AQUATIC PLANT CONTROL RESEARCH PROGRAM

INSTRUCTION REPORT A-84-2

HANDBOOK FOR OBTAINING AND USING AERIAL PHOTOGRAPHY TO MAP AQUATIC PLANT DISTRIBUTION

by

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Stepwise procedures are given for the tasks required in using low-altitude aerial photography to map aquatic plants. The tasks include problem identification, photomission design, acquisition of ground truth data, and photointerpretation and data presentation. The sources of existing aerial photographs and the general and technical requirements for aerial photography are given in Appendixes A and B, respectively.

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Preface

This handbook, prepared for the Office, Chief of Engineers (OCE), U. S. Army, by the U. S. Army Engineer Waterways Experiment Station (WES), describes procedures to be used by Corps of Engineers personnel for obtaining and using aerial photography for locating and mapping aquatic plants. The procedures described herein should simplify the manager's task of obtaining information as to the status of the aquatic plant communities within his area of responsibility. This handbook was written for the user with little or no remote sensing experience.

This handbook recommends methods for ensuring uniformity of certain procedures common to all remote sensing activities and is designed to present a general set of procedures to ensure adequate coverage of most user needs.

The Aquatic Plant Control Research Program (APCRP) funds for the effort were provided to the WES by OCE, under Department of the Army Appropriation No. 96X3122, Construction General, 92740. Much of the technology was developed through the implementation of the Seattle District's Aquatic Plant Management Program. Technical Monitor for OCE during this study was Mr. Dwight L. Quarles.

Author of this handbook at WES was Mr. James M. Leonard, Environmental Assessment Group (EAG), Mr. Jack K. Stoll, Chief. Dr. John Harrison was Chief, Environmental Laboratory (EL); Dr. C. J. Kirby was Chief, Environmental Resources Division (ERD); and Mr. J. L. Decell was Manager, Aquatic Plant Control Research Program at WES. Special acknowledgement is made to Dr. Barry S. Payne of the EAG for his helpful guidance and suggestions.

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Conversion Factors, U. S. Customary to Metric (SI) Units of Measurement

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	By	To Obtain
feet	0.3048	metres
inches	25.4	millimetres
miles (U. S. statute)	1.609347	kilometres

HANDBOOK FOR OBTAINING AND USING AERIAL PHOTOGRAPHY TO MAP AQUATIC PLANT DISTRIBUTION

Background

1. Because manpower and finances are limited, a priority list for aquatic plant control operations is usually required. Accurate and current maps of plant distribution and abundance facilitate the establishment of priorities for control efforts, especially if plants distributed throughout a large area must be managed. Maps of plant distribution in any large area under an active plant management program should be produced annually or biennially. This series of maps can be used to monitor the effectiveness of control efforts and to identify newly developing problems. Then, changes in the priorities for control operations can be made based on current data on the spatial distribution of the aquatic plant community.

2. Aquatic plants often are spread over large, diverse, and sometimes inaccessible areas. Also, most populations of aquatic plants are highly seasonal in abundance. Thus, rapid reconnaissance of large areas is necessary. Ground survey methods are slow and cost-prohibitive. Data obtained during ground surveys must be transferred to existing and often inadequate maps.

3. The Aquatic Plant Control Research Program (APCRP) at the U. S. Army Engineer Waterways Experiment Station (WES) has been developing remote sensing methods for producing up-to-date maps of aquatic plant distributions. These methods will be used operationally by aquatic plant management personnel. Low-altitude aerial photography has proved to be an effective and economical means of mapping virtually all problem populations of aquatic plants.

Purpose

4. The purpose of this handbook is to transfer the technology developed during remote sensing studies performed through the APCRP to operating elements within the Corps. Technical summaries of individual research studies which contributed to the development of techniques outlined in the present handbook are provided elsewhere (Austin and Adams 1978, Dardeau 1983, Dardeau and Lazor 1982, Leonard 1981, Long 1979, and references within these). This handbook describes a sequence of tasks that managers must accomplish to

successfully use low-altitude aerial photography to map aquatic plants.

Task Sequence

5. An overview of the tasks required when using aerial photography to map aquatic plant distributions is presented in Table 1. The following paragraphs describe the steps within each task.

Task I: Problem Identification

6. This first task involves identifying which plant species and water bodies are to be the targets of a survey and when the survey is to be conducted.

7. Step 1: Determine location and size of target sites. Locations of sites within water bodies with known or suspected populations of problem plants should be marked on a map of accurate scale. United States Geologic Survey (USGS) 7.5-min quadrangle maps are of accurate scale for marking locations of sites within water bodies to be surveyed. These USGS maps are 1:24,000 scale and are annotated with accurate bar scales. Areal estimates are made by drawing a rectangle around each target site. Total area is calculated by separately multiplying the length and width of the rectangle by the scale factor printed on the map, and then multiplying these products. An example of estimating the area of a 3- by 2-cm rectangle on a 1:24,000-scale USGS quadrangle map is:

$$
\begin{aligned}
(3 \text{ cm} \times 24{,}000)(2 \text{ cm} \times 24{,}000) &= 72{,}000 \text{ cm} \times 48{,}000 \text{ cm} \\
&= 0.72 \text{ km} \times 0.48 \text{ km} \\
&= 0.35 \text{ km}^2
\end{aligned}
$$

8. Step 2: Identify aquatic plant growth form. The growth form of the problem plant affects the selection of the film types to be used during the photomission. As these forms relate to film type selection, there are basically only two: submersed and emergent. Species identification is also necessary as it will aid in defining the period of maximum plant abundance for a specific geographic region. Species identification should be made by trained experts such as a taxonomist, botanist, or biologist.

9. Step 3: Determine optimum dates and times for survey. For photographing submersed plants, as much energy as reasonable (that is, a high sun angle) should be impinging on the target and reflecting back to the sensor.

For this reason and for most purposes, between 1000 hr and 1400 hr local time is the best time to fly. There may be instances, however, in which height of emergence of a plant may need to be known; therefore, the longer shadows produced by the earlier morning or later afternoon sun angles may be desired for accurate determination of height. The best time of year to image an area of interest depends not only on sun angle but also on the state of growth and maturity of the target plant(s). Generally, the maximum contrast between aquatic plants and their backgrounds is achieved in late summer or early fall. Local residents and experts can usually offer guidance concerning periods of maximum abundance of the plants.

Task II: Photomission Design

10. The design of the photomission requires that the following information be specified:

- a. Desired image scale.
- b. Film type.
- c. Type of product desired.
- d. Side lap of photographs.
- e. End lap of photographs.
- f. Time of day and time of year mission is to be flown.

All of the above factors will affect the cost of an aerial survey and must be specified when contracting the mission to a commercial survey firm.

11. Step 1: Check for existing photography. Before conducting new aerial photomissions, a check for available, recently obtained aerial photographs of the target area should be conducted. Government agencies and private survey firms continuously update aerial photography of various areas. If recent photography meeting the specifications listed above can be obtained from such a source, new photographs are unnecessary. Appendix A lists most of the important sources of catalogued aerial photography of the United States. Lists of available photography of specific areas can be obtained upon request. This information will include the date of photography, film type, scale, and area covered, as well as project, film roll, flight line, and frame identification information. Copies of prints can be purchased at specified prices. Orders should be placed at least 1 week before the photographs are needed. If several different prints are ordered, a photoindex should be purchased.

12. Step 2: Determine scale to be used. The distribution of most populations of aquatic plants can be mapped from 1:12,000-scale photographs.

Submersed plants generally are more difficult to detect than emergent or floating plants. Dardeau (1983) presents evidence that maps of problem-causing populations of submersed hydrilla are equally accurate if made from either 1:12,000 or, more expensive to obtain, 1:6,000-scale photographs. Images at 1:24,000 scale are difficult to interpret for aquatic plant locations, even with skilled interpreters. Larger scale photography may be used for small areas such as rivers that are less than 1000 m wide. Both banks of a 1000-m-wide river will be included in a single 23- by 23-cm frame at 1:6000 scale.

13. Step 3: Select film type. Two types of film are recommended for aerial photography of problem aquatic plants. Emergent plants are easier to identify from false color infrared (CIR) film. The recommended film for mapping these types of plants is Kodak Aerochrome number 2443, using a Wratten 12 filter. Emergent plants appear red, in contrast to the water which appears dark blue to black, making interpretation easier. Figure 1 shows an example

Figure 1. Example 1:5000-scale photograph of emergent plants using false color infrared film with filter

of emergent plants photographed with this film/filter combination. The recommended film for photographing submersed aquatic plants is true color (TC) film. Kodak Aerochrome number 2448 with Wratten HF4 and HF3 haze reduction filters is recommended for best results in most cases. Figure 2 shows an example of submersed plants photographed using this combination.

Figure 2. Example 1:5000-scale photograph of submersed plants using true color infrared film with filters

14. Step 4: Select photograph overlap. Although it is not a requisite in order to interpret the photograph and map plant infestation, stereoscopic imagery is desirable. The stereo effect results when film exposures along a single flight line are timed so that part of the area photographed during one exposure is again photographed during the next exposure. This is referred to as "end lap" and when desired the end lap should be 60 percent. When parallel flight lines are flown, adjacent flight lines are spaced so that "side lap" is achieved. The recommended amount of side lap is 30 percent. Figure 3 shows how end and side lap are created by proper spacing of photograph center points (d) and flight lines (a and b).

15. Stereoscopic imagery is useful for three reasons. First, the differing angles of view reduce the extent that sunlight reflected from the water surface obscures aquatic plants. Also, because of edge distortion inherent in all aerial photographs, interphotograph overlap minimizes the area affected by distortion and the risk of the distortion affecting the areas of interest. The same features appearing on adjacent photographs along a flight line can be

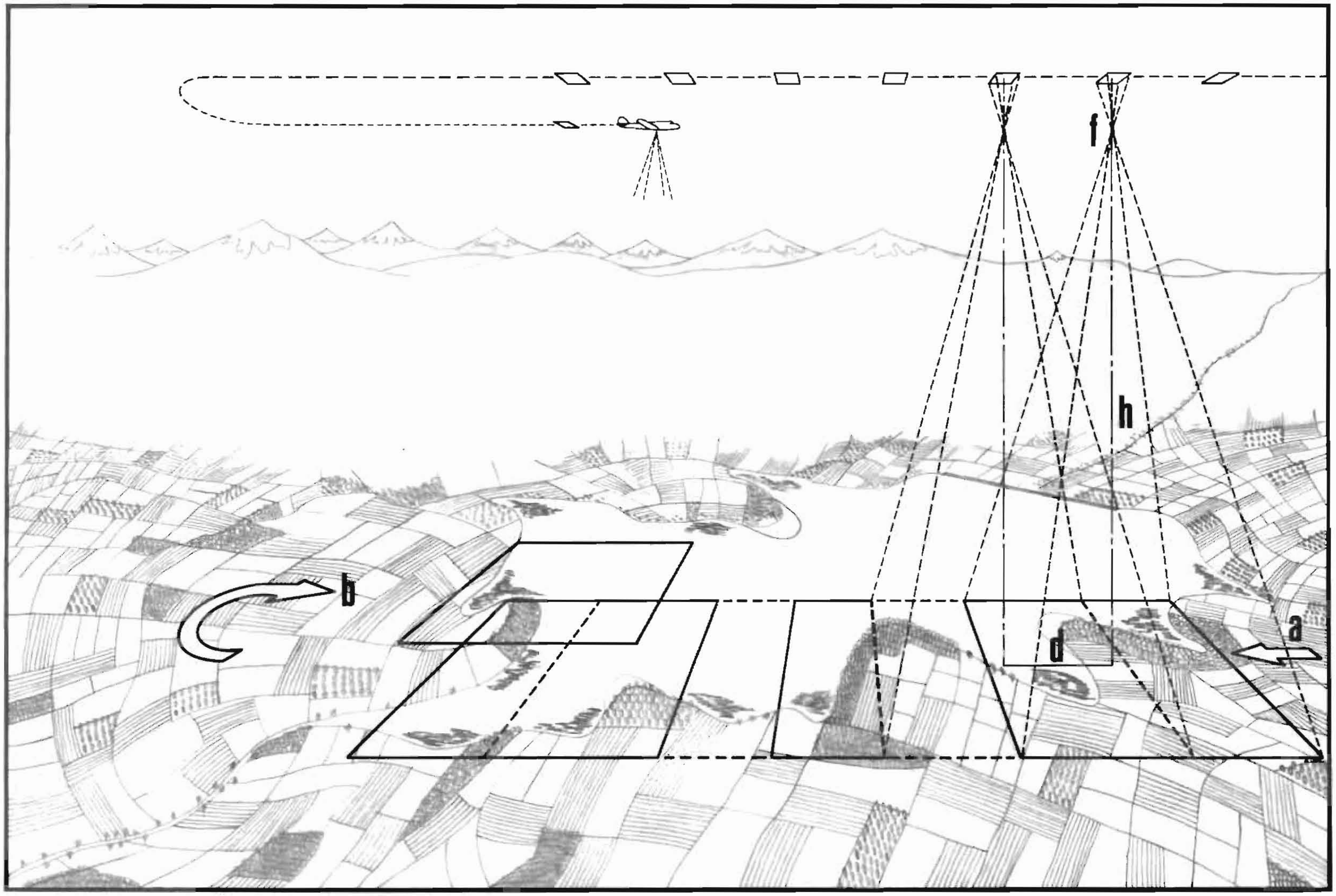

Figure 3. Representation of stereoscopic photographic coverage where a and b are flight lines, f is the focal length of the lens, h is the height above ground, and d is the distance between center points of successive frames

viewed simultaneously through a stereoscope (Figure 4) to reveal added depth not apparent on either photograph viewed singly.

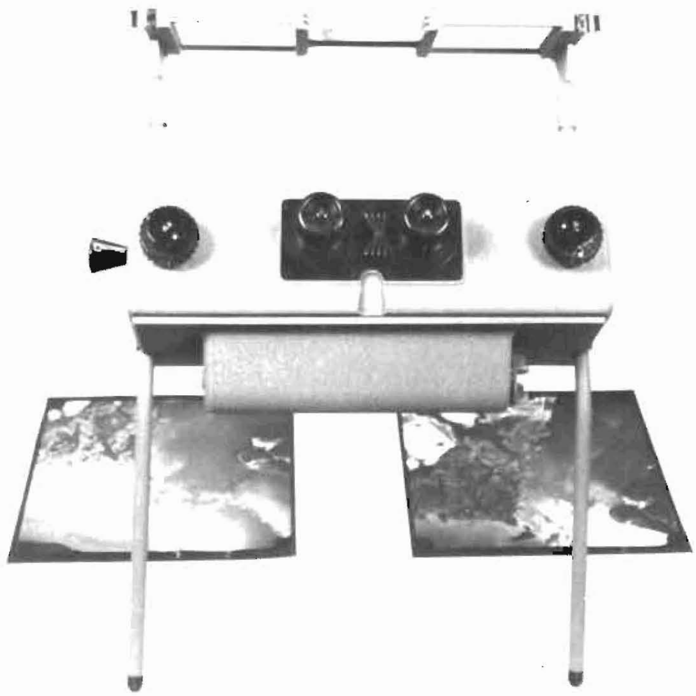

Figure 4. Old Delft scanning stereoscope

16. Step 5: Specify products desired. For best overall results, photographs with a 23- by 23-cm format should be requested. Both films recommended produce rolls of color transparencies. These transparencies can be used for direct viewing, and are also used in the photointerpretation phase (Task IV). From these color transparencies paper prints of single exposures can be produced as desired. If an entire set of prints is ordered, a photoindex should be requested. The photoindex catalogues individual photographs according to their positions in a spatially organized array and retains the individual identification number of each photograph.

17. If the area photographed is large enough to require fly-overs along parallel flight lines and the photographs are to be used to make accurate maps, a semicontrolled photomosaic should be requested. A photomosaic differs from a photoindex because the photographs are trimmed to remove interframe overlap before they are placed in proper spatial positions. Clearly visible landmarks, like fence or road intersections, are used to precisely piece together the mosaic and maintain near uniform scale. Figure 5 is an example of

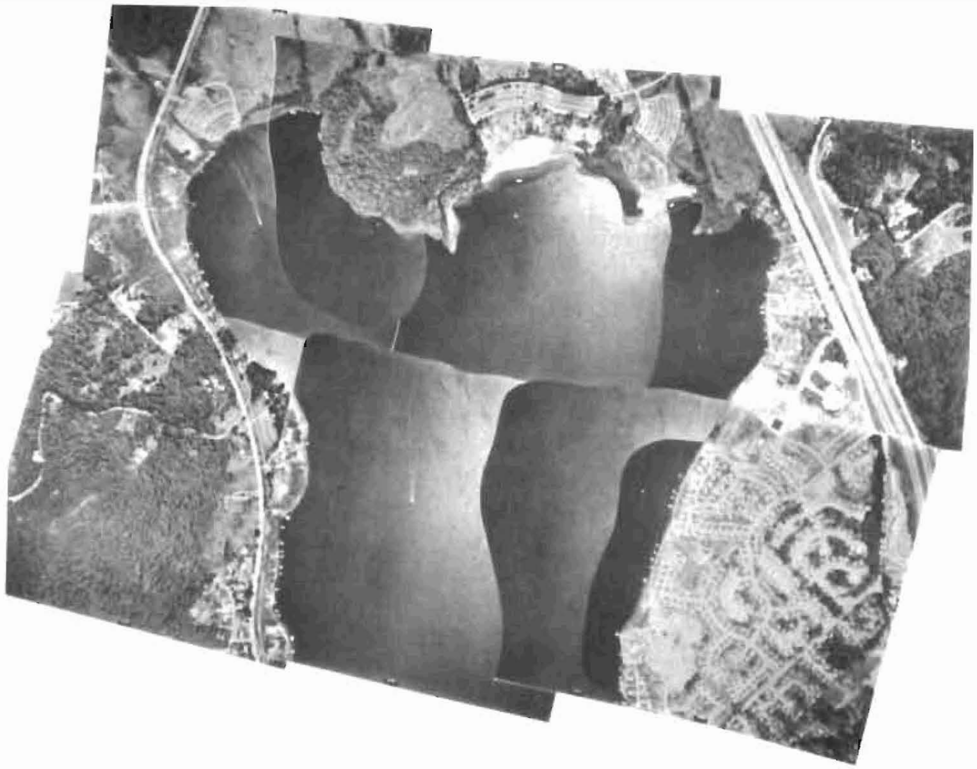

Figure 5. A semicontrolled photomosaic produced from eight individual aerial photographs

a semicontrolled photomosaic. To make photointerpretation easier (Task IV, steps 1 and 2), the photomosaic should be the same scale as the aerial photography. Because slight color differences may be apparent on adjacent photographs, most photomosaics are constructed of black-and-white prints made from color transparencies.

18. When maps of aquatic plants in rivers narrow enough to be photographed during a single flight line pass are to be made, a semicontrolled photomosaic is not required. Task IV, step 1, discusses a method for drafting accurate maps from photographs produced along a single flight line.

19. Step 6: Contract the photomission. The language in most aerial survey contracts is similar. Appendix B is an example of a contract for an aerial photographic mission.

Task III: Ground Truth Acquisition

20. "Ground truth" is a phase used to describe data obtained during onsite investigations to aid in the photointerpretation. The objective of obtaining ground truth data is to provide enough information about a small representative portion of a larger area to allow reliable extraction of the

same information from the photographs. Areas on the ground (ground truth plots) that can be easily identified on the photographs are used for obtaining the ground truth data.

21. Step 1: Select ground truth plots. Enough ground truth plots should be selected to provide association of variations in the appearance of the plant types with variations in their surroundings. For most surveys of aquatic plant populations, the target populations appear similar in photographs throughout the area of interest. Thus, only a few ground truth plots are needed. The total area of all ground truth plots should equal about 1 percent of the area of interest. Plots should be established throughout the entire survey area.

22. A portion of two aerial photographs of a ground truth plot in Lake Sammamish, Washington, is shown in Figures 1 and 2. Three aquatic plants are dominant in Figure 2: emergent spatterdock (*Nupher luteum*) and waterlily (*Nymphaea oderata*) in the nearshore zone, and submersed Eurasian watermilfoil (*Myriophyllum spicatum*) in the deeper zone. The appearance of the three species in this photograph of a ground truth plot is sufficiently similar to all the other photographs of this 2000-ha lake to allow accurate mapping of all three species.

23. Step 2: Determine time for ground truth acquisition and parameters to be measured. If possible, the collection of ground truth data should be accomplished at the same time as the photographic mission. Ground truth plot data should include information on those parameters that can be estimated from the photographs. Critical parameters are plant species present, areal extent of plant population mapped in relation to the shoreline, and growth forms of plants (emergent, submersed, floating). Only the areal extent of the plant population mapped in relation to the shoreline requires quantitative measurement.

24. Figure 6 shows an example of delineating the boundary of a plant colony using position triangulation. Points A and B, located on the shoreline, must be identifiable on both a reference map and aerial photographs. The distance between A and B is measured and serves as the baseline for subsequent triangulation. To define point A_1, B_1 along the circumference of the plant colony, the distances A_1 and B_1 are measured using an optical lens displacing-type range finder or measuring tape. Range finders with at least 5-percent accuracy at 333 m are recommended. Measurement of distances from

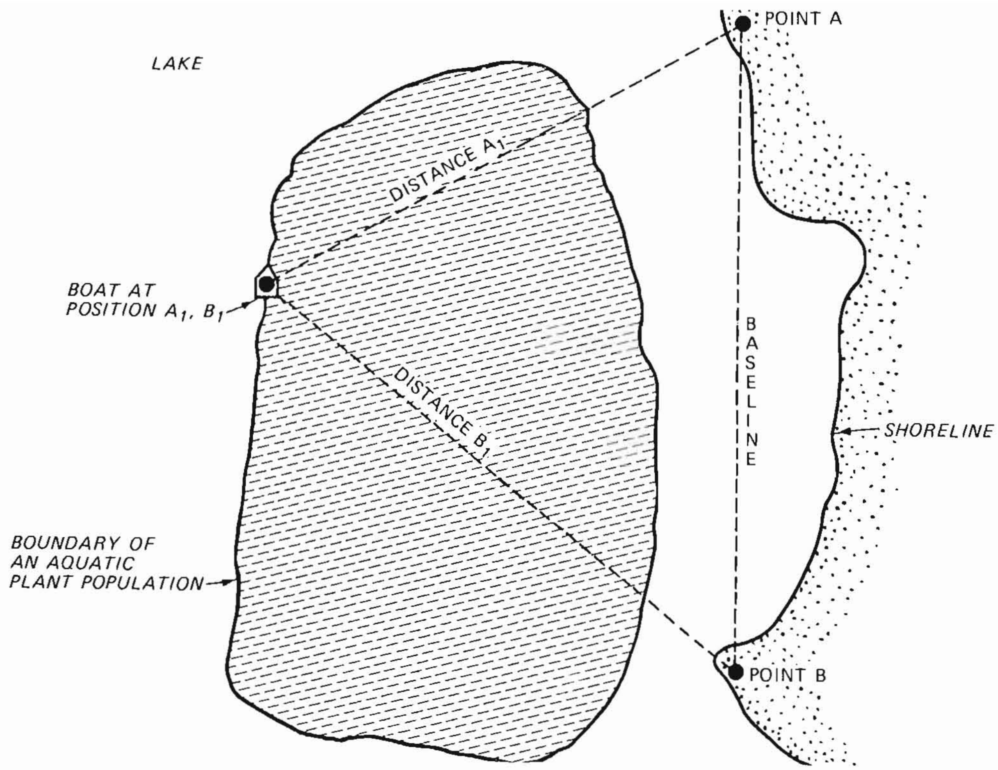

Figure 6. Delineating the boundary of an aquatic plant population using triangulation

additional points along the plant colony boundary to the A and B shoreline landmarks are continued until the colony is circumscribed. At that time, a sketch of the plant colony, annotated with all measured distances, can be drawn in the field on the reference map. Later, an accurate scale drawing can be made and used to estimate the areal extent of the plant colony within the ground truth plot (see Task IV, step 3, for discussion of areal estimation procedures). The recommended procedure for making this measurement is to triangulate the distance from points along the circumference of the plant colony to two shoreline reference landmarks a measured distance apart.

25. For plant populations that fill or extend outside the boundaries of the ground truth plot, a set of markers should be placed within the boundaries of the plant populations to mark an area of about 0.5 ha. This can be accomplished by locating four markers, of the size described in step 3 of this task, such that they mark the corners of a rectangle approximately 0.5 ha in area. The exact distance between markers should be measured using a range finder or tape measure. From these measurements, area calculations can be made and used to assess the photointerpretation accuracy.

26. Step 3: Establish scale reference points. Because aircraft altitude can vary during flight, the actual scale at which the photography is produced can vary as much as 10 percent from the nominal scale. If greater accuracy is required, reference points must be selected during ground truth acquisition and interpoint distances must be measured in order to determine the exact scale of the photograph. Usually, permanent landmarks such as bridges, houses, peninsulas, and bays are near enough to plant colonies to be included in the photographs. Reference distances can also be measured on maps of reliable scale if the landmarks on the maps are still present.

27. In areas where enough discernible landmarks to use for scale references do not exist, white markers constructed of cloth, plywood, or plastic sheets should be placed at or above the water surface, anchored securely at aircraft-visible locales and at known distances apart. These markers should be no smaller than 2 by 4 m for 1:24,000-scale photography, 2 by 3 m for 1:12,000, and 2 by 2 m for 1:6,000. Intermarker distances of about 100 m are great enough to allow reliable reference measurements. One pair of markers should be placed at each ground truth plot.

28. Step 4: Record ground truth data. The most useful way to record ground truth data is to annotate accurately scaled maps while in the field.

Task IV: Photointerpretation and Data Presentation

29. The objective of this final task is to produce accurate maps of target plant distributions from aerial photographs. The first step is to construct or obtain a precise scale base map showing the shoreline of the water body of interest. The location and areal extent of the target plant colonies are then displayed on this map or overlays with annotations of other information such as water depth and reference landmarks. Using the ground truth data, population boundaries of the same plant species are identified on all photographs. Maps of plant populations are then drawn on the base map and areal estimates made. The accuracy of the areas determined by interpretation is checked by comparing the area determined within the ground truth plot locations.

30. Step 1: Construct base map. The term "base map" refers to a vertical view drawing of the shoreline of the target water body. A base map is drawn on clear drafting plastic such as mylar. Then, using a back-lit table, the positive transparent roll of aerial photographs is positioned underneath

the clear base map. Each frame on the roll of photographs sequentially is brought into alignment with the base map. By looking through the base map to the photograph, plant population boundaries (or any other photographic data of interest) can be traced onto the base map. Often these tracings are made onto a second mylar overlay to the base map. Thus, the original base map remains uncluttered and reusable.

31. The base map is usually traced from the semicontrolled photomosaic (Task II, step 4) provided by the contractor who performed the aerial survey. Once the photomosaic is obtained, the base map is easily constructed by placing mylar over the mosaic and tracing the shoreline and scale reference marks. Semicontrolled photomosaics are made by carefully smoothing slight interphotograph variations in scale that occur mainly as a result of slight variations in aircraft altitude. A base map made from a good semicontrolled photomosaic is usually accurate enough to be used during interpretation of more than one set of aerial photographs. Aerial photographs taken of the same area and with the same nominal scale as the original mission but on a different date can usually be interpreted against the same base map. Substantial differences in scale between the base map and the photographs can be overcome if both are viewed simultaneously through a Bausch and Lomb Zoom Transfer Scope (ZTS). This device optically registers the two images. (The operation of a ZTS is described in its accompanying manual.) Use of a ZTS is not often required if photography is of the same nominal scale as photographs that are used to make a semicontrolled photomosaic.

32. An alternate method for constructing a base map is to trace the shoreline directly from the photographs onto strips of mylar. This method works well for narrow water bodies, such as rivers, that are photographed from single flight lines. Purchase of semicontrolled photomosaics is not warranted for these easily constructed base maps.

33. To directly trace a base map from a roll of photographs, mylar is cut into strips about 25 cm wide to conveniently fit over the 23-cm-wide roll of color transparencies. A mylar strip is placed, on a light table, over the first frame of the flight line. Then, the shoreline is traced from the photograph onto the mylar. The film is advanced to the next frame and the continuation of the shore is traced in. If adjacent frames overlap by 60 percent, as is recommended in Task II, much of the second frame will match the first, and so on, to the end of each flight line. Care must be taken to match each

successive frame to maintain proper spatial alignment. Figure 7 shows a photointerpreter using mylar, a roll of color transparencies, a light table, and a 10X magnifier to trace a base map of a narrow river.

Figure 7. Use of a light table with film transparency, magnifying glass, and mylar overlay

34. Because aircraft altitude varies during the flight, the scale throughout this map will vary. Photographs from successive missions probably will not exactly match the base map. Thus, a new base map of this type should be constructed for each mission. However, since a semicontrolled photomosaic is not required, each new base map is inexpensive to produce.

35. Step 2: Identify and map plant population boundaries. When the interpreter looks at any aerial image, many features are usually recognized without having seen them from that perspective before. Certain image characteristics are used and integrated to help identify the features. These characteristics are:

a. Shape. Shape alone may serve to identify some features. The shape of an object in a vertical aerial view is often significantly different from its shape as seen from the ground; therefore, when possible, another characteristic (e.g., shadow) should be used to help identify the shape.

b. Size. Both relative and absolute size are important. Relative size is the size of an unknown object in relation to the size of a known feature. Size is a function of the photographic scale.

c. Pattern. Pattern is determined by the configuration of objects large enough to be seen on an image. Some descriptive adjectives for pattern are regular, irregular, random, concentric, and radial.

d. Shadow. Shadow can be used to give the profile, shape, and height of an object. Shadow can also be a hindrance to interpretation of objects within a shaded area, such as tree-lined streambanks and lakeshores.

e. Color. When using true color film, objects will appear on film to be the same color as they are in nature. False color infrared film takes advantage of the infrared reflective properties of chlorophyll in healthy plants to produce a bright red color.

f. Texture. The visual impression of texture, degree of roughness or smoothness, is created by tonal repetition of a group of objects too small to be seen individually.

These six interpretation characteristics are used by the interpreter viewing photographs of ground truth plots to extract data from other photographs.

36. As mentioned, the recommended method for photointerpretation is to place the film transparencies on the light table, place the mylar base map over the film, and trace the location of the plants onto the base map or overlays. Figure 8 shows plant locations traced onto a strip of mylar base map from three overlapping color prints. Calculations of area and scale are made from the base map or overlays.

37. Step 3: Measure scale and area. Before any area estimates are made from the base map, the actual scale must be determined. Distances that were measured between reference points during ground truth acquisition (Task III, step 3) are used for this purpose. These reference points are marked on the base map (Task IV, step 1). The distance between two reference marks on the map divided by the distance between the same two landmarks on the ground provides an estimate of map scale:

$$\frac{\text{Base Map Distance (mm)}}{\text{Ground Distance (mm)}} = \text{Map Scale Ratio (units cancel)}$$

38. After determining the scale of the base map, the areal extent of traced plant populations can be determined using one of two common and accurate techniques (Dardeau 1983): dot grid and electronic digitizer.

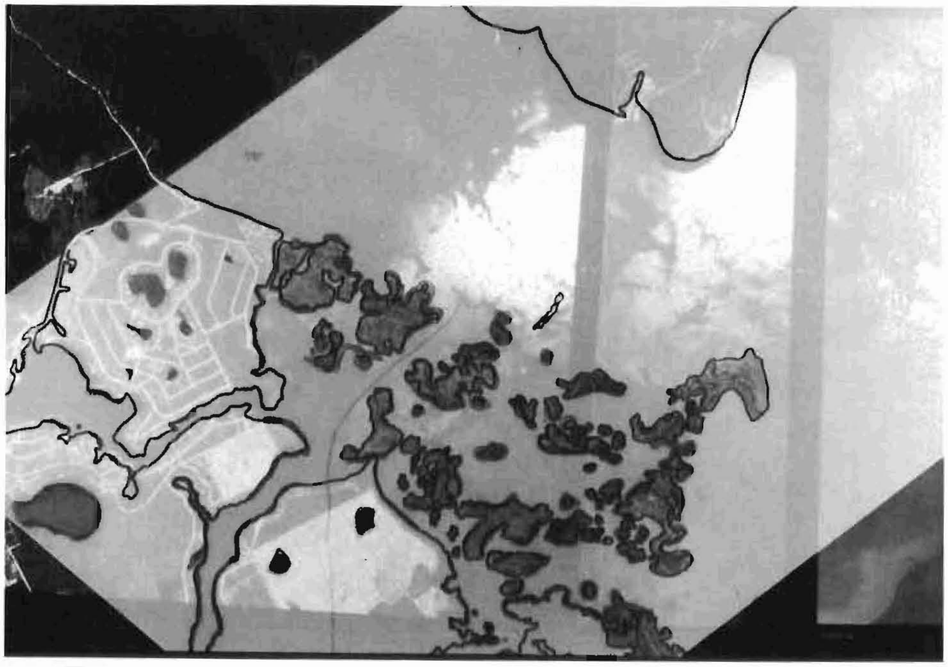

Figure 8. Plant population boundaries traced onto base map from aerial photography

39. The first technique, dot grid, is an accurate and inexpensive, but slow, area estimation technique. A dot grid is a chart divided into grids containing a random distribution of dots (Figure 9). The chart is placed randomly over each plant population traced on the map. Each dot within the population's boundary is counted. Every other dot falling on the boundary is counted. Then the total number of dots counted is multiplied by the area equivalence factor printed on the dot grid to estimate the total area of the plant population.

40. Most dot grids are constructed for a specific scale (e.g., 1:12,000, 1:20,000). Consequently, the area equivalence factor of each dot must be adjusted to the measured scale of the base map as follows:

$$\text{Area Equivalence Factor} = \frac{\text{Actual Map Scale Reciprocal}^2}{\text{Dot Grid Scale Reciprocal}^2}$$

For example, a dot grid with each dot equivalent to 1.01 ha at a scale of 1:12,000 is used on a base map of 1:12,000 scale. The area equivalence factor for each dot is adjusted as follows:

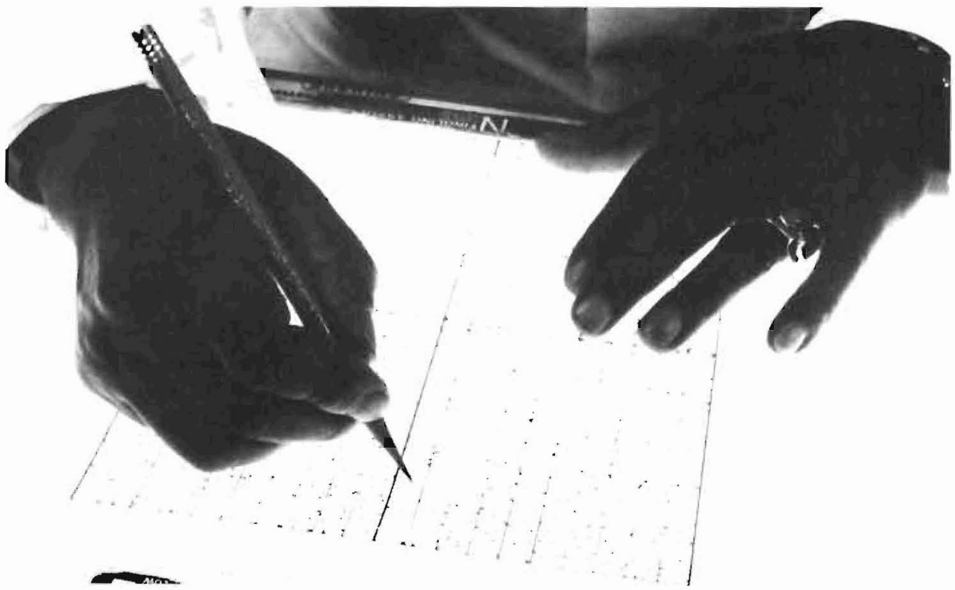

Figure 9. Example of a dot grid used for area measurements

$$\frac{(12{,}200)^2}{(12{,}000)^2} \; 1.01 \text{ ha/dot} = \text{adjusted area equivalence factor}$$

$$1.03 \times 1.01 \text{ ha/dot} = 1.04 \text{ ha/dot}$$

41. The second technique for determining areal extent is the electronic digitizer. Various electronic digitizers are available and instructions for their use accompany them. The WES has developed programs using a Tektronix 4954 digitizer and Tektronix 4014-1 terminal for measuring and computing areas of irregular shapes. The principle employed is similar to other digitizers. The interpreted map is placed on a tablet. Under the surface of the tablet are two grids of magnetostrictive wires, one set for the X-axis and one set for the Y-axis. An acoustic wave is sent along these wires and detected by a cursor. As the operator traces the boundaries of the aquatic plant populations with the cursor, a change in magnetic field caused by the acoustic wave is detected. The detected signal is transmitted to the terminal that converts the time between when the wave is sent and when it is received to digital data directly related to cursor position. This method maintains 0.03-cm resolution and can be used when the map area of an aquatic plant population is less than the 18-cm square required by a dot grid.

42. If a digitizer is not already available, the fact that area estimations of aquatic plant populations by a single Corps District will only infrequently be made leads to a recommendation that the dot grid technique be used. Estimates using dot grids are accurate as long as the rules for using a particular grid are followed. By adjusting area equivalence factors to actual base map scale and cutting and piecing together mapped boundaries of small populations such that the minimum map area for accurate estimations is obtained, the accuracy of dot count estimates is ensured.

43. Step 4: Check interpretation accuracy. A subjective method of accuracy assessment is to simply have the people who performed the ground truth portion of this project review the final map and judge its acceptability. The recommended and more quantitative method is to compare the photointerpreted estimates of areal coverage of plants within the ground truth plots to the actual areal measurements made during ground truth data collection (Task III, step 2).

44. Step 5: Display photointerpreted data. The most useful method of displaying areas of occurrence of aquatic plants is through the use of a map. Figure 10 shows a report quality map reduced for printing from a 1:12,650-scale base map constructed specifically for displaying the location of submersed aquatic plants mapped from aerial photography. Landmarks and river mile annotations are shown for orientation. Such a map can be compared to maps made of the same area in the future to document changes in aquatic plant populations through time.

45. The map in Figure 10, in its original form, can also be photomechanically reduced to closely fit a 1:24,000-scale USGS map. Printed on clear mylar, it can be used as a map overlay, thus increasing its usefulness as a spatially oriented guide to the location and extent of plant populations during onsite surveys.

Summary

46. Low-altitude aerial photography is an inexpensive and accurate method for documenting the occurrence of aquatic plants over large areas. Aerial photographs accurately map the extent of aquatic plants on a specific date. Aerial photographs of the same area taken on a future date can be used to quantitatively assess temporal changes in plant populations. The

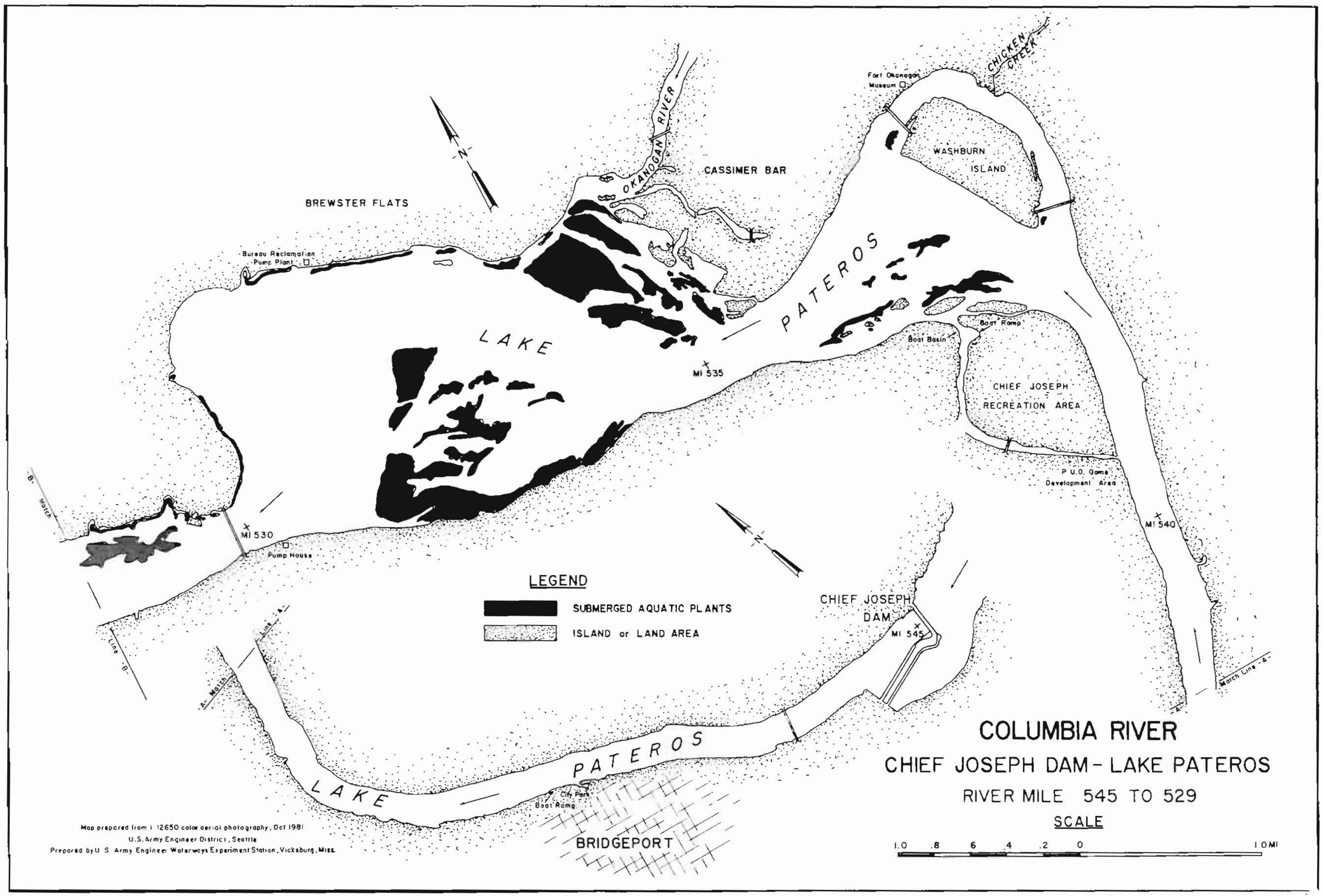

Figure 10. Map of submersed plants in a portion of the Columbia River, Washington

assessments allow aquatic plant management personnel to assess and predict trends in changes in aquatic plant distributions. Then control efforts can be assigned a priority accordingly. To complete an aerial photographic survey for mapping aquatic plants, four sequential tasks must be accomplished.

47. First plant species and water bodies of concern must be identified. This is accomplished by the receipt of information from concerned people and agencies as well as onsite investigation. A USGS 7.5-min topographic map, or other map of reliable scale, is used to mark the general location and extent of the problem plant infestations in water bodies. The optimal time period for surveying aquatic plants for mapping of near maximum abundance is usually in the late summer to early fall.

48. After the area to be photographed has been delineated, local aerial survey firms must be contracted to provide the necessary photographs and related products. The basic photomission product recommended is 23 by 23 cm, 1:12,000-scale, stereoscopic photographs of the area of interest. Film type selection is based on the growth form of the plant species being surveyed. True color film is recommended for detecting submersed species; false color infrared film is recommended for detecting emergent and floating species. Recent (1980-1981) costs for producing 1:12,000-scale photography (including only the actual flight, film, and processing) range from $0.12 to $1.26 per hectare for target areas ranging from 8100 to 405 ha (Dardeau 1983). Other products that can be obtained for additional cost are color or black-and-white prints, a photoindex, and a semicontrolled photomosaic.

49. Ground truth data collection is the third task necessary for the successful completion of an aerial survey. Information such as plant species present, plant growth form, and areal extent of plant colonies within selected ground truth plots is needed to interpret the photographs and assess the reliability of the photointerpreted data. Ground truth data are to be collected at the same time as the photomission. The time required for ground truth data collection depends on the size and complexity of the area of interest. In general, ground truth plots should total in area about 1 percent of the total area photographed.

50. The final task involves constructing a clear plastic base map showing the shorelines of target water bodies. This map is laid over the aerial photographs, on a light table, and the boundaries of plant population are traced onto the base map. Photographs of the ground truth plots provide

visual clues aiding the interpretation of photographs of all areas outside the ground truth plots. Finally, areal estimates of the mapped plant populations are made. A base map can be constructed from a semicontrolled photomosaic, plant population boundaries photointerpreted and traced on the base map, and areas of infestation quantitatively measured by a single, basically skilled photointerpreter.

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Table 1

Tasks Required for Mapping Aquatic Plant Distributions Using Aerial Photography

Task I:	Problem Identification	
	Step 1:	Determine location and size of target sites
	Step 2:	Identify aquatic plant growth form
	Step 3:	Determine optimum dates and times for surveys
	Step 4:	Identify areas that cannot be surveyed aerially
Task II:	Photomission Design	
	Step 1:	Check for existing photography
	Step 2:	Determine scale to be used
	Step 3:	Select film type
	Step 4:	Select photograph overlap
	Step 5:	Specify products desired
	Step 6:	Contract the photomission
Task III:	Ground Truth Acquisition	
	Step 1:	Select ground truth plots
	Step 2:	Determine time for ground truth acquisition and parameters to be measured
	Step 3:	Establish scale reference points
	Step 4:	Record ground truth data
Task IV:	Photointerpretation and Data Presentation	
	Step 1:	Construct base map
	Step 2:	Identify and map plant population boundaries
	Step 3:	Measure scale and area
	Step 4:	Check interpretation accuracy
	Step 5:	Display photointerpreted data

Appendix A: Sources of Existing Aerial Photographs

1. United States Department of Agriculture

   a. Agricultural Stabilization and Conservation Service (ASCS)

      (1) Photography is usually 9 by 9 in.,* 1:20,000 scale in the past, and 1:40,000 more recently, panchromatic minus-blue summer photography. Flown over agricultural areas every 5 to 10 years, beginning about 1939-40. Enlargements of various sizes and photoindexes are also available from the ASCS. The present price of a 9- by 9-in. print is $2.00. Order from Aerial Photo Field Office listed below.

          Aerial Photo Field Office
          PO Box 30010
          Salt Lake City, Utah 84125

          For ASCS coverage prior to 1941 address inquiries to:

          National Archives and Resources Service
          Cartographic Branch
          General Services Administration
          Washington, D. C. 20408

   b. U. S. Forest Service (USFS)

      (1) Photography is 9 by 9 in., 1:15,840 to 1:20,000 pan or infrared minus-blue in past years, but color 1:24,000 flown more recently of National Forests and National Grasslands. Flown every 7 to 10 years. Cover lands of other ownership if they are included in gross area or immediately adjacent. Enlargement, indexes, and other materials are also available. Black-and-white contact prints are $2.00 each and color prints are $7.00. Order from Aerial Photo Field Office listed above.

2. United States Department of the Interior

   a. Photography similar to that of the U. S. Forest Service is sometimes available for Bureau of Land Management and Bureau of Indian Affairs lands.

   b. The U. S. Geological Survey (USGS) obtains aerial photography for topographic and geologic mapping. Scales are usually somewhat smaller than ASCS or USFS photography, and in deciduous forest regions the photography is obtained when leaves are off the hardwoods. Contact prints (9 by 9 in.), enlargements, and photoindexes are available. For this region, write to:

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* A table of factors for converting U. S. customary units of measurement to metric (SI) is presented on page 4.

Rocky Mountain Region Engineer
U. S. Geological Survey
Building 25, Federal Center
Denver, Colo. 80225

3. EROS Data Center

The EROS Data Center is becoming one of the primary sources of aircraft and spacecraft imagery in the United States. The center maintains National Aeronautics and Space Administration (NASA) aerial photography, GEMINI-APOLLO photography, and standard mapping aerial photography of the USGS and other Federal agencies. Information on all imagery can be requested from the center through a computerized geographic search. Standard mapping aerial photography must be ordered using aerial photoindexes that may be obtained from the center. Order forms for each type of imagery may be obtained for ordering by mail, but orders may also be placed by personal visit or telephone.

To place an order, to inquire about the availability of data, or to establish a standing order, contact:

User Services Unit
EROS Data Center
Sioux Falls, S. D. 57198

or phone: (605) 594-6511, Ext. 151
FTS: 605-594-6151

Appendix B: Example Aerial Photographic Mission Contract*

1. Work to be Done.

a. General Scope. Furnish all personnel, plant, equipment, transportation, and materials necessary to perform and deliver aerial photography in the required quantities and all in accordance with the attached conditions, provisions, and specifications, including the exhibits made a part thereof by reference thereto. Upon notice to proceed, the contractor shall acquire the required photography between (see Task I, step 3) and (see Task I, step 3).

b. Location and Area. The sites to be photographed are throughout the ______________________ District and include portions of the following states: ____ ______________________________________. Maps delineating special target areas are provided according to 16. The total area to be surveyed equals (see Task I, step 1).

c. Type of Photography. Single lens vertical photographs at a scale of (see Task II, step 2) will be required.

d. Priorities for Photographing Project Areas. If priority areas are established, they shall be photographed as directed by the Contracting Officer or his authorized representative. Priorities may be changed to meet needs of the District and the Contractor shall make every reasonable effort to accomplish established priorities. No priority areas exist at this time.

e. Payment. In the event that all photography in 1.c. above has not been acquired as specified in 1.a., payment for acceptable photography will be made by multiplying the dollar amount of the contract by area actually photographed divided by the area to have been photographed.

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* Modified from a contract form used by U. S. Army Engineer District, Mobile.

2. Quality of Materials. All materials, supplies, or articles required for work which are not covered by detailed specifications herein shall be standard products of reputable manufacturers and entirely suitable for the purpose. They shall be new and unused, unless otherwise specified, and will be subject to the approval of the Contracting Officer.

3. Aerial Film.

a. Aerial film will be furnished by the Contractor. The Contractor will furnish aerial film of a quality that is equal or superior to Kodak Aerographic Film (see Task II, step 3) used with (Task II, step 3 filter(s)).

b. Only fresh, fine-grained aerial film shall be used. The film shall be exposed and developed in such a manner that they shall be sharp and clear, and contain all highlight and shadow detail. They shall be free of any defects which, in the opinion of the Contracting Office, render them unsuitable for their intended purpose.

4. Marking Negatives. The Contractor shall mark on each negative of the photograph assignment the date of exposure, the approximate scale number, file number, the assigned roll, flight line number, and exposure number. All such editing of numbered negatives shall be by mechanical lettering, with characters 0.2 inch tall, and shall be so placed as to appear within the image on the north or west edge of the positive prints, to read from the back edge, all in the relative positions as follows:

Example of data to be placed on each photograph:

Date	Scale	File #	Film Roll #	Flight Line #	Photo #
1 Jan 75	1:6000	SAM-XX-	xxx (The film roll # will be furnished with each mission)	1	1 (Photos to be numbered consecutively from first to last photo in that mission)

xx (See Flight Line map)

5. Delivery of Positives. All negatives shall be delivered to the Mobile District in rolls on winding spools within cans, with each can labeled to show the name and address of the contracting agency, the name of the project (to be furnished), the designating roll number of the photography, the serial numbers of the first and last numbered negative of each strip, proper identification of rejected strips, the date and mean time exposure of each strip, the approximate scale, serial numbers of the lens-camera combination used, calibrated focal length of the lens in millimeters, name and serial number of the airplane, names of pilot and photographer, the contract number, and the name and address of the Contractor who accomplished the photography. All extra and rejected exposures shall be included on the roll. At least three feet of clear film shall be left on or spliced to each end of the roll. All splices shall be of a permanent nature.

6. Paper Prints. All prints, except for photoindex, shall be made on double weight semimatte paper stock approved by the Contracting Officer. They shall be sharp and clear, shall contain all highlight and shadow detail, and shall be evenly toned. They shall be permanently fixed, thoroughly washed, processed through flattening solution, and dried without pressing, rolling, or excessive heating. Trimmed to image area, approximately 9 in. by 9 in.

7. Photoindices.

a. Photoindices of the photographs shall be prepared by directly photographing, on 10- by 12-in. (255- by 305-mm) safety-base negative film, at a scale of 1:62,500 for 7.5-minute quadrangles, an assembly (shingle mosaic) of contact prints of all edited negatives accepted for coverage of a quadrangle. Prints of the photoindices, two each required, on single-weight, glossy paper mounted on cloth or on Cronapaque (CPF-7) or equivalent, and film negative of photoindex shall be furnished.

b. All prints used for photoindex shall be generally equal in tone, contrast, and appearance. They shall be made without mask and trimmed to the edges of the photographic imagery. During assembly, the prints shall be carefully laid so that corresponding images match as closely as possible and the serial numbers of the photographs are clearly shown. Serial numbers unavoidably obscured shall be shown by stickup. The quadrangle boundaries shall be centered on the photoindex and clearly identified with cross marks and geographic coordinates, which shall read correctly from the south. Photoimagery shall be shown over the entire area of the photoindex whenever possible. Extra photographs at the ends of the flight lines, which do not fall within the limits of the photoindex, shall be indicated by appropriate stickup notation. At points where flight break occurs, the contract photos from both portions of the flight strip shall be used, so as to include two exposures beyond the quadrangle boundaries in both directions and shall show all photos in their correct positions in the flight-break area. All prints used for the photoindex will be forwarded to the Corps of Engineers.

c. A title block oriented to read correctly from the south shall be placed at the bottom of each index outside the quadrangle boundary and shall be legible at the scale of the reproduced index. It shall include a north arrow and a sketch of adjoining quadrangles with the appropriate quadrangle crosshatched. Sample indexes, including title blocks, shall be furnished to the Contractor on request. The arrangement of the information to be included in the title block is as follows:

U. S. Army Corps of Engineers

_______________ District

Project_____________________________State____________

Photography completed__________________________________

Flight height above mean ground______________________

Scale of photoindex____________________________________

Camera lens no.________________CFL_____________________

Contractor____

Quadrangle name____

8. Performance Required. Special attention of the Contractor is directed to the fact that the accuracy, thoroughness, and scheduled progress of his work are essential to the purpose for which intended. He must be cognizant of the

difficulties involved and of the contingencies which may arise, and must make certain that his personnel, plant, equipment, transportation facilities, and supply of materials are adequate at all times to ensure complete compliance with all provisions of these specifications.

9. Personnel of Plane.

a. The pilot must be well qualified, possessing a minimum of 250 hours of photographic map flying experience. The photographer shall possess a minimum of 250 hours of experience representing actual time spent in executing vertical aerial photography on photographic assignments. Oblique photography is not considered as qualifying experience.

b. No replacements whatsoever in equipment shall be made by the Contractor during the term of the contract without express consent of the Contracting Officer.

10. Airplane.

a. The airplane to be used shall be entirely capable of stable performance at the necessary altitude and air speeds, and shall be equipped with all essential navigational and photographic instruments and accessories, all maintained in operational condition during the period of the contract, and all subject to the approval of the Contracting Officer.

b. All aircraft used on Corps of Engineers contracts shall be maintained and operated in accordance with regulations of the Federal Aviation Administration and the Civil Aeronautics Board and shall be suitable for the aerial photography tasks specified. Each airplane shall have a service ceiling with operating load (crew, camera, film, oxygen, and other required equipment) of not less than the highest altitude specified in the Bidding Schedule. When the flight plan and location of any item in the proposed coverage fall within positive-control airspace, the aircraft must contain the appropriate equipment to operate in such positive-control areas within the purview of FAR 91.97.

11. Camera.

a. General. All mapping photography shall be made with a single lens precision aerial mapping camera equipped with a "high-resolution, distortion-free" type lens, calibrated by the National Bureau of Standards or an agency making calibrations of equal accuracy and approved by the Contracting Officer. Furnish copy of Report of Test of Lens. The calibrated focal length of the lens (the focal length at which the values of lens distortion, irrespective of sign, are held to the minimum within 45 degrees of the optical axis) shall be 153 millimeters, plus or minus 3 millimeters. The camera shall function properly at the necessary altitude and under the expected climatic conditions, and shall expose a 23 cm square negative. The lens-cone shall be so constructed that the lens, focal plane at calibrated focal length, fiducial markers, and marginal data markers comprise an integral unit or are otherwise fixed in rigid orientation with one another. Dimensional changes brought about by variations of temperature or other conditions shall not be of such magnitude as would cause deviation from the calibrated focal length in excess of plus or minus 0.05 millimeter or would preclude determination of the principal point location to within plus or minus 0.003 millimeter.

b. Platen. The focal plane surface of the platen shall be flat to within 0.013 millimeter and shall be truly normal to the optical axis of the lens. The camera shall be equipped with means of holding the film motionless and flat against the platen at the instant of exposure.

c. Fiducial Markers. For mapping photography, the camera shall be equipped or so modified to include a minimum of eight (8) fiducial marks suitable for making precise measurements for use in analytical aerotriangulation process. The lens, focal plane, and fiducial marks must be permanently fixed in rigid orientation with one another.

d. Lens Distortion. As referred to the calibrated focal length, the radial distortion shall not exceed plus or minus 0.02 millimeter within a 42.5 degrees half-field angle, and the tangential distortion shall not exceed 0.015 millimeter. Values of distortion at equal but opposite angular separations from the axis along the same diameter shall not differ from each other by more than 0.04 millimeter.

e. Lens Resolving Power. When installed in the camera, and with the appropriate filter mounted in place, the lens shall resolve at least 32 equally spaced lines to the millimeter in the center of the field and at least 14 equally spaced lines to the millimeter in any orientation extending to 45 degrees from its axis, all as could be determined by tests using Eastman Spectroscopic Type V-F Emulsion, or equivalent.

f. Filter. The apporpriate clear anti-vignetting filter and haze reduction filters used in color photography shall be of such quality that no appreciable reduction in resolution will result. The surfaces of the filter shall be parallel to within 10 seconds of arc.

g. Shutter. The camera shall be equipped with a between-the-lens shutter of the variable speed type, whose efficiency shall be at least 75 percent at the fastest rated speed.

h. Substitute cameras may be used in taking special purpose aerial oblique photographs and photographs to be used in the preparation of mosaics, provided that prior written approval for the use of the special camera and lens is obtained from the Contracting Officer.

12. Flight Plan. The areas to be photographed are indicated on flight maps of the photographic assignment. Photographic flight height above average elevation of the ground shall be such that the scale of the photographic film negatives will not have a variation of more than plus or minus 2 percent of the desired photo scale. Horizontal positioning along the centerline of each planned flight line shall not vary more than 10 percent of the flight height. All strips shall be flown as straight as possible, and shall be void of crab, tilt, and altitude variations to the extent that they afford good stereoscopic coverage of the entire minimum area(s) of the photographic assignment. Successive photographs along the line of flight shall overlap each other by approximately 60 percent, and parallel strips shall overlap each other by approximately 30 percent as indicated on the approved flight plan. Deviations

of more than 5 percent from these specified overlaps, except those excesses due to allowances made for abnormal relief displacements, may be cause for rejection.

13. Crabbing. Any series of two or more consecutive photographs crabbed in excess of 10 degrees as measured from the mean flight path of the airplane, as indicated by the principal points of the consecutive photographs, may be considered cause for rejection of the photographs in the flight within 10 miles of the rejected negatives.

14. Tilt. The average tilt for photographs shall not exceed 1 degree and the maximum tilt shall not exceed 3 degrees in a strip flight.

15. Suitable Conditions. All photography shall be accomplished between the hours of 9:00 a.m. and 3:00 p.m., __________ Standard Time, when the atmosphere is sufficiently clear, and when no part of the terrain being photographed is obscured by clouds, cloud shadows, smoke, fog, snow, except with the permission of the Contracting Officer. Arrangements by the Contracting Officer will make available to the Contractor all necessary information on river stages. Any day containing two or more consecutive hours of such suitable conditions, in any sizable portion of the area not yet photographed, will be considered a "Suitable Day" for aerial photography.

16. Materials Furnished by the Government. The Government will furnish to the Contractor 2 sets of maps with areas of desired photographic coverage marked. These maps will be mailed to Contractor.

17. Completion of Work. Completion of work shall include satisfactory performance of the aerial photography and delivery of acceptable products and flight data as requested in parts 1 through 15 of this contract.

18. Inspection and Acceptance.

a. Inspection During Progress. During the progress of work, any inspections of the aerial photography operations, laboratory work, etc., by the Contracting Officer shall be solely at his option. However, all work, and all the Contractor's or Subcontractor's plant and equipment engaged in the work, shall be subject to and available for inspection by the Contracting Officer at all times. The Contractor shall, at all times, keep the Contracting Officer informed as to names, working addresses, and telephone numbers of persons responsible for each phase of the work, and shall allow direct contact with them for purposes of inspection, progress estimates, and general liaison. Any instructions of the Contracting Officer arising from such contracts will be directed to the Contractor or his designated agent.

b. Contractor's Responsibility for Checking Work. It is understood that the Contractor realizes the work under the contract must be accomplished with thoroughness and skill, and that he is cognizant of the serious difficulties which could result from defective work. Therefore, it shall be his responsibility to thoroughly check each phase of the work and guarantee its accuracy.

c. Inspection of Delivered Work. As soon as practicable after delivery of work in any installment, the Contracting Officer shall inspect that work and notify the Contractor of the results of such inspection.

d. Acceptance. Tentative acceptance of work delivered in any installment shall be the basis for estimating partial payments for completed work but shall not be construed as final acceptance. Work tentatively accepted, but proven by subsequent inspection to be not acceptable, shall be corrected by the Contractor, at no additional cost to the Government. Final acceptance will not be made until all work has been delivered and found to be acceptable.

e. Deliveries. All costs of deliveries shall be borne by the Contractor. Each delivery shall be addressed to ______________________________ ______________________________________, ______________________________, _______________, and shall be accompanied by a letter or shipping form, in duplicate, listing the materials being transmitted, and being properly numbered, dated, and signed. Delivery of materials shall be made within 20 work days after completion of flying.

19. Site Investigation and Representations. The Contractor assumes responsibility for all investigations as to the nature and location of work, the

general and local conditions, particularly those bearing upon transportation and the availability of roads and airports, the uncertainties of weather and flood stages, the topography and conditions of the ground, the character of equipment and facilities needed preliminary to and during prosecution of the work, and all other matters upon which information is reasonably obtainable and which can in any way affect the work or the cost thereof under this contract. Any failure by the Contractor to acquaint himself with all the available information will not relieve him from responsibility for estimating properly the difficulty or cost of successfully performing the work. The Government assumes no responsibility for any understanding or representations made by any of its officers or agents during or prior to the execution of this contract, unless (1) such understanding or representations are expressly stated in the contract and (2) the contract expressly provides that the responsibility therefore is assumed by the Government. Representations made but not so expressly stated and for which liability is not expressly assumed by the Government in the contract shall be deemed only for the information of the Contractor.

20. Subcontractors.

a. The Contractor shall cause appropriate provisions to be inserted in all subcontracts relating to this contract, to ensure sufficient fulfillment of all contractual provisions by Subcontractors.

b. Before commencement of work under this contract by any Subcontractor, the Contractor shall furnish the Contracting Officer, in writing, the name of any such Subcontractor, together with a statement as to the extent and character of the work to be done under the subcontract. If for sufficient reason, at any time during the progress of the work, the Contracting Officer determines that any Subcontractor is incompetent or is not performing the subcontract work in any acceptable manner, he will notify the Contractor in writing accordingly and immediate steps shall be taken by the Contractor to obtain acceptable performance or for cancellation of such subcontract. Subletting by Subcontractors shall be subject to the same requirements.

c. Nothing contained in this contract shall be construed to create any contractual relation between any Subcontractor and the Government.

21. Liability of the Contractor. The Contractor will be responsible that his employees strictly observe the laws of the United States affecting operations under the contract. He will comply with the laws of the United States and of the states as to the aircraft operation and the licensing of pilots, mechanics, and other personnel. It is further understood and agreed that the Contractor assumes full responsibility for the safety of his employees, plants, and materials. He shall conform to such sanitary requirements as may be prescribed by the Contracting Officer.

22. Risks and Liabilities. The Contractor shall assume all risks in connection with performance and delivery of the work, and shall be liable for and save the Government harmless from any and all damages to persons and properties.

23. Ownership of Photographic Materials. All original aerial negatives from the instant of exposure, all duplicate negatives, intermediate positives (if required), and positive prints shall be the property of the Government. During the period the negatives, positives, and prints are in the possession of the Contractor, he may make only reproductions authorized by the Contracting Officer.

24. Permits and Clearances.

a. The Contractor shall, without additional expense to the Government, obtain all required Federal or local licenses, permits, and clearances necessary for performance of the contract. When the project falls within controlled air space, the Contractor shall contact the appropriate Air Route Traffic Control Center. If the project includes a military installation or other classified area, the Contractor may be required to visit the installation to obtain necessary clearance from the military commander. The Contracting Officer will assist in obtaining any required security clearances.

b. The Contractor must be aware of all existing regulations concerning restrictions and procedures on photographing classified military installations and on reproducing, publishing, or selling photographs of these installations. He must meet Department of Defense security requirements specified in DoD 5220.22M, "Industrial Security Manual for Safeguarding Classified Information" before photographing any Department of Defense or other installation classified with respect to aerial photography whenever all or a part of such an installation photography of classified areas shall be handled, stored, and shipped in accordance with security regulations.

25. Award and Notice to Proceed. The notice of award will be given by mail or by telegram and will constitute notice to proceed unless otherwise stated on the notice of award. Notice to proceed, if at a later date, will be given by mail or telegram.

26. Commencement and Prosecution of Work. Unless otherwise notified, the Contractor shall undertake photography of the area(s) within 5 calendar days after the notice to proceed is received. The start of work will be postponed if, in the opinion of the Contracting Officer, conditions make photography of the area(s) impractical. The Contractor shall notify the Contracting Officer or his authorized representative by registered mail or telegram the day his specified equipment and personnel arrive on the project. The Contractor shall keep the equipment and personnel continuously on the project and shall prosecute the work expeditiously until the photography specified in the contract is completed and the Contracting Officer notifies the Contractor that all the photographs are approved. If the specified photographic season ends before the photography is completed, the Contracting Officer will either extend the photographic season if conditions permit, relieve the crew until the next photographic season, or payment will be made as specified in 1.e. The Contractor may not remove the plane and camera crews from the project before completion of the work unless authorized by the Contracting Officer. The Contractor shall return the plane and camera crews to the project within 5 days after receipt of notice to resume work. Failure to comply with any of the requirements of the paragraph may be cause to annul this contract.

27. Progress Reports. On or before Monday of each week, each flight crew shall mail two copies of a weekly progress report on forms supplied by the

Contracting Officer showing the crew's progress on its assigned item for the previous week (ending Saturday). Such reports shall be filled out by each crew and mailed from their base of operations to: (District Office Address)