

COASTAL MAPPING PROGRAM

**PROJECT OH0001A
COMPLETION REPORT**

OHIO

CLEVELAND HARBOR

**A Photogrammetric Survey
based on 2000 Aerial Photography**

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Ocean Service
National Geodetic Survey
Remote Sensing Division

Agency Archive Copy

COASTAL MAPPING PROGRAM

PROJECT OH0001A COMPLETION REPORT

OHIO Cleveland Harbor

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COASTAL MAPPING PROGRAM

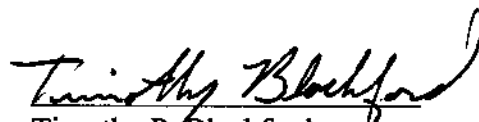
PROJECT OH0001A
COMPLETION REPORT

OHIO
Cleveland Harbor

Clearance

This report summarized the photogrammetric operations related to project completion and is submitted for approval. The project data and this report meet the requirements and standards of the Coastal Mapping Program.

Submitted by,



Timothy P. Blackford
Senior Cartographer
Applications Branch

Approved:



Robert W. Rodkey, Jr.
Chief, Applications Branch
Remote Sensing Division

5/15/01
Date



Captain Jon W. Bailey
Chief, Remote Sensing Division
National Geodetic Survey, NOS, NOAA

5/15/01
Date

**COASTAL MAPPING PROGRAM
PROJECT OH0001A
SUMMARY**

Introduction

Project OH0001A provides highly accurate digital shoreline data for Cleveland Harbor including the Lower Cuyahoga River. OH0001A is a sub-project of a larger Coastal Mapping project, OH0001, which covers from Toledo to Cleveland, Ohio.

Successful completion of this project resulted in a densification of the National Spatial Reference System (NSRS), a set of controlled metric quality aerial photographs and companion high resolution digital scans, and digital cartographic feature files of the coastal zone to complement the Nautical Charting Program (NCP) and other geographic information systems.

The project database consists of information measured and extracted from aerial photographs and metadata related to photogrammetric compilation. Base mapping was conducted in a fully digital environment using softcopy stereo photogrammetry and associated cartographic practices. Positional data is reference to the North American Datum 1983 (NAD83).

Planning

The planning phase of Project OH0001 was accomplished by the Requirements Branch, Remote Sensing Division. Photogrammetric requirements were formulated during project planning and issued in the General Information / Instructions. These instructions, included as Appendix A, discuss in detail the following: photographic requirements, flight lines, GPS control requirements, guidelines for static and kinematic data collection and handling, project priority, and communication guidelines.

Field Operations

Field operations consisted of the collection of static and kinematic GPS data and the acquisition of aerial photographs. Static GPS data were collected at Burke Lakefront Airport prior to the photo missions and applied as a local reference point. Kinematic GPS data were collected during the ensuing photo mission, rendering precise camera positions as a means of controlling the photographs. Refer to Appendix B, GPS Processing Report for OH0001A, for detailed information regarding GPS data collection and processing. Aerial photographic survey operations were conducted during August 2000, by the Cessna Citation II (N52RF) aircraft. Photographic requirements consisted of 1:30,000 scale photography, utilizing natural color film. All photos were taken using the Wild RC-20 camera with the NOS "A" lens cone.

Aerotriangulation

Softcopy aerotriangulation methods were applied to establish the network of horizontal and vertical control for mapping and to provide model parameter and orientation elements required for digital compilation. The aerotriangulation task was accomplished by the Applications Branch, Remote Sensing Division in January 2001. Refer to the Aerotriangulation Report in Appendix C for a complete discussion of this phase of the project, including source photography, geodetic control, hardware and software used, methods employed to derive an analytical solution and overall accuracy achieved. Accompanying diagrams of the project area show geographic coverage, approximate photographic flight lines and relative accuracy of the solution.

Compilation

Compilation requirements for Project OH0001A included digital base mapping, the production of cartographic feature files in ESRI shapefile format, and the construction of supplemental data for the Nautical Charting Program.

Digital mapping was accomplished by the Applications Branch, Remote Sensing Division, from January 2001 through March 2001, using the SocetSet Feature Extraction software module on a digital photogrammetric workstation (DPW), which is a configuration of computer hardware, SocetSet modular software components and other associated peripheral devices.

Cartographic features were compiled using the aerotriangulated 1:30,000 scale natural color photographs and digital stereo compilation methods. The source photographs used to compile cartographic features are described in Appendix D, Compilation Sources.

Features were compiled to meet 1.6 meters horizontal accuracy at a 95% confidence level. This predicted accuracy of compiled well-defined points is a deductive estimate based on aerotriangulation statistics. Feature identification and the assignment of cartographic codes were based on the interpretation of these photographs, NOS nautical charts, and the U.S. Coast Guard Light list Publication, 2000 (Vol. VII).

Final Review

Final review evaluation tasks were initiated in March 2001. The digital cartographic features files were evaluated for completeness and adherence to the Coastal Mapping Program (CMP) requirements and established NOS accuracy standards. Discrete point data for Project OH0001A were compared with the USCG Light List and the nautical chart for consistency. Cartographic feature codes conform with the CMP's Coastal Cartographic Object Attribute Source Table (C-COAST). Nomenclature was assigned to cartographic features which required further description.

Data review included a comparison of digital compilation against the NOS nautical chart: 14839 Cleveland Harbor, 1:10,000 scale, 35th edition. Results of this comparison are reflected on the Chart Maintenance Print, a copy of the NOS nautical chart annotated with comments to advise the nautical chart compiler. A page-size plot of the Digital Cartographic Feature File (DCFF) is included in Appendix E.

Project Final Data and Products

Agency Archive:

- Original Project Completion Report (PCR)
- Project Folder contents, e.g. field data, aerotriangulation records, memos, etc.

Agency Reference Library:

- Copy of Project Completion Report

Photogrammetric Electronic Data Library:

- Project Data Base
- Digital Cartographic Feature Files for GC-10491
- Copy of DCFF in ESRI shapefile format
- Chart Maintenance Prints
- Abbreviated copy of PCR

APPENDIX A

June 27, 2000

OH-0001
SHORE OF LAKE ERIE

PORT OF TOLEDO
PORT OF LORAIN
PORT OF CLEVELAND
OLD WOMAN CREEK NERR

STATE OF OHIO

General Information/Instructions - Aerial Photographic Survey

1.0. General: These instructions supplement the Photo Mission Standard Operating Procedure Version II, July 1, 1993; and the GPS Controlled Photogrammetry. Field Operations Manual, January 2, 1996, et al.

1.1 Introduction: Aerial survey OH0001 is a survey to provide controlled, metric quality photographic images of the Ohio, Lake Erie Shoreline from the Michigan State line to the Pennsylvania State line. The survey is being conducted in cooperation with the Sanctuaries and Reserves Office and the Office of Coast Survey in partial completion of their Nautical Charting Plan, Fourth Edition, August 1999. This survey will also provide controlled metric quality images of the Port of Toledo, the Port of Lorain, the Port of Cleveland, and the Old Woman Creek National Estuarine Research Reserve (NERR). The survey will provide imagery useful in determining any changes to the Coast, the Ports and the NERR area.

1.2. Coverage: This imagery acquisition mission will cover the state shoreline from the Michigan state line to the Pennsylvania state line along Lake Erie. Nautical charts that may be effected by this imagery are: 14820, 14824, 14825, 14826, 14828m, 14829m, 14830, 14830m, 14835, 14836, 14837, 14839, 14841, 14842, 14843, 14844, 14845, 14846, & 14847.

1.3. Scope: 2 flight lines of natural color negative imagery at 1:20,000 scale, 7 flight lines of natural color negative imagery at 1:30,000 and 11 flight lines of natural color negative imagery at 1:48,000 are required to provide adequate photographic coverage for reconnaissance of shoreline features, Ports, changes and NERRS. Control for aerotriangulation will be provided by airborne kinematic GPS data acquired concurrently with the imagery acquisition provided for in these instructions and from airborne data previously acquired.

1.4. Compilation: Compilation of new shoreline features will be done only where an examination of the imagery shows significant change.

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2.0 Photographic Requirements:

- 2.1 All exposures will be taken along the flight lines indicated on the accompanying flight maps and way point files.
- 2.2 2 Flight lines are to be flown at an altitude that produces a nominal photographic scale of 1:20,000, 7 flight lines to produce a scale of 1:30,000 and 11 flight lines to produce a scale of 1:48,000.
- 2.3. Expose all images so that they have a nominal end lap of 60%
- 2.4. All flight lines are to be flown using only natural color negative film. (Standard NOS Emulsion)
- 2.5. All flight lines will be navigated using the UNSIK flight management system.
- 2.5.1 Flight lines may be patched if flown under GPS navigation and kinematic data are received for both sides of the split flight line.
- 2.5.2. Begin the second portion of a patched flight line at least two photographs before the break.
- 2.6. The aircraft commander is not afforded the discretion to alter the required image scales without prior approval from the Requirements Branch.
- 3.0. **Flight Line Priority:**
- 3.1. The 1:30,000 lines are the first priority of the survey.
- 3.2. The 1:20,000 lines are the second priority of the survey.
- 3.3. The 1:48,000 lines are the third priority.
- 4.0. **Tide Coordination:**
- 4.1. There is no tide coordination requirement for this survey.
- 5.0. **Photographic Control for Aerotriangulation:**
- 5.1. Airborne kinematic GPS data are required for all natural color negative imagery.

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- 5.2. All flight lines may be flown with out a bank angle restriction. However caution must be observed when banking so that at least 4 satellites are being tracked continuously. (See GPS Controlled Photogrammetry, Field Operations Manual, Section X)
- 5.3. No support from the NGS Field Operations Branch is required for this aerial survey.
- 6.0. **GPS Reference Receivers:**
 - 6.1. **Primary Reference Receiver:** Establish a GPS primary reference receiver station at the airport you choose as your base of operations in accordance with the procedures given in GPS Controlled Photogrammetry, Field Operations Manual, Section V.
 - 6.1.1. The following airports within the survey area can handle operations of the Citation aircraft: Burke Lakefront Airport and Toledo Express Airport.
 - 6.2. Send the static GPS survey data to Mr. Tim Blackford of the Applications Branch via the Post Office, or commercial courier (FedX).
 - 6.3. **Secondary Reference Receivers:** There is no requirement for secondary reference receivers for this aerial survey.
- 7.0. **Project Schedule/Priority:**
 - 7.1. This survey is scheduled to be accomplished in August 2000.
 - 7.2. There is no particular priority assigned to this survey. The Mission Commander is afforded the discretion to move the survey aircraft between this and other near by aerial survey areas to take advantage of the most advantageous weather and/or tidal conditions.
- 8.0. **Data Recording/ Handling:**
 - 8.1. The imagery acquisition code for this survey is OH0001. If the photo mission diverts to obtain airport imagery contact the Requirements Branch to obtain the proper imagery acquisition codes for airport imagery.
 - 8.2. Record and handle all photographic data as provided for in the Photo Mission Standard Operating Procedure.
 - 8.3. Record and handle all digital GPS data as provided for in the GPS Controlled Photogrammetry, Field Operations Manual.
 - 8.4. Send one (1) copy of the kinematic GPS data from the aircraft and ground based receiver to Mr. Tim Blackford of the Applications Branch weekly, unless otherwise requested.

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- 8.5. Send a digital copy of the EDI files to Mr. Brian Thornton of the Systems & Quality Assurance Branch with the exposed roll of film. EDI files are critical for data management, film indexing, and photo dissemination; therefore, resolve EDI malfunctions to the best of your ability prior to acquiring imagery. If a problem persists, call the appropriate individual for guidance.
- 8.6. In addition to the data normally required on the Photographic Flight Report (PFR), clearly record data for all test exposures, accidentally taken exposures, exposures taken when not navigating a flight line, interruptions of imagery acquisition and or any situation that causes a break in imagery or data acquisition. In general; if the camera shutter trips and/or a data pulse is recorded an entry in the PFR is required.
- 8.7. Record on the PFR any GPS failure, data logger failure, failure to start the system, or any data recording failures.
- 8.8. FAX a copy of the PFR for each roll of exposed film to the Requirements Branch when the film and the original report are sent to the contract photo laboratory for processing.
- 9.0. **General Guidelines for Aircraft GPS Operations:**
 - 9.1. Download GPS satellite ephemeris and health data from the Arinc web site daily to ensure that the satellite constellation is adequate for kinematic operations. Their URL is: WWW.ARINC.COM/PRODUCTS_SERVICES/GPSSTAT.HTML Download the three files that pertain to the daily and monthly ephemeris and satellite health data. These will all run under the same SEM program that has been previously used.
 - 9.2. Run satellite visibility plots and PDOP predictions daily if necessary.
 - 9.3. Base daily operations on the most current satellite ephemeris.
 - 9.4. Standard Operating Procedures for conducting an airborne kinematic GPS survey are found in GPS Controlled Photogrammetry. Field Operations Manual Sections V.I.; V.I.B.; V.I.C.
 - 9.5. Imaging operations will be conducted within approximately 300 km of the primary reference receiver.
- 10.0. **Contacts/Communications:**
 - 10.1. E-mail, FAX, or phone a project status or move report to the Requirements Branch daily, even if there has been no change in project status or progress. A report of "no progress" or "no change" is required.

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10.2. Check your E-mail box frequently; RSD, Requirements Branch personnel will forward any project changes or other pertinent data to E-mail address: Photo1@Earthlink.net

10.3. For questions or information regarding the operational aspect of this project contact:

Lloyd W. Harrod Jr. (Requirements Branch)

Phone: (W) 301-713-2671x198

(H) 301-341-3586

(FAX) 301-713-4572

Internet: lloyd@ngs.noaa.gov

10.4. For questions or information regarding the operational or theoretical GPS aspect of this project or in the event of total GPS failure contact:

LT Mike Weaver

Phone: (W) 301-713-0443

(H) 703-864-5139

(FAX) 301-713-4572

Internet: Mike.Weaver@ngs.noaa.gov
Msweaver@erols.com

10.5. For questions or information regarding aerial camera maintenance or repair contact:

Steve Nicklas

Phone: (W) 301-713-2671

(H)

(FAX) 301-713-4572

Internet: Snicklas@ngs.noaa.gov

10.6. For questions regarding GPS processing contact:

Tim Blackford (Applications Branch)

Phone: (W) 301-713-2685 x146

(H) 301-438-3359

(FAX) 301-713-4572

Internet: Tim.Blackford@noaa.gov

10.7. Mailing Addresses:

Tim Blackford

N/NGS33

SSMC-3, #5326

1315 East West Highway

Silver Spring, MD 20910

Brian Thornton

N/NGS31

SSMC-3, #5116

1315 East West Highway

Silver Spring, MD 20910

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- 10.8. When communicating with anyone outside the Requirements Branch about any aspect of this project a copy of the communication must be forwarded to the Requirements Branch. This includes notifying the Applications Branch that data have been sent.

11.0. Data Provided with these Instructions:

Three copies of the flight maps

One floppy disk containing the files:

OH0001.wpt - comma separated version of flight lines

OH0001.wpx - way point input to flight management system

OH0001.txt - text version of way point input

Two copies of these instructions

12.0. Pilot Debriefing:

Before returning to their assigned duty stations either at the conclusion of imaging operations or at a crew swap, at least one pilot assigned to this aerial survey may be required to report to Remote Sensing Division Headquarters to participate in a debriefing of photographic operations.

13.0. Miscellaneous:


Do not acquire imagery if visibility is less than 12 miles.

Approved: 
Edward D. Allen
Chief, Requirements Branch

Date: 6/29/00

Reviewed: 
Bob Rodkey
Chief, Applications Branch

Date: 6/29/00

Reviewed: 
Steve Matula
Chief, Systems & Quality Assurance Branch

Date: 7-13-2000

Approved: 
CDR Jonathan W. Bailey
Chief, Remote Sensing Division

Date: 7/17/2000

82 35'

82 30'

82 25'

OH0001 Toledo to Cleveland

Old Woman Creek NERR

1:91045 28-JUN-2000

41 25'

41 25'

41 20'

41 20'

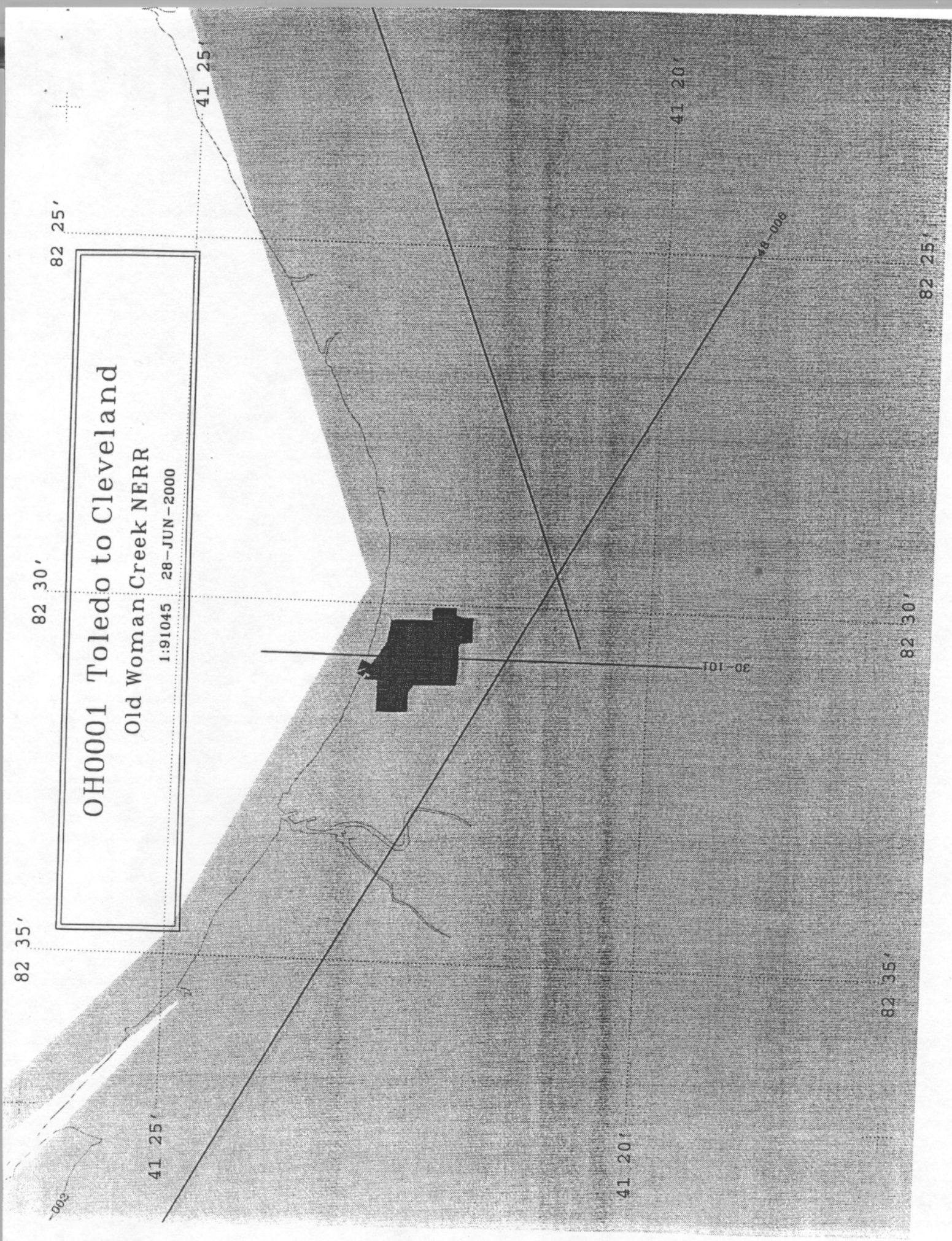
48-000

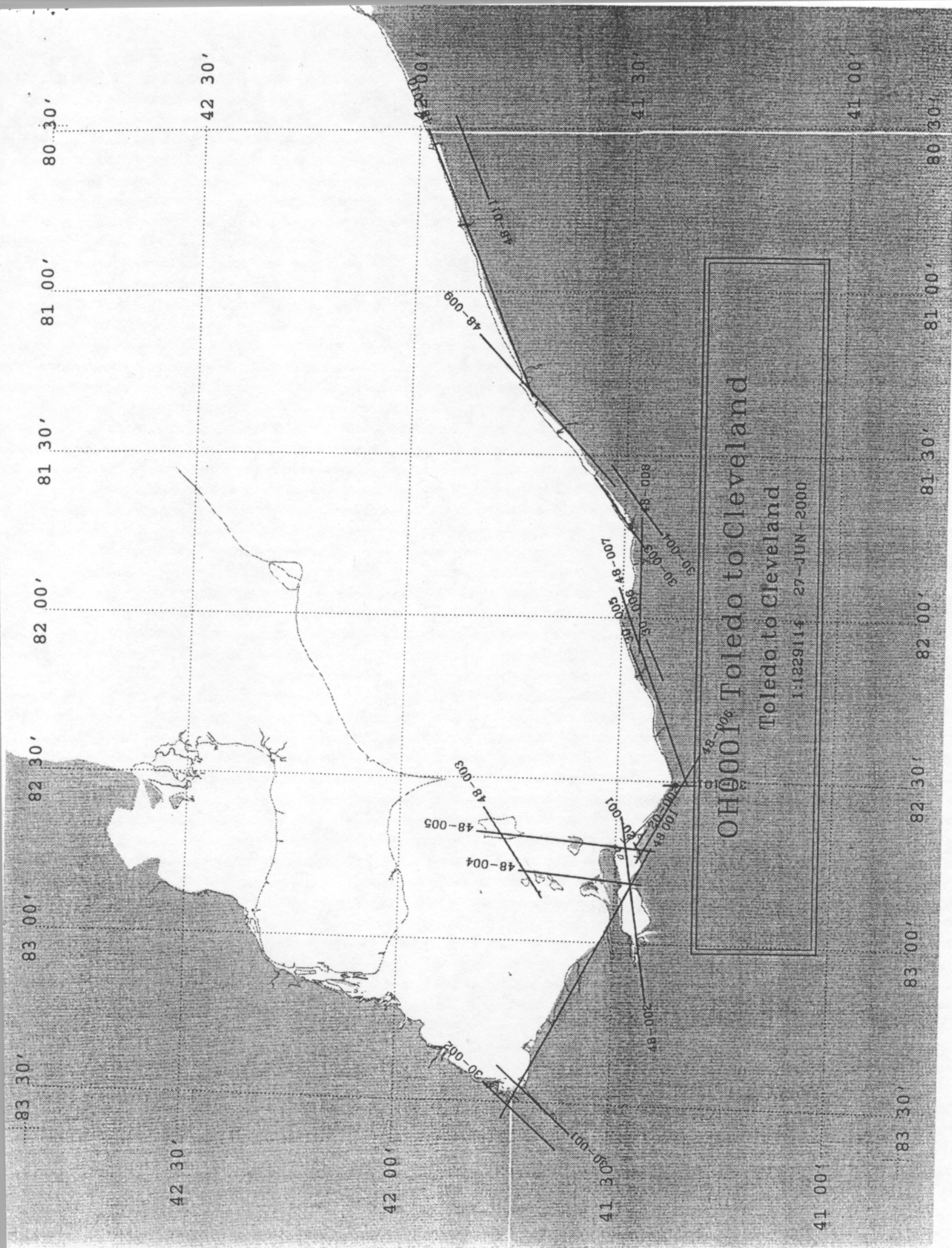
30-101

82 35'

82 30'

82 25'

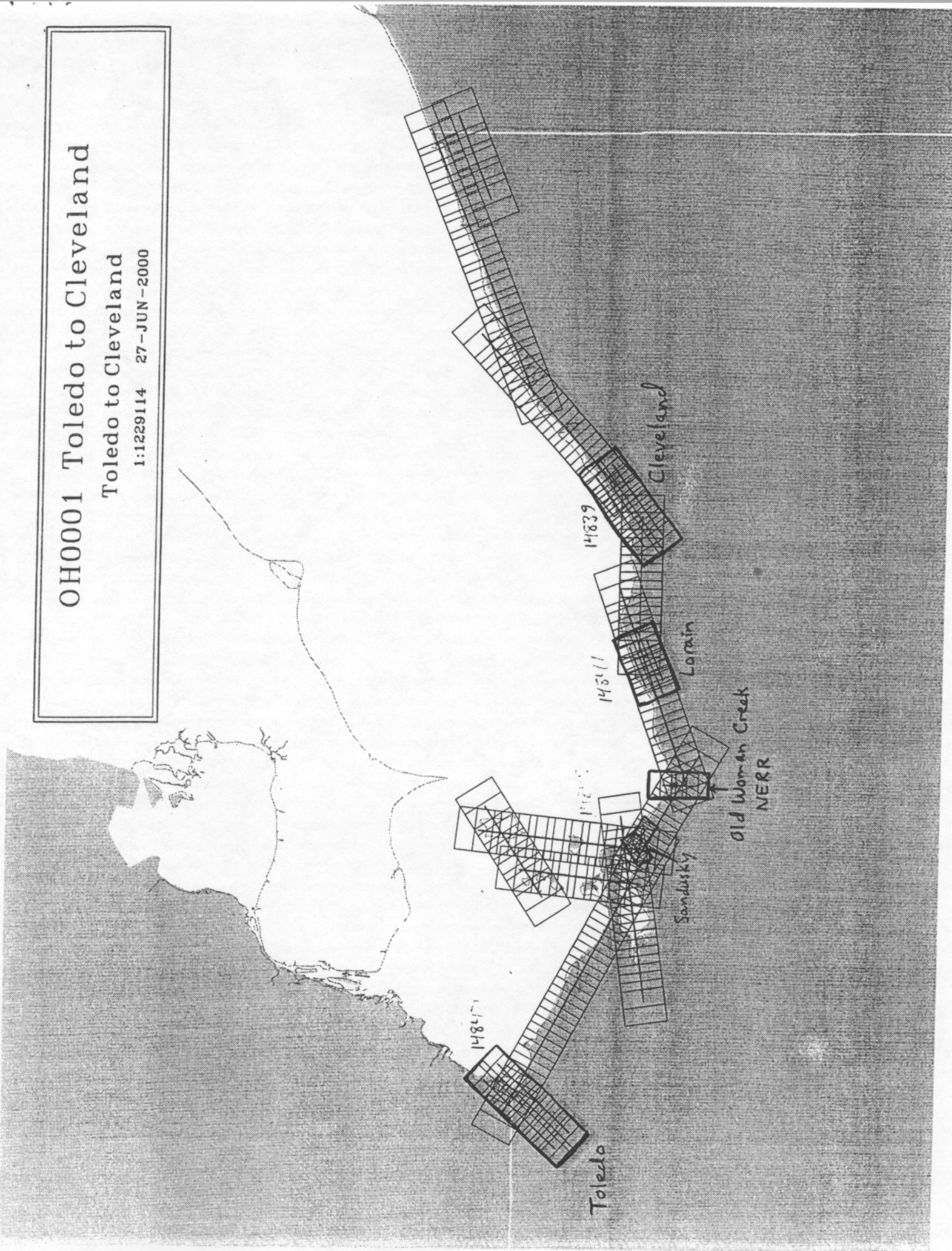




OH0001 Toledo to Cleveland

Toledo to Cleveland

1:1229114 27-JUN-2000



APPENDIX B

OH0001A Cleveland Harbor Ohio

GPS Processing Report February 2001

INTRODUCTION

The Global Positioning System (GPS) data referred to in this report was processed to provide precise positions of camera centers, to be used as photogrammetric control in the aerotriangulation phase of the Coastal Mapping Program project OH0001A (Cleveland Harbor, Ohio). The datasets processed and the aerial photography covered by those datasets are listed in the table below:

Dataset	Date	Project(s)	Description / Flight Lines
00BKL235.S	8/22/00	OH0001	1 st Static session for reference station (PBKL)
00BKL238	8/25/00	OH0001	30-06, 30-05, 30-04, 30-03
00BKL239.S	8/26/00	OH0001	2 nd Static session for reference station (PBKL)

DATA COLLECTION

GPS data was collected in August and September 2000, as detailed in the table above. The procedures followed are described in the GPS Controlled Photogrammetry Field Operations Manual, of Oct. 25, 1999. All data was collected using Trimble 4000SSi geodetic receivers. For all observation sessions the static or base station data was collected using a Trimble Compact L1/L2 antenna with ground plane set up on a 2 meter fixed height tripod.

The airport used as a base of operations was Burke Lakefront Airport (BKL) in Cleveland, OH. A PK-nail was set in the pavement to be used as a reference mark for kinematic operations, and was given the designation PBKL. Static GPS data was collected over station PBKL during two observation sessions, of 4 h. 21 m. and 6 h. 42 m. duration, on August 22nd and August 26th respectively. On August 25th a kinematic survey was conducted with the rover receiver in the NOAA Cessna Citation II (N52RF) aircraft, and the reference receiver set up over PBKL. This session was of 2 h. 39 m. duration with a measurement interval of 1 second. Four flight lines were flown, and 34 photo events were recorded. No problems were reported by the field personnel in the observation log.

All observed data was downloaded from the receivers to a portable computer. At the end of each week the data files were copied to zip disks and forwarded to headquarters for processing. Upon receipt in the office, the datasets were backed up to optical disk and project folders were created for each session. As

it became available, additional data was downloaded from the network for use in the processing stage. This supplementary data included NGS precise ephemeris files for each session, and FIF files for each film roll.

REFERENCE RECEIVER POSITIONING

To compute the coordinates of the reference mark, PBKL, the two static GPS datasets were processed using Trimble GPSurvey (ver. 2.35) along with RINEX data from four nearby CORS sites (DET1, PIT1, STKR, & ERLA). Six acceptable baselines solutions were obtained, and coordinates of PBKL were computed based on a weighted average of the baseline solutions.

Latitude:	41° 30' 50.1764" N
Longitude:	81° 41' 05.8950" W
Ellipsoidal Height:	142.60 m.

Later the static data was submitted to NGS's Online Processing User Service (OPUS) when the service became available, and the results matched within 2 cm horizontally, and 6 cm vertically.

KINEMATIC PROCESSING

The airborne kinematic GPS dataset, 00BKL238, was processed in January 2001 using Trimble GPSurvey (ver. 2.35), and utilizing the NGS computed precise satellite ephemeris, and standard meteorologic data. A continuous kinematic iono-free phase solution was obtained. The RMS of the phase residuals generally ranged from 0.5-2 cm throughout the session. The average iono-free RMS for the session was 0.9 cm. The RDOP value varied between 1.7 and 2.2 except at the end of the session, during landing and taxi, when it jumped to 4.8. But that was well after all the photos were acquired. The product, RMS x RDOP (which is a reasonable estimate of the mean square positional error), was about 2 cm during the period of photo acquisition. The folder (OH0001 Day 238) on file in the RSD GPS Archive contains this report, the field GPS Observation Log, the Static Data Processing Reports (including OPUS results), and the GPSurvey Detailed Kinematic Solution Summary report including plots of RMS and RDOP and a solution diagram (network map).

APPENDIX C

AEROTRIANGULATION REPORT

OH0001A

Cleveland Harbor, Ohio

March, 2001

Area Covered

The area covered by project Oh0001A is on the southern shore of Lake Erie, between the longitudes of 81°47' W and 81°32' W. The project centers on Cleveland Harbor and includes the Lower Cuyahoga River. To see the geographic extent of photo coverage, refer to Project Diagram.

Photography

Two strips of color photography, consisting of 14 individual exposures were bridged during the aerotriangulation phase of this project. Refer to Project Diagram for position and orientation of the flight lines.

The color strips (30-3 and 30-4) were acquired on 8/25/00. All photography was acquired using a Wild RC-30 camera with the NOS "A" lens cone at an altitude of approximately 4,300 meters above ground, for a nominal scale of 1:30,000. Photographic coverage, resolution, overlap, and metric quality were adequate for the performance of the aerotriangulation phase.

Adequacy of Control

During acquisition of the color photography, kinematic GPS control of the camera stations was employed allowing for GPS determined photo center points. The GPS controlled camera stations provided adequate horizontal and vertical control for an acceptable solution.

Method

All photographs were bridged using a softcopy 3D stereo photogrammetric system to establish the network of control required for the compilation phase. Measurements were made using the ORIMA aerotriangulation module within SocetSet in a Windows NT environment, on a Digital Photogrammetric Workstation (DPW). All photos were scanned and converted into 25 micron resolution digital images in tiled TIFF format, and subsequently imported into SocetSet. The images were measured and adjusted as a block. After subsequent processing, analysis and refinement, a final analytical adjustment was performed.

Visualization tools within ORIMA were used for evaluation of the triangulation adjustment, providing a graphic display of the horizontal and vertical standard deviations and residuals of measured points in the least squares solution. Refer to the attached diagram showing relative horizontal error ellipses as depicted in ORIMA.

The root mean square (RMS) for the standard deviations of the triangulated ground point residuals was calculated in the final analytical adjustment of ORIMA. These values were used to compute a predicted horizontal circular error of 0.8 meters for the entire project based on a 95% confidence level.

Project Database

Upon completion of the aerotriangulation phase, a project database was created under the reference number OH0001A and includes the following:

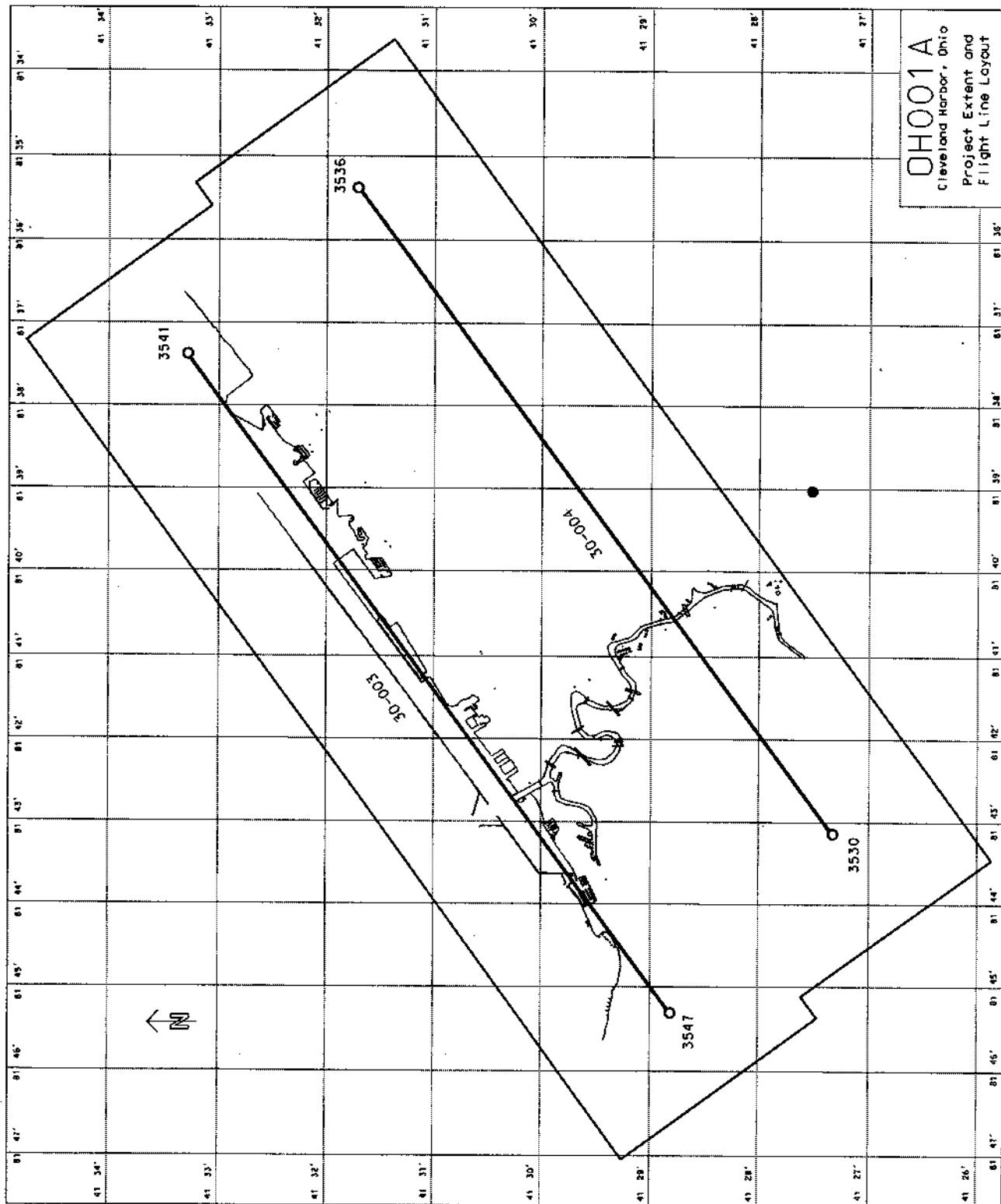
- General Project Parameters
- Camera Calibration Data
- Image Interior Orientations
- Horizontal and Vertical Control
- Frame Numbers Referenced by Strip
- Rotations Associated With Each Frame
- Refined Image Coordinates
- Positional Listing of All Measured Points Used in the Project

Select models from each strip of photography were examined in SocetSet to insure the horizontal and vertical integrity of the ORIMA solution, and to verify the suitability of the database for use in the compilation phase. Positional data is based on the North American Datum of 1983 (NAD83), and is referenced to UTM Zone 17.

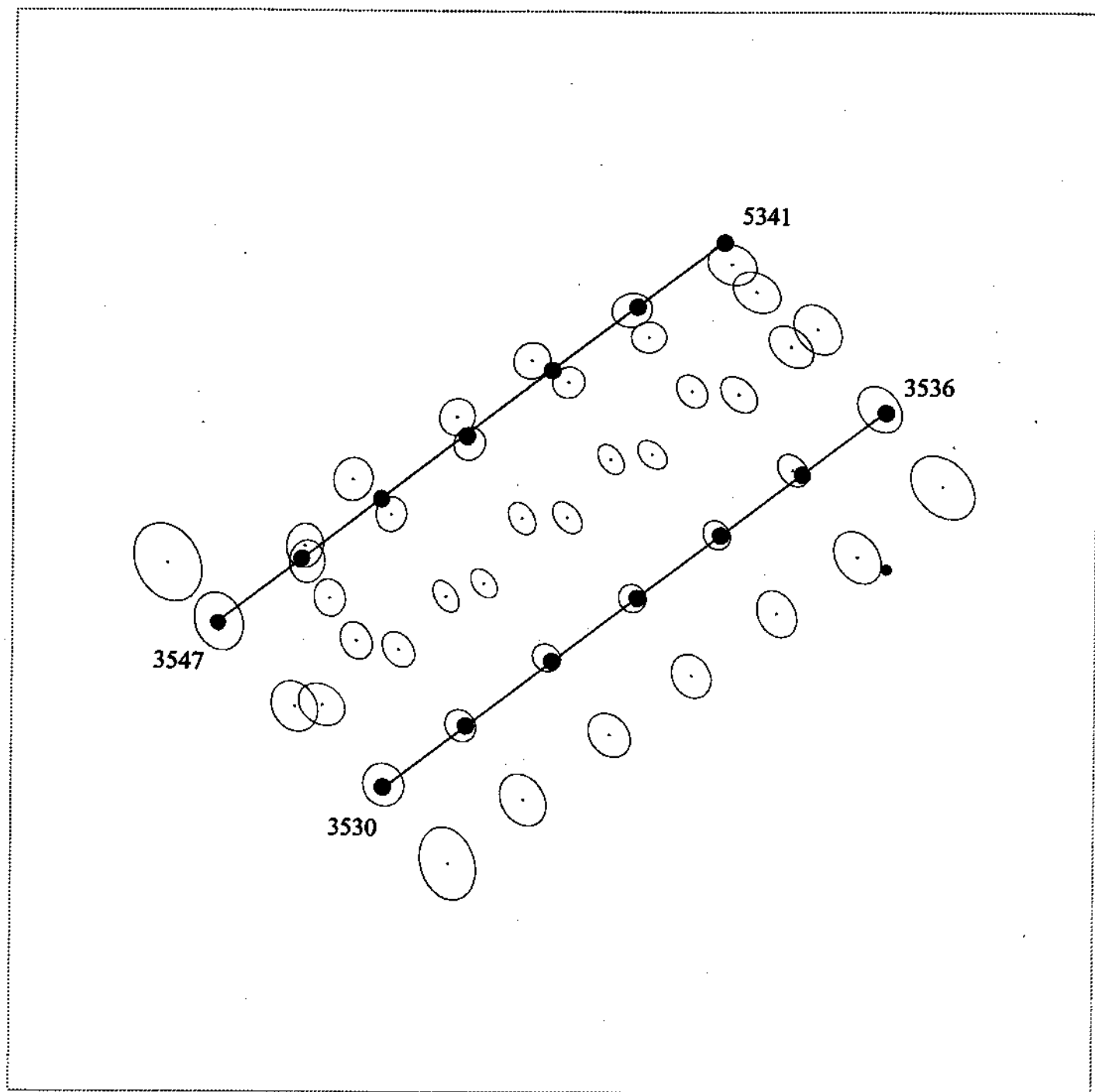
Approved and Forwarded,



Robert W. Rodkey
Chief, Applications Branch



**Relative Horizontal Error Ellipses
(with photo centers)**



APPENDIX D

Compilation Sources

Project: OH0001A

Photography:

Date	Time	Roll / Frames	Scale	Tide Level
08-25-00	1737-1740	00 ACN-18 #3528-3538	1:30,000	174.166
08-25-00	1746-1749	00 ACN-18 #3539-3549	1:30,000	174.164

Note: Water level data are in meters above the International Great Lakes Datum (IGLD) 1985 and are based on actual observations recorded by NOS gauges at Cleveland, Ohio, at time of photography. Times shown are on UTC (GMT).

APPENDIX E

