present as ferric chloride. Other impurities were also present.

The waste material was loaded into a barge at the DuPont facility, and the barge was towed to the disposal site by tugboat. The disposal is conducted under permit granted by the Environmental Protection Agency. The disposal site is east of Lewes, Delaware, and is located and sized as shown in figure 1. The disposal method is a bottom discharge from the barge typically in a figure eight pattern. The tugboat's speed and the maximum dump rate are specified by the disposal permit. The waste plume resulting from the barge discharge on August 28, 1975, is the material investigated in the test.

Participants and Roles

The participants and their roles were as follows:

---

[1] EPA/NASA IAG-0245, "Interagency Agreement between the National Aeronautics and Space Administration and the Environmental Protection Agency for the Purpose of Conducting Tests with Remote Sensors for Environmental Monitoring."

[2] NASA Grant NSF-1149 "Determination of Spectral Reflectance Signature of Coastal Pollutants."

University of Delaware, College of Marine Studies

Test organization and direction

Site selection

Coordination of participants

Test planning

Secure sea-truth ship

Collect sea-truth data

M^2S data analysis

Landsat II data analysis

Bendix Corporation

Supply and operate the Cessna 310 aircraft

Supply and operate the M^2S

M^2S data processing

DuPont, Edgemoor Facility

Coordinate acid dump with test plan

Provide acid waste sample for laboratory chemical and spectral studies

Research Vessel (R/V) Annandale

Provide ship, ship's crew, and sample collection devices for collecting sea-truth data

NASA, Langley Research Center

Coordinate NASA participation

Supply the RSS flown on the Huey UH1-B helicopter

Supply the MOCS flown on the C-54 aircraft

Assist in collection of sea-truth data

Chemical/physical analysis of sea-truth samples

M^2S data analysis

RSS data analysis

MOCS data analysis

Landsat II data analysis

Laboratory chemical and spectral studies of acid waste sample

NASA, Wallops Flight Center

Supply the C-54 aircraft and Huey UH1-B helicopter and flight crews

Supply the Hasselblad camera package and the PRT-5 aboard the C-54

NASA, Johnson Space Center

Supply the Lockheed P3-A aircraft, aircraft crews, and all equipment aboard the P3-A

Aircraft, Watercraft, and Sensors

The following aircraft and sensors were utilized in the test:

C-54 (NASA 427)

The C-54 aircraft is stationed at Wallops Flight Center and was staged from that location. It carried a crew of three plus a research engineer. Sensors carried on the aircraft included the MOCS, PRT-5, and a four Hasselblad camera package. Each camera was equipped with a different optical filter. Technical data describing the MOCS, PRT-5, and the Hasselblad camera package are given in tables I, II, and III, respectively.

HUEY UH1-B (NASA 424)

The helicopter is stationed at the Wallops Flight Center and was staged from the municipal airport at Rehoboth Beach, Delaware. It carried a crew of two. Sensors carried on the aircraft included a Tektronix RSS and a Hasselblad camera equipped with an optical filter. The spectrometer is a laboratory instrument that was modified by NASA personnel and adapted to an external attachment under the helicopter. The attachment can be seen in figure 2. Technical data describing the spectrometer and the camera are given in table IV.

Cessna 310 (Bendix Corp.)

The Cessna 310 is owned and operated by the Bendix Corporation of Ann Arbor, Michigan. The aircraft is located at Ann Arbor, Michigan, and was staged from the municipal airport at Wilmington, Delaware. It carried a crew of two. Sensors carried on the aircraft included the Bendix M^2S and a Hasselblad camera equipped with color film and a haze filter. These instruments are described in table V.

Lockheed P3-A (NASA 927)

The P3-A aircraft is stationed at the Johnson Space Center and was staged from the Langley Research Center, Hampton, Virginia. It carried a crew of five. Sensors carried on the aircraft included a Bendix M^2S similar to the one aboard the Cessna 310 and described in table V, the AMPS system, and two Zeiss cameras with optical filters. The AMPS system and Zeiss cameras are described in table VI.

R/V Annandale

The R/V Annandale is a 27.4 meters (90-ft.) research vessel owned by the Marine Science Consortium, Inc., of Millersville, Pennsylvania. The vessel stages from the Delaware Bay Marine Science Center in Lewes, Delaware. It carries a crew of four.

The Annandale provided the platform for obtaining the sea-truth samples, and it served as the field command post. Instruments and devices carried by the Annandale and used for this test included a bathermograph, Niskin sampling bottles and hoist, anenometer, depth finder, Sun inclinometer, and LORAN A and C navigation systems.

Test Operations

Operational Objectives

The primary objective of the test was to obtain as many sea-truth data stations as possible and have each data collection occur simultaneously with an overpass of the aircraft (Cessna 310) with the Bendix M^2S spectrometer aboard and the helicopter (UH1-B) with the Tektronix RSS aboard. The instruments aboard the C-54, P3-A, and Landsat II were supplemental and were included on the basis that an opportune target with supporting sea truth was available.

Chronology

The day of the test was August 28, 1975. The sequence began at approximately 1800 EDT on August 27 at which time the acid waste barge and tugboat left the DuPont-Edgemoor Facility. At 0200 EDT on August 28, the R/V Annandale left Lewes, Delaware, and proceeded to the dump area. The R/V Annandale served as a sea-truth ship and test command post. In route to the dump area, the Annandale overtook the dump barge and followed the barge to the dump area. The barge began the dump at 0650 EDT with the Annandale standing by awaiting arrival of the aircraft. The timing of the events that followed is given in table VII. The test plan specified that the C-54 aircraft would arrive at the test site prior to the 0900 EDT start time in order to guide the R/V Annandale to the waste plume. This planned timing was accomplished and would have been vital to the success of the mission had not the R/V Annandale witnessed the beginning of the dump and was, therefore, aware of the location of the plume. Upon arrival at the plume, the red/brown (rust) color of the waste was easily detected by the eye. Prior to the first data station, the R/V

Annandale accomplished a rapid crossing of the plume for obtaining a surface sample for pH analysis. To prevent acid damage to the ships equipment, the test protocol prohibited operations in waters with a value less than pH 6.0. A value of pH 6.8 was the lowest recorded in the section of the plume being studied.

The test plan specified that the initial data station be taken at 0900 EDT to coincide with the arrival of the helicopter and the Cessna 310. The helicopter would operate at an altitude of 609.6 meters (2,000 ft.) and the Cessna 310 at 914.4 meters (3,000 ft.). The C-54 would operate at 2590.8 meters (8,500 ft.) and 5,334 meters (17,500 ft.). The operations of the spectrometers aboard the two aircraft were independent of each other. It was planned, however, that the helicopter and Cessna 310 aircraft make concurrent passes over the sea-truth ship thus making one sea-truth data station suffice for both. Due to difficulty in controlling exact arrival times of the two aircraft, only one data station was common to both although the objective of obtaining sea-truth data simultaneously with overflights was maintained for the two aircraft independent of each other. A list of the data stations and craft that were over the site when each station was being visited is given in table VIII.

Data Stations and Samples Collected

Each data station, except station 1-2, was taken in the center of the plume. Station 1-2 was taken outside the plume in typical ocean water to serve as a baseline. Locations of the data stations were selected onsite based on timing considerations. The resulting locations are listed in table IX and are shown in their relative positions on figure 3. The sketch of the waste plume shown on figure 3 was scaled from a Landsat II image and depicts the actual orientation and shape of the plume. Onsite data were taken at selected stations and samples were taken at each station for laboratory analysis at a later time. Samples for laboratory analyses were taken with the Annandale's hoist and Niskin bottle sampling system. All samples were packed in ice immediately after collection and were retained on ice until arrival at the respective laboratory (Langley Research Center or University of Delaware). Samples taken for chlorophyll analysis were filtered upon arrival at the shore station, and the chlorophyll retaining filters were placed in black petri dishes and returned to refrigeration until analysis. Onsite data and laboratory samples taken at the data stations are listed in table X.

Other samples collected included a 3.785 liter (1-gal.) container of undiluted acid taken from the pipe line loading the acid waste barge and an 18.925 liter (5-gal.) container of seawater from an area near but outside of the discharge waste. These two samples were for use in laboratory dilution and spectral analysis studies conducted in support of the remote sensor tests.

Flight Lines

Three flight lines were accomplished by the helicopter at each data station. All flight lines were flown at an altitude of 609.6 meters (2,000 ft.) and each line crossed the plume at right angles to the center line of the plume. The three flight lines at any single station were flown in the same direction. The helicopter was limited to 45 to 55 minutes onsite. Data stations, therefore, had to be taken relatively close together in an attempt to maximize the number of data stations taken during the short onsite time periods. During the morning helicopter flight, two data stations were secured and during the afternoon flight, three data stations were secured.

The Cessna 310 flight lines are shown in figure 4. Line 1 was a photographic run flown at 3962.4 meters (13,000 ft.) to begin the morning period. Lines 2-8 were in support of the multispectral scanner and were flown during the morning period at 914.4 meters (3,000 ft.). Lines 10-11 were photographic runs flown at 3962.4 meters (13,000 ft.) to begin the afternoon period. Lines 12-14 were flown at 914.4 meters (3,000 ft.) in support of the multispectral scanner. The headings and time duration of the flight lines were selected at the discretion of the aircraft crew to minimize problems with Sun glint. The single requirement for the flight lines was that the lines should pass immediately over the sea-truth ship while the ship was on location at the respective data station. The lengths and direction of the flight lines shown in figure 4 were inferred from the screening imagery (black and white film print of band 5) taken from the M2S.

The C-54 flight lines are shown in figure 5. The altitudes were selected prior to the flight. The sequence and headings were selected at the discretion of the aircraft crew. They were selected to coincide with events taking place during the dump period and with activities on the sea-truth ship.

The P3-A flight lines are shown in figure 6. Coordinates of the beginning and ending of the flight lines are listed on table XI. The aircraft was a late addition to the test by the University of Delaware. The area of primary interest for the P3-A was the western shores of the Delaware Bay; however, one line was flown over the acid dump site.

The Landsat II spacecraft passed over the ocean dump site area at approximately 1055 EDT. It is in a Sun synchronous orbit at an altitude of 911 kilometers (492 nm). The orbital overpass of the test site is depicted in figure 7. The appropriate imagery identification number is NASA ERTS E-2218-14552.

PART II - RIVER/ORGANIC WASTE DISPOSAL

Material and Location

The material disposed was a variable mixture of liquid organic wastes and cooling tower water resulting from an organic materials production plant operated by the DuPont Chambers Works at Deepwater Point, New Jersey. The disposal is conducted under permit granted by the Environmental Protection Agency. The disposal site is along the eastern shore of the Delaware River immediately north of the Delaware Memorial Bridge. The location is shown in figure 8. The waste material is discharged from a surface pipeline jetty extending into the Delaware River.

Participants and Roles

The participants and their roles were as follows:

University of Delaware, College of Marine Studies

- Test organization and direction
- Site selection
- Coordination of participants
- Test planning
- Provide river-truth boat and crew
- Collect river-truth samples

Bendix Corporation

- Supply and operate the Cessna 310 aircraft
- Supply and operate the M^2S
- M^2S data processing

DuPont, Chambers Works

- Provide organic waste sample for laboratory dilution and spectral studies

City of Wilmington, Delaware

- Provide two transit sites for locating river-truth boat (Marine Terminal and City Landfill)

NASA, Langley Research Center

Coordinate NASA participation

Assist in the collection of river-truth samples

Provide transit operators

Chemical/physical analysis of river-truth samples

M^2S data analysis

Conduct laboratory chemical and spectral studies of organic waste sample

NASA, Johnson Space Center

Supply the Lockheed P3-A aircraft, aircraft crews, and all equipment aboard the P3-A

Aircraft, Watercraft, and Sensors

The following aircraft and sensors were utilized in the test:

Cessna 310 (Bendix Corp.)

The aircraft, instrumentation, and flight crews were the same as those described in PART I - OCEAN/ACID DISPOSAL.

Lockheed P3-A (NASA 927)

The aircraft, instrumentation, and flight crews were the same as those described in PART I - OCEAN/ACID DISPOSAL.

Ski Boat

The Ski Boat is a 5.8 meters (19 ft.) outboard runabout owned by the University of Delaware, College of Marine Sciences. It carried a crew of four.

The Ski Boat provided the platform for obtaining the river-truth samples, and it served as the field command post. Instruments used in this test included a secchi disc, a depth finder, and plastic bottles for storing water samples in an ice chest.

Test Operations

Operational Objectives

The primary objective of the test was to obtain one or more overpasses of the Cessna 310 with the M²S instrument aboard during the period of river truth sampling. The P3-A aircraft was supplemental and was included on the basis that an opportune target with supporting river truth was available.

Chronology

The day of the test was August 28, 1975. The sequence began at approximately 1000 EDT on the 28th. Between 1000 and 1100 EDT, two transit operators were stationed on the western shore of the Delaware River across from the eastern shore test site. One operator was stationed on property controlled by the city of Wilmington Marine Terminal. The second operator was stationed approximately 2.04 kilometers (1.27 mi.) south of the first operator on property controlled by the City of Wilmington Landfill Authority. The location of the two transit sites are shown in figure 9. After transit locations were established, bearings were taken on seven fixed location references to provide the data for locating the transit stations on maps or photographs. The fixed location references are shown in figure 9. The two transit operators then awaited the start of sampling operations. Bearings were taken on the river-truth boat at each data station. Transit operators recorded bearings upon observing a flag signal from the boat crew that a data station was in progress. The P3-A aircraft flew over the test site at 1030 EDT. The river-truth boat left the city dock at 1140 EDT and proceeded to the area of the waste plume. Prior to the taking of data, the boat crew moved throughout the area and established a sampling procedure. The collection of data began at 1300 EDT. The timing of events that followed is given in table XII.

The test plan specified that the Cessna 310 overflight of the test site would occur at approximately 1330 EDT. The aircraft was to notify the river-truth boat as the aircraft began its flight up the Delaware Bay in a northerly direction thus giving the river-truth boat time to begin sampling just prior to the overflight. Communications were not achieved and, therefore, sampling began at approximately 1300 EDT based on the anticipated 1330 EDT arrival. Twelve data stations and a control data station outside of the plume were established between 1300 EDT and 1332 EDT. At 1332 EDT, the overflight had not taken place and communications had not been established. Sampling was halted awaiting arrival of the aircraft. At 1410 EDT, the first of two overflights occurred. The flight line is shown in figure 10. The flight line passed over the test site and at its northern most point, passed adjacent to the acid holding ponds from which the ocean/acid waste material was removed for ocean disposal. Upon observing the arrival of the aircraft, the river-truth boat moved back into the waste plume and established eight more data stations between 1410 and 1427 EDT. During the second sampling period, the aircraft made a second overpass of the area passing along the eastern shore of the river as shown in figure 10.

A list of the data stations and the overflying aircraft that were onsite during collection of the data is given in table XIII.

Data Stations and Samples Collected

Each data station, except the control, was taken in the plume. The control station was taken outside the plume in typical river water to serve as a baseline. Locations of the data stations were selected onsite to maximize the number of different concentrations of the organic waste plume. The resulting locations are listed in table XIV and are shown in their relative positions in figure 11. Station 20 was not plotted because no bearing was taken with transit B.

In situ data taken consisted of Secchi disc and total depth. Three surface samples were also taken at each station. The samples were taken by hand with 1-liter plastic bottles. All samples were packed in ice immediately after collection and were retained on ice until arrival at the respective laboratory (Langley Research Center or University of Delaware). Samples taken for chlorophyll analysis were filtered upon arrival at the shore station and the chlorophyll retaining filters were placed in black petri-dishes and returned to refrigeration.

Another sample collected included a 3.785-liter (1 gal.) container of undiluted organic waste taken from the pipeline leading to the discharge point. The sample was collected by DuPont personnel at 1330 EDT and was timed to coincide with the expected time of the aircraft overpass. This sample was to be used for laboratory chemical and spectral analysis experiments in support of the remote sensor test.

Flight Lines

The two Cessna 310 flight lines are shown in figure 10. Both lines were flown at 1219.2 meters (4,000 ft.). The multispectral scanner and Hasselblad camera were operating during both overflights. The heading and time duration of the flight lines were selected at the discretion of the aircraft crew to minimize Sun glint. The pretest requirement was for one flight line that would fly upriver (northeast), pass over the organic waste plume in the river, and include the acid waste holding ponds on the west bank. The acid dumped at the offshore test site was extracted from these ponds during the previous day. The flight requirement was met with line number 1. A second flight line was flown downriver (southwest) along the eastern shore to assure good coverage of the organic waste plume. The length and direction of the flight lines shown in figure 10 were inferred from the screening imagery taken from the M^2S.

The P3-A aircraft flew one flight line over the river test site. The flight line is shown in figure 6 as line 11. The flight occurred approximately 2 1/2 hours prior to the river sampling operation.

PART III - OBSERVATIONS AND RECOMMENDATIONS

As in most field tests that include complex operational procedures involving separate but related activity groups, deficiencies in procedures are observed and unforeseen problems arise. Some of the more important deficiencies and problems encountered along with recommendations for overcoming them are listed below for use in planning similar tests at future dates.

General

Sea-Truth Ship Arrival Time

If the experiment involves an ocean dump of a pollutant, it is desirable to have the sea-truth ship on location during some portion of the actual dump period. Preferably, the sea-truth ship should witness the initiation of the dump. By being on location, the timing and pattern of the dump sequence can be recorded and dispersion patterns and color changes can be observed.

The presence of several remote sensors on separate aircraft platforms increases operational complexity and makes it difficult to secure the sea-truth data that each remote sensor engineer desires. Conflicting requirements for sea-truth ship time arise. This is true, however, only when the sea-truth ship must cater to more than one aircraft platform. If the test protocol can cater to one aircraft platform and have other platforms with sensors make use of the established test plan, the total test can be made more productive.

Instrumentation and Equipment

Instrumentation and equipment to be used onboard a ship or boat should be evaluated for compatibility with the vessel prior to the test. Vessel features such as available power, hoist capabilities, work area, storage space, etc., will influence collection and validity of data.

Specific
(Ocean/Large Ship/Well Defined Plume)

Test Crew -- Data Recorder

It is desirable to have one crewman assigned only the task of data recorder. In addition to completing prepared forms, he can observe and record additional facts that aid data analysis. Typical examples of useful details include; exact time of aircraft overpass of the ship, ship orientation in the plume, streaking of the plume, temporary changes in sky and sunlight conditions (passing cloud), unusual wind gusts, and difficulty with one or more specific instruments at a given location.

Test Crew - Unassigned Person

It is desirable to include one crewman that is not assigned a specific task. There are occasional time critical needs for extra help on specific tasks. The unassigned person can assist in these tasks as needs arise.

Sampling Technique

The technique of moving the ship into the exact location of a data station and then commencing the sampling sequence can lead to an improper sample location. In the time required to rig and deploy the sampling system, the ship may drift off location. Sampling systems need to be made ready upwind from the data station and triggered when the ship is on exact location, i.e., centerline or most concentrated area of plume.

Sample Containers

The flexible, inflatable, 1 quart plastic containers utilized during the 1975 test are not desirable. Before being filled, they are easily blown around the deck. After being filled and stacked in an ice chest or other large container, they are easily ruptured. Heavier, rigid containers are more adaptable to ocean operations.

Samples from Niskin Bottles

The storage time of Niskin bottles in the storage rack may affect the content of subsamples from the bottle when samples involve particles such as precipitated ferric chloride. Prior to withdrawing subsamples, the Niskin bottle should be vigorously shaken.

Chlorophyll Samples

The filtering of chlorophyll samples is very time consuming when the samples contain a large quantity of particulates. If chlorophyll samples are to be included, adequate shipboard or shore time must be allocated for that task.

Communications

Communications are a vital link in a complex test requiring close coordination between separate activity groups. Pre-established procedures are necessary and extraneous conversation is to be avoided. After the test was completed, it was noted that voice communication interferred with some channels in the Bendix M-S instrument. Communications are to be avoided during actual data runs. If possible, only one person should function as the ship's communicator since the variation in techniques practiced by different communicators may be confusing to aircraft crews.

Specific
(Inland/Small Boat/Poorly Defined Plume)

Plume Characteristics

If a tidal estuary is to be investigated, it would be useful to visit the plume under different current and tidal conditions prior to the test. Prior knowledge of typical plume boundaries, flow patterns, etc., would be useful in test planning. Aerial photographs of the plume would be especially useful.

Baseline Data

Pretest sampling and chemical analysis of a tidal estuary industrial waste plume would be useful in test planning. Some prior knowledge of major chemical species present would assist sample collection, processing, and analysis.

TABLE I.-MULTICHANNEL OCEAN COLOR SENSOR (MOCS)

Description

- Visible imaging spectroradiometer

Spectral Characteristics

- Total range of 400 to 700 nanometers
- Separated into 20 bands of 15 nanometers each

Operational Characteristics at Altitude of 5,334 meters (17,500 ft.)

- Swath width of 1,600 meters (5,250 ft.) - 150 spectra/swath
- Field of view - 17.1 degrees
- Instantaneous surface resolution - 10.7 x 21.3 meters (35 x 70 ft.)

Data Characteristics

- Measures spectral intensities of light from each of 150 spatial sites
- Output fed to A/D converter and stored on magnetic tape

Applications

- Designed for measurements of small differences in ocean color from aircraft or spacecraft

TABLE II.-PRECISION RADIATION THERMOMETER (PRT-5)

Description

- Thermal - infrared radiometer

Spectral Characteristics

- Total range of 800 to 1400 nanometers
- Single bandpass filter, use of full range as one band

Operational Characteristics

- Swath width of 10.7 meters (35 ft.)/304.8 meters (1,000 ft.) altitude
- Field of view - 2 degrees
- Instantaneous surface resolution - Circle with diameter of 10.7 meters/ 304.8 meters altitude

Data Characteristics

- Measures thermal - infrared radiations
- Temperature resolution - $\pm 0.5^{\circ}C$
- Output of 0 to 5 volts analog multiplexed and recorded on magnetic tape

Applications

- Provides a target temperature reference

TABLE III.-HASSELBLAD CAMERA PACKAGE

Camera	Focal length (millimeters)	Filter	Wave Length (nanometers)	Film Format (millimeters)	Film Type[1]
Hasselblad	40	5543 (green)[2]	540-580	70	2402 black/white
Hasselblad	40	5250 (blue-green)[2]	500-550	70	2402 black/white
Hasselblad	40	12 (yellow)[3]	500-700[4]	70	2402 black/white
Hasselblad	40	89B (near IR)[3]	690-900[4]	70	2424 black/white

Operational Characteristics

- Surface coverage - 419.1 meters (1,375 ft.)/304.8 meters (1,000 ft.) altitude
- Field of view - 88 degrees
- Instantaneous surface resolution - 0.38 meters (1.25 ft.) x 0.38 meters/304.8 meters altitude

[1]Kodak Film number
[2]Baird - atomic B-3 optical filter
[3]Kodak - Wratten optical filter number
[4]Cut-off by film characteristics

TABLE IV.-RAPID SCANNING SPECTROMETER WITH 300 mm TAMRON LENS
AND
HASSELBLAD CAMERA

Rapid Scanning Spectrometer

Description

- Scanning spectrometer containing a Czerny-Turner monochromator w/2 gratings, a silicon-vidicon detector, and electronics

Spectral Characteristics

- Total range of 300 to 1100 nanometers
- Range with grating A (150 lines/mm)

  300 to 700, 400 to 800, 500 to 900, 600 to 1000, 700 to 1100 nanometers
- Range with grating B (1200 lines/mm)

  40 nanometer window variable from 300 to 1100 nanometers
- Resolution

  with grating A - 4.0 nanometers

  with grating B - 0.4 nanometers

Operational Characteristics

- Swath width of 14 meters (46 ft.) at altitude of 609.6 meters (2,000 ft.) with telephoto lens.
- Field of view - 1.3 degrees w/300 mm telephoto lens
- Instantaneous surface resolution - 14 meters (46 ft.) x 0.9 meter (3 ft.)

Data Characteristics

- Measures radiant energy at different spectral wavelengths
- Voltage output of analog signal stored on magnetic tape

Applications[1]

- Laboratory and low altitude determinations of spectral signatures

TABLE IV. CONCLUDED.

Hasselblad Camera[2]	
Focal length	40 mm
Film format	70 mm
Film number	Kodak 2402 black/white
Filter	Kodak-Wratten 12
Shutter speed	1/250 sec.
F Stop	11

[1]Application by Langley Research Center. Consult manufacturer (Tektronix) for other applications.

[2]See Table III for operational characteristics

TABLE V.-MODULAR MULTISPECTRAL SCANNER
AND
HASSELBLAD CAMERA

Modular Multipsectral Scanner

Description

- Imaging spectrometer optics with reflection grating dispersing element
- 10-band silicon detector array

Spectral Characteristics

- Range - 380 to 13,000 nanometers
- Bands -

1.	380 - 440	7.	660 - 700
2.	440 - 490	8.	700 - 740
3.	495 - 535	9.	760 - 860
4.	540 - 580	10.	970 - 1060
5.	580 - 620	Thermal.	8,000 to 13,000
6.	620 - 660		

Operational Characteristics

- Swath width of 2.4 x altitude
- Field of view - 120 degrees (100 active plus 20 for roll compensation)
- Instantaneous surface resolution - 0.8 meter (2.5 ft.) x 0.8 meter/ 304.8 meters (1,000 ft.) altitude

Data Characteristics

- Measures radiant energy in 10 wavelength bands
- Voltage output of analog signal stored on magnetic tape

Applications

- Determination of spectral signatures and temperatures of Earth surface features

TABLE V.--CONCLUDED

Hasselblad Camera

Focal Length	50 mm
Film Format	70 mm
Film Number	Kodak 2448 color
Filter	Kodak-Wratten H-4
Shutter Speed	1/250 seconds
F Stop	5.6

Operational Characteristics

- Surface coverage - 335.3 meters (1,100 ft.)/304.8 meters (1,000 ft.) altitude
- Field of view - 75 degrees
- Instantaneous surface resolution - 0.3 meter (1.0 ft.) x 0.3 meter/ 304.8 meters altitude

TABLE VI.-AIRBORNE MULTISPECTRAL PHOTOGRAPHIC SYSTEM (AMPS) WITH ZEISS CAMERAS

Camera	Focal Length (inches)	Film			Shutter Speed (seconds)	F Stop	Filter Type	Wavelength (nanometers)
		Format (inches)	Number[1]	Emulsion[1]				
AMPS 3	6	2 1/4x2 1/4	2443	126-1	1/140	11	EE (Color IR)	520-880
AMPS 5	6	2 1/4x2 1/4	S0022	3-2	1/140	3.5	BB (Red)	600-700
AMPS 6	6	2 1/4x2 1/4	S0022	3-2	1/140	3.5	AA (Green)	500-600
Zeiss 1	6	9x9	S0397	52-1	1/400	Auto-matic	KL-36	400-700
Zeiss 2	6	9x9	2443	206-2	1/200	Auto-matic	C-60	510-900

Operational Characteristics - AMPS

- Surface coverage - 114.3 meters (375 ft.)/304.8 meters (1,000 ft.) altitude
- Field of view - 30 degrees
- Instantaneous surface resolution - 0.01 meter (0.03 ft.)/304.8 meters altitude

Operational Characteristics - Zeiss

- Surface coverage - 457.2 meters (1,500 ft.) 304.8 meters altitude
- Field of view - 94 degrees
- Instantaneous surface resolution - 0.04 meter (0.12 ft.) x 0.04 meter /304.8 meters altitude

[1]Eastman Kodak number

TABLE VII.-TIMING OF EVENTS OCEAN/ACID DISPOSAL SITE

Time (EDT)		Event
1800	8-27-75	Tug and barge depart DuPont Edgemoor Facility
0200	8-28-75	R/V Annandale depart shore station
0400		R/V Annandale rendezvous with tug and barge
0645		R/V Annandale arrive at test site
0650		Acid waste dump begin
0820		C-54 aircraft arrive test site
0835		UH1-B helicopter arrive test site
0849		Data station 1-0
0918		Data station 1-1A
0920		Cessna 310 aircraft arrive test site
0920		UH1-B helicopter depart test site
0943		Data station 1-1B
0956		P3-A aircraft overpass
1000		Data station 1-2
1035		Data station 2-1
1050		Data station 2-2
1055		Data station 2-3
1055		Landsat II overpass
1100		Data station 3-1
1105		Cessna 310 aircraft depart test site
1115		C-54 aircraft depart test site
1210		UH1-B helicopter arrive test site
1230		Data station 4-1
1237		Data station 4-2
1251		Cessna 310 aircraft arrive test site
1258		Data station 4-3
1300		UH1-B helicopter depart test site
1305		Data station 4-4
1326		Data station 4-5
1420		R/V Annandale depart test site
1800		R/V Annandale arrive shore station

TABLE VIII.-DATA STATIONS AND OVERFLYING CRAFT

OCEAN/ACID DISPOSAL SITE

Data Station	Time (EDT)	Overflying Craft				
		Cessna 310	Huey UH1-B	C-54	P3-A	LANDSAT II
1-0	0849		●	●		
1-1A	0918		●	●		
1-1B	0943	●		●		
1-2	1000	●		●		
2-1	1035	●		●		
2-2	1050	●		●		
2-3	1055	●		●		●
3-1	1100	●		●	●	●
4-1	1230		●			
4-2	1237	●				
4-3	1258		●			
4-4	1305	●	●			
4-5	1326	●				

Dot (●) indicates craft present during sea truth activities.

TABLE IX.-LOCATIONS OF DATA STATIONS

OCEAN/ACID DISPOSAL SITE

Station	Time (EDT)	Loran C Position[1]	Latitude	Longitude
1.0	0850	52173.8/70393.2[2]	38°33.6'N	74°22.9'W
1.1A	0920	52176.5/70387.4	38°34.0'N	74°23.9'W
1-1B	0943	52177.9/70386.2	38°34.2'N	74°24.4'W
1-2	1000	52182.0/70389.1	38°33.7'N	74°24.4'W
2-1	1035	52202.8/70406.0	38°31.2'N	74°24.0'W
2-2		No Data[3]		
2-3		No Data		
3-1	1100	52221.0/70405.8	38°30.6'N	74°26.0'W
4-1		No Data		
4-2	1237	52213.1/70392.5	38°32.2'N	74°27.1'W
4-3	1247	52210.1/70390.8	38°32.6'N	74°27.1'W
4-4	1259	52210.2/70390.7	38°32.6'N	74°27.1'W
4-5	1326	52203.9/70386.2	28°33.3'N	74°27.2'W

[1] Master Station is Cape Fear, North Carolina. Slave station is Nantucket Island, Mass. for 52,000 series numbers

[2] Numbers represent the time differentials in microseconds.

[3] Stations 2-2, 2-3, and 4-1 were short duration, surface samples only. Time did not permit obtaining position data.

TABLE X.- ONSITE DATA AND SAMPLES COLLECTED AT DATA STATIONS

OCEAN/ACID DISPOSAL SITE

Data Station	Age of Plume When Sampled (Hrs:Min)	Onsite Data Collected											Samples For Laboratory Analyses (Depth at Which Taken-Meters)											
													Chlorophyll				Sediment				Chemical and Physical			
		Wind Speed	Wind Direction	Sea State	Sky Condition	Sun Angle	Downwelling Irradiance In Air[2]	Upwelling Radiance[2]	Secchi Depth	Water Depth	pH	Bathythermograph Cast	0 (Surface)	2	4	8	0	2	4	8	0	2	4	8
1-0	1:46	•	•	•	•				•	•	•	•	•	•	•	•	•	•	•	•	•		•	•
1-1A	2:23	•	•	•	•	•			•		•		•	•	•	•	•	•	•	•	•		•	•
1-1B	2:52	•	•	•	•	•			•	•	•		•	•	•	•	•	•	•	•	•		•	•
1-2	1	•	•	•	•	•			•	•	•		•	•	•	•	•	•	•	•	•		•	•
2-1	1:37	•	•	•	•				•	•	•		•		•	•	•		•	•	•		•	•
2-2	1:46			•	•						•		•				•				•			
2-3	1:50		•	•	•						•		•				•				•			
3-1	1:46	•	•	•	•	•	•	•	•	•	•		•		•	•	•		•	•	•		•	•
4-1	3:07			•	•				•		•		•				•				•			
4-2	3:10	•	•	•	•				•	•	•		•		•	•	•		•	•	•		•	•
4-3	3:32	•	•	•	•				•	•	•		•				•				•			
4-4	3:34	•	•	•	•				•	•	•		•		•	•	•		•	•	•		•	•
4-5	4:00	•	•	•	•	•			•	•	•		•		•		•		•		•		•	•

[1] Data station 1-2 was out of the plume in typical ocean water

[2] Measurements of these parameters were attempted at other stations; however, the light intensities were not within the range of the instrument in the configuration utilized.

TABLE XI - COORDINATES OF THE P3-A FLIGHT LINES

Flight Line Number[1]	Coordinates			
	Begin		End	
	Latitude, N	Longitude, W	Latitude, N	Longitude, W
Line 2	38° 20' 00"	75° 04' 36"	39° 50' 42"	75° 53' 06"
Line 4	39° 52' 30"	75° 40' 00"	38° 35' 42"	75° 59' 36"
Line 3	38° 28' 30"	75° 01' 48"	39° 51' 12"	75° 46' 24"
Line 1	40° 00' 30"	75° 00' 36"	39° 34' 54"	75° 41' 00"
Line 5	38° 32' 54"	75° 35' 48"	38° 32' 30"	73° 50' 30"

[1]Flight lines are listed in the chronological order in which they were flown

TABLE XII.-TIMING OF EVENTS

RIVER/ORGANIC WASTE SITE

Time (EDT)	Event
1000 August 28, 1975	Establish transit locations
1030	Lockheed P3-A aircraft overpass
1140	River truth boat depart shore station
1200	River truth boat arrive test site
1257	Control data station
1304	Data station 1
1307	Data station 2
1308	Data station 3
1310	Data station 4
1313	Data station 5
1317	Data station 6
1319	Data station 7
1322	Data station 8
1324	Data station 9
1327	Data station 10
1330	Data station 11
1332	Data station 12
1410	Data station 13
1410	Cessna 310 aircraft overpass
1416	Data station 14
1418	Data station 15
1420	Data station 16
1422	Data station 17
1423	Data station 18
1425	Cessna 310 aircraft overpass
1426	Data station 19
1427	Data station 20
1430	River truth boat depart test site
1445	River truth boat arrive shore station

TABLE XII.-TIMING OF EVENTS

RIVER/ORGANIC WASTE SITE

Time (EDT)	Event
1000 August 28, 1975	Establish transit locations
1030	Lockheed P3-A aircraft overpass
1140	River truth boat depart shore station
1200	River truth boat arrive test site
1257	Control data station
1304	Data station 1
1307	Data station 2
1308	Data station 3
1310	Data station 4
1313	Data station 5
1317	Data station 6
1319	Data station 7
1322	Data station 8
1324	Data station 9
1327	Data station 10
1330	Data station 11
1332	Data station 12
1410	Data station 13
1410	Cessna 310 aircraft overpass
1416	Data station 14
1418	Data station 15
1420	Data station 16
1422	Data station 17
1423	Data station 18
1425	Cessna 310 aircraft overpass
1426	Data station 19
1427	Data station 20
1430	River truth boat depart test site
1445	River truth boat arrive shore station

TABLE XIII.-DATA STATIONS AND OVERFLYING AIRCRAFT

RIVER/ORGANIC WASTE SITE

Data Station	Time (EDT)	Overflying Aircraft	
		Cessna 310	Lockheed P3-A
	1030		•
Control	1257		
1	1304		
2	1307		
3	1308		
4	1310		
5	1313		
6	1317		
7	1319		
8	1322		
9	1324		
10	1327		
11	1330		
12	1332		
13	1410	•	
14	1416		
15	1418		
16	1420		
17	1422		
18	1423		
	1425	•	
19	1426		
20	1427		

TABLE XIV.-MAGNETIC BEARINGS OF DATA STATIONS

RIVER/ORGANIC WASTE SITE

Data Station	Magnetic Bearings From	
	Transit A[1]	Transit B[1]
Control	123°18'	96°35'
1	134°18'	104°35'
2	136°40'	105°49'
3	140°14'	108°20'
4	142°32'	109°05'
5	143°55'	108°30'
6	141°22'	107°35'
7	144°02'	109°37'
8	145°31'	111°55'
9	147°25'	111°20'
10	150°05'	113°28'
11	151°16'	113°42'
12	153°09'	115°35'
13	146°18'	108°23'
14	159°31'	123°20'
15	157°55'	121°10'
16	158°15'	120°32'
17	156°06'	118°12'
18	154°06'	115°54'
19	151°23'	113°27'
20	150°50'	No Data

[1]Transit A Located at 39°42'50" N. Latitude, 75°31'10" W. Longitude.
Transit B Located at 39°42'11" N. Latitude, 75°31'30" W. Longitude.

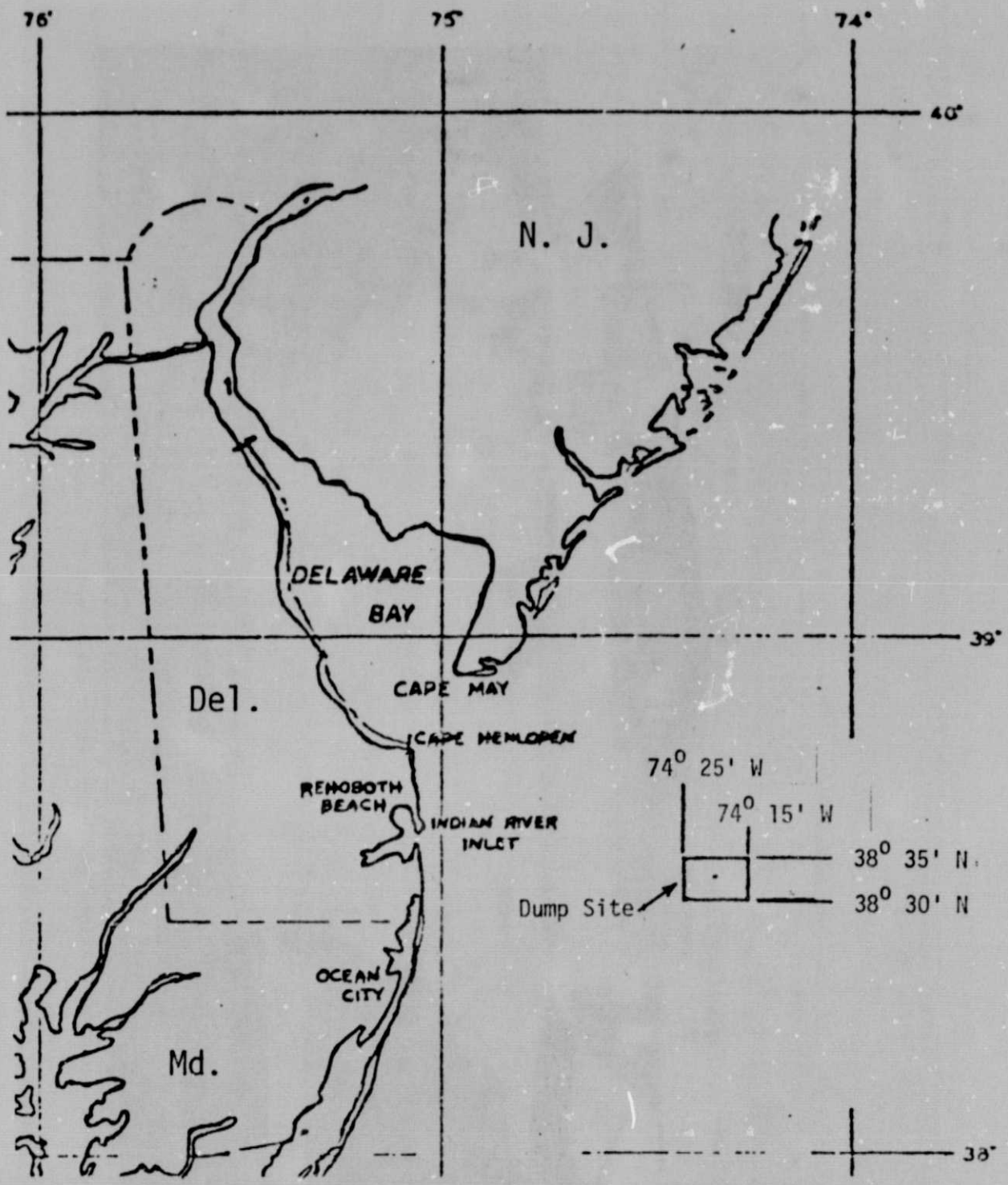


Figure 1.- Location and size of acid waste disposal site.

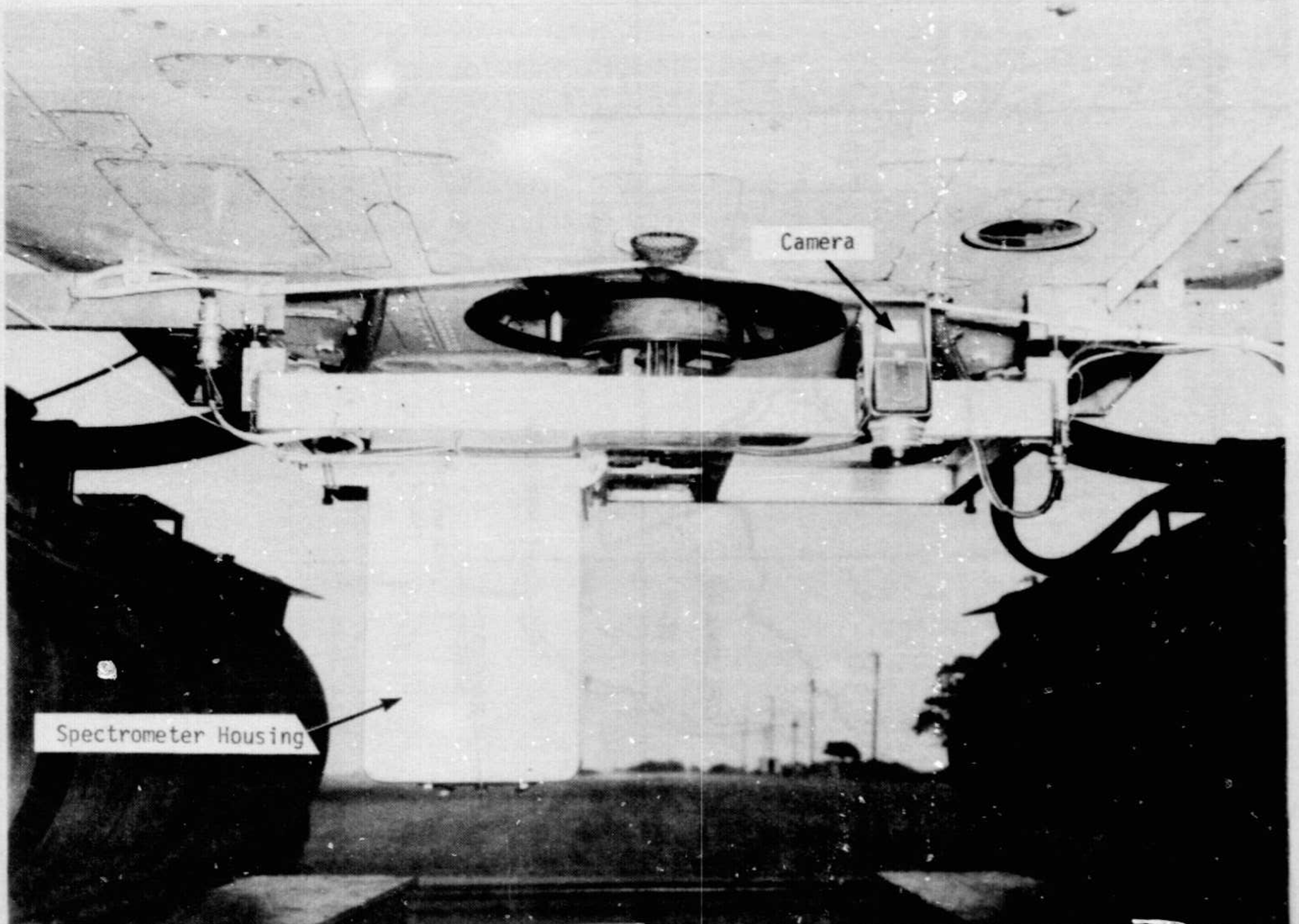


Figure 2.- Spectrometer attachment and Hasselblad camera.

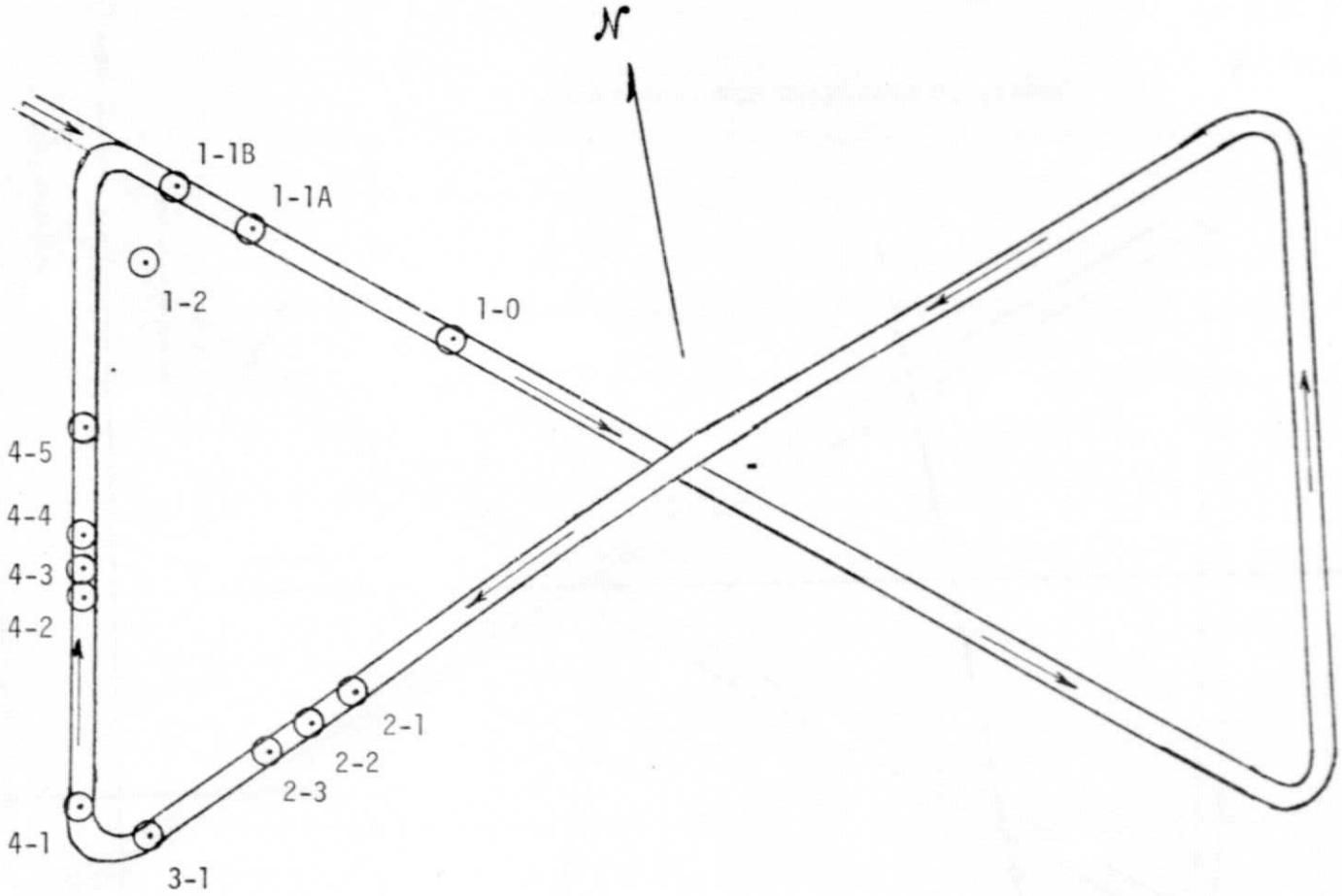


Figure 3.- Relative positions of data stations - ocean/acid disposal site.

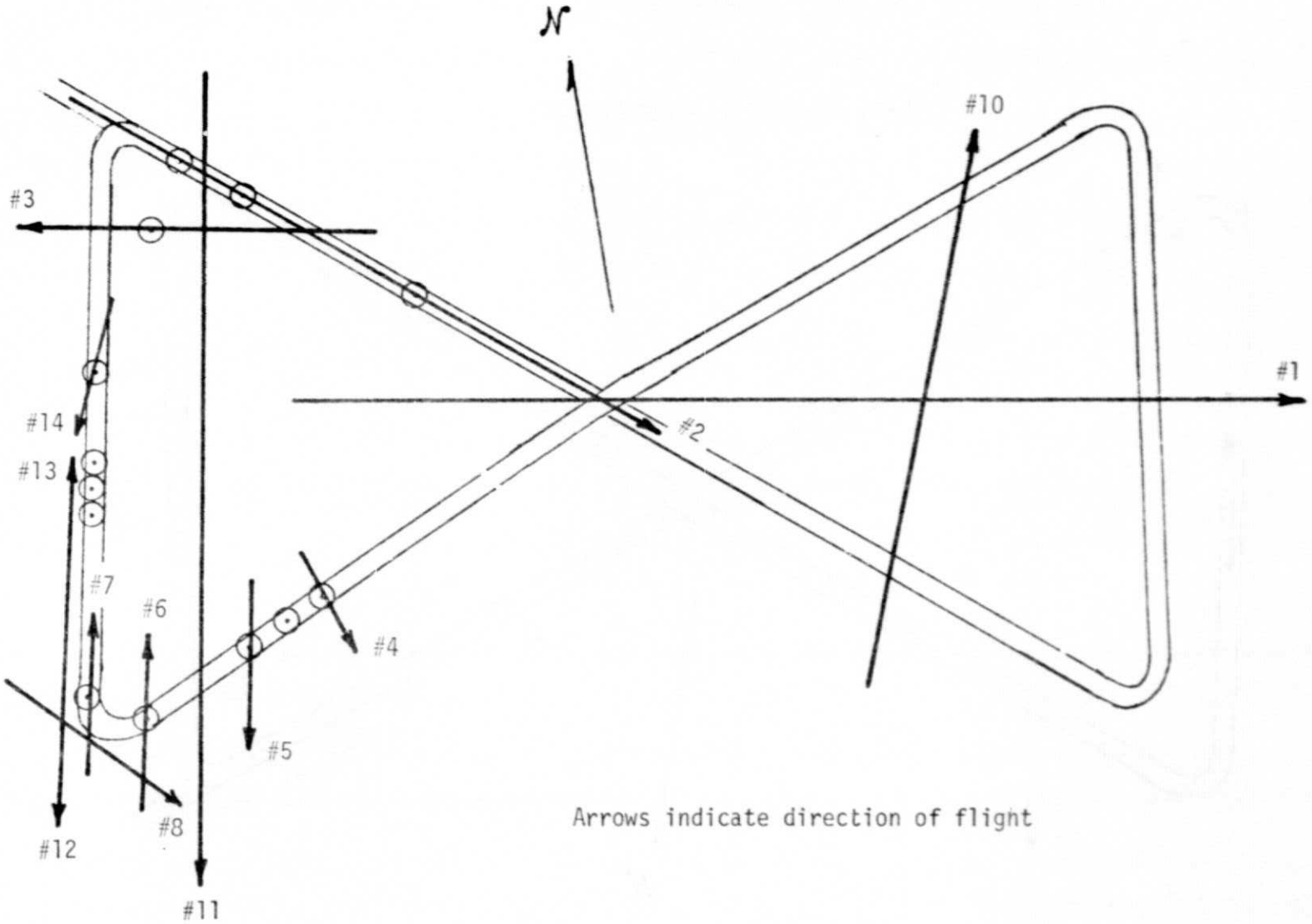
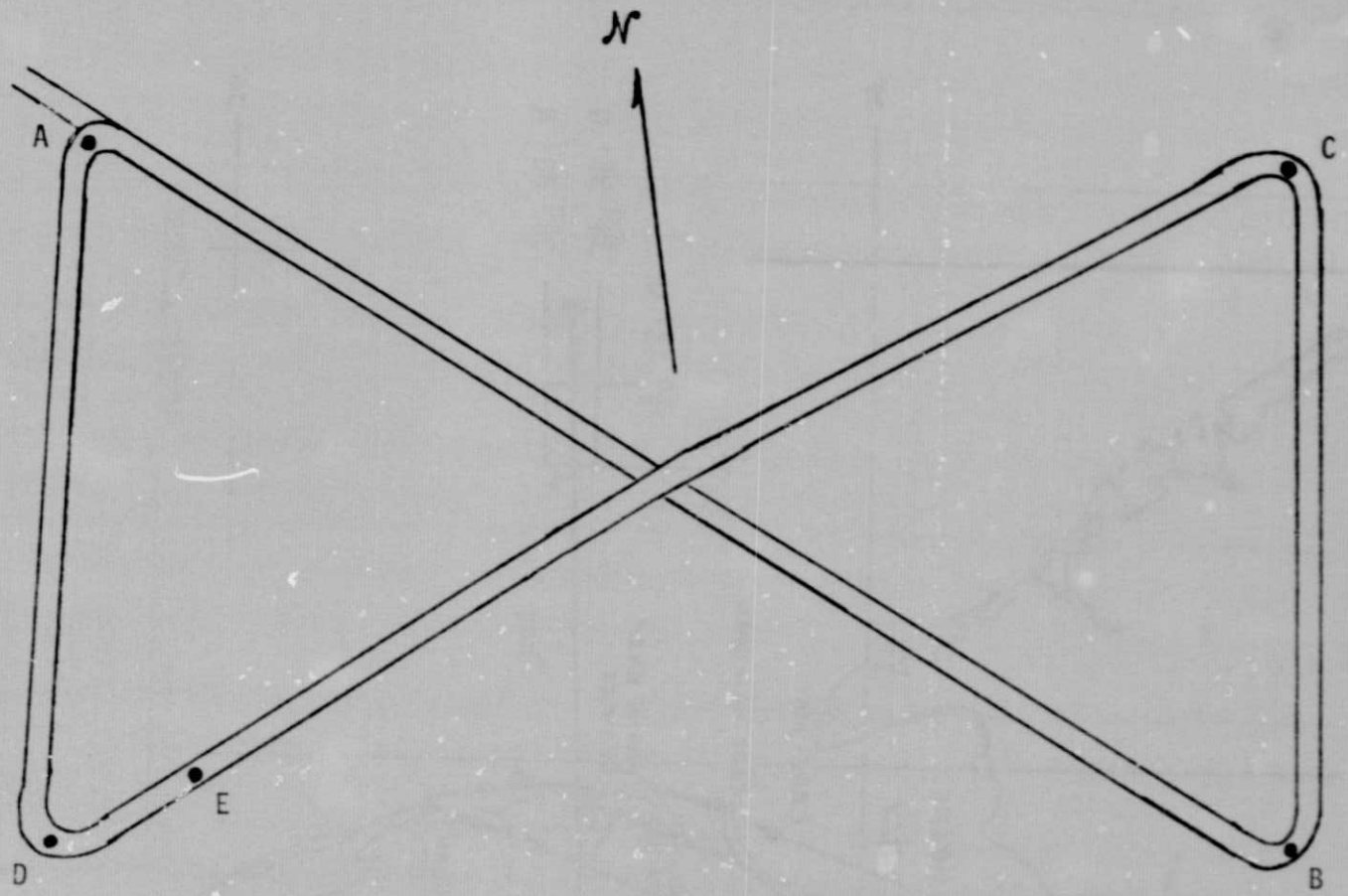
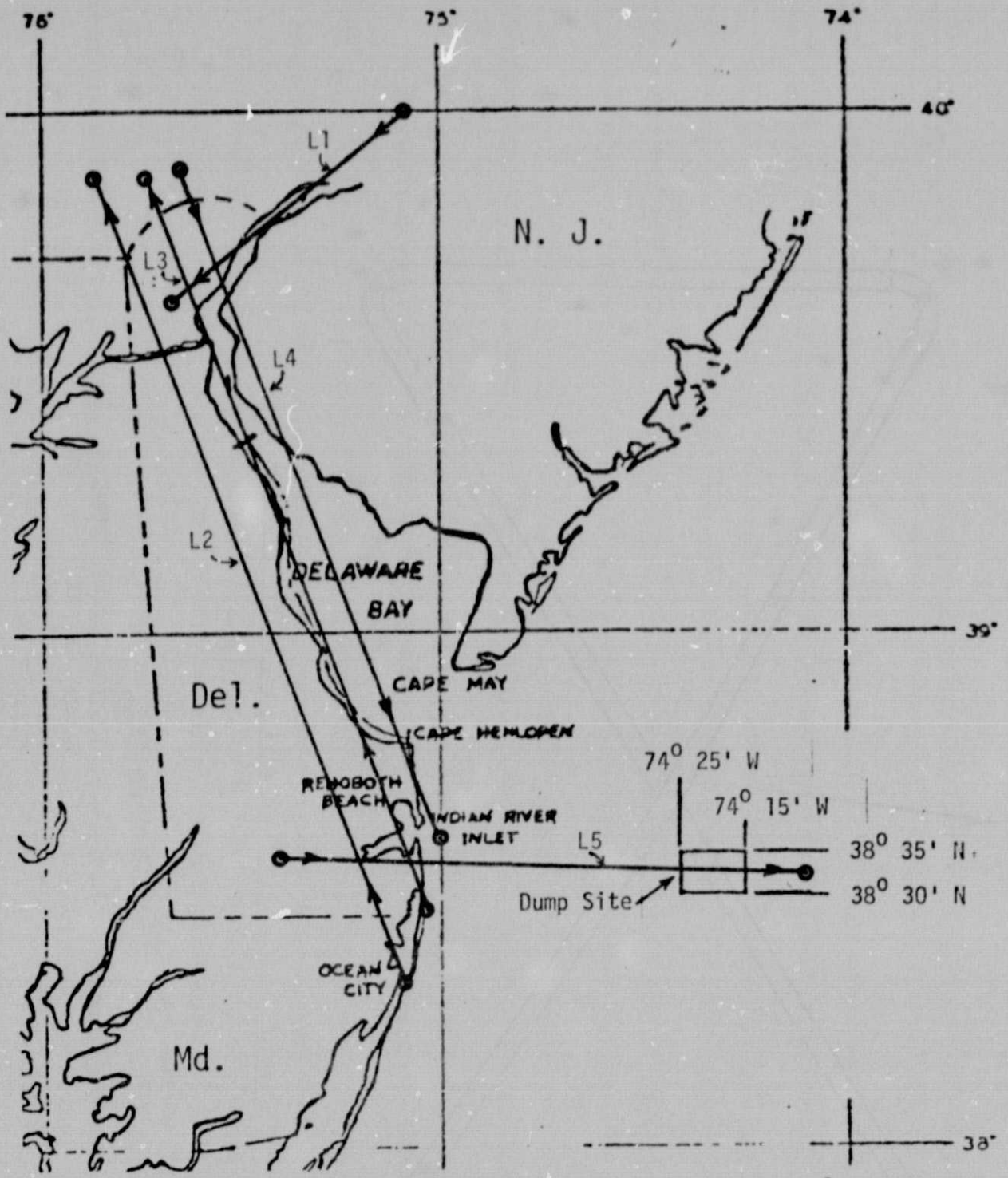


Figure 4.- Cessna 310 flight lines - ocean/acid disposal site.



Time, EDT	Line	Altitude, Meters (Ft.)
0838 - 0840	A - B	2,667 (8,750)
0842 - 0844	B - C	2,667
0904 - 0907	A - B	2,667
0920 - 0923	A - B	2,667
0940 - 0943	A - B	2,667
1002 - 1004	D - A	2,667
1033 - 1036	C - D	5,029 (16,500)
1040 - 1042	D - C	5,334 (17,500)
1052 - 1055	D - E	5,334
1058 - 1101	E - D	5,334
1108 - 1110	A - D	5,334

Figure 5.- C-54 Flight Lines



	Time, EDT	Altitude, Meters (ft.)	Heading, °True
Line 2	0912-0933	8169 (26,800)	334.9
Line 4	0938-0954	8230 (27,000)	171.2
Line 3	1001-1019	8230 (27,000)	328.4
Line 1	1029-1038	8321 (27,300)	234.4
Line 5	1056-1110	8687 (28,500)	87.7

Figure 6.- P3-A Flight Lines

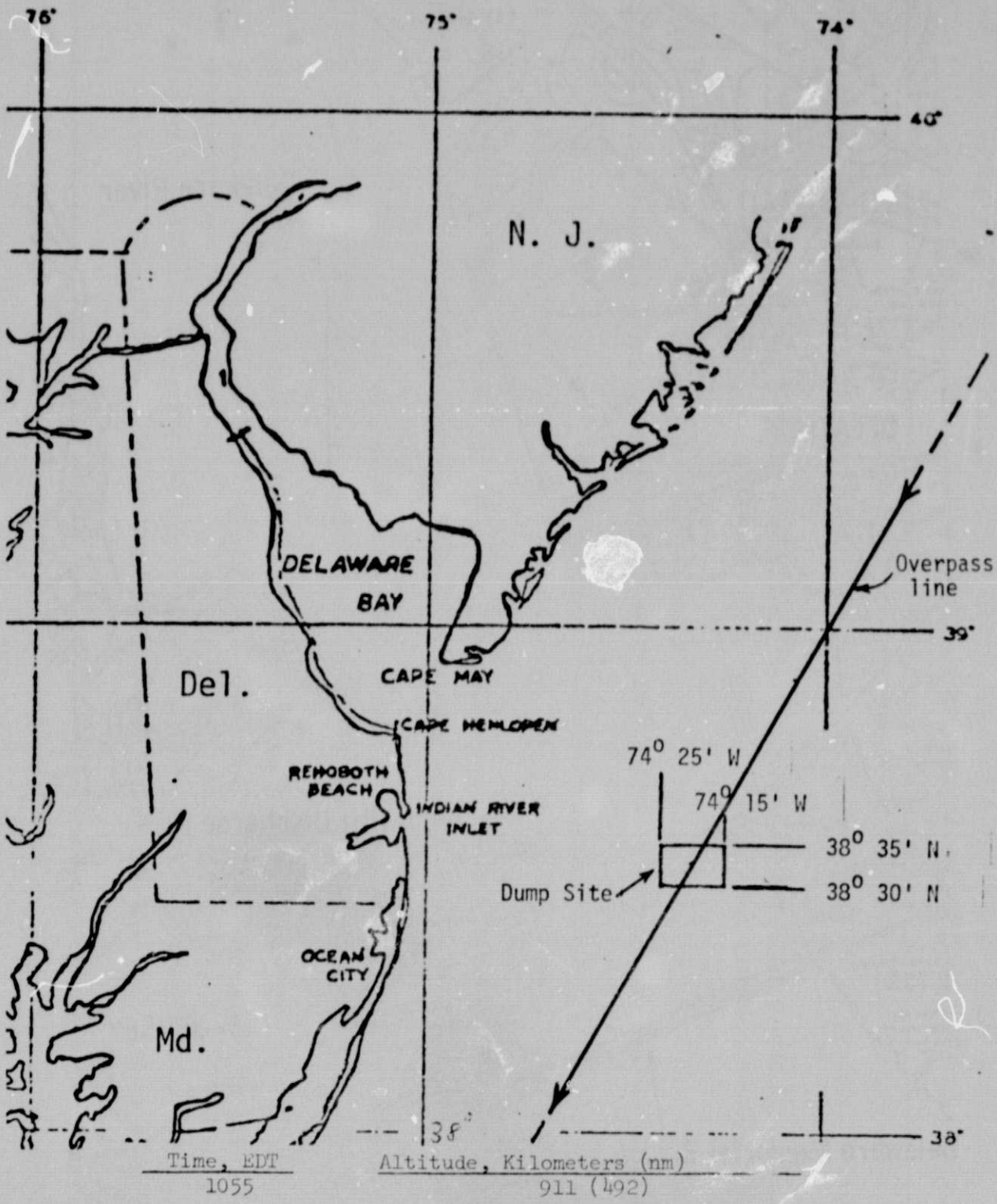


Figure 7.- Overpass of the Landsat II spacecraft.

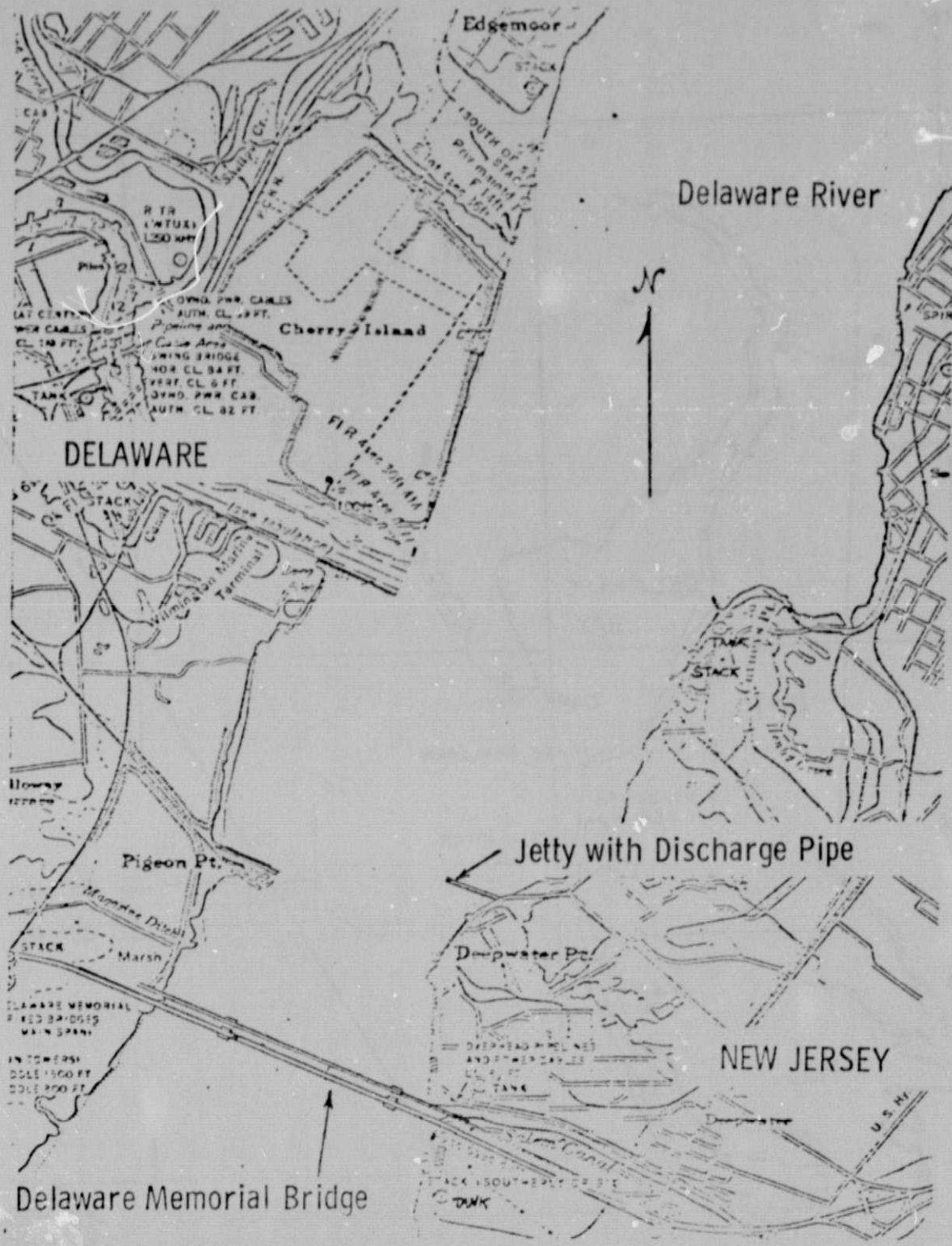


Figure 8.- Location of river/organic waste disposal site.

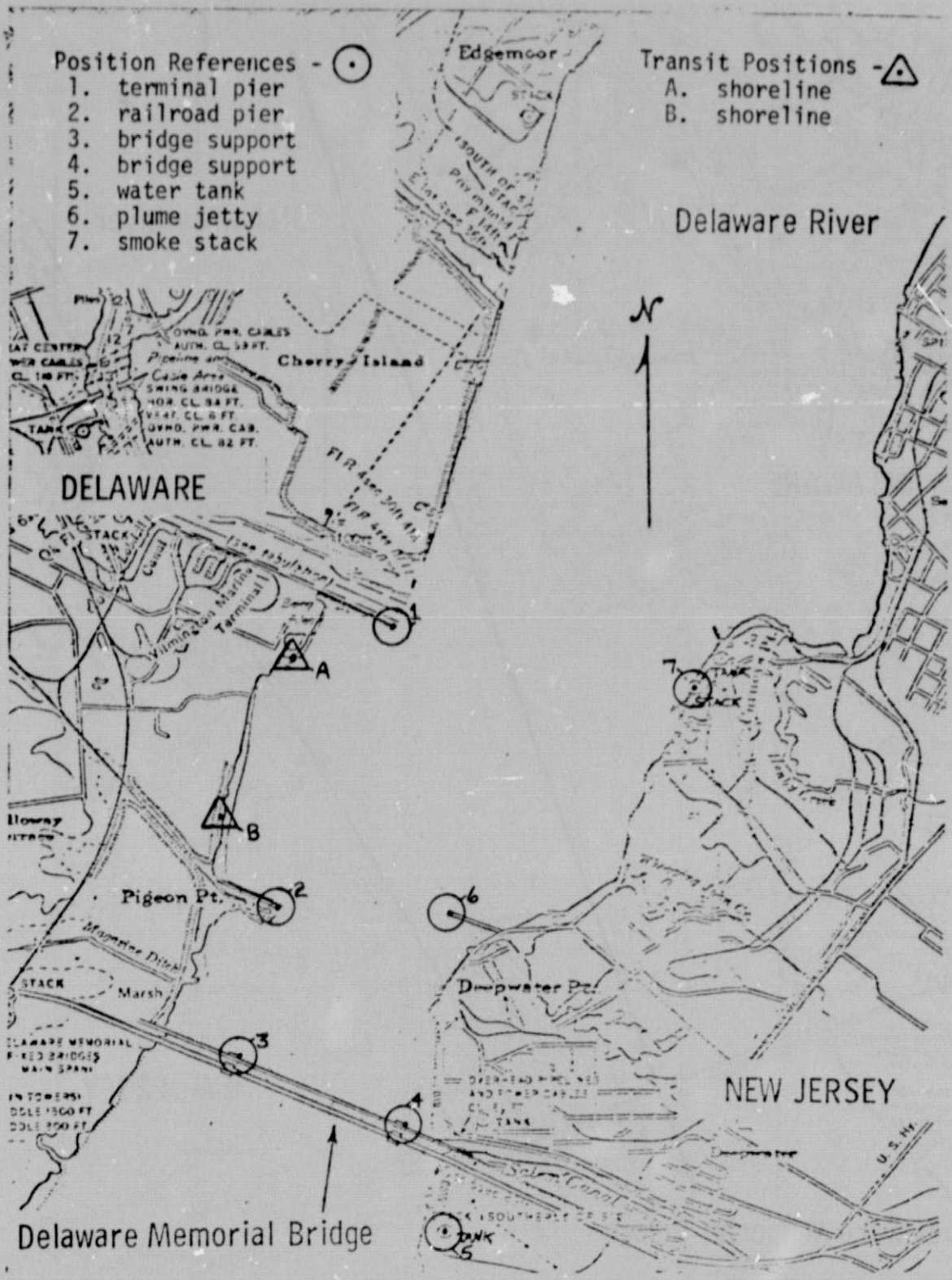


Figure 9.- Transit stations and fixed location references river/organic waste site.

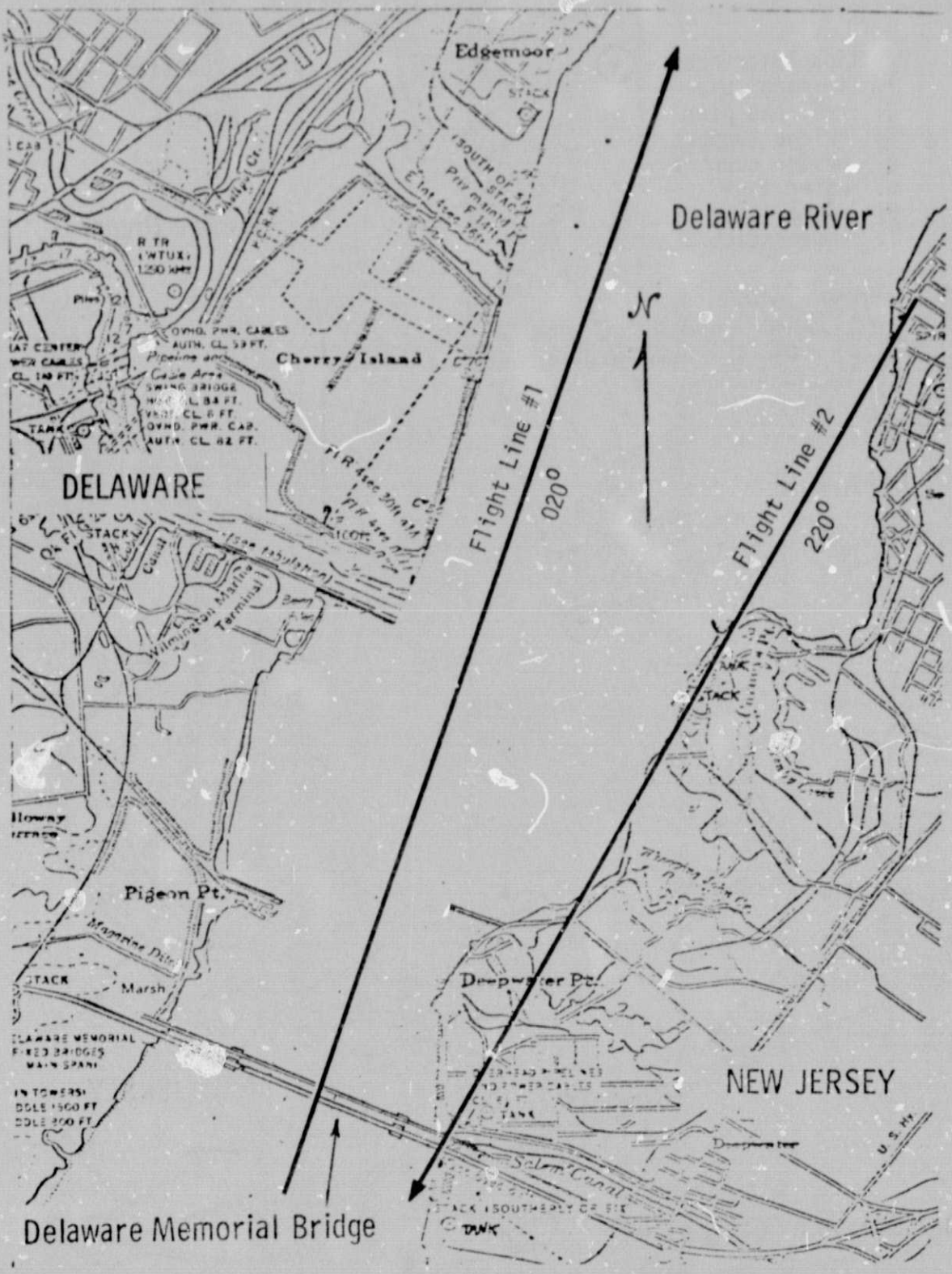


Figure 10.- Cessna 310 flight lines-river/organic waste site.

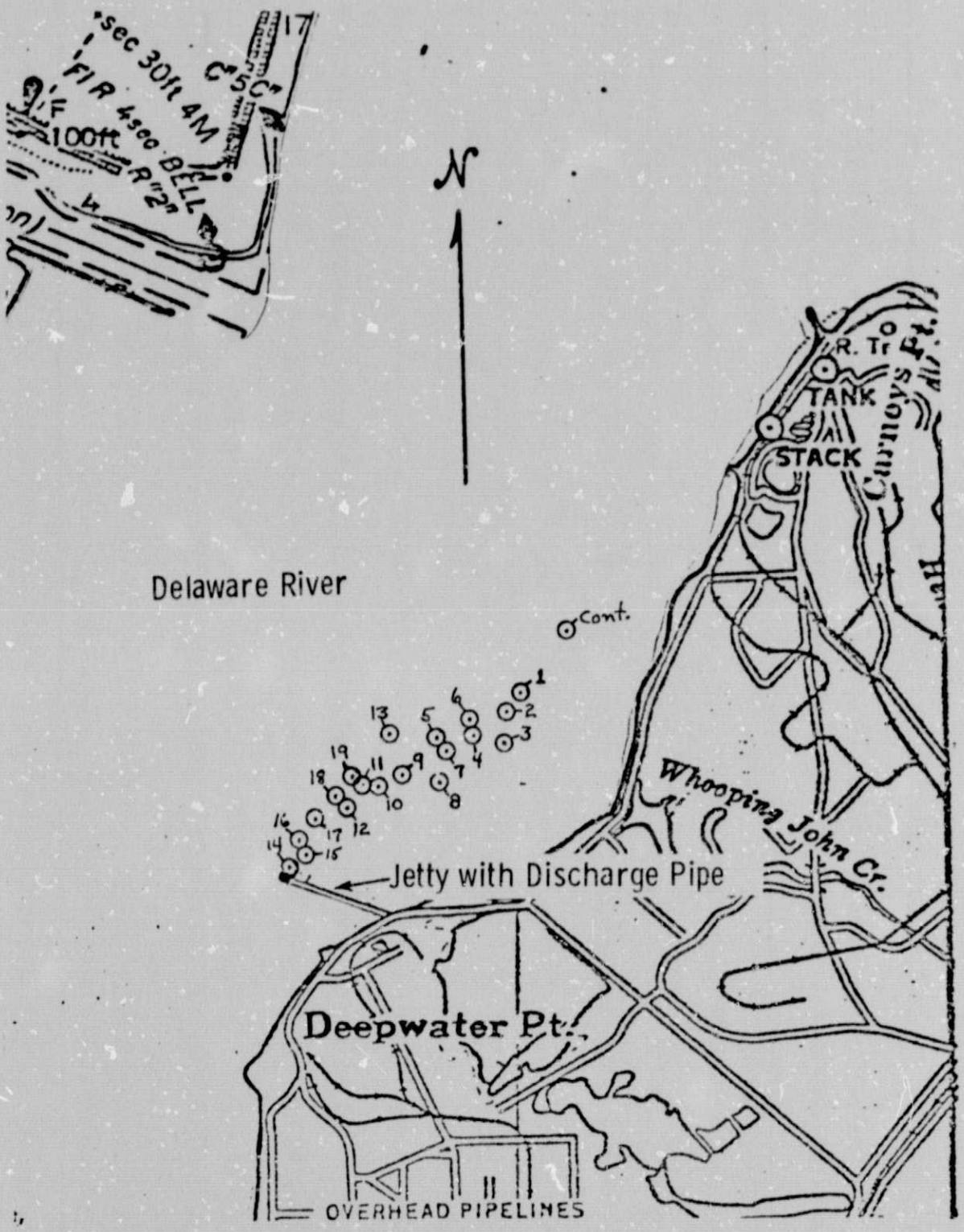


Figure 11.- Relative positions of data stations river/organic waste site.