SR 183

Special Report 183

THE USE OF ERTS-1 IMAGERY IN THE NATIONAL PROGRAM FOR THE INSPECTION OF DAMS

Harlan L. McKim, Thomas L. Marlar and Duwayne M. Anderson

December 1972

CORPS OF ENGINEERS, U.S. ARMY
COLD REGIONS RESEARCH AND ENGINEERING LABORATORY
HANOVER, NEW HAMPSHIRE

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PREFACE

This report was prepared by Dr. Harlan L. McKim, Research Soil Scientist, Mr. Thomas L. Marlar, Scientific Photographer, and Dr. Duwayne M. Anderson, Research Physical Scientist. The authors are members of the Earth Sciences Branch, Research Division, and Photo Service Laboratory, Technical Services Division, U.S. Army Cold Regions Research and Engineering Laboratory. The work was funded under a reimbursable order from the National Aeronautics and Space Administration: *ERTS-A Data User Investigation of Arctic and Subarctic Environmental Analysis Utilizing ERTS-A Imagery.*

The authors wish to express their appreciation to Mr. J.W. Jarman, Chief, Systems Branch, Policy and Analysis Division, Office of the Chief of Engineers; Mr. Frank Fogarty and Mr. E.P. Gould, Dam Safety Inspection Program, New England Division, Corps of Engineers; Dr. Dean Freitag, Technical Director, USA CRREL; and Dr. Kay Sterrett, Chief, Research Division, USA CRREL, for their time and assistance in reviewing this paper.

The contents of this report are not to be used for advertising, publication, or promotional purposes. Citation of trade names does not constitute an official endorsement or approval of the use of such commercial products.

In accordance with EC 1110-2-136, which provides instruction for the National Program for Inspection of Dams, DAEN-CWR-S is furnishing all Division Engineers in the Corps of Engineers with ERTS-1 imagery in the form of 70-mm negatives for their areas of jurisdiction. ERTS coverage is repetitive; therefore each Division should inform DAEN-CWR-S when their needs have been fulfilled and additional imagery is no longer required. NASA is providing this imagery for Corps of Engineers use only. Publications utilizing this ERTS-1 imagery must be approved by NASA. Provisions for public acquisition of ERTS-1 imagery have been made with the U.S. Geological Survey EROS Data Center in Sioux Falls, South Dakota.

Aid in securing the necessary approval can be obtained by writing to Mr. J.W. Jarman (address above).

CONTENTS

ILLUSTRATIONS

TABLES

THE USE OF ERTS-1 IMAGERY IN THE NATIONAL PROGRAM FOR THE INSPECTION OF DAMS

by

Harlan L. McKim, Thomas L. Marlar and Duwayne M. Anderson

INTRODUCTION

A requirement for a national program for inspecting dams became law (H.R. 15951) on 9 August 1972. It requires the Secretary of the Army, through the Corps of Engineers, to institute a program of inspection of dams throughout the United States. The program consists of identifying and locating dams and tabulating pertinent data. It will include all artificial barriers and appurtenant works which are 25 ft or more in height above the natural bed of a stream or watercourse, or have an impounding capacity at maximum water storage elevation of 50 acre-ft or more.[1]

Technical inspections will be made on all dams whose failure or partial failure would endanger life or cause substantial property damage. The technical inspections will include a review of all engineering data on the design, construction and operation of each dam and appurtenant structures, including electrical and mechanical operating equipment and measurements from instruments and devices. A detailed, systematic visual inspection will be made of those features affecting the operational adequacy, safety and stability of the structure.

There are a number of different ways this task can be approached but the funds and time available are a critical constraint. The progress of the program must be reported to Congress by July 1974 for review, and the final completion date has been set for 1978.

Information will be sought from all potential sources. Data on federal dams, including dams constructed by the Soil Conservation Service, will be requested from the applicable agencies. Information on non-federal dams will be obtained from state agencies. Additional sources will include county and local officials, field reconnaissance, responses to public notices, the Register of Dams in the United States compiled by the United States Committee on Large Dams (USCOLD), topographic maps, quadrangle maps, and aerial imagery.

This paper reports the details of a method for utilizing ERTS-1 imagery in the dam inventory program. A list of equipment needed for viewing the imagery is included along with suggested sources of supply. The method used is adequate to identify and locate water bodies larger than 6 acres. This information is intended to supplement data obtained from the sources listed above.

POTENTIAL UTILITY OF ERTS-1 DATA

ERTS-1, a 1-ton modified Pathfinder (Fig. 1), was launched aboard a two-stage Delta rocket from the Western Test Range, Lompoc, California, on 23 July 1972. It is in a 920-km (570-mile) near-polar orbit which permits repetitive photo coverage of any given area in the world at the same time every 18 days (Fig. 2). The satellite orbits the earth approximately every 103 minutes,

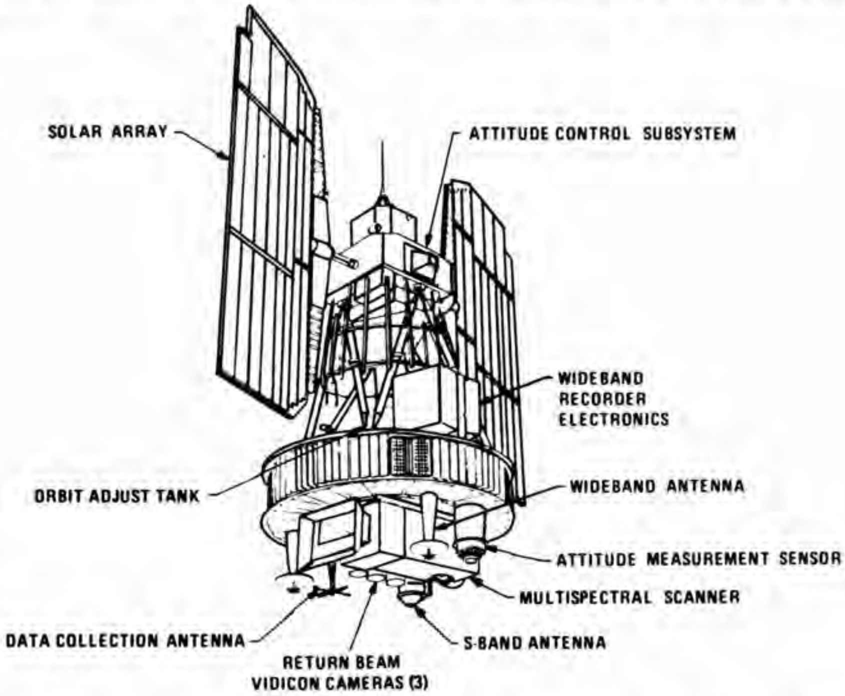


Figure 1. Environmental resources technology satellite (NASA, 1972).

continually viewing the earth through 14 orbits a day by means of two imaging systems, a return beam vidicon (RBV) and a multispectral scanner (MSS). Both systems yield photo images of an area approximately 100 nautical miles (115 statute miles) square, about 34,000 km^2 or 13,000 $miles^2$ (Fig. 2).

The methods of operation of the RBV and MSS are different. The RBV is actually a camera without a film. When the shutters of the three RBV cameras click, images are stored inside each of the three vidicon camera tubes and then scanned to provide a video picture. The cameras are shuttered every 25 seconds to produce overlapping pictures of the same ground scene.[2] In the 149th orbit there was a malfunction of the RBV system and on 6 August the tape recorder for this system was deactivated. Although there is a possibility that it may be resumed, at present the system remains deactivated.

The MSS produces images by a different process. It forms an image by breaking a scene into many tiny segments. The segments are obtained in rapid succession by means of a scanning, moving mirror in the optical system.[2] The final data product from either system is a black and white rendition of every scene in each of the seven bands, three bands for the RBV and four for the MSS. The ERTS-1 imagery available for use in this application consists of 70-mm negatives of MSS spectral bands 4 (500-600 mμ), 5 (600-700 mμ), 6 (700-800 mμ), and 7 (800-1100 mμ). Each scene overlaps the preceding scene by 10%.

For the dam inventory, bands 7 and 5 provide the most useful information. In band 7, the near-infrared portion of the spectrum, water bodies appear black and contrast greatly with surrounding terrain. Band 5 is excellent for distinguishing land use, vegetation, and drainage patterns and for road network mapping.

Images representing three areas of the United States have been examined in detail to provide experience and serve as examples for this report. The areas are located in New England, the Midwest and the Northwest (Fig. 3, 4, 5). Many different sizes, shapes and configurations of manmade and natural water bodies are represented in these images. They also include a wide diversity in topography, surficial geology, soils and hydrology. An explanation of the alphanumeric annotations printed at the bottom of the imagery in Figures 3-5 is given in Figure 6.[3]

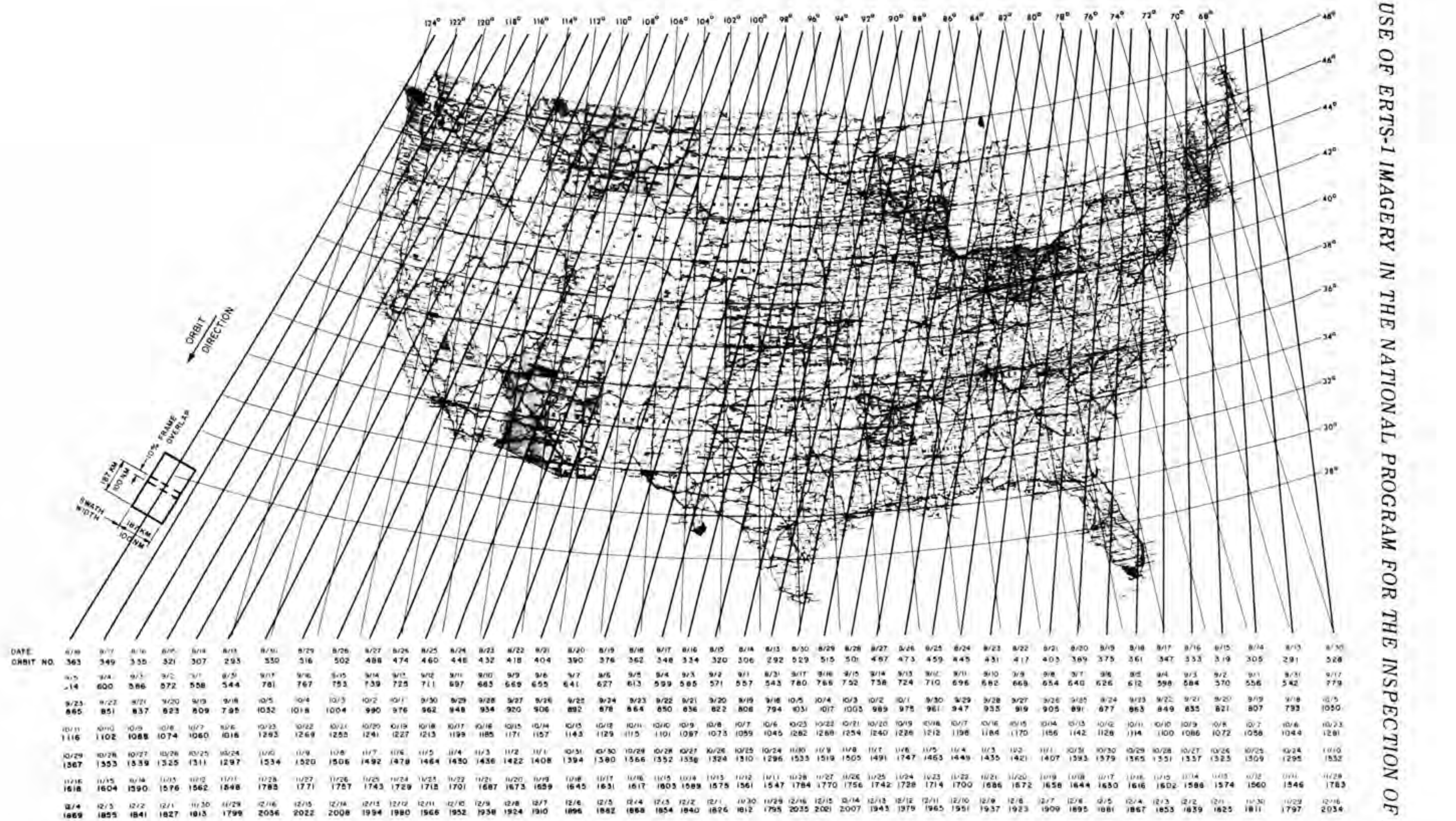


Figure 2. ERTS-1 Coverage of the United States, 1972. (General Electric Co.)

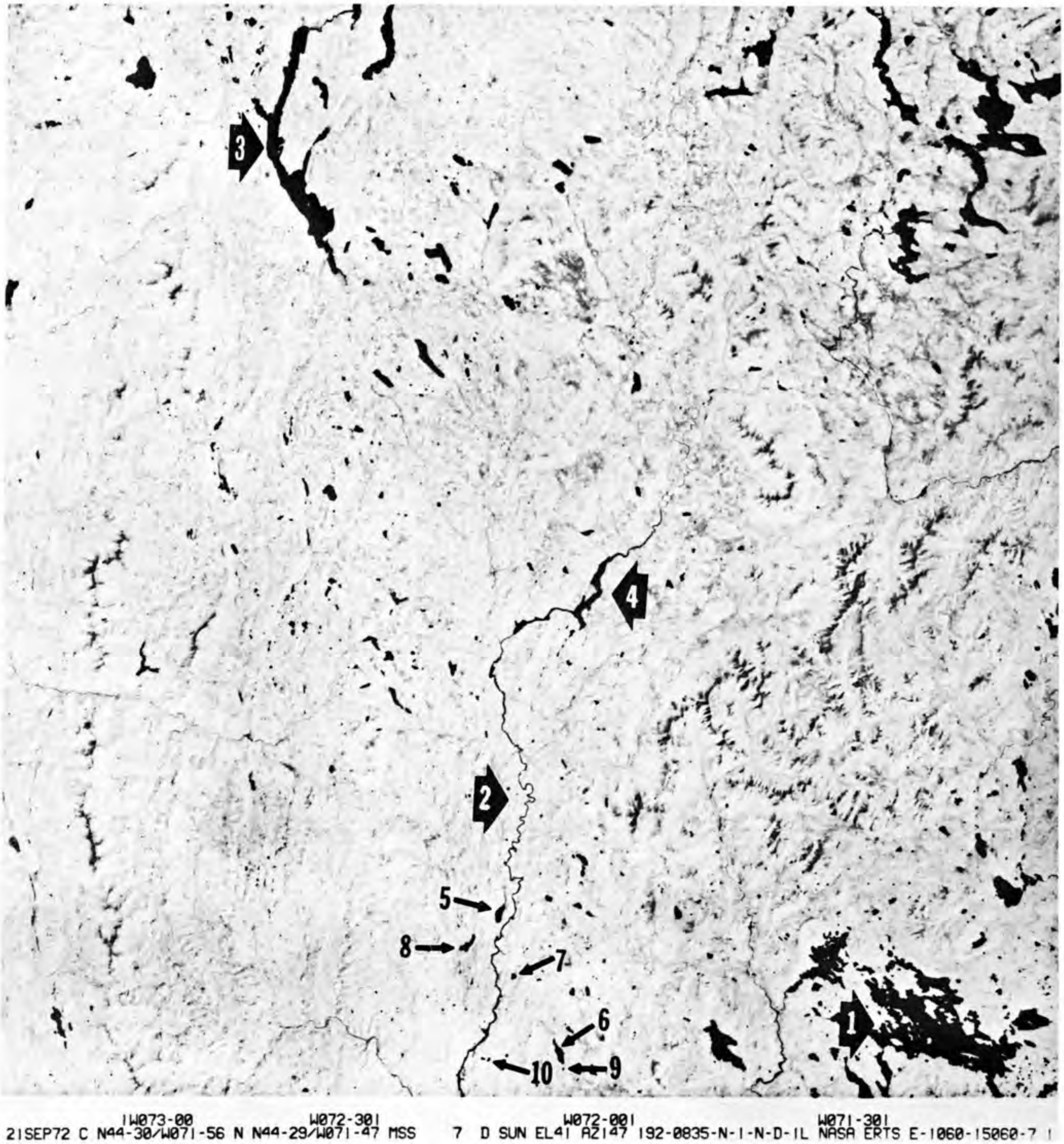
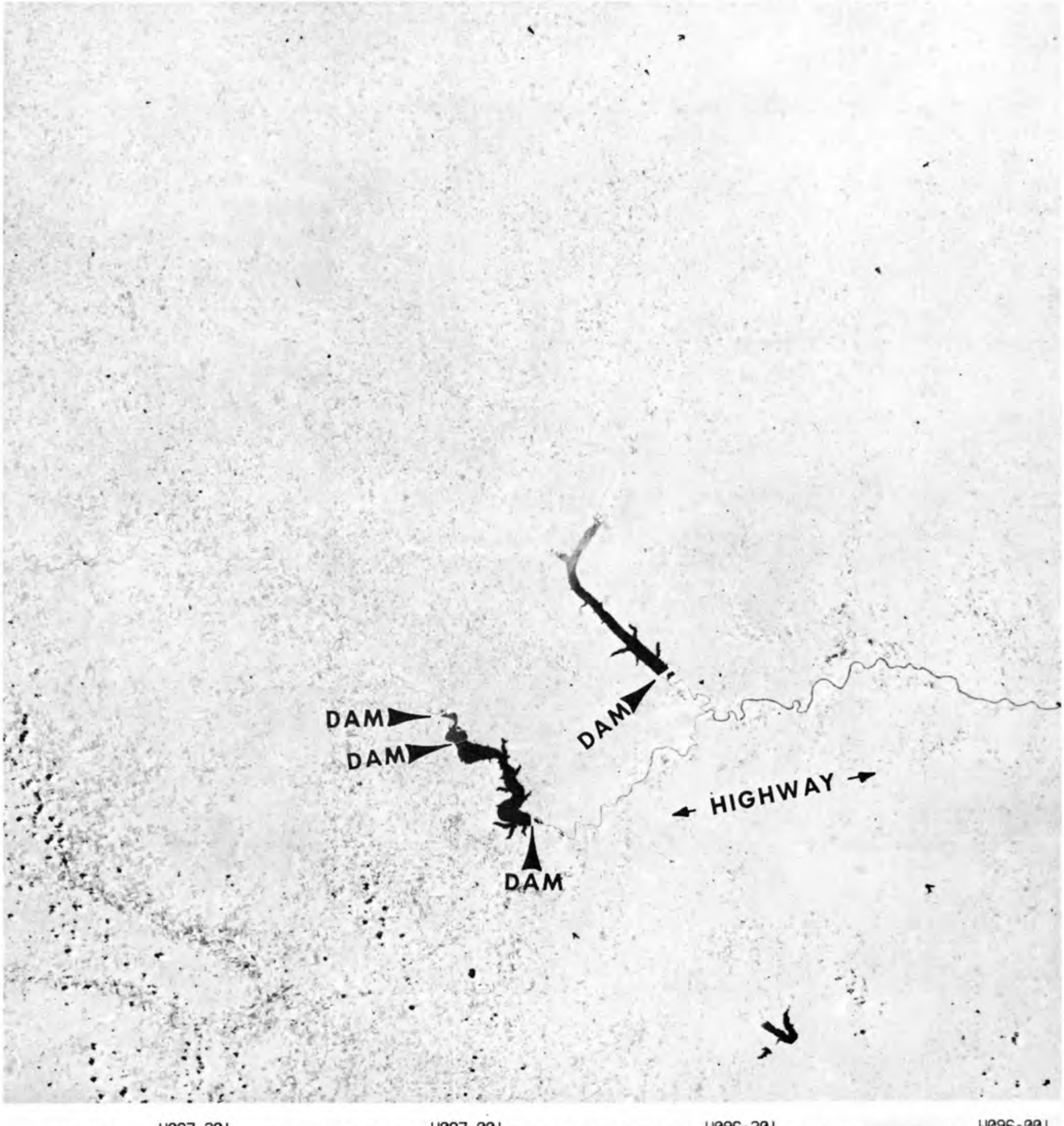


Figure 3. ERTS-1 MSS band 7 image of northern New England and a portion of southern Canada. Lake Winnipesaukee is shown in the southeastern corner of the photo (1). The Connecticut River (2) runs north-south through the center of the image, separating Vermont from New Hampshire. Lake Memphremagog (3) is clearly identified in the northwestern section of the image and Moores Reservoir (4) is easily discernible in the central portion. A dam can be seen on the southwestern tip of Moores reservoir. In the south central portion of the image there are many small lakes, ponds and reservoirs, including: Lake Morey (5), 960 acres; Goose Pond (6), 720 acres; Post Pond (7), 120 acres; Lake Fairlee (8), 560 acres; Little Goose Pond (9), 10 acres; Hanover Reservoirs (10), 40 acres and 30 acres.

*a. **Band 5.** The dark gray dendritic drainage pattern is clearly evident. Milfred (1) and Tuttle Creek (2) Reservoirs can be seen in the central portion of the image. Reservoir boundaries on this band are not clearly defined. The various tones appearing in the reservoirs are related to both sediment load and depth. The three dams of Milfred Reservoir and the lower dam on Tuttle Creek Reservoir can be identified. Major streams may be located by land use patterns. Interstate Highway 70 (3) runs diagonally across the lower ⅓ of the photo, from Manhattan to Topeka. Scattered small clouds (4) may be seen in the lower portion of the image.*

Figure 4. ERTS-1 MSS images of northeast Kansas and southeast Nebraska.

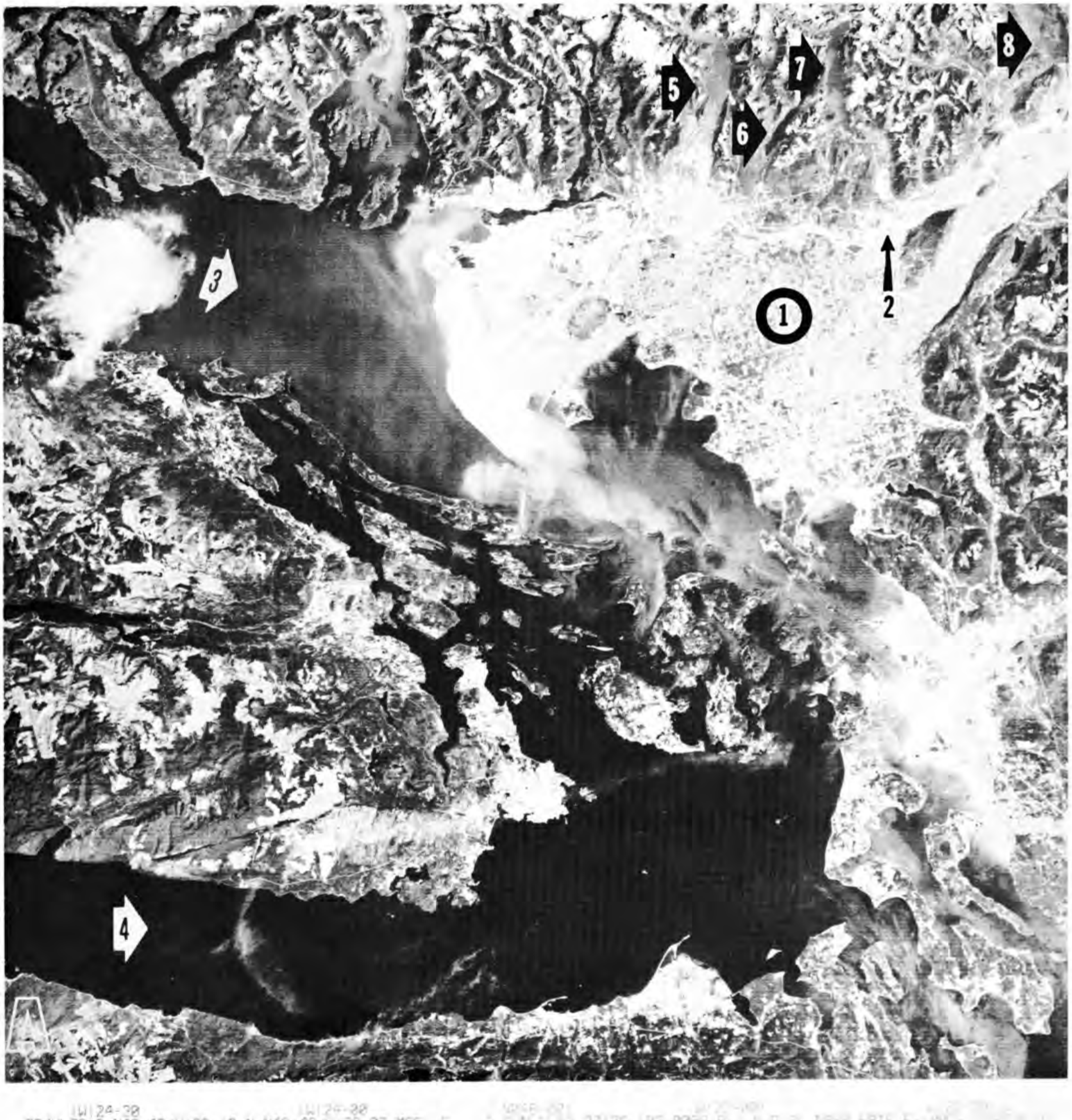


b. Band 6. The dendritic drainage patterns are not as clearly defined in this band as on band 5.. Major waterways are observable and the boundaries of the large reservoirs can easily be delineated. Sedimentation patterns and the four major dams on the reservoirs can be seen. The lower dam on the Milfred Reservoir is not as clearly defined on band 6 as on band 5. Land use patterns are subdued and Interstate Highway 70 is a faint lineation considerably less distinct than on band 5.

Figure 4 (Cont'd). ERTS-1 MSS images of northeast Kansas and southeast Nebraska.

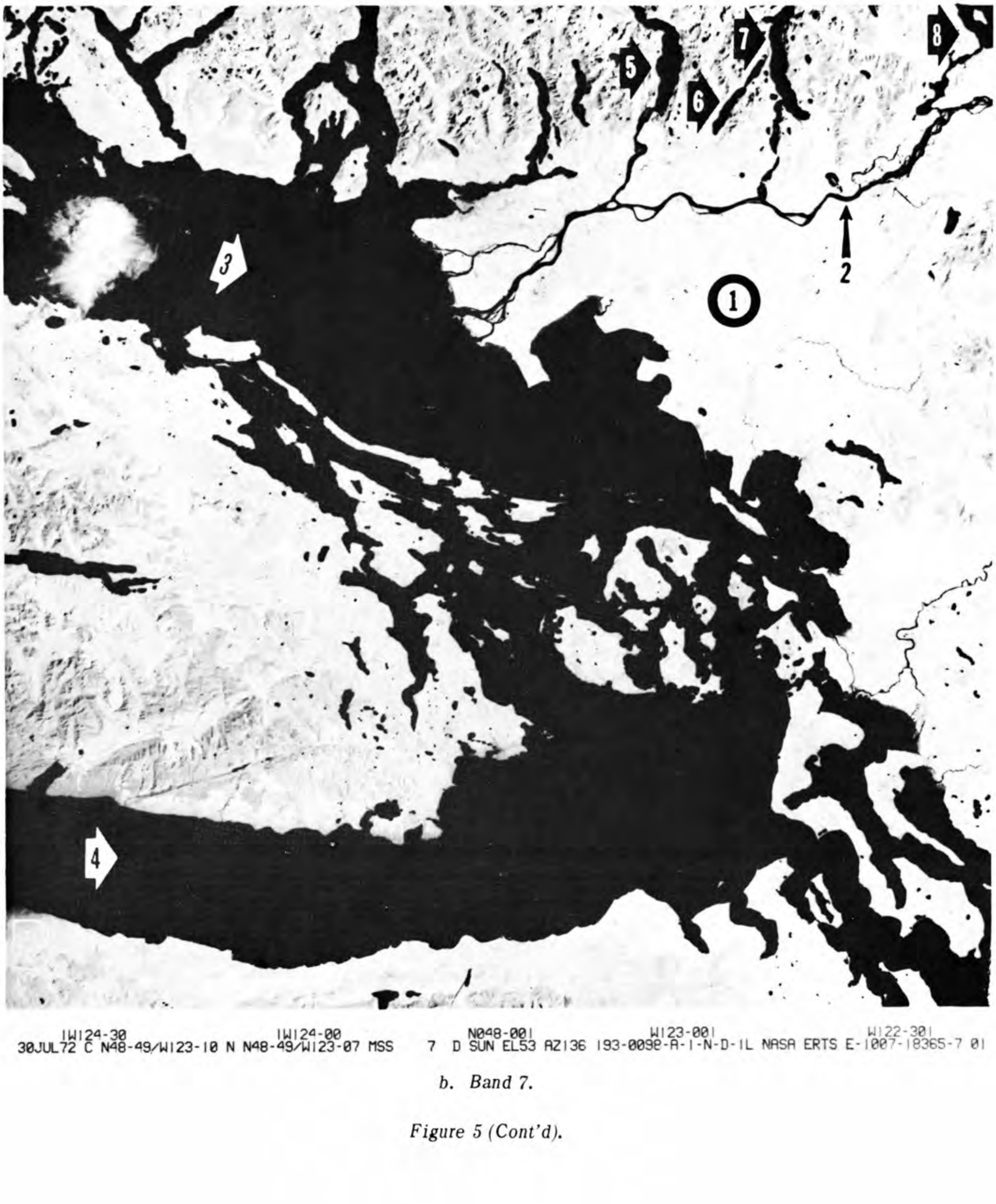
c. Band 7. Band 7 is most useful for identification of water bodies. There is a large contrast between water bodies and the surrounding land features. The course of the Republican River (1) extends from the left center of the image, entering the upper corner of Milfred Reservoir. The Blue River (2) enters the upper portion of Tuttle Creek Reservoir. The Kansas River (3) begins at the base of Milfred Reservoir and flows in an easterly direction toward the Missouri River. Drainage patterns are greatly subdued and the lineation of Interstate Highway 70 completely disappears.

Figure 4 (Cont'd).



a. Band 5.

Figure 5. ERTS-1 image of the area around Vancouver, B.C. (1). The Fraser River (2) enters the Strait of Georgia (3) in four distinct channels. On band 5 plumes of sediment are observed from all four streams. The sediments are carried near shore in a southerly direction down to the group of islands separating the straits of Georgia and Juan de Fuca. The Strait of Juan de Fuca (4) contains little sediment. The four lakes, Pitt (5), Alouette (6), Stave (7) and Harrison (8), along the northern edge of the photo are very interesting. On band 5, Pitt, Stave and Harrison Lakes indicate large sediment load, algae, other coloration or a very shallow depth to bottom because of the light tone of gray. Alouette lake is black on band 5, which would indicate a low sediment load or a deep body of water. All four lakes are black when viewed on band 7.



b. Band 7.

Figure 5 (Cont'd).

	a	b	c	d	e	f	g	h	i	
										← ①
	12345678	1 2 90123456789012345	3 4 67890123456789012	5 345678901234	6 56789012345678	7 90123456789	8 0123456789	9 012345678	1 1 0 1 901234567890123456	← ②
RBV	07JUN72	C N33-05/W115-18	N N33-04/W115-20	RBV 1 RXAI RBV 2 RBV 3	SUN EL30 AZ015	194-1234-A	1-N-P-	NASA ERTS	E-1042-16032-10 2 3	← EXAMPLE

NOTES: ① THE LETTERS "a" THROUGH "i" REFER TO PARAGRAPHS IN THIS DOCUMENT THAT EXPLAIN THE ANNOTATION BLOCK.

② CHARACTER "POSITION" IN THE ANNOTATION BLOCK.

	12345678	1 2 90123456789012345	3 4 67890123456789012	5 345678901234	6 56789012345678	7 90123456789	8 0123456789	9 012345678	1 1 0 1 901234567890123456	← ②
MSS	07JUN72	C N33-05/W115-18	N N33-04/W115-20	MSS 4 D MSS 5 MSS 6 MSS 7 MSS 8	SUN EL30 AZ015	194-1234-G	1-N-P-1H	NASA ERTS	E-1042-16032-4 5 6 7 8	← EXAMPLE

a. Character Positions 01-08. 07JUN72
Day, month and year of picture exposure.

b. Character Positions 09-25. CN33-05/W115-18
Format Center — Latitude and longitude at the center of the RBV and MSS image format is indicated in degrees and minutes. The MSS Format Center is identical to the RBV Format Center. Format Center is defined as the geometric extension of the spacecraft yaw axis to the earth's surface.

c. Character Positions 26-42. N N33-04/WII5-20
Latitude and longitude of the nadir (the intersection with the earth's surface of a perpendicular line from the spacecraft to the earth ellipsoid) is indicated in degrees and minutes. The NASA Ellipsoid is the Earth model.

d. Character Positions 43-54. RBV 1 DXA
The characters in this group are sensor and spectral band specific:
For RBV Images:

43-49 Sensor and NDPF spectral band identification code. Note that the spectral identification code numbers are purposely staggered to permit identification of the spectral images used to make a color composite transparency.

50 "D" indicates direct transmission (real time); "R" indicates stored data played back from the satellite wideband video tape recorder.

51-52 RBV Shutter Duration Code

The "XA" means the shutter for Camera 1 was set for 4.0 milliseconds, Camera 2 for 4.8 ms, and Camera 3 for 6.4 ms.

"XB" would indicate the shutter setting for Camera 1 is 5.6 ms, Camera 2 is 6.4 ms, and Camera 3 is 7.2 ms.

Alphabetic Code	Duration of Exposure Time		
	Camera 1	Camera 2	Camera 3
A	4.0	4.8	6.4
B	5.6	6.4	7.2
C	8.0	8.8	8.8
D	12.0	12.0	12.0
E	16.0	16.0	16.0

53-54 Aperature Correction Indicator
Ib — Aperature correction "in"
Ob — Aperature correction "out"
b — blank

For MSS images

43-51 The sensor and NDPF spectral band identification code.

53 Type of transmission, direct or recorded.

e. Character Position 55-68. SUN EL30 AZ015
Sun Angles - the sun elevation angle and sun azimuth angle measured clockwise from true North at the time of RBV exposure or midpoint of MSS frame is specified to the nearest degree.

f. Character Positions 69-79. 194-1234-A
Spacecraft heading, orbit revolution number, and ground recording station.

The "194" is spacecraft heading to the nearest degree, measured clockwise from true North. It is the orbital path plus spacecraft yaw. Heading relative to an image is always toward the image annotation block.

The "1234" is a four digit orbit revolution. Rev "0001" starts with the first ascending node (south to north equator crossing) after launch.

The "A" indicates the ground recording station. G=Goldstone, A=Alaska, N=NTTF.

g. Character positions 80-89 1-N-P-1H
The "1" means the image is full size.

The "N" means the image was processed using normal processing procedures. Abnormal processing will be indicated with "A".

The "P" means "predicted" orbit ephemeris data was used to compute image center; a "D" indicates "definitive" or best fit ephemeris was used. Normally the latter is used since it is more accurate.

The "1" indicates a linear mode, a "2" indicates a compressed mode of MSS signal processing prior to transmission from satellite to ground station.

(This applies to Bands 4, 5, and 6 only. See Appendix A)

NOTE: Compressed data will be decompressed during processing.

"H" is high gain, "L" is low gain for Bands 4 and 5 only, which have a commandable gain option.

h. Character positions 90-98 NASA ERTS

Identifies the Agency and the Project.

i. Character positions 99-114 E-1042-16032-10

Frame Identification Number—each image or frame will have a unique identifier which will contain encoded information consisting primarily of time of exposure relative to launch. Its format is E-ADDD-HHMMS-BCRR and is interpreted as follows:

E — Encoded Project Identifier
A — ERTS Mission: 1=ERTS A; 2=ERTS B
DDD — Day number relative to launch at time of observation
HH — Hour at time of observation
MM — Minute at time of observation
S — Tens of seconds at time of observation
B — NDPF Identification Code (RBV: 1, 2, 3; MSS: 4, 5, 6, 7, 8)
C — Blank for earth images, either 0, 1, or 2 for RBV radiometric calibration images, indicating lowest to highest exposure level respectively.
RR — Regeneration number. This is used to indicate the re-run of a video tape in the event of a malfunction in the prior run.

Figure 6. Details of bulk image annotation block (NASA, 1972).

CHARACTERISTICS OF ERTS-1 IMAGERY

Resolution

Preliminary tests have shown that the resolution of the ERTS imagery will allow identification of circular water bodies about 152 m (500 ft) in diameter. It is possible to identify smaller water bodies in certain ERTS scenes, and linear patterns such as streams, high power transmission lines, drainageways and road networks are readily discernible. The approximate geographical location of water bodies or dams may be determined from the ERTS-1 imagery alone and accurate location mapping is possible when the imagery is used in conjunction with USGS 7.5-min or 15-min quadrangle sheets.

Gray tones

A 15-step gray scale is given on every frame of imagery as it is produced on the Electron Beam Recorder (EBR). This scale is carried through the same copying and processing procedures as the image to which it is attached. The gray scale gives the relationship between a level of gray on the image and the electron beam density used to expose the original image. The electron beam density is related to the energy incident on the sensor.[1]

The negatives supplied by NASA tend to be very dense. This is sometimes a cause for misjudging the photographic printing techniques needed for optimum results in the finished product. The following information is supplied for photographic processing control.

Nominal scene density (diffuse) of the archival ERTS imagery ranges from 0.10 to 2.10 (Table I). The photographic duplication facility maps these densities in a second generation negative to 2.40 to 0.40 (Fig. 7). Thus, the 0.10 density of the original becomes 2.40 and the 2.10 density of the original becomes 0.40. The macrodensity duplication transfer function is nearly linear between 0.40 and 2.40 for the duplication system so that second generation negatives duplicate the original dynamic range accurately but with a 0.30 density increase bias. The bias is needed so that the duplicate is not printed on the "toe" of the characteristic curve which would reduce the dynamic range of the duplicate compared to the original.*

Table I. Approximate nominal densities of the step tablet on the original photography and the second generation mapped values.*

Step	*Archival density*	*Second generation density*
1	.10	2.40
2	.13	2.37
3	.17	2.33
4	.21	2.29
5	.25	2.25
6	.29	2.21
7	.34	2.16
8	.40	2.10
9	.46	2.04
10	.54	1.96
11	.63	1.87
12	.75	1.75
13	.92	1.48
14	1.19	1.31
15	2.10	.40

*Personal communication, Richard G. Holmer.

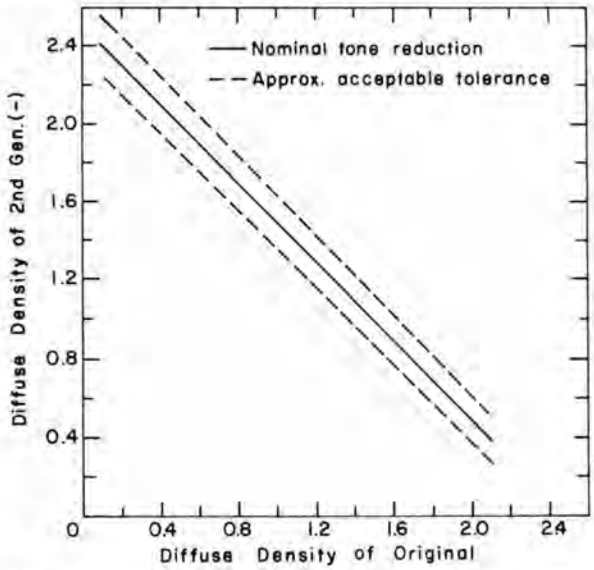


Figure 7. Relationship of the diffuse density of the original image to the diffuse density of the second generation image.

EQUIPMENT AND SUPPLIES REQUIRED

The equipment needed for utilization of the ERTS-1 imagery in this application is neither sophisticated nor complex. The basic requirements are: a light box or light table, clear acetate sheeting, marking pens, and a magnifying viewer (5X - 7X) with an integral millimeter scale. If this equipment is not on hand, it is available from commercial suppliers for a total cost of about $100.00. A list of commercial suppliers and prices for the needed items is given in the Appendix. In addition to viewing and marking supplies, it is recommended that USGS quadrangle sheets (15 min, 1 in. = 1 mile) be obtained to use as an inventory base map. If USGS quadrangle sheets of this scale are not available, 7½-min or 30-min quadrangle sheets, detailed highway maps, aviation sectional charts (scale 1:500,000) or other state and local government maps may be used. A transparent overlay will be useful; it should be large enough to cover the enlarged ERTS-1 imagery (Fig. 8). Each grid segment is 1 cm and represents approximately 10 km on the 1:1 million transparency.

RECOMMENDED METHOD

1. Each Corps of Engineers Division is to be furnished with 70-mm negatives of MSS bands 5 and 7 covering its area of jurisdiction. The 70-mm negatives of bands 5 and 7 should be enlarged to 18.69 cm (7.36 in.) on a side, equivalent to a scale of approximately 1:1 million. Positive transparencies preserve much more useful information than paper prints. For this reason, it is suggested that transparencies be used unless circumstances make this impossible.

2. Excellent positive transparencies may be made with a standard photographic enlarger. The following procedure is recommended:

a. Place negatives in a standard photographic enlarger. A 300-watt light bulb will give an exposure of 1 second at $f = 5.6$ on Kodalith Royal Ortho film (Estar base). This exposure is suggested as a starting point but may vary with the equipment used.

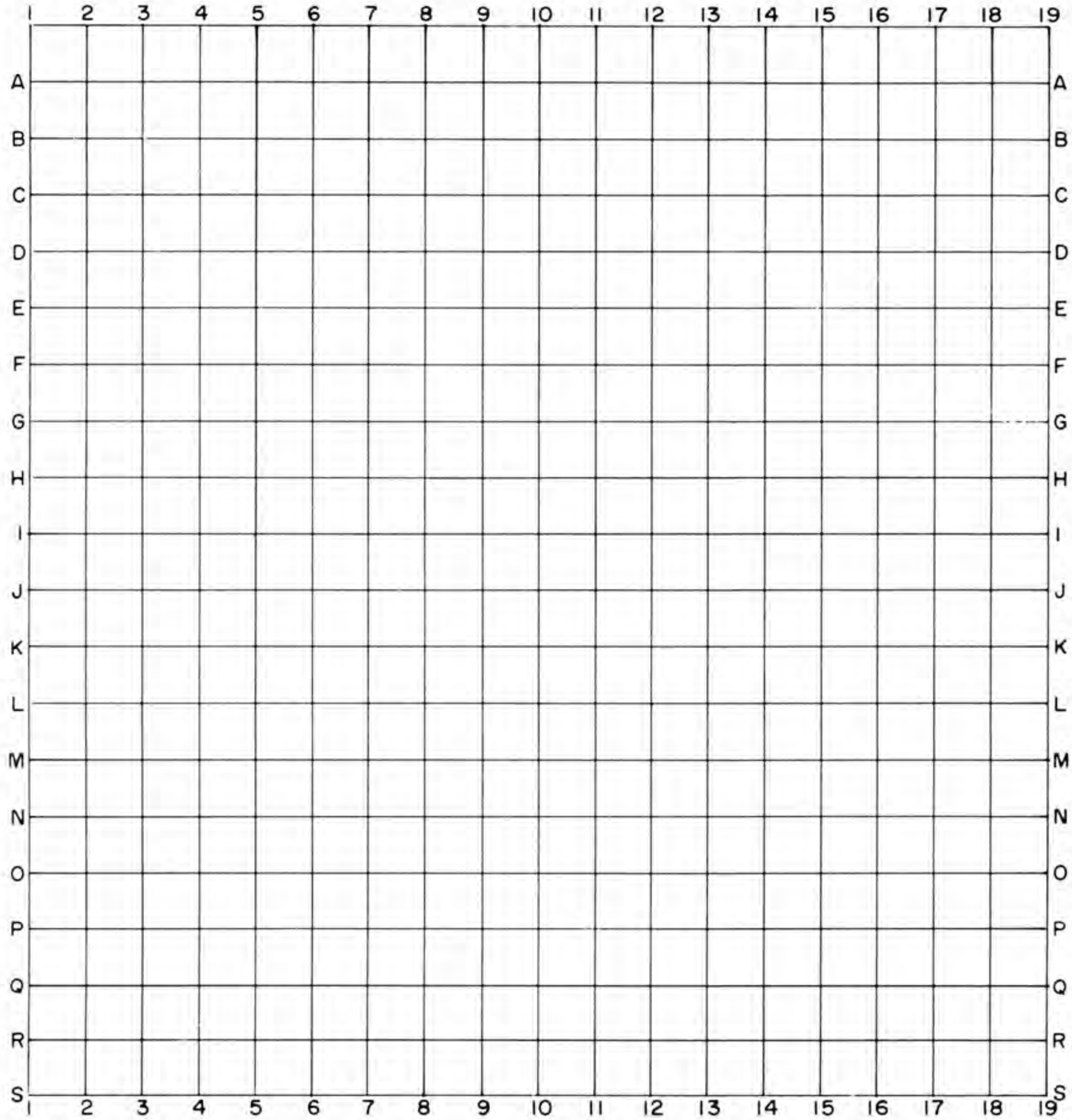


Figure 8. Gridded transparent overlay. Each segment is 1 square centimeter (not to scale).

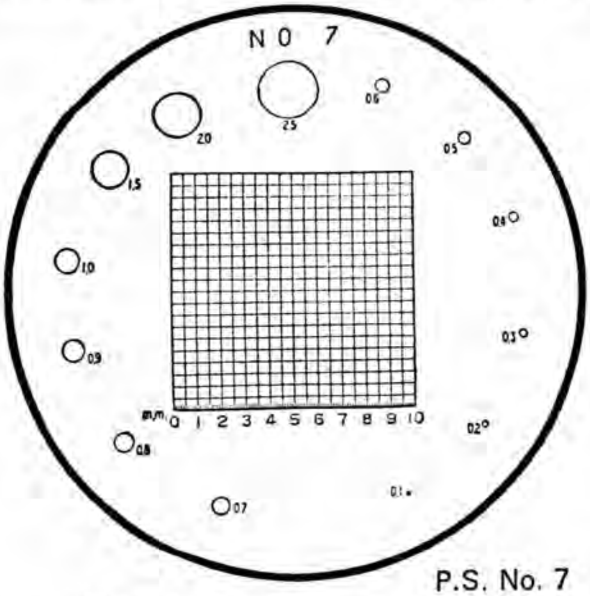


Figure 9. Sample comparator grid.

b. Develop in Kodak Dektol mixed 1:2. Use a development time of 30 seconds with constant agitation. All processing solutions should be at a temperature of 68°F.

c. Fix in Kodak rapid fixer and dry, using conventional photographic methods.

The Kodalith film is recommended because of its excellent contrast, ease of handling and ready availability. The use of dimensionally stable film base products minimizes scale changes during reproduction. It is possible to control the contrast of the transparency using conventional exposure/processing manipulations. The specification of Kodak products above, however, is not meant to exclude use of similar products of other manufacturers. Exposure and processing tests must be made when substituting other materials.

3. Prepare base maps of selected areas and cover with clear acetate sheeting.

4. Place 1:1 million positive transparency on a light table or light box and position the gridded transparency overlay. The grid is used to determine the areas of large water bodies and to locate smaller water bodies. The examination of the transparency for images of water bodies should be systematic. For example, one might examine all grid squares on line A, left to right, then line B, etc. All water bodies should be marked on the acetate overlay of the base map as they are encountered. Area measurements may be made by using a millimeter scale and converting the scaled reading to meters or feet. Smaller water bodies are best examined with a magnifier. The one recommended contains a 1-cm grid separated into millimeters. The bottom scale is divided into tenths of millimeters. An additional scale is provided for measuring circular areas (Fig. 9). For example, a water body 0.4 mm in diameter on the transparency is approximately 40 acres. In measuring a dam on a river or reservoir, if the feature is 1 mm long on the transparency it is actually 1000 m (3281 ft) long (Table II). These calculations assume a standard 187 × 187 km image.

5. It will be difficult in many instances to distinguish natural lakes from lakes formed by dams. Larger dams may be distinguished by a linear termination in a drainageway. Dams on streams may be indicated by an abrupt increase in stream width above the dam.

6. At the end of the inventory processes, the overlay will contain all visible water bodies. Most artificial impoundments will have been noted and a cataloging system of numbers will have been prepared as a means of cross indexing.

Table II. Measurement data.

These conversion measurements are based on an average of 30 measurements of the scene dimensions.

Negative

1. 70-mm ERTS-1 negative measures 5.48 cm (2.156 in.)
2. Scale of negative is 1:3.38 million
3. 5.48 cm (2.156 in.) on negative = 187 km ground measurement

Enlarged transparency

1. Positive transparency enlarged to 18.51 cm (7.287 in.) = scale of 1:1 million
2. 1 cm on transparency = 1 million cm (393,700 in.) = 32,808 ft ground measurement
3. 1 mm = 3280.8 ft
4. 0.1 mm = 328 ft

CONCLUSIONS

ERTS-1 imagery can be profitably used in the National Program for Inspection of Dams. Recognizing that it alone is not sufficient to satisfy all needs, it is valuable nevertheless in augmenting other methods of data gathering. Dams on streams can be identified by an abrupt change in stream width. A linear termination on a water body is a reliable indication of a dam, particularly when it is inconsistent with the normal drainage pattern. Care must be exercised to avoid confusing cloud shadows with water bodies. However, the association of a cloud with its shadow usually can be accomplished since the sun angle is noted in the data given on each ERTS image.

The following information generally can be derived from ERTS imagery:

1. The location of water bodies
2. The size and shape of water bodies
3. The identification of dam sites on major rivers
4. The direction of stream flow of major hydrologic networks
5. Relative water depths and/or gross sedimentation patterns.

ERTS-1 imagery, in general, does not supply information suitable for determining:

1. Dam height
2. Type of dam construction (concrete or earth fill)
3. Depth of water bodies
4. Location of water bodies less than 6 acres.

LITERATURE CITED

1. Office of the Chief of Engineers (1972) National program for the inspection of dams. Circular No. 1110-2-136, 31 August.

2. Earth Resources Inventory (1972) *Army Research and Development Magazine.* August, p. 38.

3. NASA (1972) Data Users Handbook, NASA Earth Resources Technology Satellite. Goddard Space Flight Center, Document No. 715D4249, May 4.

APPENDIX: COMMERCIAL SUPPLIERS

The listing of commercial suppliers and items is for general guidance only and in no way constitutes government endorsement of these suppliers or items.

1. *Light Boxes or Tables*

   a. Richard Manufacturing Co.
   5914 Noble Ave.
   P.O. Box 2041
   Van Nuys, CA 91404
   (213) 785-0326

   Idealite 10 × 10 in. transparency illuminator, model 010, $27.95.

   b. Claus Gelotte, Inc.
   185 Alewife Brook Parkway
   Cambridge, MA 02138
   (617) 868-2366

   Porta-trace, portable X-ray viewer, 10 × 12 in., model 1012, $29.50.

2. *Magnifier 7X*

   a. Brookstone Co.
   Dept. C11
   Brookstone Building
   Peterborough, NH 03458

   Optical comparator with no. 7 reticle, Cat. no. D-1922-4, $12.95.

   b. Edmund Scientific Co.
   Edscorp Building
   Barrington, NJ 08007
   (609) 547-3488

   Edscorp Jr. comparator, 6X power, Cat. no. 30,169, $13.50. Reticle for above, Cat. no. 30,588, $7.75.

3. *Clear Acetate*

   Dick Blick
   P.O. Box 1267
   Galesburg, IL 61401
   (309) 343-6161

   Clear acetate in sheets and rolls. Various sizes and thicknesses available. Roll stock is more economical.

4. *Marking Pens*

   Available at most stationery or art supply stores. Fast-drying permanent marking pens should be used.

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) U.S. Army Cold Regions Research and Engineering Laboratory Hanover, New Hampshire 03755	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

THE USE OF ERTS-1 IMAGERY IN THE NATIONAL PROGRAM FOR THE INSPECTION OF DAMS

4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*

5. AUTHOR(S) *(First name, middle initial, last name)*

Harlan L. McKim, Thomas L. Marlar and Duwayne M. Anderson

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
December 1972	20	3

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S) Special Report 183
b. PROJECT NO.	
c.	9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)*
d.	

10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES Sponsored by National Aeronautics and Space Administration	12. SPONSORING MILITARY ACTIVITY

13. ABSTRACT

ERTS-1 imagery can be useful in locating circular water bodies over 152 m (500 ft) in diameter. Dams on streams can be identified by an abrupt change in stream width. A linear termination on a water body is a reliable indication of a dam, particularly when it is inconsistent with the normal drainage pattern. Care must be exercised to avoid confusing cloud shadows with water bodies. However, the association of a cloud with its shadow usually can be accomplished since the sun angle is noted in the data given on each ERTS image.

The following information generally can be derived from ERTS imagery:

1. The location of water bodies
2. The size and shape of water bodies
3. The identification of dam sites on major rivers
4. The direction of stream flow of major hydrologic networks
5. Relative water depths and/or gross sedimentation patterns.

ERTS-1 imagery, in general, does not supply information suitable for determining:

1. Dam height
2. Type of dam construction (concrete or earth fill)
3. Depth of water bodies
4. Location of water bodies less than 6 acres.

Unclassified

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Dams						
Data acquisition						
Hydrographic surveys						
Photogrammetry						
Reconnaissance surveys						
Reservoirs						
Spaceborne photography						

Unclassified

Security Classification