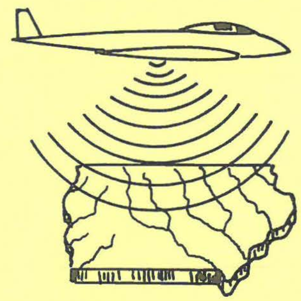
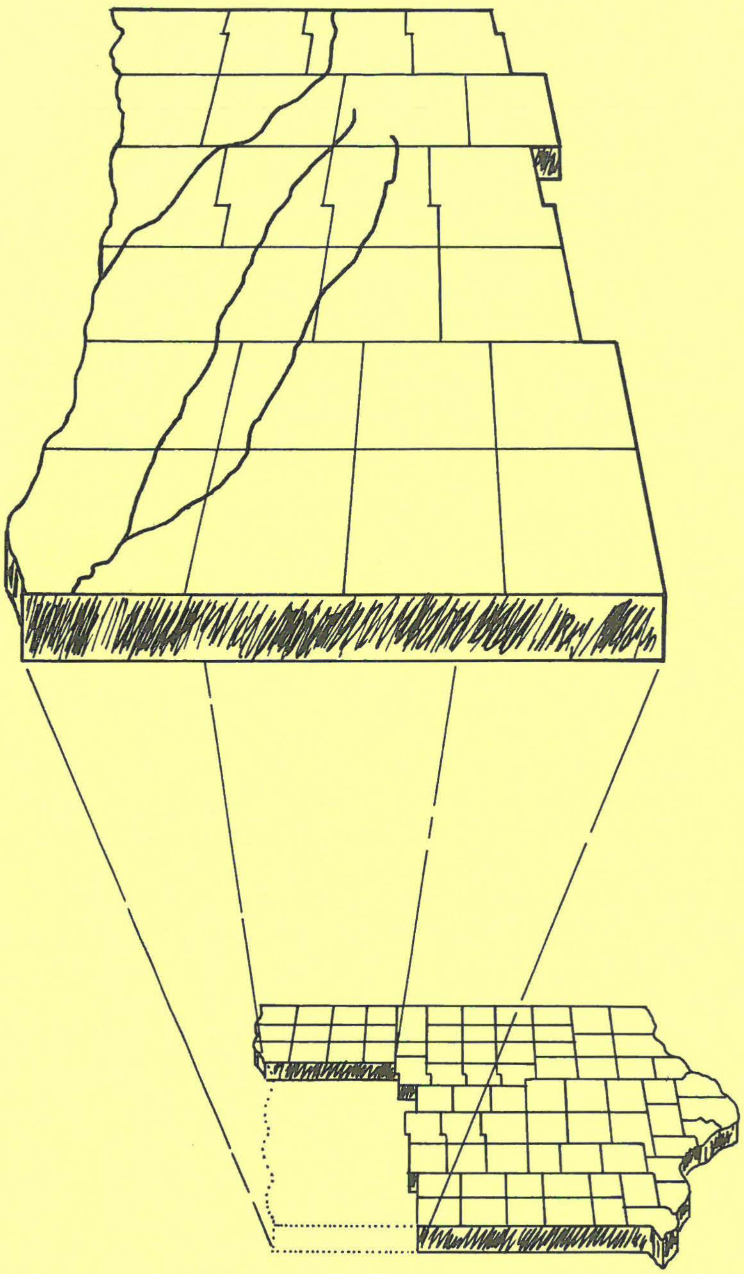
IOWA REMOTE SENSING LABORATORY





AERIAL FLOOD MAPPING IN SOUTHWESTERN IOWA

A PRELIMINARY REPORT

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Flooding is the cause of major disaster to many communities situated on rivers and streams throughout Iowa. Melting snow in the spring often results in widespread flooding along major waterways, while localized flooding is a frequent occurrence following summer thunderstorm activity. Melting snow and thunderstorms cannot be controlled, but the potentially disastrous effects of their runoff can be decreased with proper floodplain planning and management. However, current knowledge of the physical characteristics of the river and adjoining floodplain is necessary for effective action. This information must be quickly compiled into a format that is readily usable by the many federal, state, and local agencies concerned with flood problems. Existing remote sensing techniques provide a unique tool for coordinated data collection, suitable to meet the immediate and future needs of communities along Iowa's streams. The imagery, acquired a few days after flood crest and processed rapidly, may be quickly and easily interpreted yielding reliable information on the flood extent and damage. A continuous strip of photographs along the flooded river provides a permanent record of the flooded areas which can be utilized in the administration of emergency relief, damage assessment, and floodplain management.

East Nishnabotna Flood Study

West-central Iowa was hard hit by a storm on September 10, 11, and 12, 1972. An official weather observation station registered 15.25 inches of rain at

Harlan. Unofficial observation stations recorded more than 20 inches through the 72-hour period (fig. 1). The Boyer and Nishnabotna River systems carried most of the runoff from this storm. According to stream gage records at Atlantic, Iowa, the resultant flood stage recorded on September 12, 1972 was 2.37 feet higher and the discharge 6,200 cubic feet per second (32 percent) greater than any previously recorded flood.

The Iowa Geological Survey, Remote Sensing Laboratory, and the U.S. Geological Survey, Water Resources Division, combined efforts to determine the possibilities of operationally mapping this flooded area using aerial photography. The investigation centered on the East Nishnabotna River in southwestern Iowa. Aerial Services, Inc., Cedar Falls, Iowa, was contracted to provide the flying services.

Special aerial cameras as well as conventional hand-held 35mm cameras were employed to acquire photographic imagery along the river between Hamburg and Interstate 80 north of Atlantic. Three conventional films and two infrared sensitive films were used. The conventional films record the energy normally seen by our eyes--"white light." The infrared films recorded this same light and additional reflected solar energy not sensed by our eyes. Unique to this study was the use of a special multispectral camera which simultaneously records the same scene in four separate images. Each image, however, appears somewhat different because filters are used to separately record blue, green, and red visible energy, and non-visible infrared energy as it reflects from the landscape. The use of this camera makes it possible to detect unique, reflective properties of the landscape which developed in response to flooding. This may help us better understand the effect of the flood on the environment.

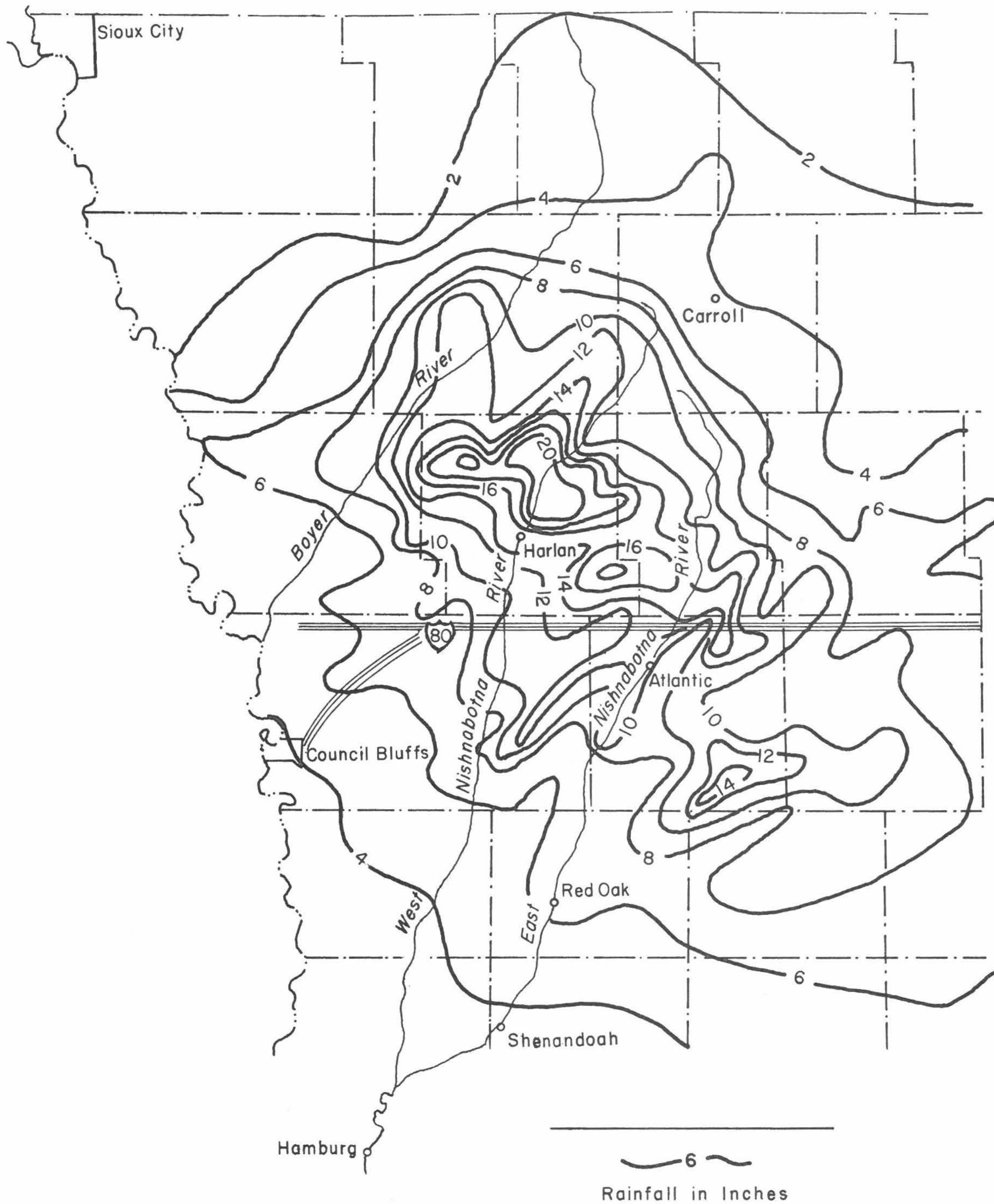


Figure I. PRECIPITATION PATTERN
10-12 September 1972

From: Climatological Data, N.O.A.H.
September, 1972

Aerial photographs were obtained on September 14th and 15th from altitudes of 2,000 to 8,000 feet above ground level. Floodwaters near Atlantic had receded by these dates, but the flood was still cresting downstream between Shenandoah and Hamburg. This delay in the crest allowed a comparison of imagery both at flood crest and after flood recession.

Analysis of Data

Analysis of the various types of aerial photographs and comparison of the photographs with ground-acquired data indicates that flood mapping can be effectively accomplished using the remote sensing approach. Two considerations were determined to be of utmost importance to successfully map floods in late summer--infrared sensitive film and stereoscopic viewing.

The utilization of infrared sensitive film is of primary importance for flood delineation. Water and saturated soils absorb much of the solar infrared energy and thus appear darker on the infrared imagery. Flood-stressed plants appear darker, too, because they do not reflect as much infrared energy back to the camera as unaffected plants. These effects are noticeable for imagery acquired several days after flood recession and ERTS-1 satellite imagery indicates that these effects can be mapped for at least one week following flood cessation. Blue, green, and red light do not photographically record these differences as well as infrared energy. A comparison of the four multispectral images indicates that the flooded area is best shown in figure 2-4 produced only with infrared energy. Infrared sensitive films may be either black and white or color, however, the color infrared film seems superior for delineating flooded areas. In addition, judicious use of the color-infrared film may allow assessment of a flood's damage to crops and other types of vegetation. It should be noted, though, that blue

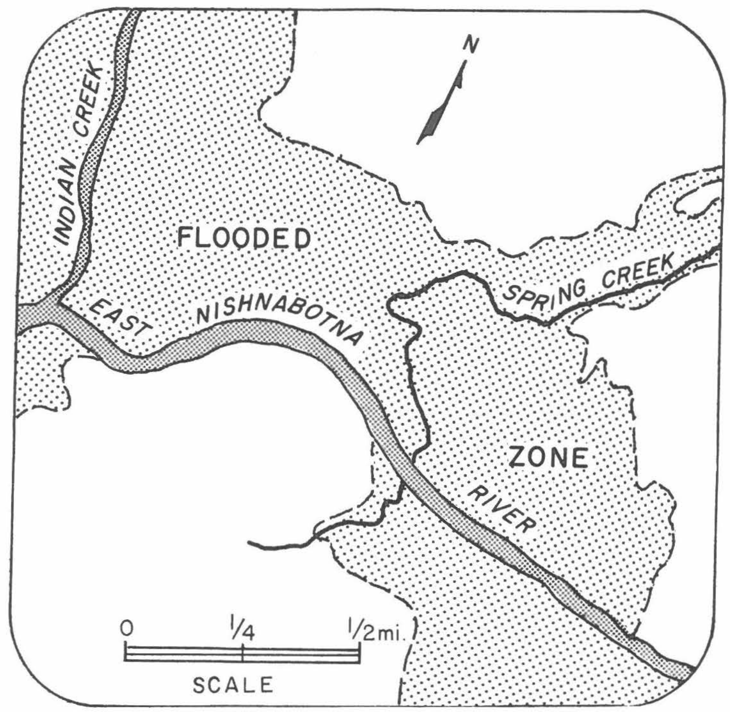
1. BLUE: The flooded area appears as lighter toned areas and can be quite easily traced. Areas of standing water or saturated soils reflect more blue energy than surrounding areas. Blue energy is commonly filtered to reduce unwanted scattering. This practice would result in a loss of flood mapping data.

2. GREEN: The flooded area is not easily identified in this image. The amount of green energy reflected remains almost constant for both flooded and non-flooded areas.

3. RED: The flooded area is not well delineated. Conventional films record a combination of blue, green, and red light. Thus, these films record that portion of the reflected energy least important for mapping floods.

Figure 2. Multispectral images of the September 1972, East Nishnabotna River Flood. The pictured area is located 10 miles south of Atlantic at Indian Creek. Normal "white light" consists of equal amounts of blue, green, and red energy. Other wavelengths of energy not detected by our eyes may also be recorded on film. Each image on this and the following page represents reflected portions of energy from the sun: blue, green, red, and infrared, respectively.

4. INFRARED: The darker tones delineate where flood water stood two days before this picture was made. Wet soils, water, and flood-stressed plants reflect less energy in this band. Reflected energy not visible to our eyes is the most important for successful flood mapping using aerial photography.



Map of the East Nishnabotna River Flood based on the information recorded on the multispectral photographs. Color infrared film, which records visible light and invisible infrared energy, proves to be most successful for mapping flooded areas.

light is also quite effective for flood mapping because standing water and saturated soil reflect blue energy more strongly than adjacent drier areas.

Stereoscopic viewing allows the analyst to view surface relief in three-dimensions. The interpreter may then easily check that a certain tone or color may logically be considered the highest elevation of flooding. Acquiring the photographs so that adjacent images overlap allows the steroscopic viewing for interpretive purposes as well as for the production of accurate contour maps of the floodplain.

Scale of Imagery

Another consideration is the scale at which the imagery is produced. Successful flood mapping would require continuous coverage for the full width of the flooded stream. Size of the river, nature of the floodplain, magnitude of the flood, and immediate and future uses of the photography must be considered in determining the scale. Generally, as the river, its valley, or the flooded area increase in size, the photography should be acquired at higher altitudes to achieve greater area coverage. For example, if a conventional aerial mapping camera were flown at 6,000 feet above ground level, the resulting image would cover a valley up to 1.7 miles wide. If flown at 12,000 feet above ground level, it would produce imagery covering a strip 3.4 miles wide--suitable for a larger river system. Urban, river basin, and regional planning groups would probably find more application for the wider coverage photography. Agencies doing hydrologic studies could find use for any imagery, but may find lower altitude photography more suitable especially if elevation measurements are necessary. Photography from 6,000 feet can yield topographic maps with five-foot contour intervals or point locations of ±1.5 feet. The one-foot contouring used for reconstruction on roads, bridges, or levees may require flying at 1,500 feet.

Not everyone's interests can be effectively served with one set of photographs. Generally, photographs acquired from altitudes of 6,000 to 12,000 feet above ground level seem most suitable for flood mapping, damage assessment, and planning purposes. Aerial photography obtained for engineering purposes would generally be flown at altitudes of 1,500 to 6,000 feet. However, contracting for all photography at the same time could result in somewhat lower total acquisition cost. Agencies requiring flood data include the U.S. Geological Survey, U.S. Army Corps of Engineers, U.S. Soil Conservation Service, Iowa Natural Resources Council, Iowa Highway Commission, Iowa Department of Civil Defense, Iowa Geological Survey, and various state, regional, and municipal planning boards. These agencies should determine their information needs and define possible coordinated data collection utilizing aerial flood mapping. This should include coordinated ground surveying as well as the aerial surveying itself. Most companies involved in aerial mapping could provide services that would satisfy these considerations for flood mapping.

Flood Mapping Cost Analysis

The cost of acquiring aerial photography for flood mapping is of prime importance to all agencies involved. Generally, mapping a 100-mile flooded river system in Iowa could be accomplished for about $1,500.00 to $2,500.00. This would include flying, film, and processing to an "interpretation ready" product--photographic prints from black and white infrared film or transparencies from the color infrared film. The cost of the original data acquisition is about the same for either film, but photographic reproductions of the color infrared

Table 1. Approximate cost of flood mapping and associated products.

	Complete 100-Mile River Coverage	
Imagery Acquired at:	6,000 feet	12,000 feet
Data Acquisition		
Infrared, stereoscopic imagery processed to an "interpretation ready" product	$1,500-2,500	$1,500-2,500
Additional Photographic Imagery		
One set of imagery from:		
Black and white infrared film	$ 200	$ 100
Color infrared film	650	325
Possible Additional Products		
Enlarged mylar reproduction ($45 each)	$ 3,500	$ 1,750
Contour maps ($125 minimum each)		
Five-foot contours	9,500 (min.)	-----
Ten-foot contours	9,500 (min.)	4,750 (min.)
Valley profiles ($75 each)		
One per mile	7,500	-----

images may cost about three times as much as reproductions of the black and white infrared images. Perhaps of more importance is the difference in processing time necessary for the two film types. The black and white prints may be processed locally within 24 hours, whereas the color film could take about one week to be processed out of the state. Duplicate imagery, which may be necessary for multiple agency usage or for public information, would take correspondingly longer periods of time for processing.

Flood planning can be greatly enhanced with several other products produced directly from the photographic imagery. Enlarged mylar reproductions, at scales of 1:3,000 or 1:6,000, could be particularly useful in the floodplain management near urban areas. Inexpensively reproduced by an ozalid process, the mylars could prove valuable in educating the public of flood danger. Communities situated on floodplains often are in need of topographic maps because of the paucity of these maps in Iowa. Imagery produced at 6,000 feet above ground level could provide maps with a five-foot contour interval for a minimum of $125.00 each. Valley profiles, indicating point elevations ±1.5 feet, can be constructed from this same imagery for about $75.00 each. These profiles, spaced from one to five per mile, are important for hydrologic studies of floodplains.

Summary

Results from the study of the September, 1972, East Nishnabotna River flood indicate that flood mapping can be conducted with aerial photography. The use of color infrared, stereoscopic photographs obtained with an aerial mapping camera provides a method of quickly and accurately delineating flood high water over large areas. In addition, the photographs may be used for damage assessment of property and crops, engineering and hydrologic studies, and local and regional planning along Iowa's river systems. The versatility of this photography will prove useful to many federal, state, and local agencies in Iowa.

Acknowledgements

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