053074

SEMI-ANNUAL STATUS REPORT

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Grant No. NGL 15-005-186

Title of Investigation

The Application of Remote Sensing Technology to the Solution of Problems in the Management of Resources in Indiana.

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Submitted to:

The Office of University Affairs
Code PY
National Aeronautics and Space Administration
Washington, D. C. 20546

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I. Introduction

This semi-annual status report covers the period from 1 December 1973 to 31 May 1974 and contains a review of the research and applications, completed or in progress, as funded by the Office of University Affairs, NASA and conducted by the Laboratory for Applications of Remote Sensing, Purdue University.

In order to implement the objectives of the original proposal LARS staff members are required to seek out agencies (local, regional and state) which have responsibilities for planning, monitoring, managing and developing the resources of Indiana. Once this contact has been established, it is necessary to determine how remote sensing technology might be of value to these agencies and then to work cooperatively with them to apply this technology to their needs.

During the period of 1 December 1973 to 31 May 1974 twenty-six meetings, talks, presentation and lectures were given to more than 550 people representing twenty-two agencies in the state of Indiana. The primary purpose of these meetings was the promotion and use of remote sensing technology for the solution of problems in the management of resources in Indiana. This program has been well received, but there is a continuing need for constant contact with the user community in order that full use will be made of this technology.

Fourteen meetings were held with representatives of four departments of state government to explore possible uses of remote sensing. These departments and divisions with each department are as follows:

1. Department of Natural Resources

   A. Bureau of Forests, Lands and Wildlife

      1. Division of Forestry
      2. Division of Reclamation
      3. Division of State Parks
      4. Division of Fish and Wildlife
      5. Division of Entomology
      6. Division of Outdoor Recreation

   B. Bureau of Water and Minerals

      1. Division of Water
      2. Geological Survey
      3. Division of Coal and Oil
      4. State Soil Conservation Committee

2. Indiana Department of Commerce

   A. Division of Research and Planning

3. State Highway Commission

   A. Division of Materials and Test
   B. Division of Planning

4. State Board of Health

   A. Division of Water Pollution Control

In addition to these state agencies, meetings were held with the Indiana Heartland Coordinating Commission and the Kankakee-Iroquois Regional Plan Commission. These two groups are responsible for coordinating planning activities that have regional (multi-county) significance. Both groups began operation this year and lack many of the basic inventories necessary to assess the natural resources within their areas of responsibility.

Meetings were also held with two county planning organizations. Vigo County (Terre Haute) and Marion County (Indianapolis) planning agencies requested and received briefings on the use of remote sensing technology and its applications to land use management.

The Planning Committee for the annual meeting of the State Association of Soil Conservation District Supervisors requested that a presentation be made at the annual meeting. A talk was presented to this group of several hundred, challenging them to consider the potential of remote sensing as an aid to managing the state soil and water resources. As a result of this presentation, numerous requests were received to present a similar talk at local Soil Conservation District annual meetings throughout the state. This opportunity allows for yet another group of resource managers and users to be acquainted with remote sensing.

The Indiana Planning Association holds a workshop for state and local planners each year. This was "The Third Annual State Conference for Local Planning Officials". A presentation was made to this group explaining how remote sensing can aid land use planning and encouraging planners at all levels to consider remote sensing technology as a viable tool for their work.

The Lake Michigan Region Planning Council requested a talk on remote sensing at one of their bi-monthly meetings. More than fifty architects, planners, educators and government officials heard a talk on ways that this new technology can help meet the demands of regional planning.

The Hoosier Heartland Association of Conservation Districts is an eight-county organization that assists land owners and users in planning and developing the natural resources of the area. These natural resources include soil, water and vegetation and their interdependence. This association requested a briefing on remote sensing at their quarterly meeting. A presentation was made to this group explaining all kinds of remote sensing technology and the potential applications for this group. The Hoosier Heartland Association has recently submitted an application to the U.S. Department of Agriculture to become a Resource Conservation and Development Project (RC & D). Remote sensing can play a valuable part in the establishment and development of this RC & D project. Further contact will be maintained with this group.

This status report summarizes work that has been completed and work that is in progress in a brief synoptic form. There is a full bibliographic reference (Section IV) of all published and unpublished reports that have been completed during the reporting period. Other reports will be referenced in later status reports.

Seven different projects are summarized in this status report. They are divided into three categories and are listed as follows:

A. Water Resources

1. Thermal Pollution Study of the Cayuga Power Plant Test Site
2. Thermal Mapping of a Waste-Heat Plume from a Power Plant on the White River at Indianapolis
3. Water Quality in Strip Mines in Indiana
4. Thermal Discharge into Water Bodies as a Part of a Siting Package for Electric Generating Power Plants
5. Recreational River Evaluation

B. Land Use Inventories

1. Land Use Inventory of the Indiana Heartland Area
2. Land Use Inventory in the Southwestern Indiana Strip Mine Region

C. Data Base Development

1. Data Base Study of an Area in Elkhart County, Indiana

The NASA Technical Officer for this project is:

Mr. J. A. Vitale
Chief, Engineering System Design
Code PY
Office of University Affairs
NASA Headquarters
Washington, D. C. 20546

II. Project Reports

A. Water Resources--Water resources projects and applications were undertaken mainly in the area of thermal discharge into rivers and streams. In addition, one project studied the ability of two remote sensing systems to detect water quality in a strip mine area of Indiana (Figure 1).

1. Thermal Pollution Study of the Cayuga Power Plant Test Site.

Background

In 1970 Public Service Indiana built an electric power generating plant at Cayuga, Indiana. This plant is located on the Wabash River in Vermillion County and uses river water for cooling purposes in the generation of electricity. During the construction of this plant multispectral scanner data were collected over the Wabash River above and below the plant site. These data were in 12 channels in the visible, reflective and thermal portions of the electromagnetic spectrum.

In 1972 and 1973 after two 500-megawatt generating units were in operation, aircraft missions were flown during three different periods to gather multispectral scanner data over the Wabash River near the plant. The dates of these missions were August 9, 1972, October 17, 1972 and May 4, 1973. These three data sets were processed at LARS and a calibrated thermal map of the river was produced.

Figure 2 is an aerial photograph showing the location of the Wabash River in relation to the power plant, canal, cooling towers and cinder pond.

Figure 3 is a map of water temperatures of the Wabash River above and below the power plant on May 4, 1973. Water was separated from all other classes using the "layered classifier". The mean radiant temperatures are shown to the nearest tenth of a degree centigrade and are accurate within two tenths of a degree centigrade.

These thermal maps, which show the waste-heat effluent flowing downstream from the outfall for several miles, have been utilized by J. R. Gammon of DePauw University, Greencastle, Indiana. Dr. Gammon is a fisheries biologist and used these maps to study the effect of heated water on the fish population at the test site.

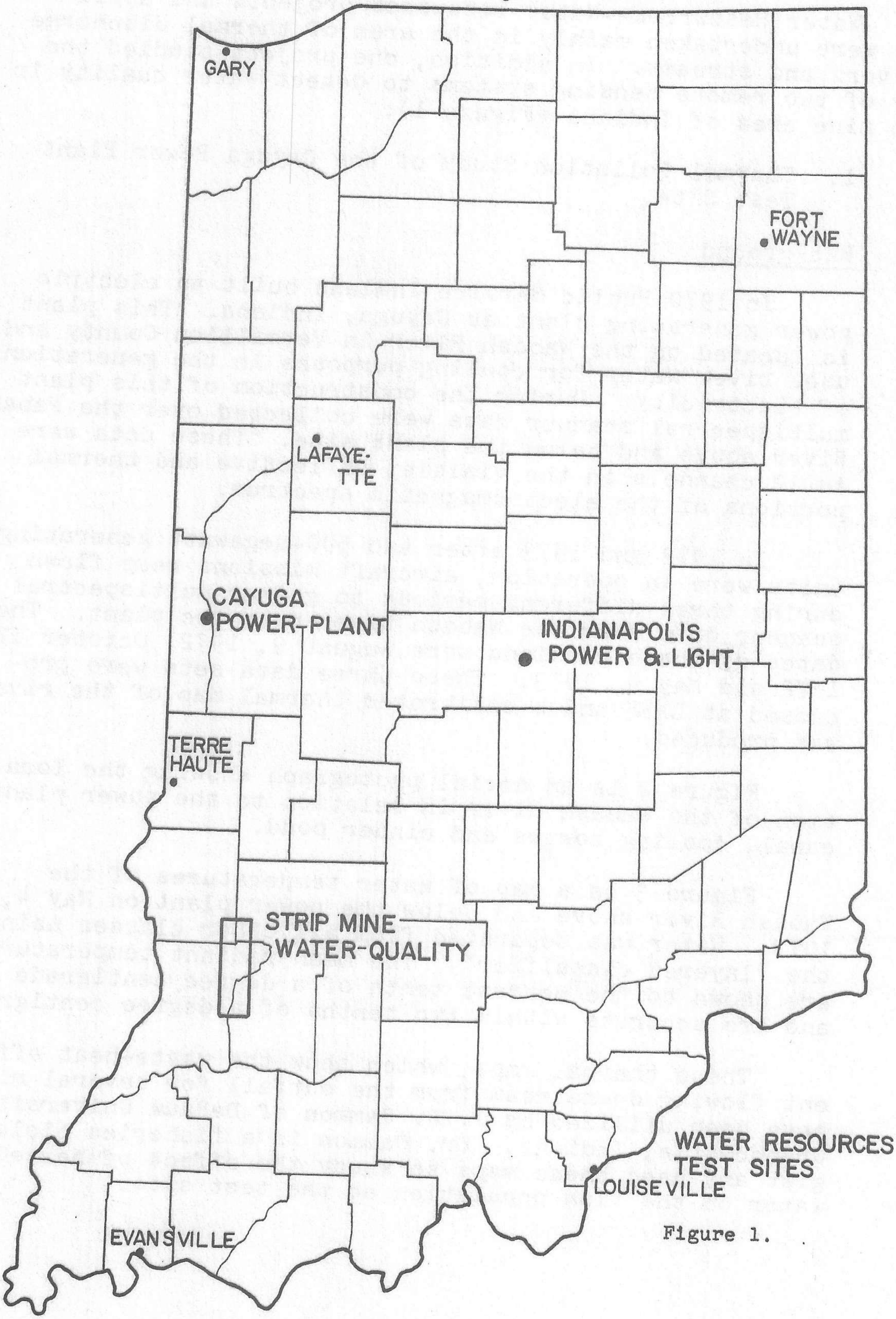

GARY
FORT WAYNE
LAFAYE-TTE
CAYUGA POWER-PLANT
INDIANAPOLIS POWER & LIGHT
TERRE HAUTE
STRIP MINE WATER-QUALITY
WATER RESOURCES TEST SITES
LOUISEVILLE
EVANSVILLE

Figure 1.

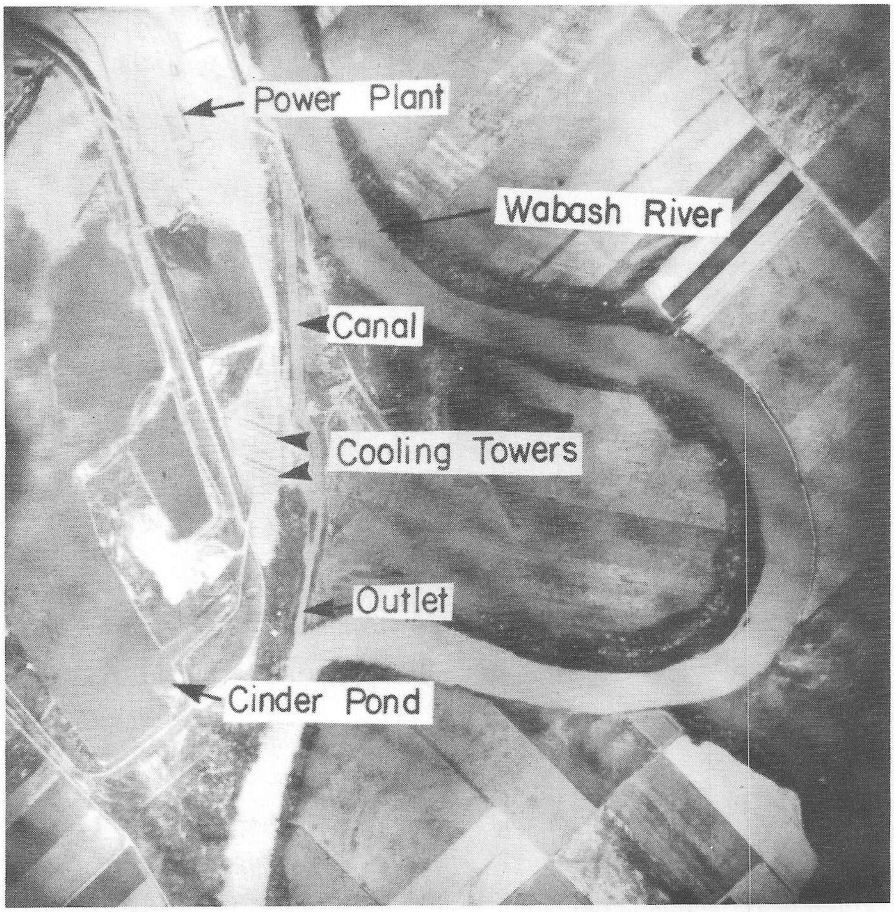
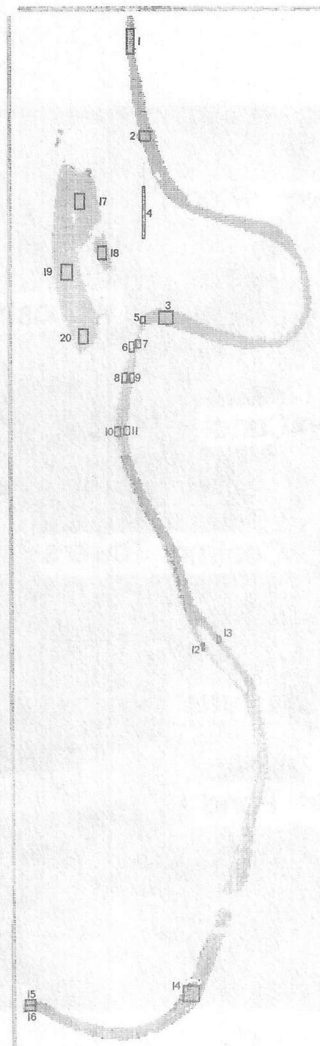


Figure 2. Aerial photograph of the Cayuga power plant and the Wabash River in Vermillion County, Indiana.



Test Areas		Mean Radiant Temp. (°C)
Above Intake	(1)	20.6
	(2)	21.0
	(3)	20.9
Canal	(4)	25.8
Below Outlet	(5)	24.9
	(6)	24.1 West Bank
	(7)	21.1 East Bank
	(8)	24.2 West Bank
	(9)	21.1 East Bank
	(10)	23.6 West Bank
	(11)	20.6 East Bank
	(12)	22.7 West Bank
	(13)	21.3 East Bank
	(14)	22.5
	(15)	21.3
	(16)	20.8
Cinder Pond	(17)	22.5
	(18)	20.8
	(19)	22.5
	(20)	22.7

Figure 3. Thermal map of water only, obtained from the "layered classifier." Data collected in the 9.3-11.7 μm band from an altitude of 1,500 meters (5,000 ft.).

Status of Project

To date, all the remotely sensed data have been processed and calibrated. The final phase of this work will involve the correlation of the computer generated thermal maps with the existing ground-truth data furnished by Dr. Gammon.

Conclusions

It is expected that a final report on this project will be completed during the next semi-annual status reporting period (1 June 1974 to 31 December 1974). This report will include a detailed description of the methods used and the results obtained from this research.

Publications*

"Effects of Altitude and Wavelength Band Selection on Remote Measurements of Water Temperature" by L. A. Bartolucci, R. M. Hoffer and J. R. Gammon; Presented at the First Interamerican Symposium on Remote Sensing, Panama City, Panama, 1973.

"Water Temperature Mapping through a Layered Classifier" by L. A. Bartolucci, C. L. Wu and P. H. Swain; LARS Information Note 042973.

*All publications including abstracts are listed in section IV of this report.

2. Thermal Mapping of a Waste-Heat Plume from a Power Plant on the White River at Indianapolis

Background

The Indiana State Board of Health, Division of Water Pollution Control is responsible for determining and monitoring the water quality of streams and rivers throughout the state of Indiana. One phase of this work is the measurement of thermal effluent introduced into water bodies from electric generating power plants. This information is being used by the State for thermal load allocations.

The method used by the Division of Water Pollution Control to map thermal effluent is based on the assumption that the rate of heat transfer is proportional to the temperature differential between water and air. River water temperature observed above and below a power plant and the average top width of the river are used to calculate the coefficient of heat transfer. The thermal model used to determine the coefficient of heat transfer was developed by LeBosquet[1].

In order to evaluate the results obtained using the above described method, the Division of Water Pollution Control personnel asked LARS if multispectral scanner data were available for a portion of the White River near the Indianapolis Power and Light Plant at the south edge of Indianapolis (Figure 4). Three sets of aircraft data were available for this site. The missions were flown in August 1972 and January and May 1973. The August 10, 1972 data were analyzed, and a thermal map of the water was made (Figure 5). These results were given to the Division personnel in order for them to check the accuracy of their original maps.

Status of Project

The results of the classification of the multispectral scanner data were reviewed by the Division and found to be more dependable than the system that they were then using. The Division personnel determined that this method not only verified their previous findings but also produced a more accurate and a more detailed thermal profile map of the river. By using the LARS processed calibrated scanner data they were able to extract enough information to evaluate the thermal impact on the White River from the electric generating power plant.

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(1) Velz, C.J. "Applied Stream Sanitation" Wiley-Interscience, 1970, pp. 279-280.

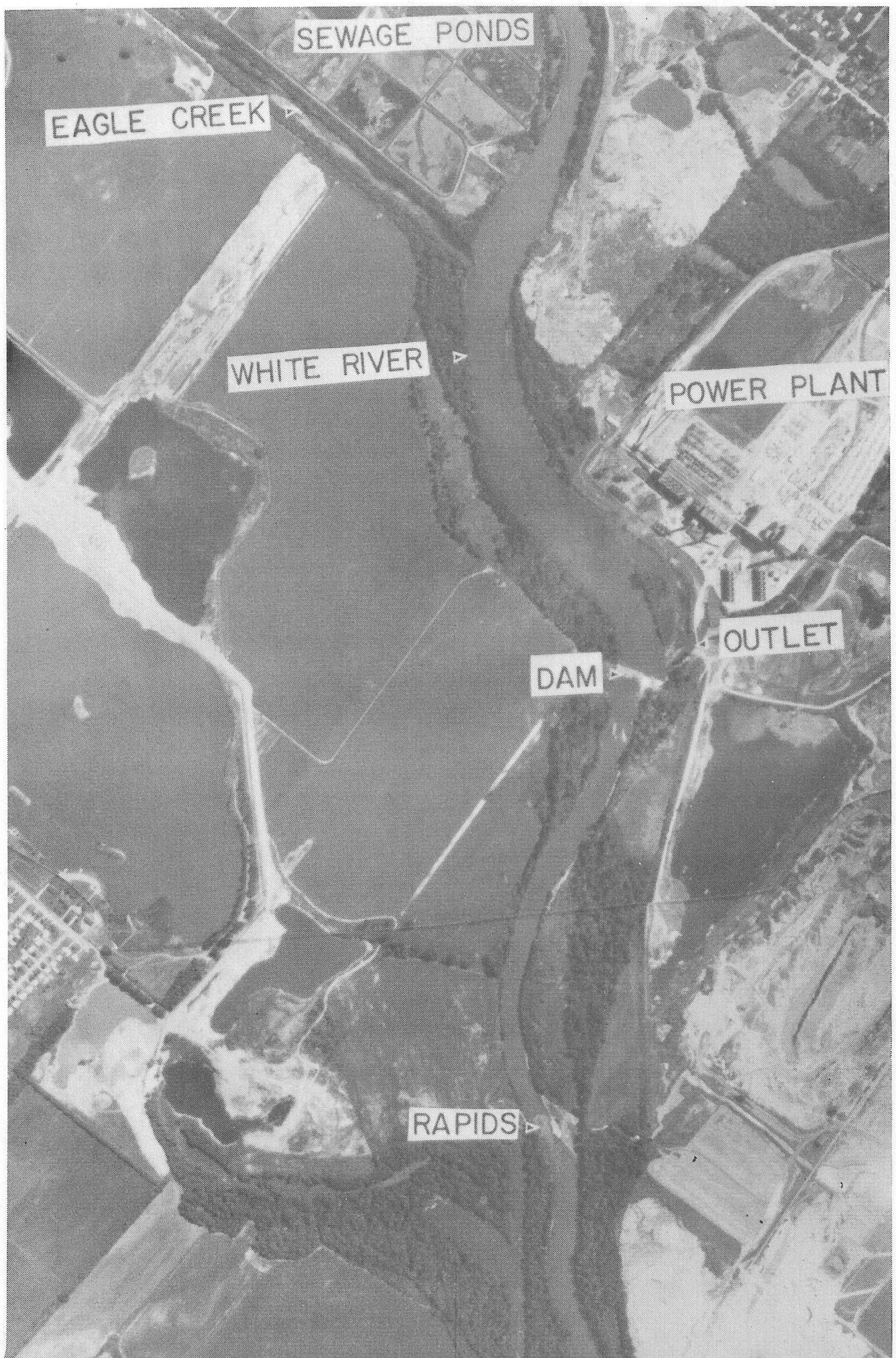
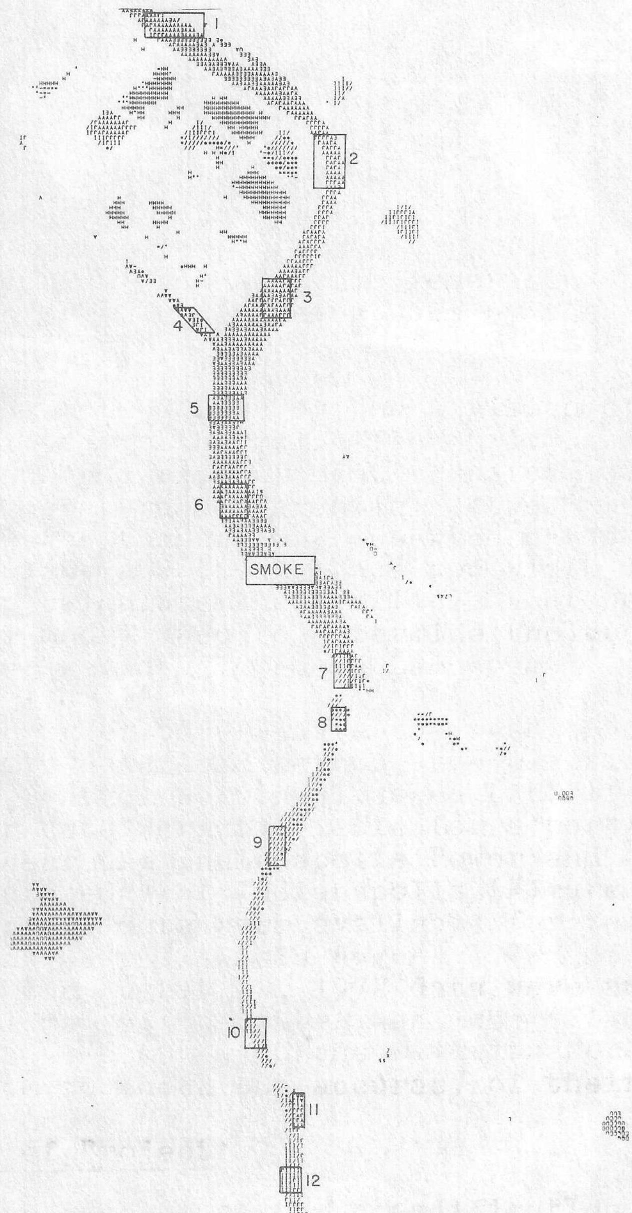


Figure 4. Aerial photograph taken August 10, 1972 of the Indianapolis Power and Light Company, Stout Plant near Indianapolis, Marion County, Indiana.



TEST AREA		MEAN RADIANT TEMP. (°C)
Above Eagle Creek	(1)	21.5
	(2)	22.0
	(3)	22.0
Eagle Creek	(4)	21.0
Below Eagle Creek	(5)	21.5
	(6)	22.0
Above Dam	(7)	23.0
Below Outlet	(8)	24.0
	(9)	23.5
	(10)	23.0
Below Rapids	(11)	22.5
	(12)	22.0

Figure 5. Thermal map of the White River near the Stout Plant. Data collected in the 9.3-11.7μm band from an altitude of 1500 meters (5,000 ft).

Conclusion

The Division of Stream Pollution Control is anxious to use other multispectral scanner data that is available at LARS. These data were collected over the Cayuga power plant and a 26 mile portion of the Wabash River from Lafayette south. They are interested in looking at other pollutants such as sediment and also the dissolved oxygen content and the biochemical oxygen demand (BOD) in the water at these sites.

There is some indication that they might be willing to financially support the processing of this data and research into ways that sedimentation, dissolved oxygen and BOD can be determined from the available data.

This system appears to have great potential value for the water resource monitoring activities within the state of Indiana. Environmental impact statements are required for all future electric generating plants. With the advent of nuclear reactors for this purpose there has been much interest in thermal monitoring of cooling water and its effect on the environment. This state agency has an ever increasing demand for more data prior to and after construction of these plants as well as an accurate modeling system to reliably predict thermal discharge for environmental impact assessment.

Further contact with the Indiana State Board of Health will be maintained as it is felt that remote sensing has a valuable contribution to make to this state agency.

The State Board of Health is also anxious to continue this dialogue since they are aware of the value of remote sensing as a tool to accomplish their mission within the State of Indiana.

3. Water Quality in Strip Mines in Indiana

Background

In 1973 Mr. Charles C. Burner, Fisheries Biologist, Bureau of Sport Fisheries and Wildlife, U.S. Department of Interior, requested the use of color infrared photography available through the LARS data library to study the acidity of water in strip mine pits in Indiana. Burner wanted to determine whether or not it was possible to detect the pH of water from its spectral reflectance using conventional photo-interpretative techniques.

A second phase of this project was to study the feasibility of detecting the pH of the water using multispectral scanner data gathered by an aircraft at 1500 feet altitude. LARS would perform an analysis of the multispectral scanner data and provide Burner with the results.

The third phase of this project was to delineate all the water bodies associated with strip mines so that field crews could check the pH of all water. Burner felt that if every pond was located before the crews went to the field, a great deal of time would be saved that would otherwise have been spent by the field crews just searching for all water bodies.

Status of Project

Results of photo-interpretation of color infrared photography showed that it was possible to distinguish seven classes of water. This distinction was based on various color shades and probable pH conditions (Figure 6).

The second phase of the project using multispectral scanner data for a computer-aided classification of the area showed that there is no correlation between the pH of water and the spectral response. Several classes of water were separated, but this separation was primarily due to differences in turbidity and specular reflection (sun-scanner look angle effect).

In the third phase of the study Burner found that the use of the photography for pit and pond location was an excellent aid to ground crews. He found many small pits which would in all probability have been overlooked by the ground crews had it not been for the maps derived through the analysis of the photography.

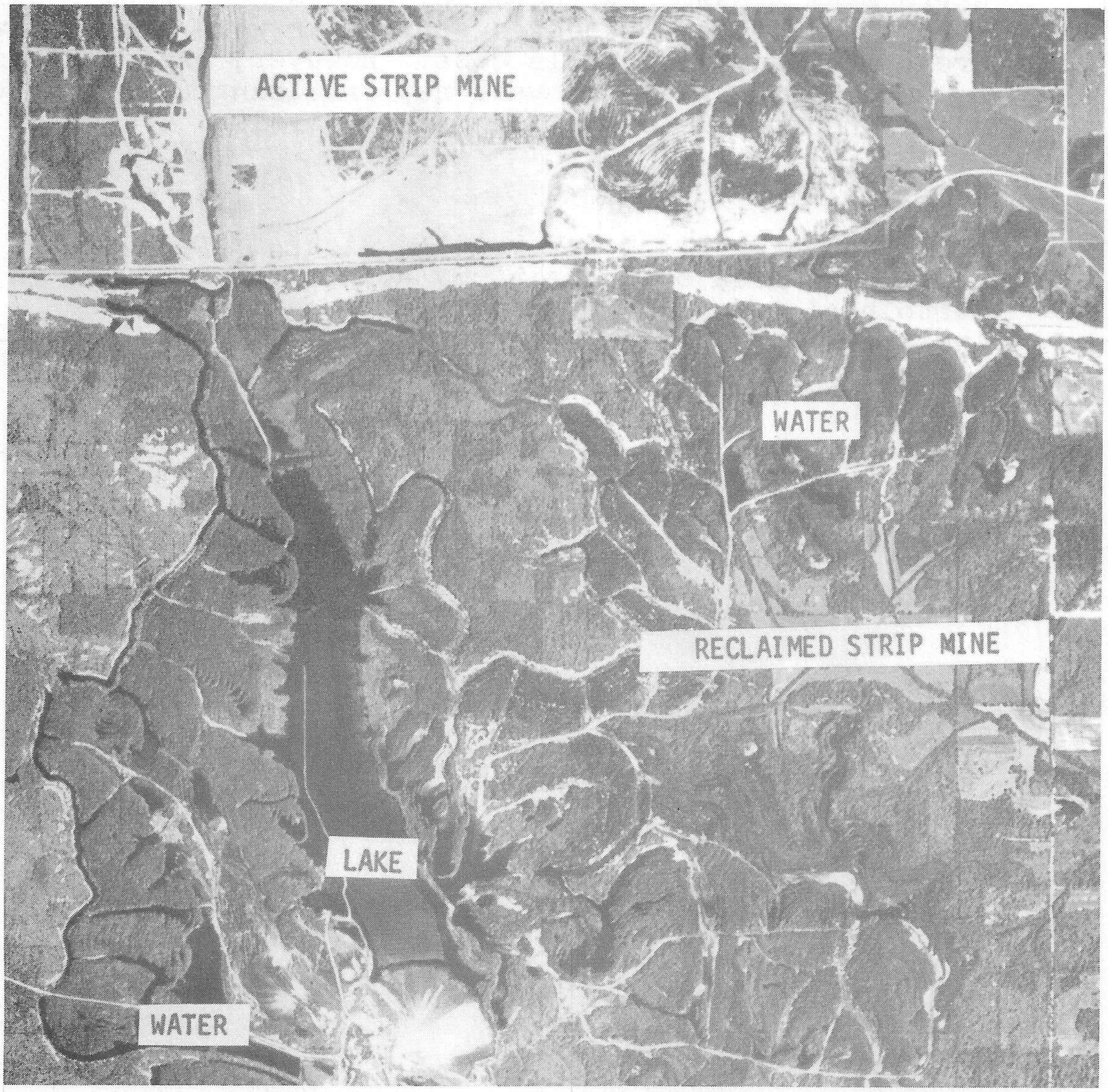


Figure 6. Black and white reproduction of a color infrared aerial photograph showing strip mines and water bodies in Knox County, Indiana.

Conclusions

This project did aid in the location of water in strip mine areas. Furthermore, generalized maps showing location of water-inundated strip pits were produced with great accuracy and little cost. However, expected results in determining water pH were not promising using either photo-interpretation or MSS data analysis.

Publications

"Computer-Aided Analysis of Aircraft Data in a Strip Mine Area of Indiana" by R. M. Hoffer, L. A. Bartolucci and J. S. Berkebile; Proceedings of the Indiana Academy of Science for 1973, Vol. 83, 1974.

4. Thermal Discharge into Water Bodies as a Part of a Siting Package for Electric Generating Power Plants

Background

A long range project to develop a comprehensive package of analytical tools to aid in the selection of potential power plant sites in Indiana has been initiated at LARS. This involves the socio-economic as well as physical modeling of the impact of a power plant and is designed to evaluate the total effect of the facility on the community in which it is located.

Electric utilities within the state are in search of an unbiased and reliable system that is capable of predicting the behavior of power plant thermal discharges into water bodies. Environmental impact assessment is a requirement of federal and state regulations governing the establishment of new plants. At present there is a plan to begin construction of a nuclear power plant along the Ohio River near Louisville, Kentucky within the next five years. This project will aid in the development of the necessary evaluation parameters for this plant as well as other plants that are fossil fueled.

Status of Project

This is a new project that has been under way for only a few months. The primary thrust so far has been the adaptation of certain computer programs for the most efficient processing and display of aircraft-gathered multispectral scanner data of the thermal properties of water.

A second area of accomplishment has been to implement on the LARS computer a three-dimensional time dependent transport code for flowing rivers and streams. This code was developed at Purdue University, and it is planned that the validity of the code in predicting the behavior of power plant discharges will be tested. The data collected by multispectral scanners will be used to establish boundary conditions for the three-dimensional code as well as an aid in the verification of the code's results.

Conclusions

Other than the work reported in the previous section, there are few results available at this time.

An important contact has been made as a result of this project. Mr. David Griffiths, Executive Director of Environmental Quality Control, Incorporated has visited LARS to establish liaison between Indiana industry, Indiana government and LARS. The Environmental Quality Control is a non-profit organization devoted to environmentally sound industrial practices within the existing state and local regulations and statutes. There is a great potential for remote sensing technology to support this organization, and continued contact will be made to bring this about.

5. Use of Remote Sensing Data in Recreation Resource Evaluation

Background

A Purdue University recreation planning team was assigned the job of developing and testing a river evaluation system, including criteria for selecting the rivers most suitable for designation under a 1973 Natural, Scenic and Recreational Rivers Act of the State Legislature. The evaluation system had to be economically practical, accurate, objective and relatively rapid in execution. This would allow the under-staffed Department of Natural Resources to conduct appropriate studies with a minimum of additional manpower. Two types of materials were required. The first was the set of topographic maps for the state, produced by the United States Geological Survey. Most of the maps utilized were several years old, some dating back as far as 15 years. Therefore, to update the topographic maps, a set of aerial photographs of recent vintage were needed.. These also had to be of a relatively small scale, so that long segments of rivers could be covered on comparatively few photographs. At the same time, this aerial imagery had to provide enough detail so vegetation and man-made structures could be readily identified along the streams, since the natural stream system was designed to identify streams that had the least intrusion of man on them, and to classify these in order of priority. The small scale color infrared transparencies met these requirements and proved very successful in application.

The photography used for this project was obtained by NASA's WB-57 aircraft in 1971 for use in the "Corn Blight Watch" experiment which was coordinated at LARS. The resultant 9-inch by 9-inch color infrared transparencies had a scale of 1:120,000. Each image covered an area on the ground of about 290 square miles, or 17 miles by 17 miles (Figure 7). The characteristic enhancement of vegetation and water features on color infrared photos proved particularly advantageous in this project. These small scale photos were interpreted on a rear-view enlargement device, which has a capability for up to 32 times enlargement of the original transparency. The use of this machine in conjunction with such small scale photography allowed many miles of the streams to be studied using a relatively small number of photos. Since the photographs were on continuous strips wound on reels, access to them by the power-driven viewing machine was quite rapid. For example, examination of the bank vegetation and the man-made structrues along the Wabash River were studied for a length of 335 miles in about two hours.

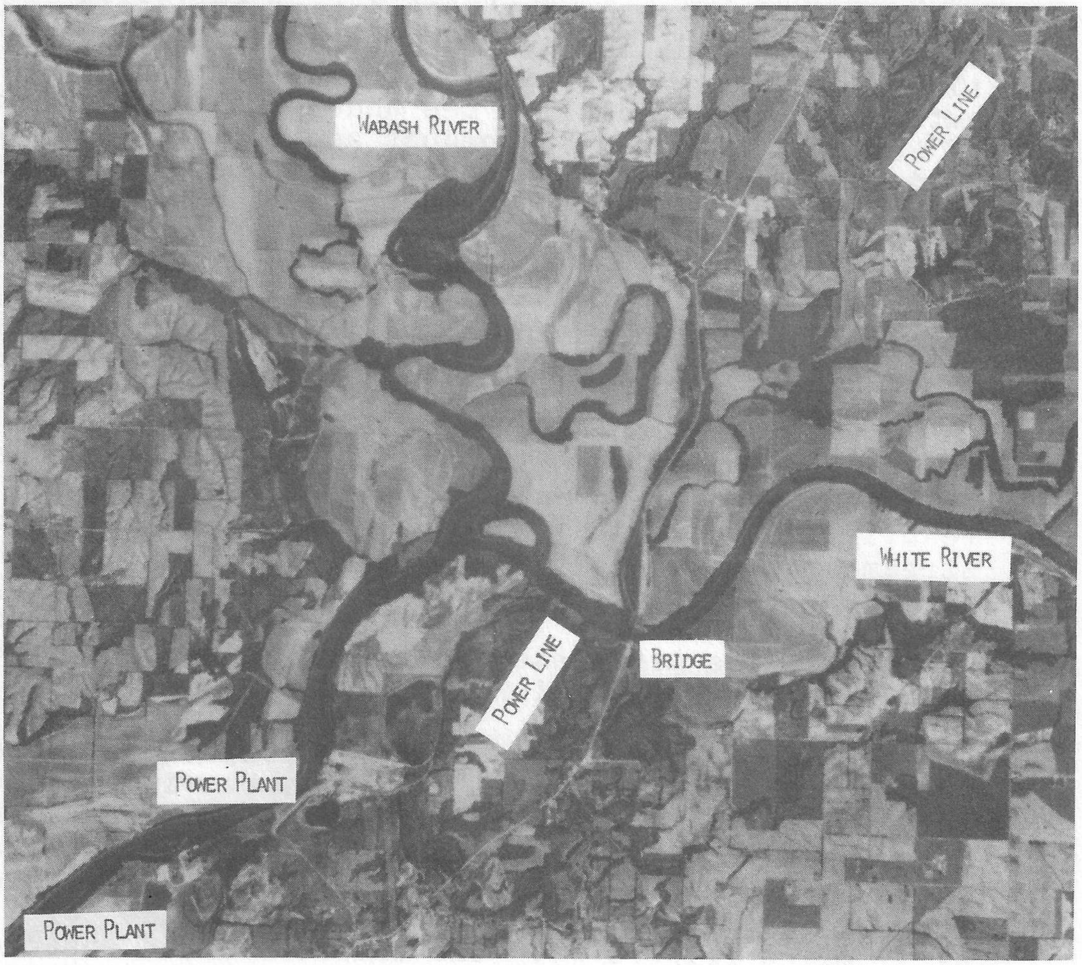


Figure 7. Black and white reproduction of a color infrared aerial photograph showing the Wabash and White Rivers near Petersburg, Indiana. This kind of photography was used to evaluate scenic and recreation rivers in the state.

Status of Project

This project has been completed and the results given to the Indiana Department of Natural Resources, Division of Outdoor Recreation. An unpublished report and abstract are listed in Section IV as there is a plan to publish this report in the near future.

Conclusion

The Purdue River Evaluation Study proposed and tested criteria for selecting streams which might be included in the state system of natural, scenic and recreational streams. The photography allowed two men to evaluate the "necessary criteria" on 36 streams in less than one week. It allowed a very rapid up-dating of the topographic maps so that current cultural features could be identified. New bridges, new roads and new buildings could be easily spotted from the photographs and added to the topo maps. Likewise, vegetation changes and land use changes could be picked up.

The use of small-scale (1:120,000) infrared transparencies proved a successful and valuable tool in evaluation of the natural conditions of the rivers in Indiana. Springtime photographs (before the trees leafed out) were used, thereby allowing quick and definite identification of most cultural features. Since the photographs had been recently obtained, they were useful in updating older maps and other materials. The greatest value of the photographs, however, was the time-saving element that they offered. By quick, thorough study of the photographs, personnel time required for field work was reduced significantly, and many weeks of field study could be eliminated. This was especially true where rivers obviously did not meet the criteria of naturalness required for this system. Preliminary study of the photos provided valuable information on location of the most strategic field studies.

B. Land Use Inventory--Two projects are reported here. One is the land use inventory of the eight county area around Indianapolis that is being made for the regional planning commission. The second project is a land use study of a strip mine area in southwestern Indiana (Figure 8).

1. Land Use Inventory of the Indiana Heartland Area

<u>Background</u>

On January 1, 1974 the Indiana Heartland Coordinating Commission (IHCC) came into being. It is a regional planning body that provides direction for planning activities that have regional significance. Regional growth and development, human resources and environmental quality are the areas of primary concern for this group.

The Heartland area covers about 8% of the state's land area and has more than 20% of the state's population. There are great paradoxes of population distribution in the area as it is not only the industrial center of the state but also has a large farming area that is under the pressure of population expansion. Many conflicts of land use are present and most of them have regional significance.

The IHCC has a limited staff, a small budget and practically no current land use inventories available for their use. The IHCC has requested that LARS prepare a land use inventory of each county using ERTS-1 data and computer-aided analysis techniques. These inventories will be used to identify basic land use patterns within the area. Examples of how this organization plans to utilize this type of data are as follows:

1. To determine the population growth patterns from the central residential areas into the surrounding agricultural lands.
2. To assess the conflict of agricultural land vs. commercial/residential land use and develop appropriate guidelines to solve this conflict on a regional basis.
3. To identify significant problems arising from the various land uses that have regional implications.
4. To identify environmentally significant areas such as prime agricultural land, stream corridors, forest preserves and ecologically sensitive areas so that appropriate action can be planned for their use.

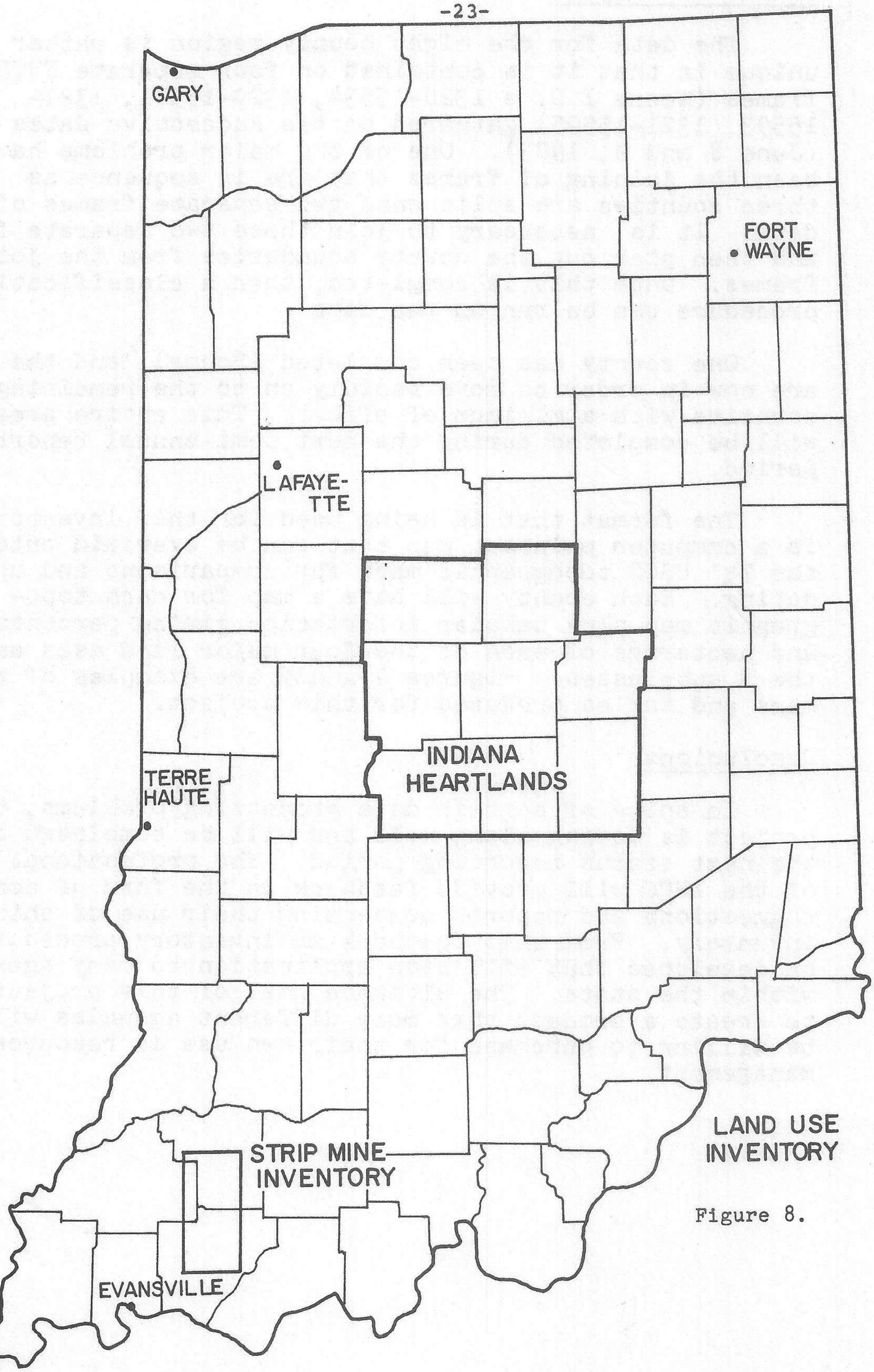

GARY
FORT
WAYNE
LAFAYE-
TTE
TERRE
HAUTE
INDIANA
HEARTLANDS
LAND USE
INVENTORY
STRIP MINE
INVENTORY
EVANSVILLE

Figure 8.

Status of Project

The data for the eight county region is rather unique in that it is contained on four separate ERTS frames (scene I.D.'s 1320-15534, 1320-15541, 1321-15593, 1321-15595) gathered on two successive dates (June 8 and 9, 1973). One of the major problems has been the joining of frames that are in sequence as three counties are split onto two separate frames of data. It is necessary to join these two separate frames and then pick out the county boundaries from the joined frames. Once this is completed, then a classification procedure can be run on the data.

One county has been completed (Boone), and the data are now in order to move rapidly on to the remaining counties with a minimum of effort. This entire area will be completed during the next semi-annual reporting period.

The format that is being used for this inventory is a computer printout map that can be overlaid onto the 7½' USGS topographic maps for comparisons and up-dating. Each county will have a map for each topographic map plus tabular information giving percentages and hectarage of each of the four major land uses and the 8 subclasses. Figures 9 and10 are examples of the maps and tables produced for this project.

Conclusions

In spite of certain data processing problems, this project is moving along well and will be completed during the next status reporting period. The professional staff of the IHCC will provide feedback in the form of comments, suggestions and reports concerning their use of this inventory. From this feedback an inventory procedure will be developed that will have application to many agencies within the state. The ultimate goal of this project is to create a product that many different agencies will be willing to purchase for their own use in resource management.

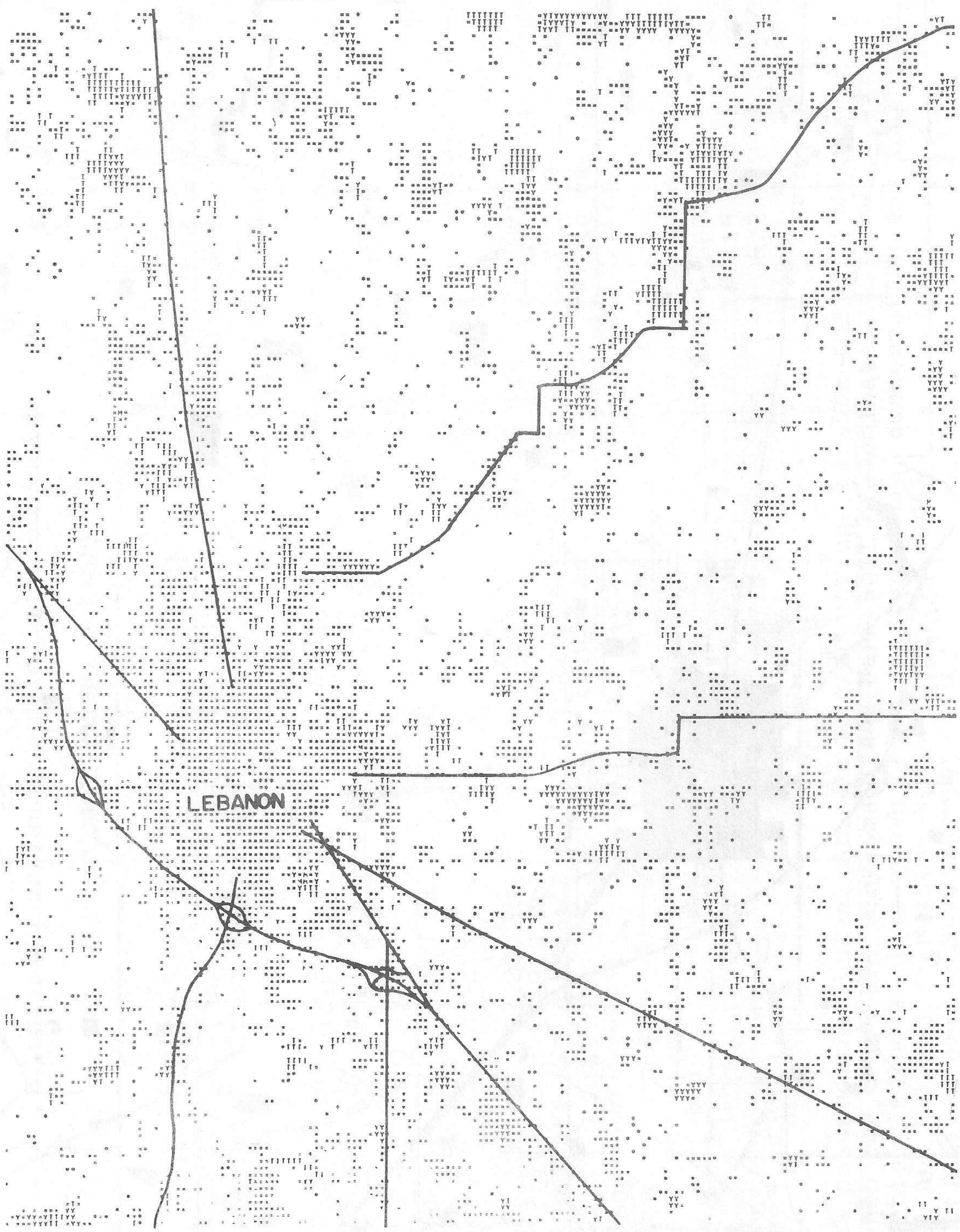


Figure 9. Classification of ERTS-1 data from June 9, 1973 for a portion of Boone County, Indiana. The area covered by this print out is the same as the USGS quadrangle map in Figure 10.

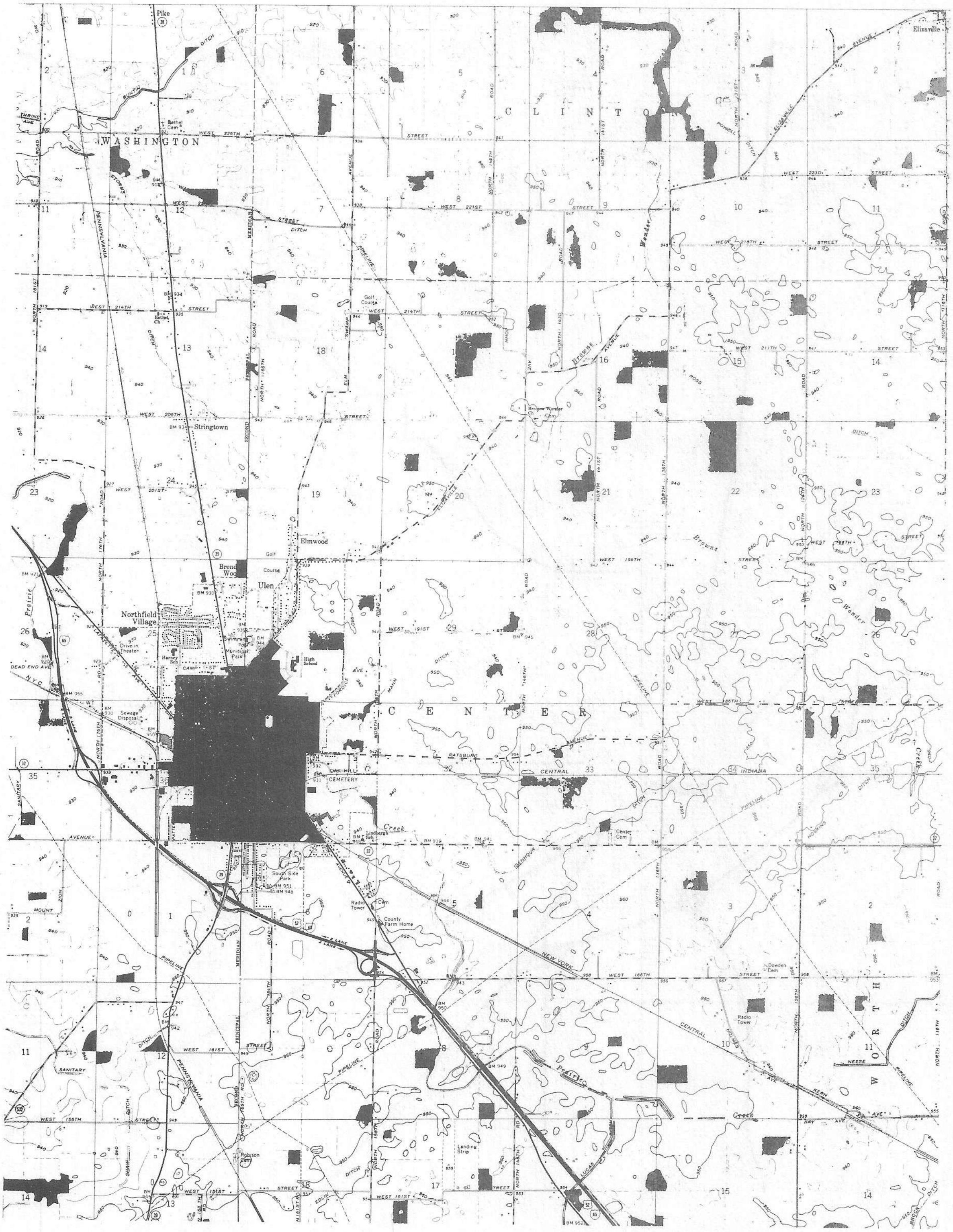


Figure 10. U. S. Geological Survey topographic map of the Lebanon, Indiana quadrangle. ERTS data is made to overlay on the appropriate quadrangle map for the Indiana Heartland Coordinating Commission.

Land Use Inventory

Indiana Heartland Coordinating Commission

Boone County Areal Summary

Source:	Agriculture: Bare Soil[a]	Agriculture: Other Vegetation[b]	Woods	Water	Built-up Land
1967 CNI[c]	85,500 Ha 211,172 Ac 77.2 %	13,800 Ha 34,100 Ac 12.5 %	4,600 Ha 11,407 Ac 4.2 %	82 Ha 203 Ac .1 %	6,600 Ha 16,398 Ac 6.0 %
1972 SRS[d]	60,000 Ha 147,600 Ac	7,300 Ha 18,000 Ac	-	-	-
ERTS[e]	67,600 Ha 167,144 Ac 62.2 %	23,200 Ha 57,313 Ac 21.3 %	Dense 5,300 Ha 13,025 Ac 4.8 %	72 Ha 179 Ac .1 %	Commercial 1,750 Ha 4,318 Ac 1.6 %
			Scattered 4,050 Ha 10,012 Ac 3.7 %		Residential 6,800 Ha 16,815 Ac 6.3 %

a. Bare soil is assumed the equivalent of row crop acreage because the data was taken on June 9 when row crops are very small and bare soil predominates.
b. Other vegetation includes close-grown crops, pasture, hay, conservation and idle land.
c. Indiana Soil and Water Conservation Needs Inventory, 1968
d. State Statistical Reporting Service, 1972
e. Earth Resource Technology Satellite data classification

2. Land Use Inventory in the Southwestern Indiana Strip Mine Region

Background

Coal is the primary source of energy for the generation of electricity in Indiana. About 85% of the state's coal production is used to generate electricity in coal-fired, steam generating plants. These plants manufacture 96% of the electricity in Indiana's coal market area.

The Department of Commerce has estimated that nearly 80,000 hectares of land has been disturbed by all forms of strip mining. Coal mining represents about 75% of the total hectarage disturbed. Strip mining for coal proceeds at the rate of about 1,200 hectares per year.

A study was begun at LARS in 1973 using ERTS data collected over an area of intense strip mining in Pike and Warrick Counties, Indiana. The study was to determine the spectral separability of strip mines and the accuracy of areal estimates made from ERTS multispectral scanner data.

The Department of Reclamation of the Indiana Department of Natural Resources is charged with the responsibility for issuing strip mine permits and monitoring the reclamation of strip mine areas pursuant to the statutes of the state. This department has an obvious need for impartial and periodic monitoring of strip mine activities. Up to now there has been no possible means by which they could adequately do the job before them.

Status of Project

This project is in the final evaluation stage and will be published as a LARS Information Note during the next semi-annual status reporting period.

Conclusion

This study found it was possible to delineate several different cover types associated with strip mines (Figure 11). This separation was possible on the basis of spectral separability. The accuracy of areal estimates was found to be within reasonable limits. The ability of computer-aided analysis techniques to quickly produce an accurate inventory at a reasonable cost to the

Figure 11. Classification of ERTS-1 data of a strip mine area in Warrick County, Indiana overlaid on an aerial photograph.

Symbol	Land Use
*,w	Water
M,-	Strip mine
1,0,·	Revegetated strip mine
Blank	Agriculture

consumer has great potential for required monitoring by this state agency. The Department of Reclamation requested that this inventory be made as they do not have an easy and accurate method for evaluating the results of strip mine re-vegetation.

C. Data Base Management

1. Data Base Study of an Area in Elkhart County, Indiana

Background

An adaptation of the Harvard "Grid" system of data base handling is called RIAT (Resource Inventory Analysis Techniques). This system was developed in the Landscape Architecture School at Purdue University and has great potential for data base management of many resources within a given area. Through a system of weights, a decision model can be generated to indicate areas of high or low suitability for almost any land use.

This program supported a study of a 1,600 hectare tract in Elkhart County that is about to be developed for residential use. Although this program's involvement was minimal the results are worthy of more than passing mention.

Status of Project

A senior design student in Landscape Architecture prepared a report on the area in Elkhart County. It is called TIAD (Tamarak Inventory, Analysis and Development). The professional quality of the report is impressive as it contains 107 pages, many of them as overlay maps of the area. The final product is a land use plan for the area that is based on ten different parameters of natural and cultural resource features. The sources for these parameters were such things as USGS topographic maps, USDA soil survey maps and ERTS data, as well as field observations.

This report is an unpublished document with only a very few copies available (less than 10). It is important to note, however, that the result will be used for the final development plan of the area. The local plan commission is aware of it, and the student is now working for the architectural firm that is planning the area.

Conclusions

Data base development of an area such as a county or a watershed appears to be a logical alternative to land use plans that are not flexible enough to meet the demands for change. If the development of a data base such as that reported in this project is able to inventory an area (county or watershed) and then provide logical alternatives that are in keeping with environmental constraints and still produce the highest and best use of the land, then this system should be further expanded and promoted.

LARS contributed to the alternatives that the user had to choose from by implementing the data base for this project.

This data base system is now under investigation by the Indiana Department of Commerce, Division of Planning and Research. This Division is in the process of developing a data base for the entire state and is looking at all systems that are available. Contact with this agency is being maintained in order to be able to aid in the development of the statewide data base.

III. Summary

To date, the projects that have been worked on have produced encouraging results. As time goes on, more interest will be generated by those who have benefited from the use of remote sensing.

Water resource applications, land use inventories and data base development are only the beginning of the potential applications projects in the state of Indiana. In all probability remote sensing technology applications will continue to increase in the future.

A necessary part of this project is the concentrated effort to continually present remote sensing technology to those people, groups and agencies that are in a position to make land use and resource management decisions. Without this effort, this valuable tool, remote sensing, will not be used to its fullest potential.

Three kinds of remote sensing products have been used by this project to meet the needs of the user community. These products are: (1) interpretations of aerial photographs, (2) computer-aided analysis of aircraft multispectral scanner data and (3) computer-aided analysis of ERTS-1 multispectral scanner data. Careful selection of the proper remote sensing technique is a basic requirement before any problem can be solved. The selection of the right technique will require that all methods be evaluated and the correct system chosen as the ultimate method available. This analysis of the problem is an integral part of the educational process for effective applications of remote sensing.

Many state and local agencies and groups are beginning to respond to this educational process. The introduction of a new technology means that old methods may need to be changed, enlarged or abandoned altogether. Naturally, such changes are slow to take place, but it is encouraging to note that there is a general acceptance of the premise that remote sensing has a place in the wise use and management of our natural resources.

IV. Publications and Abstracts

Bartolucci, L. A., R. M. Hoffer, J. R. Gammon. 1973. Effects of Altitude and Wavelength Band Selection on Remote Measurements of Water Temperature. 1st Int. Symposium on Remote Sensing. Panama City, Panama. 1973.

ABSTRACT

Various remote sensing instrumentation and analysis techniques are being developed to allow thermal mapping of water bodies over large geographical areas. In pursuing the objectives of further developing computer processing techniques for obtaining accurate radiometric temperature measurements from remote platforms, it was found that aircraft altitude and atmospheric window selection had significant effects on the results. However, as demonstrated in this study involving the influence of the Cayuga power plant effluent on the Wabash River, proper selection of atmospheric window and detector band-width, coupled with adequate calibration procedures, allows temperature measurements to be obtained with an accuracy of about 0.2°C at altitudes of at least 1500 meters. This figure is based upon the correspondence between the remotely measured temperatures and temperature measurements obtained on the river at the time of the overflight.

The results of this study offer a great deal of insight into the potentials and limitations of automatically calibrating and processing thermal infrared scanner data. Such techniques could be applied on an operational basis, not only to situations involving thermal pollution, but also to situations in which indications of potential fresh water supplies are being sought.

Bartolucci, L. A., C. L. Wu, P. H. Swain. 1973. Water Temperature Mapping through a Layered Classifier. LARS Information Note 042973.

ABSTRACT

A layered classification scheme was developed and successfully applied to thermal mapping of water.

In order to produce a map of water temperature from multispectral scanner data that measures thermal infrared reflectance (8.0 to 14.0μm), it is necessary to separate the water from all other cover types and then to calibrate the thermal infrared data corresponding to water only.

Water has radiative properties that are nearly the same as those of a blackbody in the thermal infrared region. In a multispectral scanner the emittance of two black reference plates maintained at a constant known temperature is recorded by the scanner for absolute calibration of the sensor response. This "internal calibration" permits direct temperature observations from materials such as water that have approximately the same emissivity as the black plates.

A layered or multilevel classifier uses a pattern recognition algorithm for which multiple decision functions can be used successively in order to reach a classification result.

To use the layered classifier, training areas of representative ground cover types are selected. The means and covariance matrices of the samples are then calculated. A spectral plot is used to define decision boundaries between the water class and the remaining spectral classes.

Once the water is separated from all other ground cover types, the linear calibration of the thermal response is applied to the water.

The results indicate that accurate temperature measurements of surface water can be achieved through a layered classifier.

Hoffer, R. M., L. A. Bartolucci, J. S. Berkebile. 1973. Assessment of Characteristics of Strip-Mined Areas in Indiana. Indiana Academy of Science. Vol. 83. 1974.

ABSTRACT

Due to pending legislation in Congress dealing with strip-mining procedures, detailed information is needed concerning the areal extent and condition of lands affected by strip-mining. Further information is required for a Department of Interior study dealing with assessment of the extent and quality of surface waters in strip-mined areas for fisheries potential. Small-scale color infrared imagery (1:120,000) was used to estimate the areas of water bodies located in strip-mined areas of Indiana and to correlate spectral characteristics of the water with various aspects of water quality. The need for additional information prompted a computer-aided classification of multispectral scanner data gathered by aircraft over strip-mined land in Greene, Sullivan, Knox, and Daviess Counties. The correlation of spectral classes of water with pH levels was attempted. Acreage estimates of surface water, agriculture, strip mine, and forest covers have been made. The results suggest a potential method for rapidly assessing many qualitative and quantitative characteristics of strip-mined land.

Knudson, D. M., R. M. Hoffer. 1973. Use of Remote Sensing Data in Recreation Resource Evaluation. Unpublished.

ABSTRACT

Small-scale (1:120,000) color infrared photographic imagery was used in evaluation of rivers for possible inclusion in the Natural, Scenic and Recreational Rivers System of Indiana. The evaluation concerned recreational, scenic and natural qualities of the rivers. The aerial imagery proved to be very helpful in increasing accuracy of evaluations and reducing the field study time necessary for the evaluations. Recreation planners were able to quickly eliminate disqualified rivers, and accurately identify areas which needed intensive field study. This allowed for efficiency in planning and executing field investigations, and provided up-to-date information on ground conditions, many of which were not visible from the stream itself.